J. Fish. Sci. Tech. 1(1), 129~146, 1998

Fatty Acid Composition of 72 Species of Korean Fish

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(Received March 1998, Accepted une 1998)

Fatty acid compositions of seventy-two species of Korean fish muscle, 59 species of sea water fish and 13 species of fresh water fish, were studied. Polyunsaturated fatty acid (PUFA) was the richest fatty acid group in all fish samples, accounting for 38.0 ± 10.3% of total fatty acids. Monounsaturated fatty acids (MUFA, 31.4 ± 9.67%) and saturated fatty acids (SFA, 30.5 ± 3.81%) showed a similar level. There was a positive correlation between the total lipid content and MUFA ($r=0.7788$, $p<0.001$) and a negative correlation between the total lipid content and PUFA ($r=-0.7786$, $p<0.001$) while there was no correlation between the total lipid content and SFA. The proportion of n-3 PUFA and n-6 PUFA was 29.7 ± 8.73% and 6.48 ± 3.70%, respectively, in all fish samples. The n-3 PUFA was rich in sea water fish while n-6 PUFA was rich in fresh water fish. The migratory fish contained the highest level of the n-3 PUFA (1.82 ± 1.01 g/100 g muscle), followed by the fresh water fish (1.09 ± 1.04 g/100 g muscle), the reef fish (0.90 ± 0.60 g/100 g muscle) and the demersal fish (0.77 ± 0.38 g/100 g muscle). There was a positive correlation between the total lipid and n-3 PUFA content, $y=0.2083x+0.05$ ($r=0.9352$, $p<0.001$).

Key words: Korean fish, fatty acid composition, n-3 PUFA, lipid content

Introduction

The annual consumption of marine food in Korea has been increased in the last five years, from 35.9 kg/caput (1991) to 46.0 kg/caput (1995) (Korea rural economic institute, 1996). This increase is thought to have occurred because a number of data have suggested that marine oil has beneficial effects on human health (Lees, 1990). The data have demonstrated that marine oil reduce the symptoms and death from cardiovascular disease, arthritis and cancer etc., and these effects have been known to be caused by n-3 fatty acids rich in marine oil, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Lees, 1990). Therefore, the lipid content and n-3 fatty acid composition of marine food are very important in the aspect of nutrition and physiology for human being. The consumer usually would like to know "How much lipid and n-3 fatty acids in a species of fish are contained?". Food scientists thus should answer the question. Recently, a few workers have begun to immerse themselves with that problem. For example, Sigurgisladottir and Palmadottir (1993) reported the lipid content and fatty acid composition of 35 Icelandic fish species, and Belling *et al.* (1997) also reported those of 11 species of Queensland (Australia) fish. Korean consume the third-large amount of marine food in the world (Korea rural economic institute, 1996). We could not find a detailed data on the lipid content and n-3 fatty acid composition of a number of Korean fish species though. In our previous paper (Jeong *et al.*, 1998), we reported the proximate composition, cholestrol and α-tocopherol content of 72 species of Korean fish. We consecutively report the detailed fatty acid composition contained n-3 fatty acids of the Korean fish. This work demonstrates a comprehensive survey of the fatty acid composition of the vast Korean edible fish species for the first time.

Material and Methods

Lipid content and fatty acid composition were analyzed in 72 species of fish muscles, of which 59 species were sea water fish and 13 species were

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fresh water fish. In most cases, fish samples were purchased as alive from a fish market at Tongyeong and Sancheong in Korea and moved to our laboratory. The fish samples were recorded by body length, body weight and fish number, and then filleted. About 300~500 g of fish muscles were taken out from more than two individuals of each fish species and mixed by a speed cutter. Total lipid was extracted and purified according to the method of Bligh and Dyer (1959), and the content was determined gravimetrically. Fatty acid was determined after methylation (AOCS, 1990). Fatty acid composition was analyzed with a gas-liquid chromatography (Shimadzu GC 14A, Shimadzu Seisakusho, Co. Ltd., Kyoto, Japan) fitted with an Omegawax 320 fused silica capillary column (30 m×0.32 mm, ID., Supelco Park, Bellefonte, PA, USA). The injector and the flame-ionization detector were held at 250℃ and column was programed from 180℃ (initial time 8 min) to 230℃ at 3℃/min and final time set for 15 min. Helium was used as a carrier gas at the constant inlet pressure of 1.0 Kg/cm^2 with split ratio of 1 : 50. Fatty acids were identified by comparison with authentic standards (Sigma Chemical Co., St. Louis, MO, USA) and an oyster sample which had been analyzed by Koizumi *et al.* (1990). Data were calculated as the peak area percent of total area of fatty acids. Methyl tricosanoate (99%, Aldrich Chem. Co., Milw, WI, USA) was used as an internal standard for the quantitative calculation of PUFA. All the data are presented as mean value of 4 determines (2 group×2 times) for the each fish species. Standard deviation for these analysis was less than 0.90%.

Results and Discussion

Table 1 lists 59 species of sea water fish samples, which caught off the coast of Tongyeong in the Southern Sea (Nam-Hae) at a latitude of about 32°N, and 13 species of fresh water fish samples which caught in the Kyeongho river, the Southern area of Korea, from March 1995 to January 1996. It also shows the mean body length, mean body weight and lipid content of each fish species analyzed. The lipid content for these fish species reported in the previous paper (Jeong *et al.*, 1998), is quoted here to help the illustration of the n-3 fatty acid content of the fish samples. The fish samples selected are commonly edible species in Korea. The sea water fish were grouped by their habitats or habit; mid-surface dwelling and migratory fish (migratory fish), coastal and reef dwelling fish (reef fish), and demersal fish.

The lipid content showed a obvious characteristics of the fish group. The migratory fish contained the highest amount of lipid in all fish groups, accounting for 1.26~16.6% (6.09 ± 4.25%) and the demersal fish contained the lowest amount of lipid, 0.53~9.47% (2.12 ± 2.41%), and the reef fish and the fresh water fish showed an intermediate level (3.41 ± 2.68% and 4.40 ± 5.90%, respectively). The migratory fish may need a large amount of lipid for their energetic action. In fact, the lipid is used as the energy source and the lipid source of gonad during feeding and spawning migration. Therefore, the migratory fish seems to accumulate a large amount of lipid in their muscles. For example, eel, one of the fresh water fish, is a migratory fish and contained the highest level of lipid in this study, accounting for 20.4%. The eel lives in river for 5~12 years and then migrates to a spawning ground known as deep sea. During the migration, the eel starves and the gonad develops, which causes degeneration in its digestive organ (Chyung, 1991). The eel therefore may accumulate high level of lipid in its muscle for long distance travel to deep sea, a spawning ground. In case of the demersal fish, which do not migrate, their lipid content may be enough for their life, except that of sea eel which contained the highest level of lipid (9.19%) in the demersal fish group. On the other hand, the reef and the fresh water fish are the intermediate in their movement of all fish groups, and thus they may contain an intermediate amount of lipid.

The fatty acid compositions of total lipid in 72 species of fish muscles are shown in Table 2. Table 3 shows the content of n-3 and n-6 PUFA (g/100 g muscle), and the proportion of SFA, MUFA and PUFA of all fish species. Fig 1 shows the correlation between lipid content and saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids as the percent of total fatty acids.

In most fish, the prominent fatty acids were 16 : 0, 18 : 1 (n-9) (or n-7), 20 : 5 (n-3) and 22 : 6 (n-3). These results were similar to those of Icelandic fish (Sigurgisladottir and Palmadottir, 1993) and Australian fish (Belling *et al.*, 1997). In this study, PUFA was the richest fatty acid group in all fish species, accounting for 38.0 ± 10.3% of the total fatty acids. The demersal fish showed the

Table 1. Body length, body weight and lipid content of 72 species of Korean fish

Common name (Korean name)	Scientific name	Body length (cm)	Body weight(g)	Total lipid (wt %)	Collection month
Mid-surface dwelling, Migratory fish					
1. Sardine (Jeong-eo-ri)	*Sardinops melanoticta*	20.5	116	6.28	Mar. 1995
2. Anchovy (Myeol-chi)	*Engraulis japonica*	11.0	14	3.66	Mar. 1995
3. Horn fish (Hag-gong-chi)	*Hemilamphus sajori*	23.9	43	1.26	Mar. 1995
4. Ice goby (Sa-baeg-eo)	*Leucopsarion petersi*	4.7	5.3	4.52	Mar. 1995
5. Striped mullet (Sung-eo)	*Mugil cephalus*	27.3	313	3.52	Mar. 1995
6. Hickoryshad (Jeon-eo)	*Konosirus punctatus*	18.5	92	6.08	Apr. 1995
7. Yellow tail (Bang-eo)	*Seriola quinqueradiata*	37.0	850	6.59	Apr. 1995
8. Sea bass (Nong-eo)	*Lateolabrax japonicus*	38.7	700	2.98	Apr. 1995
9. Nothern sand lance (Gga-na-ri)	*Ammodytes personatus*	9.0	4.0	10.6	May 1995
10. Mackerel (Go-deung-eo)	*Scomber japonicus*	27.5	365	16.6	May 1995
11. Ocean perch (Mang-sang-eo)	*Ditrema temmincki*	19.0	190	2.63	May 1995
12. Jack mackerel (Jeon-gaeng-i)	*Trachurus japonicus*	15.8	85	11.5	May 1995
13. Hair tail (Gal-chi)	*Trichirus lepturus*	81.0	270	9.98	Jun. 1995
14. Coho salmon (Eun-yen-eo), (A)*	*Oncorhynchus kisutch*	47.5	1840	9.76	Jun. 1995
15. Coral fish (Ja-ri-dom)	*Chromis notatus*	10.5	50	1.26	Jul. 1995
16. Seapike (Ae-ggo-chi)	*Sphyraena japonica*	24.0	110	1.99	Jul. 1995
17. Yellow drum (Su-jo-gi)	*Nibea albiflora*	19.0	100	1.61	Aug. 1995
18. Spanish mackerel (Sam-chi)	*Scomberomorus niphonius*	39.5	470	4.93	Aug. 1995
19. Redlip croaker (Cham-jo-gi)	*Pseudosciaena polyactis*	19.5	160	9.87	Sep. 1995
Coastal and reef dweelling fish					
20. Black rockfish (Bol-nag)	*Sebastes inernis*	19.6	190	3.12	Apr. 1995
21. Red sea bream (Cham-dom)	*Chysophrys major*	20.2	210	1.56	May 1995
22. Schlegel's black rockfish (Jo-pi-bol-nag)	*Sebastes schlegeli*	24.0	410	7.47	May 1995
23. Black sea bream (Gam-seong-dom)	*Acanthopagus schlegelii*	23.0	300	2.37	May 1995
24. Rock trout (Cham-no-rae-mi)	*Agrammus agrammus*	28.8	460	2.62	May 1995
25. File fish (Jwi-chi)	*Stephanolepis cirrhifer*	14.5	110	0.88	May 1995
26. Multicolorfin rainbowfish (Yong-chi-nol-rae-gi)	*Halichoeres poecilopterus*	17.5	100	1.08	Jun 1995
27. Cocktail wrasses (Eo-reng-nol-rae-gi)	*Pteragogus flagellifera*	17.7	170	2.38	Aug. 1995
28. Sevenband grouper (Neung-seong-eo)	*Epinephelus septemfasciatus*	20.8	245	1.64	Aug. 1995
29. (Hwang-jeom-bol-nag)	*Sebastes oblongus*	15.0	120	1.24	Aug. 1995
30. (Ga-sung-eo)	*Liza haematocheila*	28.0	470	8.80	Aug. 1995
31. Striped beakperch (Dol-dom)	*Oplegnathus fasciatus*	19.5	300	8.03	Sep. 1995
32. Largescale blackfish (Beng-e-dom)	*Girella punctata*	20.0	265	3.81	Sep. 1995
33. Gold porgy (Hog-dom)	*Semicossyphuss reticulatus*	31.5	860	2.80	Sep. 1995

Table 1. (continued)

Common name (Korean name)	Scientific name	Body length(cm)	Body weight(g)	Total lipid (wt %)	Collection month
Demersal fish					
34. Common brackish goby (Mun-jeol-mang-dug)	*Acanthogobius flavimanus*	16.9	50	0.79	Mar. 1995
35. Green ling (Jwi-no-rae-mi)	*Hexagrammos otakii*	26.6	355	0.93	Mar. 1995
36. Spotted haibut (Beom-ga-ja-mi)	*Versaper variegatus*	26.1	345	1.16	Mar. 1995
37. Sea eel (Bung-jang-eo)	*Astroconger myriaster*	70.0	223	9.19	Apr. 1995
38. Bastard, Flatfish (Neob-chi)	*Pararlichthys olivaceus*	29.0	365	0.76	Apr. 1995
39. Red tongue-sole (Cham-seo-dae)	*Areliscus joyneri*	29.2	150	1.02	May 1995
40. Red gurnard (Dal-gang-eo)	*Lepidotrigla microptera*	25.0	244	2.19	May 1995
41. Flounder sole (Cham-ga-ja-mi)	*Limanda herzensteini*	22.5	180	1.70	May 1995
42. Stone flounder (Dol-ga-ja-mi)	*Kareius bicolaratus*	30.0	750	2.53	May 1995
43. File fish, Scraper (Mal-jwi-chi)	*Navodon modestus*	17.5	110	0.89	May 1995
44. Angler, Goose fish (A-gwi)	*Lephiomus setigerus*	31.0	850	1.35	Jun. 1995
45. Flat head (Yang-tae)	*Platycephalus indicus*	30.5	320	1.39	Jun. 1995
46. Finespotted flounder (Do-da-ri)	*Pleuronichthys cornutus*	18.5	250	1.49	Jun. 1995
47. Long shanny (Jang-gaeg-i)	*Stichaeus grigorjewi*	37.0	310	5.12	Jun. 1995
48. Harvest fish (Byeong-eo)	*Pampus argenteus*	15.0	140	4.73	Jun. 1995
49. Grass puffer (Bog-seom)	*Takifugu niphobles*	14.7	130	0.78	Jun. 1995
50. Japanese stargazer (Eol-rug-tong-gu-meong)	*Uranoscopus japonicus*	19.0	240	0.60	Jun. 1995
51. Saddled weever (Ssang-dong-ga-ri)	*Parapericis sexfasciata*	18.0	120	2.52	Jun. 1995
52. Electric ray (Jeon-gi-ga-o-ri)	*Narke japonica*	24.5	495	0.74	Aug. 1995
53. Sand smelt (Bo-ri-myeol)	*Sillago sihama*	16.5	50	1.19	Aug. 1995
54. Devil stinger (Ssu-gi-mi)	*Inimicus japonicus*	28.0	320	1.06	Aug. 1995
55. Blenny (Be-do-ra-chi)	*Enedrias nebulosus*	30.2	120	1.71	Oct. 1995
56. Inshore hagfish (Meog-jang-eo)	*Eptatretus burgeri*	42.5	200	9.47	Oct. 1995
57. Skate (Sang-eo-ga-o-ri)	*Raja porosa*	28.5	480	0.66	Dec. 1995
58. Grass fish (Ggom-chi), (f)**	*Liparis tanakae*	40.3	980	0.53	Jan. 1996
59. Grass fish (Ggom-chi), (m)***	*L. tanakae*	42.0	970	0.63	Jan. 1996
Fresh water fish					
60. Pale chub (Pi-ra-mi), (f)**	*Zacco platypus*	13.3	31	4.30	Jul. 1995
61. Pale chub (Pi-ra-mi), (m)***	*Zacco platypus*	15.0	46	2.40	Jul. 1995
62. Perch (Ggeok-ji)	*Coreoperca herzi*	14.8	88	1.45	Jul. 1995
63. Dark sleeper (Dong-sa-ri)	*Mogurnda obscura*	12.5	29	0.79	Jul. 1995
64. False (Mo-rae-mu-ji)	*Pseudogobio esocinus*	15.0	28	1.11	Jul. 1995
65. Striped shiner (Dol-go-gi)	*Pungtungia herzi*	11.0	13	2.68	Jul. 1995
66. Gold fish (Bung-eo)	*Carassius carassius*	13.4	36	1.10	Jul. 1995
67. Spined loach (Gi-reum-jong-gae)	*Cobitis taenia*	16.5	25	2.59	Jul. 1995
68. Cornet fish (Nu-chi)	*Hemibarbus labeo*	19.0	46	1.88	Jul. 1995
69. Mandarin fish (Sso-ga-ri)	*Siniperca scherzeri*	17.5	125	3.40	Jul. 1995
70. Eel (Baem-jang-eo)	*Anguilla japonica*	440.0	250	20.4	Jul. 1995
71. Bass (A)*	*Micropterus almoides*	24.6	280	1.24	Sep. 1995
72. River eight-eye lamprey (Chil-seong-jang-eo)	*Lampetra japonica*	42.0	220	13.9	Oct. 1995

* A, Aquaculture.

** f, female.

*** m, male.

Table 2. Fatty acid composition of 72 species of Korean fish*

Fatty acid	Mid-surface dwelling and migratory fish							
	1. Sardine	2. Anchovy	3. Horn fish	4. Ice goby	5.Striped Mullet	6.Hickory-shad	7.Yellow tail	8.Sea bass
12:0	0.20	0.20	tr	tr	tr	0.13	tr	tr
14:0	6.25	5.78	0.99	5.51	4.30	9.53	2.71	2.60
15:0, iso	0.21	0.17	tr	0.11	tr	0.13	0.11	0.08
15:0, anteiso	tr***	tr	0.10	tr	tr	tr	0.02	tr
15:0	0.36	0.46	0.37	0.16	1.51	0.51	0.56	0.28
16:0, iso	tr	tr	0.17	tr	0.14	0.06	0.08	0.08
pristanic	tr	tr	0.21	0.11	0.32	0.11	0.08	0.12
16:0	18.30	18.84	20.24	17.32	22.02	22.22	19.93	20.27
17:0, iso	0.21	0.29	0.25	0.16	0.15	0.20	0.27	0.24
17:0, anteiso	0.19	0.18	0.19	0.10	0.49	0.17	0.11	0.12
phytanic	0.36	0.59	tr	tr	tr	0.34	tr	tr
17:0	0.48	0.53	0.56	0.24	0.39	0.38	0.69	0.41
18:0	3.83	3.36	6.54	5.91	4.16	3.21	5.74	4.80
19:0	0.24	tr	0.32	0.29	0.56	0.27	0.27	0.17
20:0	0.45	0.28	0.23	0.13	0.15	0.32	0.36	0.15
22:0	tr	tr	tr	0.06	tr	tr	0.14	tr
∑ Saturates	31.08	30.68	30.17	30.10	34.19	37.58	31.07	29.32
14:1(n-7)	tr	tr	tr	tr	0.14	tr	tr	tr
14:1(n-5)	tr	tr	tr	tr	0.13	0.09	0.04	0.16
15:1(n-8)	tr	tr	tr	tr	0.17	tr	0.02	tr
16:1(n-7)	5.63	5.89	2.47	4.32	13.78	10.02	5.48	10.15
16:1(n-5)	0.19	0.17	0.15	0.11	0.22	0.15	0.12	0.20
17:1(n-8)	1.12	1.19	0.29	0.16	3.83	1.53	0.69	0.38
18:1(n-11)	tr	tr	tr	tr	0.27	tr	tr	0.21
18:1(n-9)	6.16	5.28	6.00	18.23	6.80	15.60	22.15	18.29
18:1(n-7)	2.68	2.71	2.24	2.28	3.38	3.65	3.29	4.61
18:1(n-5)	tr	0.18	0.11	0.18	tr	tr	0.15	0.21
20:1(n-11)	0.93	0.70	0.21	tr	tr	0.12	0.58	0.30
20:1(n-9)	5.26	2.43	1.43	0.77	0.25	0.70	2.10	0.77
20:1(n-7)	0.27	0.23	0.18	0.07	0.89	0.39	0.22	0.29
22:1(n-11)	7.14	4.02	0.63	tr	0.36	tr	1.48	tr
22:1(n-9)	0.64	0.31	0.16	0.11	0.26	tr	0.35	tr
22:1(n-7)	0.41	0.40	tr	tr	tr	tr	0.09	tr
22:1(n-5)	0.20	0.17	tr	tr	tr	tr	tr	tr
24:1(n-9)	0.91	0.47	0.26	tr	tr	tr	0.80	tr
∑ Monoenes	31.54	24.15	14.13	26.23	30.48	32.25	37.56	35.57
16:2(n-4)	1.22	1.04	0.88	0.83	1.96	0.91	0.84	0.51
16:3(n-4)	tr	tr	tr	tr	0.14	tr	tr	tr
16:4(n-3)	tr	tr	0.23	0.15	0.19	tr	tr	0.13
16:4(n-1)	0.57	0.91	0.10	0.14	0.88	0.65	tr	0.06
17:2(n-8)	0.18	0.16	0.25	0.35	tr	0.11	0.21	0.21
18:2(n-9)	tr	tr	0.09	0.07	0.30	0.08	tr	0.34
18:2(n-6)	0.65	0.76	0.76	1.48	0.63	0.75	1.73	0.83
18:2(n-4)	0.29	0.22	0.12	0.11	0.30	0.19	0.12	0.10
18:3(n-4)	0.18	0.17	0.20	0.11	0.43	0.05	0.22	0.11
18:3(n-3)	0.21	0.45	0.34	0.56	0.38	0.17	0.56	0.31
18:4(n-3)	0.52	1.08	0.23	1.85	1.23	0.62	0.53	0.43
18:4(n-1)	tr	tr	tr	tr	0.13	tr	tr	tr
20:2NMID(5,11)**	tr	tr	tr	tr	tr	0.23	tr	tr
20:2(n-6)	tr	0.13	0.19	0.16	tr	0.17	0.20	0.23
20:3(n-6)	tr	tr	tr	tr	0.16	tr	0.05	0.05
20:3(n-3)	tr	tr	0.11	0.06	tr	tr	0.05	0.05
20:4(n-6)	3.49	2.99	2.54	0.31	1.84	2.69	1.39	2.69
20:4(n-3)	0.33	0.33	0.45	0.08	0.63	0.27	0.35	0.22
20:5(n-3)	11.36	14.26	4.30	7.35	10.67	12.42	4.21	6.91
21:5(n-3)	0.45	0.44	0.17	0.13	tr	0.35	0.16	0.08
22:4(n-6)	0.26	0.16	0.32	tr	0.30	0.23	0.21	0.64
22:5(n-6)	0.47	0.43	1.04	0.06	0.42	0.28	0.70	0.34
22:5(n-3)	2.16	1.20	5.51	0.50	7.48	1.95	2.34	2.59
22:6(n-3)	15.04	20.44	37.87	29.23	7.26	8.05	17.50	18.28
24:6(n-3)	tr	tr	tr	0.14	tr	tr	tr	tr
∑ Polyenes	37.38	45.17	55.70	43.67	35.33	30.17	31.37	35.11

* The data are presented as mean values (%) of 4 (2 groups x 2) determinations.
** NMID, nonmethylene-interrupted diene.
*** tr, trace.

Table 2. (continued)

Fatty acid	Mid-surface dwelling and migratory fish							
	9.Northern sand lance	10.Mackerel	11.Ocean perch	12.Jack mackerel	13.Hair tail	14.Coho salmon	15.Coral fish	16.Sea pike
12:0	0.04	0.08	0.04	0.07	0.07	0.06	0.03	0.06
14:0	3.86	3.13	1.91	4.46	5.33	3.07	3.02	3.57
15:0, iso	0.27	0.13	0.06	0.10	0.10	0.13	0.11	0.11
15:0, anteiso	0.12	0.03	0.02	0.02	0.03	0.04	0.04	0.04
15:0	0.42	0.46	0.27	0.30	0.46	0.40	0.46	0.35
16:0, iso	0.16	0.09	0.06	0.05	0.06	0.07	0.06	0.07
pristanic	tr	tr	0.05	0.20	0.06	0.04	0.19	0.11
16:0	23.50	17.22	20.49	21.31	27.47	16.93	21.00	20.60
17:0, iso	0.27	0.33	0.26	0.19	0.23	0.19	0.17	0.22
17:0, anteiso	0.13	0.09	0.12	0.10	0.08	0.09	0.14	0.09
phytanic	0.67	-	0.48	0.62	0.51	0.35	0.23	0.56
17:0	0.44	0.53	0.54	0.31	0.49	0.38	0.62	0.48
18:0	3.72	5.28	5.36	5.96	5.95	4.57	7.42	6.09
19:0	0.08	0.19	0.28	0.14	0.12	0.14	0.21	0.11
20:0	0.34	0.30	0.34	0.23	0.28	0.19	0.43	0.34
22:0	0.14	0.10	0.09	0.09	0.13	0.07	0.18	0.09
24;0	tr	tr	tr	tr	0.18	tr	tr	tr
Σ Saturates	34.16	27.96	30.37	34.15	41.55	26.72	34.31	32.89
14:1(n-7)	0.08	tr	0.04	0.06	tr	0.05	0.03	0.05
14:1(n-5)	0.07	tr	0.06	0.07	0.16	0.06	0.06	0.07
16:1(n-9)	tr	tr	tr	0.05	tr	tr	tr	tr
16:1(n-7)	8.81	4.45	6.12	8.78	5.85	6.61	5.73	6.35
16:1(n-5)	0.21	0.11	0.14	0.16	0.15	0.13	0.20	0.22
17:1(n-10)	tr	tr	tr	tr	tr	0.18	0.12	0.35
17:1(n-8)	0.10	0.32	0.20	0.41	0.40	0.41	0.18	0.28
18:1(n-11)	tr	tr	0.08	tr	tr	tr	tr	tr
18:1(n-9)	12.28	21.75	17.70	17.09	25.50	24.54	9.04	15.23
18:1(n-7)	2.20	3.86	2.97	2.95	tr	3.15	2.31	3.19
18:1(n-5)	0.25	0.17	0.19	0.14	0.17	0.23	0.13	0.20
20:1(n-11)	0.13	tr	0.33	tr	0.63	1.26	2.98	-
20:1(n-9)	1.06	4.83	1.86	3.40	1.25	2.23	-	0.40
20:1(n-7)	0.25	0.38	0.39	0.17	0.10	0.21	0.25	0.16
22:1(n-11)	1.47	3.14	0.44	4.81	-	-	-	-
22:1(n-9)	0.22	0.85	0.26	0.28	1.37	1.84	1.79	1.49
22:1(n-7)	0.35	0.18	tr	0.10	0.19	0.37	0.63	0.16
24:1(n-9)	0.65	0.69	tr	0.61	0.59	0.41	0.98	0.44
24:1(n-7)	tr	tr	tr	tr	tr	tr	tr	0.05
Σ Monoenes	28.13	40.73	30.78	39.08	36.36	41.68	24.43	28.64
16:2(n-7)	tr	tr	tr	tr	tr	0.05	tr	tr
16:2(n-4)	0.57	1.20	0.23	0.72	0.21	0.31	0.19	0.30
16:3(n-3)	tr	0.31	0.33	0.18	tr	0.03	tr	tr
16:4(n-3)	0.10	tr	0.10	tr	tr	0.03	0.36	0.13
16:4(n-1)	0.24	0.19	0.10	0.25	0.07	0.12	0.08	0.30
17:2(n-8)	0.38	0.24	0.33	0.13	0.15	0.17	0.17	0.21
18:2(n-9)	0.09	tr	0.28	0.02	0.10	0.11	0.20	0.11
18:2(n-7)	tr	tr	0.06	tr	0.04	0.07	0.05	0.04
18:2(n-6)	0.92	0.66	0.93	0.54	0.73	3.80	1.08	0.83
18:2(n-4)	0.09	0.21	0.13	0.14	0.08	0.21	0.10	0.11
18:3(n-6)	tr	tr	tr	tr	tr	tr	0.22	tr
18:3(n-4)	0.10	0.24	0.20	0.14	0.18	0.26	0.09	0.15
18:3(n-3)	0.71	0.31	0.33	0.31	0.49	0.83	0.24	0.38
18:4(n-3)	2.15	0.58	0.49	0.52	0.50	0.71	0.44	0.85
18:4(n-1)	tr	0.08	tr	tr	tr	0.14	tr	tr
20:2NMID(5,11)	tr	tr	0.11	tr	tr	tr	tr	tr
20:2NMID(5,13)	0.05	tr	0.06	tr	tr	tr	tr	tr
20:2NMID	tr	tr	0.18	tr	tr	tr	tr	tr
20:2(n-9)	tr	tr	tr	tr	tr	0.10	0.16	tr
20:2(n-6)	0.18	0.19	0.32	0.09	0.13	0.25	0.22	0.13
20:3(n-6)	0.02	0.06	0.11	0.08	-	0.11	0.11	0.06
20:3(n-3)	0.07	0.14	0.12	-	0.11	0.10	0.06	0.03
20:4(n-6)	0.30	2.56	2.59	1.99	0.83	1.19	1.98	1.87
20:4(n-3)	0.29	0.34	0.37	0.30	0.61	0.57	0.22	0.29
20:5(n-3)	10.16	7.41	10.20	8.89	4.26	4.78	5.71	6.68
21:5(n-3)	0.28	0.31	0.30	0.30	0.17	0.31	0.15	0.22
22:2NMID(7,13)	tr	tr	0.15	tr	tr	0.05	0.10	0.05
22:2NMID(7,15)	tr	tr	0.04	tr	tr	tr	tr	tr
22:2NMID	tr	tr	0.02	tr	tr	tr	tr	tr
22:4(n-6)	tr	0.33	0.40	0.17	tr	0.19	0.15	0.09
22:4(n-3)	tr	tr	tr	tr	tr	0.03	tr	tr
22:5(n-6)	0.06	0.55	0.48	0.19	0.25	0.40	1.01	0.48
22:5(n-3)	0.45	1.86	2.24	2.11	1.43	2.66	0.92	1.41
22:6(n-3)	20.50	13.54	17.65	9.70	11.75	14.02	27.25	23.75
Σ Polyenes	**37.71**	**31.31**	**38.85**	**26.77**	**22.09**	**31.60**	**41.26**	**38.47**

Table 2. (continued)

Fatty acid	Mid-surface dwelling and migratory fish			Coastal and reef dwelling fish				
	17.Yellow drum	18. Spanish mackerel	19.Redlip croaker	20.Black rock fish	21.Red sea bream	22.Schlegel's black rock fish	23.Black sea bream	24.Rock trout
12:0	0.13	0.05	0.07	0.12	tr	tr	0.06	0.06
14:0	1.86	3.77	1.68	4.69	3.44	2.99	3.35	1.72
15:0, iso	0.09	0.12	0.07	0.13	0.04	0.16	0.11	0.07
15:0, anteiso	0.06	0.04	0.02	tr	0.08	0.05	tr	0.03
15:0	0.47	0.44	0.32	0.34	0.28	0.61	0.50	0.25
16:0, iso	0.11	0.08	0.07	0.07	0.03	0.10	0.11	0.09
pristanic	0.24	0.08	0.04	0.08	0.05	tr	0.13	0.06
16:0	20.09	20.25	26.25	21.28	19.26	16.02	20.03	24.38
17:0, iso	0.33	0.22	0.37	0.21	0.19	0.30	0.36	0.39
17:0, anteiso	0.17	tr	0.13	0.11	0.09	0.15	0.17	0.16
phytanic	0.22	0.49	tr	tr	0.28	tr	0.29	tr
17:0	0.64	0.54	0.48	0.43	0.41	0.58	0.56	0.44
18:0	6.72	5.34	4.24	5.67	5.41	3.85	5.28	3.54
19:0	0.19	0.22	tr	0.14	0.10	0.31	0.15	0.10
20:0	0.36	0.58	0.17	0.26	0.26	0.19	0.31	0.12
22:0	0.19	0.22	0.08	0.13	0.07	tr	0.12	tr
24;0	0.08	tr	tr	tr	tr	tr	tr	tr
∑ Saturates	31.95	32.44	33.99	33.66	29.99	25.31	31.53	31.41
14:1(n-7)	0.05	0.06	0.04	tr	tr	0.06	0.04	0.07
14:1(n-5)	0.10	0.04	0.05	0.19	0.03	0.05	0.28	0.10
16:1(n-9)	tr	tr	tr	tr	tr	0.05	tr	tr
16:1(n-7)	9.83	5.78	18.59	11.20	6.20	6.39	6.87	14.28
16:1(n-5)	0.21	0.15	0.31	0.16	0.18	0.16	0.31	0.26
17:1(n-10)	0.05	0.33	tr	tr	0.25	tr	tr	tr
17:1(n-8)	0.63	0.37	0.42	0.51	0.20	0.86	0.59	0.52
18:1(n-11)	0.15	tr	0.16	tr	tr	tr	0.24	tr
18:1(n-9)	12.42	18.13	19.79	19.34	19.80	20.39	16.14	24.47
18:1(n-7)	3.40	3.00	3.52	3.64	3.96	4.27	4.19	5.80
18:1(n-5)	0.14	0.16	0.30	0.24	0.33	0.20	0.18	0.37
20:1(n-11)	0.32	tr	0.21	0.34	0.89	1.95	1.28	0.35
20:1(n-9)	0.89	2.39	0.93	1.50	1.80	tr	1.07	0.55
20:1(n-7)	0.40	0.25	0.20	0.35	0.17	0.22	0.68	0.26
22:1(n-11)	tr	tr	0.08	1.30	1.00	0.64	0.18	tr
22:1(n-9)	0.09	1.81	0.08	0.26	0.34	0.28	0.32	0.08
22:1(n-7)	0.07	0.35	tr	0.16	tr	tr	tr	tr
22:1(n-5)	tr	0.78	0.34	tr	tr	tr	tr	tr
24:1(n-9)	0.25	0.07	tr	0.71	0.87	tr	tr	0.20
∑ Monoenes	29.00	33.67	45.02	39.90	36.02	35.52	32.37	47.31
16:2(n-7)	tr	tr	0.15	tr	tr	tr	tr	tr
16:2(n-4)	0.22	0.38	0.58	0.38	0.32	0.98	0.16	0.29
16:3(n-3)	0.05	tr	tr	tr	tr	0.09	tr	tr
16:4(n-3)	0.41	0.04	0.03	0.06	0.08	0.06	0.22	0.10
16:4(n-1)	0.11	0.23	0.04	0.09	0.23	0.06	0.14	-
17:2(n-8)	0.25	0.23	0.18	0.15	0.10	0.27	0.20	0.20
18:2(n-9)	0.06	0.07	0.28	tr	0.19	0.10	0.19	0.42
18:2(n-7)	0.03	0.04	tr	tr	tr	tr	0.08	tr
18:2(n-6)	0.71	0.86	0.95	0.49	4.64	1.84	0.99	0.35
18:2(n-4)	0.14	0.18	0.09	0.10	0.19	0.15	0.15	0.12
18:3(n-6)	0.04	tr	tr	tr	0.10	tr	tr	tr
18:3(n-4)	0.17	0.19	0.13	0.10	0.18	0.22	0.18	0.10
18:3(n-3)	0.19	0.51	0.76	0.26	0.56	0.99	0.82	0.07
18:4(n-3)	0.30	0.99	0.87	0.29	0.53	1.19	0.42	0.08
18:4(n-1)	tr	0.04	tr	tr	0.14	tr	tr	tr
20:2NMID(5,11)	tr	tr	0.05	tr	tr	tr	0.47	tr
20:2NMID(5,13)	tr	tr	tr	tr	tr	tr	0.20	tr
20:2NMID	tr	tr	tr	tr	tr	tr	0.38	tr
20:2(n-9)	tr	0.04	tr	tr	0.23	tr	tr	tr
20:2(n-6)	0.27	0.17	0.18	0.14	0.15	0.22	0.37	0.09
20:3(n-6)	0.06	0.09	tr	tr	0.11	0.09	0.33	tr
20:3(n-3)	0.05	0.10	0.08	tr	tr	0.12	0.22	tr
20:4(n-6)	3.37	1.27	0.73	1.41	0.93	1.65	5.06	2.24
20:4(n-3)	0.21	0.40	0.27	0.33	0.64	0.47	0.55	tr
20:5(n-3)	8.80	6.88	4.70	6.51	6.21	6.53	5.94	7.94
21:5(n-3)	0.17	0.28	0.14	0.13	0.24	0.23	0.28	0.09
22:2NMID(7,13)	0.07	0.12	0.10	tr	tr	tr	0.60	tr
22:2NMID(7,15)	0.07	tr	tr	tr	tr	tr	0.58	tr
22:4(n-6)	0.58	0.14	0.26	0.21	0.17	0.25	1.72	0.22
22:5(n-6)	0.79	0.38	0.26	0.28	0.28	0.80	0.42	0.17
22:5(n-3)	2.40	1.96	0.73	1.19	3.44	1.86	5.71	0.75
22:6(n-3)	19.53	18.30	9.43	14.32	14.33	20.88	9.72	8.05
24:6(n-3)	tr	tr	tr	tr	tr	0.12	tr	tr
∑ Polyenes	**39.05**	**33.89**	**20.99**	**26.44**	**33.99**	**39.17**	**36.10**	**21.28**

Table 2. (continued)

Fatty acid	Coastal and reef dwelling fish							
	25.File fish	26.Wrasses	27.Cocktail wrasse	28.Seven band grouper	29.Hwang-jeom-bol-nag	30.Ga-sung-eo	31.Striped beakperch	32.Largescale blackfish
12:0	tr	0.07	0.25	0.26	0.18	tr	0.02	tr
14:0	0.58	2.81	10.54	3.40	2.24	4.81	3.43	4.13
15:0, iso	0.02	0.08	0.11	0.10	0.09	0.09	0.08	0.08
15:0, anteiso	0.05	0.05	0.04	0.05	tr	tr	0.03	0.02
15:0	0.21	0.48	0.41	0.42	0.36	0.47	0.34	0.36
16:0, iso	0.06	0.11	0.12	0.09	0.09	0.04	0.08	0.06
pristanic	tr	0.71	0.08	0.46	0.15	tr	0.06	0.12
16:0	16.21	16.48	15.45	19.57	21.99	29.38	23.62	24.89
17:0, iso	0.33	0.40	0.39	0.24	0.32	0.24	0.34	0.25
17:0, anteiso	0.20	0.23	0.16	0.11	0.13	0.08	0.14	0.23
phytanic	tr	tr	0.36	0.13	0.29	tr	tr	0.2
17:0	0.53	0.57	0.68	0.57	0.55	0.54	0.45	0.43
18:0	9.49	6.10	5.75	5.21	4.91	7.35	4.75	4.38
19:0	0.38	0.18	0.17	0.21	0.14	0.13	0.11	0.13
20:0	0.43	0.30	0.41	0.35	0.22	0.32	0.18	0.21
22:0	tr	tr	0.21	0.25	0.19	0.14	0.1	0.15
24;0	tr	tr	tr	0.09	tr	tr	tr	tr
Σ Saturates	28.49	28.57	35.13	31.51	31.85	43.59	33.73	35.64
14:1(n-7)	tr	tr	0.04	0.05	tr	tr	tr	0.03
14:1(n-5)	0.09	0.07	0.2	0.2	0.07	0.16	0.12	0.12
16:1(n-7)	2.24	3.47	4.35	10.86	9.35	6.31	12.4	8.29
16:1(n-5)	0.41	0.19	0.18	0.17	0.24	0.26	0.29	0.24
17:1(n-10)	tr	0.16	0.49	0.24	0.21	tr	0.22	0.22
17:1(n-8)	0.5	0.27	0.41	0.48	0.4	0.19	0.28	0.32
18:1(n-11)	0.37	0.24	tr	0.06	0.15	tr	0.19	tr
18:1(n-9)	9.04	8.84	14.18	13.12	15.6	23.09	18.13	15.47
18:1(n-7)	3.74	2.88	2.94	4.21	5.4	3.00	6.01	4.66
18:1(n-5)	0.18	0.16	0.25	0.11	0.19	0.45	0.42	0.25
20:1(n-11)	0.74	0.81	0.92	0.14	0.17	tr	0.47	0.37
20:1(n-9)	0.4	1.29	2.16	1.05	0.61	2.28	0.93	0.15
20:1(n-7)	0.49	0.45	0.51	0.24	0.2	0.17	0.43	0.36
22:1(n-11)	0.05	0.19	tr	tr	tr	tr	0.33	tr
22:1(n-9)	0.33	0.32	0.35	tr	tr	1.89	0.19	0.12
22:1(n-7)	tr	0.13	0.34	0.11	tr	0.32	0.28	0.12
22:1(n-5)	tr	tr	tr	tr	tr	tr	tr	tr
24:1(n-9)	tr	tr	0.36	0.15	0.32	0.74	0.35	0.27
24:1(n-7)	tr	tr	0.07	tr	tr	tr	tr	tr
Σ Monoenes	18.58	19.47	27.75	31.19	32.91	38.86	41.04	30.99
16:2(n-4)	0.58	0.76	0.38	0.29	0.25	0.32	tr	0.31
16:3(n-3)	tr	tr	tr	tr	tr	tr	tr	0.22
16:4(n-3)	tr	0.39	0.16	0.28	0.21	tr	0.07	0.72
16:4(n-1)	tr	0.1	0.32	0.15	0.13	tr	0.19	0.19
17:2(n-8)	0.22	0.38	0.4	0.25	0.21	0.1	0.14	0.12
18:2(n-9)	tr	tr	0.32	tr	tr	0.24	0.33	tr
18:2(n-7)	tr	tr	0.04	0.07	tr	0.06	0.13	0.12
18:2(n-6)	0.42	0.82	0.58	0.76	0.78	0.63	1.46	1.75
18:2(n-4)	0.3	0.21	0.3	0.15	0.15	tr	0.21	0.15
18:3(n-6)	tr	tr	0.11	0.09	tr	tr	0.11	0.27
18:3(n-4)	0.25	0.28	0.37	0.2	tr	0.12	0.16	0.12
18:3(n-3)	0.05	0.3	0.23	0.24	0.36	0.39	0.47	2.84
18:4(n-3)	0.18	0.56	0.52	0.28	0.42	0.28	0.59	1.85
18:4(n-1)	tr	tr	0.08	0.08	tr	tr	0.07	0.04
20:2NMID(5,11)	tr	0.17	0.12	tr	tr	tr	0.07	tr
20:2NMID(5,13)	tr	tr	0.12	tr	tr	tr	tr	tr
20:2NMID	tr	tr	0.19	tr	tr	tr	tr	tr
20:2(n-9)	tr	tr	tr	0.14	tr	0.34	tr	tr
20:2(n-6)	0.15	0.42	0.33	0.27	0.20	0.12	0.13	0.17
20:3(n-6)	0.10	0.17	0.11	0.18	tr	tr	0.08	0.23
20:3(n-3)	tr	0.12	0.14	0.14	tr	tr	0.07	0.22
20:4(n-6)	8.85	5.62	3.73	4.16	4.60	0.62	1.19	3.31
20:4(n-3)	0.16	0.33	0.25	0.44	0.16	0.45	0.40	0.57
20:5(n-3)	16.88	8.02	10.64	8.37	12.23	2.34	8.20	8.75
21:5(n-3)	0.23	0.36	0.34	0.23	0.20	tr	0.23	0.17
22:2NMID(7,13)	tr	0.07	0.13	tr	tr	tr	0.07	tr
22:2NMID(7,15)	tr	0.39	0.18	tr	tr	tr	tr	tr
22:2NMID	tr	0.39	0.14	tr	tr	tr	tr	tr
22:4(n-6)	1.19	1.77	0.54	0.99	0.59	0.11	0.30	0.71
22:4(n-3)	tr	tr	tr	0.06	tr	tr	tr	tr
22:5(n-6)	0.80	1.05	0.47	0.78	0.40	0.28	0.21	0.34
22:5(n-3)	4.37	4.64	1.78	5.03	1.69	1.76	1.99	2.96
22:6(n-3)	17.76	24.64	14.1	13.67	12.66	9.31	8.36	7.24
24:6(n-3)	0.44	tr	tr	tr	tr	tr	tr	tr
Σ Polyenes	**52.93**	**51.96**	**37.12**	**37.3**	**35.24**	**17.47**	**25.23**	**33.37**

Table 2. (continued)

Fatty acid	Demersal fish							
	33.Gold porgy	34.Common blackish goby	35.Green ling	36.Spotted hailbut	37.Sea eel	38.Bastard	39.Red tongue-sole	40.Red gurunard
12:0	0.14	tr	tr	tr	0.04	tr	0.05	0.11
14:0	9.83	1.90	0.60	4.14	4.45	3.44	2.05	3.16
15:0, iso	0.02	0.12	tr	0.25	0.13	0.14	0.20	0.14
15:0, anteiso	tr	0.09	tr	0.12	0.07	0.04	0.09	0.04
15:0	0.59	0.47	0.19	0.52	0.39	0.62	0.85	0.56
16:0, iso	0.11	0.17	-	0.20	0.09	0.06	0.25	0.08
pristanic	0.11	0.08	0.22	1.55	0.06	0.42	0.03	0.14
16:0	18.72	15.79	17.39	15.41	18.56	19.88	17.64	19.58
17:0, iso	0.42	0.81	0.17	0.54	0.25	0.28	0.67	0.25
17:0, anteiso	0.24	0.37	0.09	0.27	0.12	0.10	0.43	0.10
phytanic	0.38	tr	tr	1.13	0.48	tr	0.75	tr
17:0	0.61	0.62	0.42	0.48	0.35	0.57	0.96	0.58
18:0	4.03	7.00	6.71	6.23	2.71	4.70	6.13	5.40
19:0	0.10	0.28	0.13	tr	tr	0.29	0.29	0.17
20:0	0.24	0.24	0.14	0.23	0.16	0.23	0.38	0.28
22:0	0.19	0.15	0.13	0.50	tr	tr	0.20	0.13
24:0	tr	tr	0.17	tr	tr	tr	tr	tr
∑ Saturates	35.73	28.09	26.36	31.57	27.86	30.77	30.97	30.72
14:1(n-7)	0.02	tr	tr	0.11	tr	tr	0.05	0.07
14:1(n-5)	0.09	tr	tr	0.15	0.10	0.12	0.08	0.19
15:1(n-8)	tr	tr	0.20	tr	tr	tr	0.03	-
16:1(n-9)	tr	tr	tr	0.33	tr	tr	0.19	-
16:1(n-7)	9.87	3.93	2.53	4.55	7.98	5.06	4.85	7.50
16:1(n-5)	0.38	0.30	0.17	0.25	0.14	0.17	0.36	0.19
17:1(n-10)	0.33	tr	tr	tr	tr	tr	tr	tr
17:1(n-8)	0.58	0.63	0.29	0.73	0.73	0.50	1.05	0.47
18:1(n-11)	0.15	0.39	tr	0.33	tr	tr	0.25	tr
18:1(n-9)	14.43	7.55	9.36	5.33	28.80	13.04	8.22	22.31
18:1(n-7)	4.96	5.77	3.14	3.17	3.57	3.25	3.75	3.87
18:1(n-5)	0.29	0.24	0.18	0.20	0.19	0.15	0.31	0.18
20:1(n-11)	0.94	0.59	0.28	1.81	0.60	0.91	1.22	0.28
20:1(n-9)	0.71	0.46	0.67	0.79	2.66	1.87	0.79	1.30
20:1(n-7)	0.97	0.93	0.27	0.91	0.22	0.25	1.05	0.24
22:1(n-11)	tr	0.11	tr	0.19	1.84	1.21	0.22	0.42
22:1(n-9)	0.18	0.43	0.12	0.18	0.41	tr	0.55	0.32
22:1(n-7)	0.16	tr	tr	0.42	tr	tr	0.30	0.04
22:1(n-5)	tr	tr	tr	0.22	tr	tr	tr	tr
24:1(n-9)	0.23	0.22	0.17	0.28	0.43	tr	0.19	0.09
24:1(n-7)	tr	0.32	tr	tr	tr	0.32	tr	tr
∑ Monoenes	34.29	21.87	17.38	19.95	47.67	26.85	23.46	37.47
16:2(n-4)	0.37	0.93	0.42	0.51	0.37	1.06	0.25	0.35
16:3(n-3)	tr	tr	tr	tr	tr	tr	0.09	0.04
16:4(n-3)	0.15	0.50	0.40	0.10	tr	tr	0.27	0.17
16:4(n-1)	0.19	0.19	0.14	0.44	0.11	0.09	0.12	0.04
17:2(n-8)	0.27	0.28	0.21	0.30	0.18	0.21	0.39	0.20
18:2(n-9)	tr	0.43	tr	tr	tr	tr	tr	0.25
18:2(n-7)	tr	tr	tr	tr	tr	tr	tr	0.12
18:2(n-6)	0.81	1.07	0.51	0.57	0.90	3.96	0.90	0.74
18:2(n-4)	0.21	0.23	0.09	0.31	0.19	0.15	0.23	0.09
18:3(n-6)	0.08	0.11	tr	0.25	tr	tr	tr	tr
18:3(n-4)	0.25	0.18	0.09	0.24	0.28	0.21	0.24	0.13
18:3(n-3)	0.43	0.35	0.11	0.11	0.68	0.69	0.25	0.33
18:4(n-3)	0.55	0.28	0.09	0.23	0.33	0.77	0.29	0.10
18:4(n-1)	tr	tr	tr	tr	0.15	tr	tr	tr
19:3(n-6)	tr	tr	tr	tr	tr	tr	0.04	tr
20:2NMID(5,11)	0.10	tr	tr	tr	tr	tr	tr	tr
20:2NMID(5,13)	0.08	tr	tr	tr	tr	tr	tr	tr
20:2(n-6)	0.31	0.28	0.11	0.22	0.20	0.27	0.34	0.20
20:3(n-6)	0.09	0.29	tr	tr	0.03	0.06	0.06	0.08
20:3(n-3)	tr	0.09	tr	tr	0.03	0.16	0.03	0.10
20:4(n-6)	2.47	7.26	4.02	7.11	1.16	1.79	4.89	1.89
20:4(n-3)	0.24	0.38	0.12	0.13	0.70	0.32	0.12	0.31
20:5(n-3)	8.75	16.94	8.72	17.94	5.05	5.51	9.39	4.50
21:5(n-3)	0.30	0.30	tr	0.32	0.19	0.20	0.30	0.11
22:2NMID(7,13)	0.36	0.29	tr	tr	tr	tr	0.24	tr
22:2NMID(7,15)	0.46	0.14	tr	tr	tr	tr	0.39	tr
22:2NMID	tr	tr	tr	tr	tr	tr	0.21	tr
22:4(n-6)	0.55	1.69	0.26	1.70	0.30	0.24	1.84	0.45
22:5(n-6)	0.89	0.88	0.62	0.46	0.40	0.78	1.16	0.72
22:5(n-3)	2.18	5.64	1.53	6.87	2.16	2.87	3.66	2.78
22:6(n-3)	9.89	11.31	38.59	9.43	11.06	23.04	19.67	18.06
24:6(n-3)	tr	tr	0.23	1.24	tr	tr	0.20	0.05
∑ Polyenes	**29.98**	**50.04**	**56.26**	**48.48**	**24.47**	**42.38**	**45.57**	**31.81**

Table 2. (continued)

Fatty acid	Demersal fish							
	41.Flounder sole	42.Stone flounder	43.File fish, Scraper	44.Angler, Goose fish	45.Flat head	46.Finespotted flounder	47.Long shanny	48.Harvest fish
12:0	0.26	0.10	0.03	0.02	tr	tr	0.28	tr
14:0	2.99	3.65	0.53	1.28	1.52	1.60	3.44	2.12
15:0, iso	0.13	0.12	0.03	0.04	0.11	0.15	0.25	0.13
15:0, anteiso	0.42	0.03	0.08	0.04	0.04	0.05	0.04	0.04
15:0	0.40	0.34	0.32	0.28	0.38	0.71	0.45	0.85
16:0, iso	0.20	0.09	0.05	tr	0.15	0.33	0.24	0.17
pristanic	0.47	0.20	tr	tr	0.26	0.38	0.04	0.06
16:0	18.98	17.52	18.92	15.75	19.03	19.63	17.42	22.32
17:0, iso	0.36	0.24	0.29	0.23	0.53	0.76	0.53	0.84
17:0, anteiso	0.22	0.10	0.12	0.10	0.25	0.56	0.25	0.23
phytanic	0.35	0.72	tr	0.37	tr	tr	0.44	tr
17:0	0.49	0.27	0.61	0.47	0.54	0.98	0.49	0.98
18:0	4.19	2.65	8.53	6.48	5.75	5.25	2.72	6.92
19:0	0.16	0.16	0.34	0.18	0.20	0.41	0.09	0.31
20:0	0.30	0.16	0.24	0.26	0.21	0.35	0.19	0.31
22:0	0.17	tr	tr	tr	tr	tr	0.13	0.16
∑ Saturates	30.09	26.35	30.09	25.50	28.97	31.16	27.00	35.44
14:1(n-7)	0.08	0.06	0.31	tr	0.05	tr	0.08	tr
14:1(n-5)	0.21	0.15	tr	0.07	0.08	0.09	0.23	0.05
16:1(n-11)	tr	tr	tr	tr	tr	tr	0.12	tr
16:1(n-7)	9.47	8.48	2.16	3.95	6.40	9.33	9.36	7.93
16:1(n-5)	0.17	0.15	0.39	0.24	0.23	0.11	0.29	0.09
17:1(n-10)	tr	tr	tr	tr	tr	tr	0.40	tr
17:1(n-8)	0.66	0.72	0.39	0.44	0.62	0.85	tr	0.53
18:1(n-11)	0.07	tr	0.26	tr	0.16	0.12	0.17	tr
18:1(n-9)	17.59	18.29	8.18	8.70	12.66	10.86	18.36	24.20
18:1(n-7)	4.27	4.47	2.49	3.28	4.68	2.71	4.30	3.22
18:1(n-5)	0.22	0.21	0.19	0.14	0.23	0.24	0.37	0.16
20:1(n-11)	0.42	0.77	0.58	0.32	0.36	0.42	0.82	0.10
20:1(n-9)	1.66	2.86	0.44	1.17	0.65	0.76	1.16	1.55
20:1(n-7)	0.45	0.36	0.34	0.19	0.46	1.53	0.52	0.60
22:1(n-11)	0.73	1.86	0.14	tr	tr	tr	0.05	tr
22:1(n-9)	0.39	0.51	tr	0.71	0.15	0.22	0.68	0.45
22:1(n-7)	0.13	0.10	tr	tr	tr	0.48	0.27	0.49
22:1(n-5)	tr	tr	tr	tr	tr	tr	tr	tr
24:1(n-9)	0.38	0.05	tr	tr	0.19	0.21	0.24	0.38
24:1(n-7)	tr	tr	0.18	0.18	tr	tr	tr	tr
∑ Monoenes	36.90	39.04	16.05	19.39	26.92	27.93	37.42	39.75
16:2(n-7)	tr	tr	tr	0.16	0.14	tr	0.12	tr
16:2(n-6)	tr	tr	tr	0.26	tr	tr	0.06	1.77
16:2(n-4)	0.22	0.38	0.50	0.38	0.56	1.77	0.52	tr
16:3(n-3)	tr	tr	tr	tr	0.05	tr	0.54	tr
16:4(n-3)	tr	tr	tr	0.32	0.47	tr	tr	tr
16:4(n-1)	tr	tr	tr	0.58	0.10	0.08	0.21	0.41
17:2(n-8)	0.27	0.21	0.21	0.29	0.23	0.54	0.27	tr
18:2(n-9)	tr	tr	tr	tr	0.47	tr	0.15	tr
18:2(n-7)	tr	tr	tr	tr	0.10	tr	0.07	0.52
18:2(n-6)	0.62	0.87	0.44	0.87	0.75	0.30	0.80	0.14
18:2(n-4)	0.19	0.12	0.11	0.15	0.16	0.14	0.28	0.10
18:3(n-6)	tr	tr	tr	tr	tr	tr	tr	0.35
18:3(n-4)	0.18	0.19	0.14	0.17	0.16	0.47	0.38	0.27
18:3(n-3)	0.19	0.41	0.13	0.24	0.23	0.12	0.35	0.18
18:4(n-3)	0.13	0.52	0.10	0.35	0.19	0.16	0.05	tr
18:4(n-1)	tr	0.05	tr	tr	tr	tr	0.16	tr
19:3(n-6)	tr	tr	tr	tr	tr	tr	tr	0.20
20:2NMID(5,11)	tr	tr	tr	tr	tr	tr	tr	0.06
20:2(n-9)	tr	tr	tr	tr	0.20	tr	tr	tr
20:2(n-6)	0.22	0.23	0.13	0.11	0.20	0.22	0.23	0.11
20:3(n-6)	0.04	0.05	tr	0.10	0.13	tr	0.08	2.68
20:3(n-3)	0.04	0.21	tr	tr	tr	tr	0.09	0.22
20:4(n-6)	3.21	2.39	7.45	5.40	5.37	1.96	3.31	6.71
20:4(n-3)	0.15	0.31	0.17	0.18	0.24	0.14	0.36	0.10
20:5(n-3)	8.77	8.13	10.89	8.02	7.94	8.18	13.69	0.17
21:5(n-3)	0.19	0.26	0.10	0.13	0.20	0.16	0.45	tr
22:2NMID(7,13)	tr	tr	tr	tr	0.17	0.61	0.10	tr
22:2NMID(7,15)	tr	tr	tr	tr	tr	0.12	tr	tr
22:2NMID	tr	tr	tr	tr	tr	0.15	tr	tr
22:4(n-6)	0.65	0.31	0.52	0.33	1.22	3.25	0.34	1.03
22:5(n-6)	0.36	0.38	1.79	1.24	0.95	0.46	0.33	0.40
22:5(n-3)	4.15	3.17	2.41	1.61	3.87	7.48	2.22	4.01
22:6(n-3)	13.43	16.42	27.99	34.22	20.01	14.60	10.42	5.38
24:6(n-3)	tr	tr	0.78	tr	tr	tr	tr	tr
∑ Polyenes	**33.01**	**34.61**	**53.86**	**55.11**	**44.11**	**40.91**	**35.58**	**24.81**

Table 2. (continued)

Fatty acid	Demersal fish							
	49.Grass puffer	50.Japanese stargazer	51.Saddled weever	52.Electric ray	53.Sand smelt	54.Devil stinger	55.Blenny	56.Inshore hagfish
12:0	tr	0.03	0.06	tr	0.04	tr	0.06	0.03
14:0	1.31	1.09	3.55	0.88	1.98	1.63	2.91	5.13
15:0, iso	tr	0.09	0.19	0.11	0.19	0.06	0.13	0.06
15:0, anteiso	0.08	0.07	0.16	tr	0.09	tr	0.04	0.04
15:0	0.32	0.37	0.64	0.56	0.52	0.23	0.37	0.23
16:0, iso	0.05	0.08	0.26	0.41	0.18	tr	0.08	0.04
pristanic	1.40	0.89	0.11	0.97	0.23	0.57	0.3	0.09
16:0	13.95	18.01	18.08	16.30	17.29	19.56	18.41	18.02
17:0, iso	0.27	0.29	0.50	0.90	0.58	0.20	0.31	0.19
17:0, anteiso	0.25	0.20	0.31	0.83	0.26	0.21	0.21	0.1
phytanic	tr	0.57	tr	tr	0.26	0.36	0.29	tr
17:0	0.58	0.64	0.64	0.86	0.74	0.35	0.48	0.31
18:0	10.09	7.72	4.87	9.76	6.80	6.78	4.44	3.91
19:0	0.32	0.29	0.29	0.18	0.23	0.11	0.14	0.11
20:0	0.29	0.20	0.37	tr	0.31	0.15	0.22	0.31
22:0	tr	tr	0.16	0.07	0.21	tr	tr	tr
∑ Saturates	28.91	30.54	30.19	31.83	29.91	30.21	28.39	28.57
14:1(n-7)	tr	tr	0.10	0.2	0.1	tr	0.07	0.02
14:1(n-5)	0.15	0.07	0.08	0.22	0.14	0.08	0.08	0.05
16:1(n-9)	tr	tr	tr	1.38	tr	tr	tr	1.29
16:1(n-7)	1.83	3.38	10.61	3.69	6.25	5.75	8.45	4.49
16:1(n-5)	0.27	0.21	0.25	0.38	0.29	0.29	0.28	0.09
17:1(n-10)	tr	tr	0.44	tr	tr	tr	0.22	tr
17:1(n-8)	0.37	0.54	0.60	0.77	0.56	0.22	0.34	0.54
18:1(n-11)	0.25	tr	0.35	0.33	0.26	tr	0.14	tr
18:1(n-9)	7.59	10.32	11.04	9.27	6.27	12.67	14.56	48.62
18:1(n-7)	3.51	3.08	4.64	5.9	3.12	2.55	4.30	tr
18:1(n-5)	0.13	0.19	0.21	0.27	0.2	tr	0.21	0.25
20:1(n-11)	0.41	0.25	1.87	0.24	0.82	0.34	0.34	0.20
20:1(n-9)	0.45	0.82	1.08	0.56	0.61	1.54	1.00	1.82
20:1(n-7)	0.49	0.22	0.63	0.29	0.69	tr	0.18	0.24
22:1(n-11)	tr	tr	tr	tr	tr	tr	tr	0.06
22:1(n-9)	0.11	0.21	0.46	0.14	0.33	0.71	0.45	0.39
22:1(n-7)	tr	tr	0.29	tr	tr	tr	0.12	0.58
24:1(n-9)	tr	tr	0.41	0.14	0.24	0.54	0.33	0.18
∑ Monoenes	15.56	19.29	33.06	23.78	19.88	24.69	31.07	58.82
16:2(n-9)	tr	tr	tr	tr	0.09	tr	tr	tr
16:2(n-7)	tr	tr	0.12	tr	tr	tr	tr	tr
16:2(n-6)	tr	tr	tr	0.1	tr	tr	tr	tr
16:2(n-4)	0.74	0.77	1.03	0.43	0.54	0.17	0.42	0.37
16:3(n-3)	tr	tr	tr	0.11	0.08	tr	tr	tr
16:4(n-3)	0.56	0.31	0.12	0.7	0.35	0.4	0.27	0.06
16:4(n-1)	0.10	0.24	0.19	0.57	tr	0.22	0.18	0.03
17:2(n-8)	0.30	0.25	0.3	0.59	0.41	0.13	0.22	0.16
18:2(n-9)	tr	0.11	0.12	0.09	0.08	tr	0.07	0.13
18:2(n-7)	tr	tr	0.08	tr	tr	tr	tr	tr
18:2(n-6)	0.73	0.72	0.76	0.64	0.76	0.76	1.11	0.37
18:2(n-4)	0.19	0.12	0.24	0.14	0.13	tr	0.11	0.1
18:3(n-6)	tr	tr	tr	tr	tr	tr	0.08	tr
18:3(n-4)	0.17	0.23	0.33	0.17	0.16	tr	0.14	0.15
18:3(n-3)	0.14	0.15	0.3	0.08	0.24	0.19	0.8	0.11
18:4(n-3)	0.13	0.04	0.46	0.07	0.44	0.33	0.9	0.06
18:4(n-1)	tr	tr	0.1	tr	tr	tr	tr	tr
20:2NMID(5,11)	0.05	tr	0.08	tr	tr	tr	0.05	tr
20:2(n-6)	0.30	0.16	0.39	0.31	0.36	tr	0.19	0.09
20:3(n-6)	0.19	0.13	0.09	0.2	0.11	tr	0.05	tr
20:3(n-3)	0.10	0.04	0.1	tr	tr	tr	0.04	0.97
20:4(n-6)	10.08	5.91	3.39	5.78	3.83	3.92	3.06	0.04
20:4(n-3)	0.18	0.27	0.4	tr	0.29	tr	0.32	0.14
20:5(n-3)	9.01	6.33	10.19	3.13	10.25	5.56	9.5	0.78
21:5(n-3)	0.26	tr	0.3	0.16	0.28	tr	0.2	0.04
22:2NMID(7,13)	1.1	tr	0.26	tr	0.16	tr	0.09	0.14
22:2NMID(7,15)	tr	tr	0.29	0.42	0.43	tr	tr	0.07
22:2NMID	0.07	tr	0.17	tr	0.23	tr	tr	tr
22:4(n-6)	2.32	1.37	1.03	8.23	1.15	0.41	0.68	0.56
22:5(n-6)	1.57	1.39	0.43	0.88	0.88	1.21	0.34	0.06
22:5(n-3)	7.15	4.25	3.2	9.39	3.17	1.47	2.2	5.56
22:6(n-3)	20.09	27.38	12.4	12.2	25.79	30.33	19.52	2.62
∑ Polyenes	**55.53**	**50.17**	**36.75**	**44.39**	**50.21**	**45.1**	**40.54**	**12.61**

Table 2. (continued)

Fatty acid	Demersal fish			Fresh water fish				
	57.Skate	58.Grass fish(f)	59.Grass fish(m)	60.Pale chub(F)	61.Pale chub(m)	62.Perch	63.Dark sleeper	64.False
12:0	tr	tr	0.48	0.15	0.43	0.72	0.04	0.12
14:0	0.51	0.82	0.02	1.23	1.54	2.41	0.97	1.54
15:0, iso	0.05	0.03	0.02	0.16	0.14	0.27	0.12	0.31
15:0, anteiso	0.05	tr	tr	0.05	tr	0.11	0.08	0.14
15:0	0.41	0.31	0.15	0.26	0.24	0.40	0.25	0.38
16:0, iso	tr	0.05	0.03	0.16	0.10	0.10	0.09	0.29
pristanic	0.07	0.13	0.09	0.10	0.26	0.30	1.14	0.56
16:0	23.39	16.15	16.42	18.48	17.22	19.81	17.52	16.67
17:0, iso	0.27	0.20	0.20	0.89	0.53	0.29	0.47	1.11
17:0, anteiso	0.35	0.15	0.09	0.86	0.45	0.23	0.39	0.82
phytanic	0.1	0.21	tr	0.11	0.13	0.19	0.3	0.23
17:0	0.93	0.47	0.39	0.42	0.51	0.62	0.58	0.98
18:0	5.93	4.75	4.94	2.50	4.40	5.32	9.58	7.35
19:0	0.09	0.10	0.09	0.04	0.09	0.10	0.21	0.19
20:0	tr	tr	tr	0.15	0.26	0.15	0.31	0.32
22:0	tr	0.12	0.07	tr	0.09	0.06	tr	0.12
24;0	tr	tr	tr	tr	tr	tr	0.16	tr
∑ Saturates	32.15	23.49	22.99	25.56	26.39	31.08	32.21	31.13
14:1(n-7)	tr	tr	tr	0.2	0.25	0.28	0.08	0.15
14:1(n-5)	0.07	tr	tr	0.08	0.12	0.16	0.21	0.11
15:1(n-8)	tr	tr	tr	tr	tr	0.08	tr	tr
16:1(n-9)	0.32	tr	tr	1.01	0.63	0.79	0.89	0.61
16:1(n-7)	2.81	2.63	1.52	20.52	14.67	11.35	3.92	7.28
16:1(n-5)	0.24	0.21	0.14	0.5	0.39	0.62	0.36	0.33
17:1(n-10)	tr	0.29	tr	0.41	tr	0.39	tr	tr
17:1(n-8)	0.45	0.31	0.25	0.82	0.78	0.39	0.50	0.70
18:1(n-11)	0.15	0.06	0.04	tr	tr	tr	0.09	0.25
18:1(n-9)	10.06	8.17	10.99	11.89	15.02	8.93	7.35	9.2
18:1(n-7)	4.70	4.96	4.18	5.21	6.98	6.83	4.75	5.69
18:1(n-5)	0.17	0.21	0.18	0.31	0.28	0.17	0.14	0.27
20:1(n-11)	0.07	0.13	0.22	0.06	0.08	0.04	0.23	1.15
20:1(n-9)	0.36	0.53	0.72	0.14	0.42	0.24	0.48	0.38
20:1(n-7)	0.12	0.18	0.09	tr	0.11	0.08	0.23	0.21
22:1(n-11)	tr	0.12	0.16	tr	tr	tr	0.23	0.44
22:1(n-9)	tr	tr	tr	tr	tr	tr	0.11	0.12
24:1(n-9)	tr	0.02	0.02	tr	tr	0.14	0.21	tr
24:1(n-7)	tr	0.24	0.09	tr	tr	tr	0.04	tr
∑ Monoenes	19.52	18.06	18.6	41.15	39.73	30.49	19.82	26.89
16:2(n-7)	tr	tr	tr	tr	tr	0.13	tr	tr
16:2(n-6)	tr	tr	tr	0.14	0.07	0.06	tr	0.07
16:2(n-4)	0.06	0.18	0.22	0.89	0.57	0.94	0.24	0.45
16:3(n-3)	tr	tr	tr	1.53	0.56	0.57	tr	tr
16:3(n-1)	tr	tr	tr	tr	tr	0.06	tr	tr
16:4(n-3)	tr	0.25	0.16	0.29	0.06	0.1	0.46	0.3
16:4(n-1)	tr	0.12	tr	0.07	0.04	0.07	tr	0.07
17:2(n-8)	0.38	0.31	0.22	tr	0.1	0.19	tr	0.09
18:2(n-9)	tr	tr	tr	0.1	0.06	0.11	0.05	0.09
18:2(n-7)	tr	tr	tr	0.06	0.05	0.06	0.03	0.07
18:2(n-6)	0.72	0.83	0.64	4.1	3.66	3.11	3.28	2.74
18:2(n-4)	0.11	0.08	0.03	0.52	0.54	0.4	0.29	0.34
18:3(n-6)	tr	tr	tr	0.35	0.17	0.31	0.17	0.14
18:3(n-4)	tr	0.06	0.06	0.53	0.35	0.28	0.3	0.27
18:3(n-3)	0.14	0.18	0.12	10.37	7.11	5.55	2.48	3.09
18:3(n-1)	tr	tr	tr	tr	tr	0.04	0.03	tr
18:4(n-3)	tr	0.2	0.09	1.06	0.54	1.01	tr	0.21
18:4(n-1)	tr	tr	tr	0.17	0.11	0.09	0.22	tr
20:2(n-6)	0.19	0.12	0.08	0.12	0.19	0.18	0.5	0.64
20:3(n-6)	tr	tr	tr	0.22	0.21	0.2	0.45	0.44
20:3(n-3)	tr	tr	tr	0.55	0.62	0.36	0.32	0.71
20:4(n-6)	3.42	6.2	4.52	1.08	2.12	2.86	9.15	5.21
20:4(n-3)	0.12	0.15	0.09	0.63	0.62	0.46	0.42	0.59
20:5(n-3)	6.03	14.56	11.48	4.5	6.94	6.5	12.22	10.62
22:4(n-6)	0.52	0.12	0.2	tr	0.07	0.32	1.08	0.4
22:4(n-3)	tr	tr	tr	tr	tr	0.1	tr	tr
22:5(n-6)	0.66	0.47	0.53	tr	0.1	0.19	0.63	0.38
22:5(n-3)	4.47	1.28	0.91	2.17	2.6	3.77	6.18	4.23
22:6(n-3)	31.51	33.34	39.06	3.84	6.42	10.41	9.47	10.83
∑ Polyenes	**48.33**	**58.45**	**58.41**	**33.29**	**33.88**	**38.43**	**47.97**	**41.98**

Table 2. (continued)

Fatty acid	Fresh water fish							
	65.Striped shiner	66.Gold fish	67.Spined loach	68.Cornet fish	69.Mandarin fish	70.Eel	71.Bass	72.River eight-eye lamprey
12:0	1.81	0.13	0.26	0.32	0.12	0.18	tr	0.11
14:0	3.13	1.05	1.47	2.47	2.61	4.98	0.91	3.06
15:0, iso	0.28	0.21	0.48	0.38	0.34	0.20	tr	0.07
15:0, anteiso	0.18	0.16	0.18	0.16	0.09	0.07	tr	tr
15:0	0.34	0.48	0.46	0.50	0.51	0.35	0.15	0.19
16:0, iso	0.14	0.20	0.44	0.20	0.19	0.09	tr	0.04
pristanic	0.36	1.19	0.35	0.32	0.11	tr	0.38	tr
16:0	19.06	16.81	16.06	18.47	18.10	17.39	20.49	12.40
17:0, iso	0.56	1.34	1.90	0.84	0.70	0.26	tr	0.17
17:0, anteiso	0.58	0.60	1.25	0.59	0.61	0.13	tr	0.10
phytanic	tr	tr	tr	0.57	0.89	0.33	tr	0.14
17:0	0.83	0.78	0.95	0.69	0.77	0.28	0.24	0.11
18:0	5.13	8.09	4.38	5.53	4.24	3.48	4.44	1.73
19:0	0.13	0.35	0.22	0.15	0.10	0.12	0.17	0.04
20:0	0.37	0.29	0.24	0.27	0.13	0.20	tr	tr
22:0	0.14	tr	0.09	0.10	tr	tr	tr	tr
24;0	0.05	tr	tr	tr	tr	tr	tr	tr
∑ Saturates	33.09	31.68	28.73	31.56	29.51	28.06	26.78	18.16
14:1(n-7)	1.05	0.10	0.30	0.23	0.10	0.06	tr	0.04
14:1(n-5)	0.18	0.24	0.18	0.14	0.14	0.19	0.08	0.08
15:1(n-8)	0.11	tr	0.10	tr	tr	tr	tr	tr
16:1(n-11)	tr	0.49	tr	tr	tr	tr	tr	0.83
16:1(n-9)	tr	0.57	tr	0.75	0.13	0.51	0.40	0.76
16:1(n-7)	10.81	4.53	14.46	11.15	12.00	9.82	3.74	11.41
16:1(n-5)	0.37	0.33	0.48	0.39	0.33	0.17	0.22	0.28
17:1(n-10)	tr	tr	tr	0.72	0.43	0.21	tr	0.15
17:1(n-8)	0.85	0.55	1.14	0.47	0.70	0.35	0.20	0.29
18:1(n-11)	tr	0.15	0.34	0.19	0.16	tr	tr	tr
18:1(n-9)	13.14	7.44	14.29	11.80	16.84	30.27	21.19	33.46
18:1(n-7)	4.72	5.14	6.67	5.63	4.54	4.40	3.23	7.49
18:1(n-5)	0.21	0.16	0.40	0.27	0.23	0.17	0.16	0.53
20:1(n-11)	0.27	0.47	1.46	0.38	0.23	1.07	0.30	2.63
20:1(n-9)	0.40	0.56	0.22	0.34	0.68	tr	0.74	1.88
20:1(n-7)	0.12	0.16	0.26	0.22	0.27	0.28	tr	0.17
22:1(n-11)	tr	0.17	0.10	tr	tr	tr	tr	tr
22:1(n-9)	tr	0.10	0.06	0.07	tr	0.21	0.18	0.56
22:1(n-7)	0.05	tr	tr	tr	tr	0.07	tr	0.17
24:1(n-9)	tr	0.10	tr	tr	0.10	tr	tr	tr
∑ Monoenes	32.28	21.26	40.46	32.75	36.88	47.78	30.44	60.73
16:2(n-7)	tr	tr	tr	tr	tr	0.05	tr	tr
16:2(n-6)	tr	0.08	0.16	0.18	0.08	tr	tr	t
16:2(n-4)	0.79	0.39	0.67	0.86	tr	0.36	0.13	0.35
16:3(n-3)	0.85	0.25	0.35	0.4	0.6	tr	tr	tr
16:3(n-1)	0.06	tr	tr	tr	tr	tr	tr	tr
16:4(n-3)	0.08	0.22	0.1	0.12	0.08	0.07	0.21	tr
16:4(n-1)	0.09	0.16	0.08	0.1	0.14	0.2	0.26	0.14
17:2(n-8)	0.41	0.08	0.16	0.19	0.24	0.2	tr	0.09
18:2(n-9)	0.08	0.12	0.15	0.09	0.2	0.15	tr	tr
18:2(n-7)	0.09	0.05	0.15	0.11	0.12	0.06	tr	tr
18:2(n-6)	2.98	3.95	2.56	2.97	4.48	1.3	17.54	1.31
18:2(n-4)	0.33	0.28	0.39	0.34	0.27	0.17	0.25	0.14
18:3(n-6)	0.13	0.13	0.16	0.15	0.3	0.06	tr	tr
18:3(n-4)	0.39	0.26	0.34	0.52	0.52	0.23	tr	0.12
18:3(n-3)	7.95	2.83	3.69	5.35	4.24	0.6	0.60	0.55
18:3(n-1)	0.04	tr	0.02	0.01	tr	tr	tr	tr
18:4(n-3)	0.29	0.17	0.36	0.57	0.55	0.44	0.06	0.76
18:4(n-1)	0.10	tr	0.03	0.13	0.11	0.21	tr	0.08
20:2(n-9)	tr	tr	0.22	tr	0.09	0.11	tr	tr
20:2(n-6)	0.33	0.68	0.62	0.31	0.36	0.22	0.44	0.09
20:3(n-6)	0.34	0.74	0.45	0.31	0.49	0.21	0.2	tr
20:3(n-3)	0.75	0.53	0.51	0.48	0.44	0.14	tr	tr
20:4(n-6)	2.51	8.92	3.36	3.06	2.89	1.15	1.37	1.07
20:4(n-3)	0.75	0.54	0.45	0.89	0.92	0.92	0.09	0.33
20:5(n-3)	7.05	7.35	5.86	7.72	4.59	5.98	1.29	7.68
21:5(n-3)	0.05	tr	0.11	0.16	0.14	0.37	tr	0.23
22:4(n-6)	0.19	0.93	0.45	0.23	0.37	0.34	tr	tr
22:5(n-6)	0.11	1.00	0.29	0.37	0.66	0.18	0.76	tr
22:5(n-3)	1.96	4.29	2.89	2.8	2.51	3.57	1.02	0.95
22:6(n-3)	5.93	13.11	6.23	7.27	8.22	6.87	18.56	7.22
∑ Polyenes	**34.63**	**47.06**	**30.81**	**35.69**	**33.61**	**24.16**	**42.78**	**21.11**

Table 3. Distribution of n-3 and n-6 polyunsaturated fatty acids of 72 species of Korean fish

Fish species	n-3 PUFA		n-6 PUFA		ω-3/ω-6	SFA	MUFA	PUFA
	(Area %)	(wt %)	(Area %	(wt %)	(wt%/wt%)		(Area %)	
Mid-surface dwelling, Migratory fish								
1. Sardine	30.1	1.85	4.87	0.30	6.18	31.1	31.5	37.4
2. Anchovy	38.2	1.22	4.47	0.14	8.55	30.7	24.2	45.2
3. Horn fish	49.1	0.40	4.85	0.04	10.12	30.2	14.1	55.6
4. Ice goby	40.0	1.77	2.01	0.09	19.90	30.1	26.2	43.6
5. Striped mullet	27.8	0.85	3.35	0.10	8.30	33.9	30.3	35.3
6. Hickoryshad	23.8	1.42	4.12	0.25	5.78	37.6	32.3	30.1
7. Yellow tail	25.9	1.67	4.28	0.28	6.05	31.1	37.6	31.5
8. Sea bass	29.1	0.75	4.78	0.12	6.09	29.3	35.6	35.2
9. Nothern sand lance	34.7	3.64	1.48	0.16	23.45	34.2	28.1	37.7
10. Mackerel	24.9	4.09	4.35	0.71	5.72	28.2	40.9	31.4
11. Ocean perch	32.3	0.74	4.83	0.11	6.69	30.4	30.8	39.0
12. Jack mackerel	22.3	2.54	3.06	0.35	7.29	34.4	39.9	26.8
13. Hair tail	19.2	1.90	1.94	0.19	9.90	41.6	36.4	22.0
14. Coho salmon (A)*	24.1	2.33	5.94	0.57	4.06	26.7	41.7	31.7
15. Coral fish	35.5	0.29	4.77	0.04	7.44	34.4	24.4	41.4
16. Seapike	33.7	0.43	3.46	0.04	9.74	32.9	28.5	38.5
17. Yellow drum	31.2	0.32	5.32	0.05	5.86	32.0	29.0	39.0
18. Spanish mackerel	29.6	1.43	2.91	0.14	10.17	22.4	33.7	34.0
19. Redlip croaker	17.1	1.67	2.38	0.23	7.18	34.0	45.0	21.1
Average	29.93	1.54	3.85	0.21	8.87	31.9	32.1	35.6
Standard deviation	7.71	1.06	1.27	0.18	4.87	4.10	7.40	8.11
Coastal and reef dwelling								
20. Black rock fish	23.1	0.63	2.53	0.07	9.13	33.7	39.9	26.5
21. Red sea bream	26.0	0.26	6.38	0.06	4.08	30.0	36.0	33.9
22. Schlegel's black rockfish	32.5	2.38	4.85	0.36	6.70	28.3	35.5	39.2
23. Black sea bream	23.7	0.49	8.82	0.18	2.69	31.5	32.4	35.8
24. Rock trout	17.2	0.39	3.07	0.07	5.60	31.4	47.5	21.4
25. File fish	38.9	0.20	11.4	0.06	3.41	28.5	18.6	52.2
26. Multicolorfin rainbowfish	39.4	0.27	9.85	0.07	4.00	28.6	19.5	52.0
27. Cocktail wrasses	28.0	0.58	5.87	0.12	4.77	35.1	27.8	37.0
28. Sevenband grouper	28.8	0.30	7.23	0.08	3.98	31.5	31.2	37.3
29. Hwangjeombolang	27.5	0.22	6.57	0.05	4.19	31.9	32.9	35.2
30. Gasungeo	14.5	1.25	1.46	0.13	9.93	43.6	38.9	17.5
31. Striped beakperch	20.3	1.60	3.48	0.27	5.83	33.7	41.0	25.2
32. Largescale blackfish	25.1	0.83	6.78	0.22	3.70	35.6	30.8	33.0
33. Gold porgy	22.3	0.54	5.40	0.13	4.13	35.7	34.3	30.0
Average	26.2	0.71	5.98	0.13	5.15	32.8	33.3	34.0
Standard deviation	7.19	0.63	2.83	0.09	2.13	4.02	7.83	9.96

Table 3. (continued)

Fish species	n-3 PUFA (Area %)	n-3 PUFA (wt %)	n-6 PUFA (Area %)	n-6 PUFA (wt %)	ω-3/ω-6 (wt%/wt%)	SFA (Area %)	MUFA (Area %)	PUFA (Area %)
Demersal fish								
34. Common brackish goby	34.8	0.16	11.6	0.05	3.00	28.1	21.9	49.3
35. Green ling	49.8	0.26	5.52	0.03	9.02	26.4	17.4	56.3
36. Spotted haibut	36.4	0.27	10.3	0.08	3.53	31.6	20.0	48.5
37. Sea eel	20.3	1.85	2.99	0.27	6.79	27.9	47.7	24.6
38. Bastard, Flatfish	33.4	0.14	7.00	0.03	4.77	30.8	26.8	42.1
39. Red tongue-sole	34.1	0.22	9.23	0.06	3.69	31.0	23.5	45.4
40. Red gurnard	26.5	0.50	4.08	0.08	6.50	30.7	37.7	31.8
41. Flounder sole	26.9	0.29	5.10	0.06	5.27	30.1	36.9	32.9
42. Stone flounder	29.5	0.65	4.23	0.09	6.97	26.4	39.0	34.7
43. File fish, Scraper	41.8	0.21	10.3	0.05	4.06	30.1	15.9	53.8
44. Angler, Goose fish	45.1	0.39	8.31	0.07	5.43	25.5	19.4	55.1
45. Flat head	32.5	0.29	8.32	0.07	3.91	29.0	26.7	43.1
46. Finespotted flounder	30.9	0.29	6.19	0.06	4.99	31.2	27.9	41.0
47. Long shanny	28.0	1.40	5.15	0.26	5.44	27.0	37.4	35.4
48. Harvest fish	17.0	0.79	4.99	0.23	3.41	35.4	39.8	24.8
49. Grass puffer	38.3	0.17	15.2	0.07	2.52	28.9	15.9	56.2
50. Japanese stargazer	38.8	0.13	9.68	0.03	4.01	30.5	19.3	50.2
51. Saddled weever	27.4	0.60	6.09	0.13	4.50	30.2	32.1	36.8
52. Electric ray	25.8	0.11	16.1	0.07	1.60	31.8	23.8	44.3
53. Sand smelt	40.9	0.31	7.09	0.05	5.77	29.9	19.9	50.2
54. Devil stinger	38.3	0.26	6.27	0.04	6.11	30.2	24.7	45.0
55. Blenny	33.7	0.37	5.51	0.06	6.12	28.4	31.1	40.5
56. Inshore hagfish	9.40	0.88	2.05	0.19	4.59	28.6	58.9	12.6
57. Skate	41.6	0.16	5.51	0.02	7.55	32.1	20.1	47.8
58. Grass fish (f)	50.0	0.15	7.74	0.02	6.46	23.5	18.6	58.4
59. Grass fish (m)	51.7	0.19	5.97	0.02	8.66	23.0	19.7	57.3
Average	34.0	0.43	7.33	0.09	5.18	29.2	27.8	43.0
Standard deviation	10.08	0.41	3.37	0.07	1.81	2.73	10.7	11.4
Fresh water fish								
60. Pale chub (f)	25.1	1.06	6.01	0.25	4.18	25.6	41.2	33.5
61. Pale chub (m)	25.5	0.53	6.47	0.14	3.94	26.4	39.7	33.8
62. Perch	28.8	0.27	7.23	0.07	3.98	31.1	31.5	38.4
63. Dark sleeper	31.6	0.14	15.3	0.07	2.07	32.2	19.8	48.0
64. False	30.6	0.22	10.0	0.07	3.90	31.1	26.9	42.0
65. Striped shiner	25.7	0.60	6.59	0.15	3.90	33.1	32.3	34.6
66. Gold fish	29.3	0.21	16.4	0.12	1.79	31.7	21.3	47.0
67. Spined loach	20.5	0.46	8.05	0.18	2.55	28.7	40.5	30.8
68. Cornet fish	25.7	0.31	7.58	0.09	3.39	31.6	32.8	35.6
69. Mandarin fish	22.3	0.66	9.63	0.28	2.32	29.5	36.9	33.6
70. Eel	19.0	3.84	3.46	0.70	5.49	28.1	47.8	24.2
71. Bass	21.7	0.17	20.1	0.16	1.08	26.8	30.4	42.5
72. River eight-eye lamprey	16.5	2.27	2.47	0.34	6.68	19.9	60.7	19.4
Average	24.79	0.83	9.18	0.20	3.48	28.9	35.5	35.6
Standard deviation	4.61	1.07	5.16	0.17	1.54	3.62	11.0	8.21

*A, Aquaculture
** f, female
***m, male

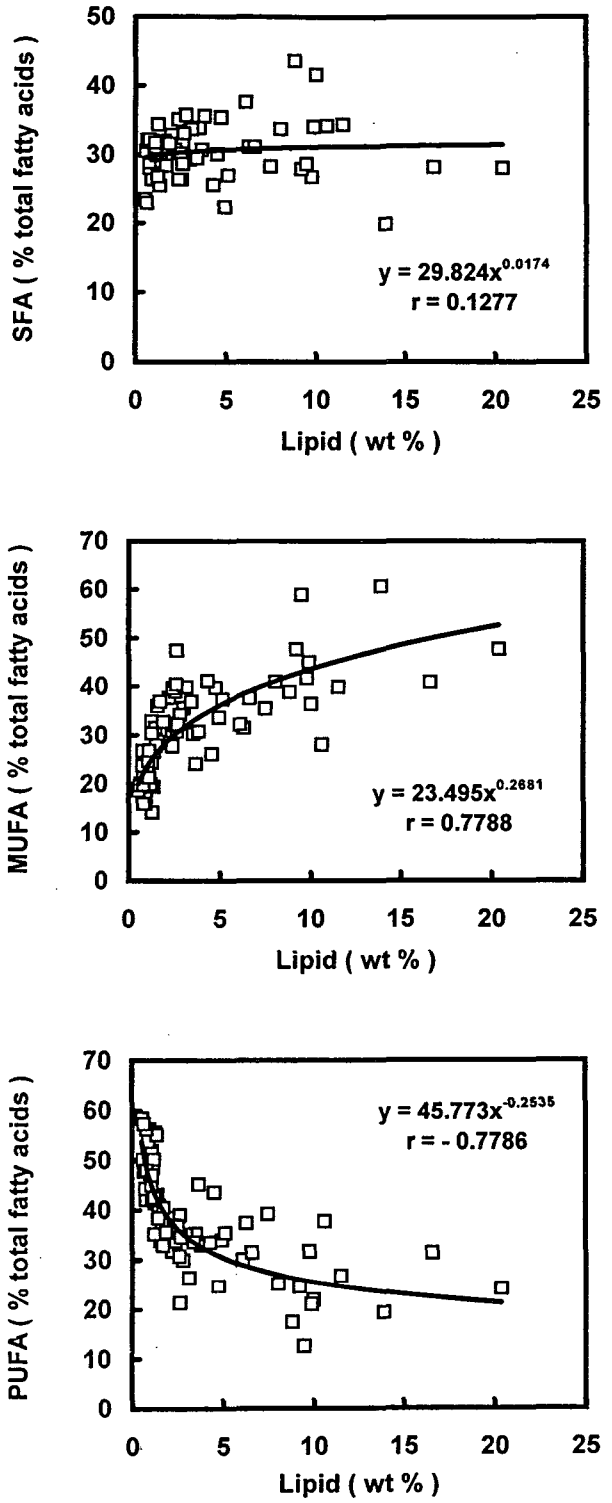

Fig. 1. Correlation between total lipid (wt %) and saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids (% of total fatty acids) of 72 species of Korean fish.

highest level of PUFA in all fish groups, accounting for 43.0 ± 11.4%, and the migratory and the fresh water fish were the second-rich species in PUFA, accounting for 35.6% in the both groups, and the reef fish showed slightly low level of PUFA (34.0 ± 9.96%). In general, PUFA is rich in lean fish, because the fish contain the high proportion of phospholipid (PL) which is rich in PUFA compared with fat fish containing a large amount of triglyceride (TG) which is poor in PUFA (Fogerty *et al.*, 1986). However, the migratory fish contained more PUFA than the reef fish. This is considered due to the difference in their diet or a species specificity. On the other hand, there was more n-3 PUFA (29.7 ± 8.73%) than n-6 PUFA (6.48 ± 3.70%) in all fish samples. The n-3 PUFA level in all fish groups was high in the following order; the demersal fish (34.0 ± 10.1%) > the migratory fish (29.9 ± 7.71%) > the reef fish (26.2 ± 7.19%) > the fresh water fish (24.8 ± 4.61%). However, the n-6 PUFA showed a opposite trend to the n-3 PUFA in all fish species; the fresh water fish (9.18 ± 4.96%) > the demersal fish (7.38 ± 3.30 %) > the reef fish (5.98 ± 2.72%) > the migratory fish (3.85 ± 1.23%). Therefore, the sea water fish was rich in n-3 PUFA, while the fresh water fish was rich in n-6 PUFA. The proportion of n-3 PUFA (29.7 ± 8.73%) in this study was higher than that of Australian fish (24.4 ± 5.4%), but the proportion of n-6 PUFA (6.48 ± 3.70%) was lower than that of Australian fish (16.5 ± 4.5%) (Belling *et al.*, 1997). These results reflect both the higher n-3 PUFA and the lower n-6 PUFA of Northern Hemisphere fish, compared with Southern Hemisphere fish such as Australian fish (Brown *et al.*, 1989). The different distribution of n-3 and n-6 PUFA in each fish group might be resulted from the difference of both fatty acids in the marine food chain surrounding the fish's habitat (Sinclair *et al.*, 1984).

The prominent fatty acids in PUFA were docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) of n-3 fatty acids in most fish species, but 22 : 5 (n-3) was relatively rich in the demersal fish and 18 : 3 (n-3) was relatively rich in the fresh water fish. DHA was a predominant fatty acid in most fish species compared with EPA. The latter was predominant only in 12 species; striped mullet, hickoryshad, largescale blackfish, common blackish goby, spotted halibut, long shanny, pale chub (female and male), dark sleeper, striped shinner, cornet fish, river eight-eye lamprey. An unusual fatty acid, 24 : 6 (n-3), was found in white flesh

fish such as spotted halibut (Ota *et al*, 1994). The prominent n-6 fatty acid was 20 : 4 (n-6) in all fish samples, but 18 : 2 (n-6) or 22 : 4 (n-6) was high in certain fish species. For example, bass which belongs to the fresh water fish was rich in 18 : 2 (n-6) (17.3%) and electric ray which belongs to the demersal fish was rich in 22 : 4 (n-6) (8.23%).

The proportion of MUFA and SFA in all fish samples were similar, 31.39 ± 9.67% and 30.53 ± 3.81%, respectively. The SFA was similar to that (31.6 ± 3.5%) of the Australian fish, while the MUFA was higher than that (17.4 ± 4.3%) of the latter (Belling *et al.*, 1984). The MUFA was the highest in the fresh water fish (35.5 ± 11.0%) and was the lowest in the demersal fish (27.8 ± 10.7%), and the migratory fish (32.1 ± 7.40%) was similar to that (33.3 ± 7.83%) of the reef fish. The prominent fatty acids of MUFA were 18 : 1 (n-9) (or n-7) and 16 : 1 (n-7) in all fish samples. The 18 : 1 (n-9) fatty acid was the most prominent fatty acid of MUFA. Particularly, the proportion of 18 : 1 (n-9) was over 20% of total fatty acids in some fish such as yellow tail, mackerel, coho salmon, schlegel's black rockfish, rock trout, Ga-sung-eo (*Liza haematocheila*), red gurnard, harvest fish, inshore hagfish, eel and river eight-eye lamprey. Moreover, some migratory fish such as sardine, mackerel, jack mackerel, anchovy, spanish mackerel, yellow tail contained a significant amount of 20 : 1 and 22 : 1 fatty acids. On the other hand, the prominent fatty acids of the SFA were 16 : 0, 18 : 0 and 14 : 0 in all fish samples. The reef fish (32.8 ± 4.02%) and the migratory fish (31.9 ± 4.10%) contained a similar amount of SFA, and both fish groups contained more SFA than the fresh water fish (28.9 ± 3.62%) and the demersal fish (29.2 ± 2.73%). There was a significant correlation between the total lipid content and MUFA ($y=23.495x^{0.2681}$, $r=0.7788$, $p<0.001$) and PUFA ($y=45.773x^{-0.2535}$, $r=-0.7786$, $p<0.001$), but not with SFA ($y=29.824x^{0.0174}$, $r=0.1277$) (Fig. 1). The proportion of MUFA rose with increasing lipid content while that of PUFA fell. These relationships could be explained that low-fat fish contains a high proportion of PL riched in PUFA. These results were similar to those of Australian fish (Belling *et al.*, 1997), but different in SFA level, which rose with increasing lipid content such as MUFA.

As shown in Fig 2, the n-3 PUFA content (g/100 g muscle) was proportional to the lipid content ($r=0.9352$, $p<0.001$). Therefore, there is an

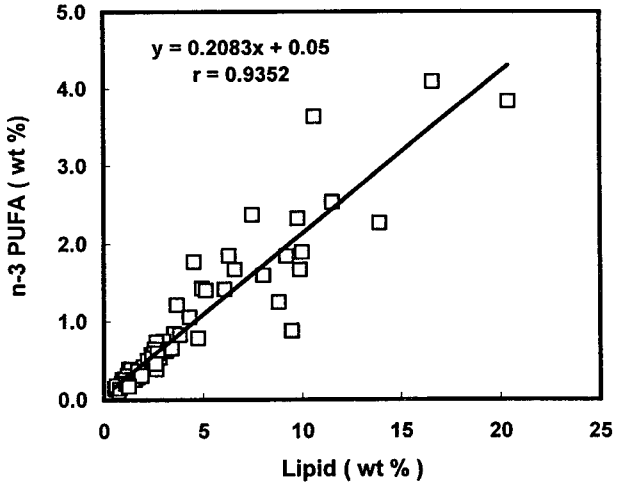

Fig. 2. Correlation between total lipid (wt %) and n-3 polyunsaturated fatty acids (PUFA, wt %) of 72 species of Korean fish.

inverse relationship between Figs 1 and 2, but the result shown in Fig 2 is more important than that of the Fig 1 for the consumer. This data may provide the consumer, particularly dieticians with a better idea of the nutritional value of the different fish species. The consumer can find useful information from this data, which presented as portion of the edible part of fish. The migratory fish contained the highest level of the n-3 PUFA, ranged from 0.29~4.09 g/100 g muscle (1.82 ± 1.01 g), followed by the fresh water fish (1.09 ± 1.04 g), the reef fish (0.90 ± 0.60 g) and the demersal fish (0.77 ± 0.38 g). Mackeral, a migratory fish, contained the highest amount of n-3 PUFA (4.09 g/100 g muscle) in all fish species, whereas electric ray, a demersal fish, contained the lowest amount (0.11g).

No information about the fatty acid compositions have been found for such a vast number of fish species, especially in Korea. Authors hope that these results can be used to the nutritionist, dietician or consumer as useful information for n-3 fatty acids of fish species in the North Hemisphere at the latitude about 32°N.

Acknowledgment

This paper was supported in part by SPECIAL FUND for UNIVERSITY RESEARCH INSTITUTE, Korea Research Foundation.

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