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Comparison of Lipid Classes and Fatty Acid Compositions among Eight Species of Wild and Cultured Seawater Fishes

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Lipid classes and fatty acid compositions of eight species of wild and cultured seawater fish in Korea were investigated. Total lipid (TL) contents of wild and cultured fish were 2.64 ± 1.88% and 5.42 ± 1.76%, respectively, except for rockfish and striped beakperch. Non-polar lipids (NL) in all fish samples comprised approximately 84% of the TL content. The proportion equation of NL content to TL content was y=0.9296x−0.4468 (R^2=0.9812, p< 0.001). The most abundant NL class was triglyceride. The prominent fatty acids in all fish samples were 16 : 0, 18 : 1(n-9), 22 : 6(n-3) (docosahexaenoic acid, DHA), 16 : 1(n-7), 20 : 5 (n-3) (eicosapentaenoic acid, EPA), 18 : 0 and 18 : 1(n-7). The polyunsaturated fatty acid (PUFA) group was the richest among the total fatty acids (TFA). DHA and EPA were comprised of approximately 85% of n-3 PUFA. There was a positive correlation between TFA content and n-3 PUFA content; y=0.292x−0.0055 (R^2=0.9349, p<0.001). The n-3 PUFA content of the cultured fish was approximately twice as much as that of the wild fish. Therefore, cultured fish were proven to provide better sources of n-3 PUFA if compared to wild fish.

Key words: lipid classes, lipid content, n-3 polyunsaturated fatty acids, wild and cultured seawater fish

Introduction

The Korean people enjoy eating sliced raw fish in which they called "Hoe" and in Japan is called "Sashimi". The fish used in the dish "Hoe" is a higher-priced fish in which some has been cultured in Korea. This practice has brought about the development of culture techniques for seawater fish, which resulted in a large increase in the production of cultured fish over the last decade, from 331 metric tons in 1984 to 39,121 metric tons in 1997 in Korea (Ministry of Maritime Affairs and Fisheries, 1998). Moreover, the production of cultured fish is expected to increase, because of increased fish consumption. Today, Koreans consume the third-largest amount of seafood in the world, 46.0 Kg/capita in 1995, which is an increase of about 10 Kg/capita over the last 5 years (Korea Rural Economic Institute, 1996). The increase in fish consumption is probably due to the fact that sea food lipid is beneficial to human health (Lees, 1990). It has been shown to reduce symptoms and the incidents of death from cardiovascular disease, arthritis, cancers, and others and to promote learning ability. Such effects have been attributed to the n-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) found in seafood (Bang *et al.*, 1980; Enslen *et al.*, 1991; Kremer *et al.*, 1985; Singer *et al.*, 1983). Koreans generally prefer wild fish to cultured fish. This results in a lower-price for cultured fish as compared to wild fish. It is, therefore, in the interest of the fish culture industry, to inform the consumers of the benefits of cultured fish in order to elevate the consumption of cultured fish. A detailed nutritional analysis of the food components of cultured fish may be one way to address the pro-blem. Currently, there is no nutritional information available on cultured seawater

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fish in Korea, although a few studies have been carried out on cultured fresh water fish (Choi *et al.*, 1986; Kim and Lee, 1986).

In the present study, lipid classes and fatty acid compositions of 8 higher-priced fish species of wild and cultured seawater fish were investigated.

Materials and Methods

Samples

Eight species of cultured and wild fishes were analyzed for lipid content and fatty acid composition. Live cultured fish were purchased from a fish farm, Tongyeong, Korea and live wild fish samples from a fish market. The wild fish were caught off the coast of Tongyeong in the Southern Sea (Nam-Hae) at a latitude of about 32°N. Both samples were transported to our laboratory in an ice box. Body length, body weight, and numbers of fish were recorded before the fish were filleted. About 300~500 g of fish muscle was taken from at least two or more individuals of each fish species and mixed using a speed cutter.

Lipid extraction

Total lipid (TL) was extracted and purified according to the method of Bligh and Dyer (Bligh and Dyer, 1959), and its content was determined gravimetrically. Phospholipid (PL) content in the TL was obtained by multiplying total phosphorus content by 25 (Bartlett, 1959). Non-polar lipid (NL) content was calculated as the difference between TL and PL content (Jeong *et al.*, 1990).

Determination of lipid class composition

The compositions of the NL and PL lipids in terms of classes were determined as described in a previous published paper (Jeong *et al.*, 1990).

Determination of fatty acid composition

Fatty acid composition was determined after methylation (AOCS, 1990) and analysis by gas-liquid chromatography (Shimadzu GC 14A, Shimadzu Seisakusho, Co. Ltd., Kyoto, Japan) using 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 temperature were maintained at 250℃ and the column was programmed to operate from 180℃ (initial time 8 min) to 230℃ at 3℃/min with the 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 a split ratio of 1 : 50. Fatty acids were identified by comparison to authentic standards (Sigma Chemical Co., St. Louis, MO, USA) and a sample of oyster which had been analyzed by Koizumi *et al.* (1990). Data were calculated as the peak area percent of the total area of fatty acids. Methyl tricosanoate (99%, Aldrich Chem. Co., Milwaukee, WI., USA) was used as an internal standard for the quantitative calculation of PUFA. All the data are presented as means value of 4 determinations (2 groups×2 determinations) for each fish species. The standard deviations of these analyses were less than 0.90%.

Results and Discussion

Comparison of lipid class composition

Lipid content and lipid class composition of the 8 species of wild and cultured fish are shown in Table 1. TL content was in most cases approximately two times higher in the cultured fish (5.42 ± 1.76%) than the wild fish (2.64 ± 1.88%). Only striped beak perch and rockfish contained a slightly higher amount of TL in the wild fish population than the cultured fish. The PL content, representing membrane lipids, showed only a small difference between cultured and wild fishes, whereas NL, which represents generally depot lipids, was present at much higher levels in cultured fish. The NL content was in proportion to the TL content. Particularly, TL and NL content were dependent upon triglyceride (TG) content, the most prominent lipid class, which composed approximately 84% of the NL content. Thus, there was a positive correlation between TL and NL content, and TG as percentage of TL content in all fish samples; the correlation between TL and NL content was $y=0.9296x-0.4468$ ($R^2=0.9812$, $p<0.001$), and the correlation between TL content and TG was $y=23.727\,Ln(X)+39.697$ ($R^2=0.7584$, $p<0.001$) (Fig. 1 A). However, PL content was inversely proportional to TL content. Particularly, in wild bastard which contained the smallest amount of TL (0.76%) of all the fish samples, the proportion of PL exhibited the

Table 1. Lipid class composition of 8 species of wild and cultured seawater fish in Korea

Fish species(Scientific name)		TL	NL	PL	NL class (% of total lipid content)				PL class (% of total lipid content)[a]				
		(g/100 g muscle)			ST	DG	TG	SE	SPM	PC	PS	PI	PE
1. Yellow tail	Wild	6.59	5.77	0.82	3.98	tr[b]	83.5	tr	0.09	8.12	0.20	0.46	3.64
(*Seriola quinqueradiata*)	Cultured	8.09	7.01	1.08	3.54	tr	83.1	tr	tr	7.1	2.16	1.24	2.9
2. Sea bass	Wild	2.64	1.99	0.65	10.5	tr	64.8	tr	0.49	13.6	0.73	2.08	7.74
(*Lateolabrax japonicus*)	Cultured	5.05	4.34	0.71	3.58	tr	82.4	tr	0.24	9.14	0.39	0.99	3.30
3. Red sea bream	Wild	1.56	1.13	0.43	10.4	tr	61.8	tr	0.26	16.4	0.24	2.01	8.87
(*Chysophrys major*)	Cultured(K)[c]	4.87	4.03	0.84	3.80	tr	79.0	tr	tr	14.1	0.19	0.70	2.22
	Cultured(J)[d]	6.08	5.32	0.76	3.47	tr	84.0	tr	0.08	9.06	0.13	0.95	2.3
4. Striped beakperch	Wild	5.86	4.26	1.60	2.57	tr	70.1	tr	tr	17.9	tr	1.77	7.66
(*Mugil cephalus*)	Cultured	5.54	4.18	1.36	3.76	tr	71.7	tr	tr	18.0	tr	1.50	5.10
5. Rockfish	Wild	7.47	6.73	0.74	2.82	tr	85.4	1.81	0.10	7.72	0.10	0.55	1.46
(*Sebastes schlegeli*)	Cultured	7.14	6.70	0.44	3.75	tr	88.6	1.48	0.13	4.14	0.05	0.35	1.48
6. Black rock fish	Wild	2.65	2.24	0.41	5.93	tr	78.6	tr	0.19	9.29	0.22	0.76	5.00
(*Sebastes inermis*)	Cultured	6.29	5.12	1.17	4.08	tr	78.6	tr	tr	12.3	0.43	1.09	4.75
7. Sevenband grouper	Wild	1.64	1.19	0.45	8.62	2.94	61.0	tr	tr	20.4	1.02	1.17	4.91
(*Epinephelus septemfasciatus*)	Cultured	5.68	5.16	0.52	3.52	tr	86.6	tr	tr	6.9	0.14	0.49	1.62
8. Bastard, Flatfish	Wild	0.76	0.13	0.63	7.11	tr	9.59	tr	1.49	55.9	1.10	4.76	20.1
(*Pararlichthys olivaceus*)	Cultured	1.85	1.26	0.59	6.40	1.40	57.2	3.07	0.23	20.2	0.17	2.47	8.82

[a] TL, total lipid; NL, non-polar lipid; ST, free sterol; FFA, free fatty acid; TG, triglyceride; SE, steryl ester. PL, phospholipid; SPM, sphingomyelin; PC, phosphatidylcholine; PS, phosphatidylserine; PI, phosphatidylinositol; PE, phosphatidylethanolamine.
[b] tr, trace. [c](K), cultured fish in Korea. [d](J), cultured fish in Japan.

highest level, approximately 83% of the TL content. The prominent PL classes were phosphatidylcholine (PC) and phosphatidylethanolamine (PE) in all fish samples. Therefore, there were negative correlations between TL content and PC content, $y=30.524x-0.6722$ ($R^2=0.6145$, $p<0.001$), and PE content, $y=12.918x-0.8288$ ($R^2=0.6202$, $p<0.001$) (Fig. 1B). These data exhibit a similar tendency to those of 12 species of fish reported by Jeong *et al.* (1998). Thus we concluded that the increase or decrease in TL content in a fish was dependent on the depot of TG.

Comparison of fatty acid compositions

Table 2 shows the fatty acid composition of the 8 species of cultured and wild fish. The prominent fatty acids were similar in all fish; 16 : 0, 18 : 1(n-9), 22 : 6(n-3) (docosahexaenoic acid, DHA), 16 : 1(n-7), 20 : 5(n-3) (eicosapentaenoicacid, EPA), 18 : 0, 18 : 1(n-7). Some fish had relatively high levels of 14 : 0, 22 : 5(n-3), 18 : 2(n-6) and 20 : 4(n-6) accounting for 2~4% of total fatty acids. These fatty acid profiles were essentially similar to those of 35 Icelandic fish (Sigurgisladottir and Palmadottir, 1993), 11 species of Australian fish (Belling *et al.*, 1997), and 72 species of Korean fish (Jeong *et al.*, 1998). Polyunsaturated fatty acids (PUFA) were found to occupy the highest level among the fatty acid groups (36.22 ± 6.07%). They were followed by monounsaturated fatty acids (MUFA, 33.29 ± 6.66%) and saturated fatty acids (SFA, 30.49 ± 2.57 %) in all fish samples. These results were significantly different from those of the 11 species of Australian fish in which the proportions of PUFA, MUFA and SFA were 42.3 ± 6.9%, 17.4 ± 4.3%, and 31.6 ± 3.5%, respectively (Belling *et al.*, 1997). However, they coincided with those of the 72 species of Korean fish (Jeong *et al.*, 1998).

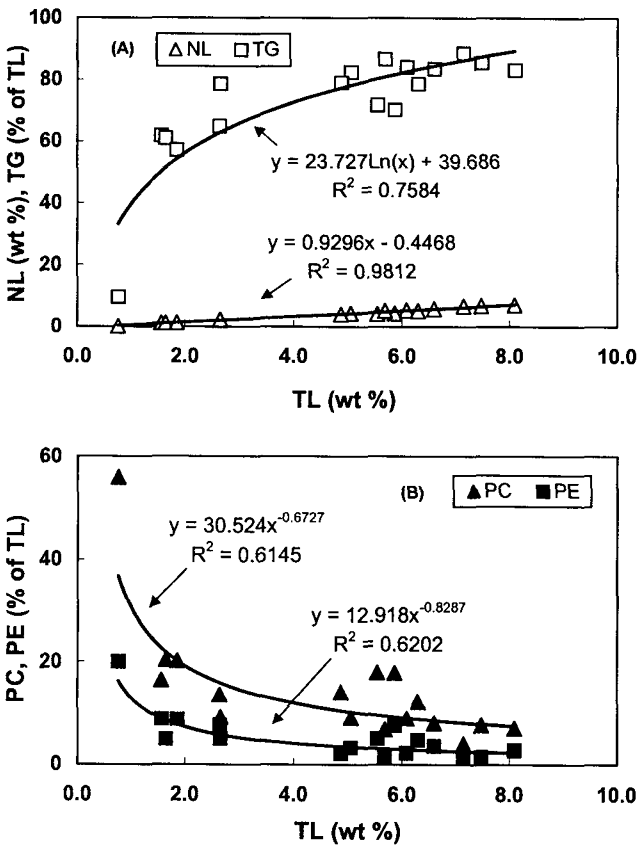

Fig. 1. Correlations between total lipid (TL) content and the percentages of non-polar lipid (NL) and triglyceride (TG) (A) and between total lipid (TL) content and percentages of phosphatidylcholine (PC) and phosphatidylethanolamine (PE) (B) in 8 species of wild and cultured seawater fish in Korea.

In general, lipid content and fatty acid composition of a fish are greatly affected by endogenous and exogenous factors (Joseph, 1989; Kinsella, 1987; Stansby, 1986). In particular, ecological factors are most influential; mid-surface dwelling and migratory fish need a large amount of TG (depot lipid) as energy stores for long-distance journeys such as in spawning or feeding migrations. However, coastal and reef dwelling fish and benthonic fish do not need a lot of TG, because they occupy only a small area for their activities. This fact has been well demonstrated among the 72 species of Korean fish described by Jeong *et al.* (1998, 1999). They reported lipid contents for migratory fish, reef fish, and benthonic fish of 6.1 ± 4.2%, 3.4 ± 2.7%, and 2.1 ± 2.4%, respectively, with n-3 PUFA contents (mg/100 g muscle) in proportion to their TL content. Among all the fish samples, the SFA content was highest in wild rockfish accounting for 35.9%. Cultured seven band grouper had the highest level of MUFA (41.2%). On the other hand, the proportion of PUFA was highest in cultured bastard, accounting for 51.8%. Among the wild fish, the proportions of n-3 and n-6 PUFAs in the total fatty acid content were 28.8 ± 3.31% and 5.16 ± 1.56 %, respectively. These values are similar to those collected from the 72 species of Korean fish (Jeong *et al.*, 1998), while they differ from the 11 species of Australian fish analyzed (Belling *et al.*, 1997). The 8 species of Korean wild fish analyzed in this study were higher in n-3 PUFA and much lower in

Table 2. Fatty acid compositions of 8 species of wild and cultured seawater fish in Korea (Area %)[a]

Fatty acid	1. Yellow tail		2. Sea bass		3. Red sea bream			4. Striped beakperch		5. Rockfish		6. Black rock fish		7. Sevenband grouper		8. Bastard	
	W[b]	C[c]	W	C	W	C(K)[d]	C(J)[e]	W	C	W	C	W	C	W	C	W	C
12 : 0	tr[f]	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.05	tr	0.26	tr	tr	tr
14 : 0	2.71	3.08	1.72	3.56	3.44	2.77	2.50	3.00	2.85	2.99	2.96	3.63	4.58	3.40	3.30	3.44	1.59
15 : 0 iso	0.11	0.13	0.06	0.12	0.04	0.13	0.12	0.15	0.10	0.16	0.15	0.11	0.15	0.10	0.10	0.14	0.06
15 : 0 anteiso	0.02	0.04	0.02	0.16	0.08	0.04	0.80	0.04	0.03	0.05	0.04	0.03	0.04	0.05	0.02	0.04	0.05
15 : 0	0.56	0.62	0.25	0.47	0.28	0.57	0.59	0.43	0.33	0.61	0.55	0.35	0.43	0.42	0.29	0.62	0.40
16 : 0 iso	0.08	0.08	0.05	0.07	0.03	0.08	0.58	0.08	0.05	0.10	0.09	0.07	0.06	0.09	0.05	0.06	0.05
pristanic	0.08	tr	0.18	0.06	0.05	0.05	0.11	0.08	0.08	tr	tr	0.12	0.04	0.46	0.05	0.42	1.09
16 : 0	19.9	18.0	23.9	20.8	19.3	17.0	17.8	22.9	20.7	16.0	16.6	23.6	20.7	19.6	20.5	19.9	20.1
17 : 0 iso	0.27	0.36	0.27	0.27	0.19	0.26	0.36	0.29	0.26	0.30	0.29	0.33	0.25	0.24	0.22	0.28	0.30
17 : 0 anteiso	0.11	0.12	0.11	0.10	0.09	0.11	0.54	0.10	0.09	0.15	0.13	0.13	0.13	0.11	0.08	0.10	0.18
phytanic	tr	tr	0.34	0.51	0.28	0.97	0.59	0.44	0.42	tr	tr	0.40	0.12	0.13	0.31	tr	tr

[a] The data are represented as mean values of four determinations (two group×two determinations).
[b] W, wild fish. [c] C, cultured fish. [d] C(K), cultured fish in Korea. [e] C(J), cultured fish in Japan.
[f] tr, trace. [g] NMID, non-methylene interrupted diene. [h] ND, not detected.

Table 2. (continued)

Fatty acid	1. Yellow tail		2. Sea bass		3. Red sea bream			4. Striped beakperch		5. Rockfish		6. Black rock fish		7. Sevenband grouper		8. Bastard	
	W[b]	C[c]	W	C	W	C(K)[d]	C(J)[e]	W	C	W	C	W	C	W	C	W	C
17:0	0.69	0.72	0.47	0.46	0.41	0.67	0.81	0.54	0.36	0.58	0.53	0.67	0.40	0.57	0.38	0.57	0.49
18:0	5.74	5.40	4.15	3.03	5.41	5.42	7.29	4.13	3.35	3.85	3.74	5.97	3.96	5.21	4.45	4.70	7.36
19:0	0.27	0.32	0.05	0.10	0.1	0.28	0.36	0.16	0.15	0.31	0.30	0.11	0.13	0.21	0.14	0.29	0.27
20:0	0.36	0.40	0.11	0.19	0.26	0.31	0.47	0.20	0.17	0.19	0.20	0.21	0.18	0.35	0.21	0.23	0.23
22:0	0.14	0.16	tr	tr	0.07	0.12	0.28	0.04	tr	tr	0.07	0.11	tr	0.25	tr	tr	tr
24:0	tr	0.10	tr	tr		tr	0.13	tr	tr	tr	tr	tr	tr	0.09	tr	tr	tr
ΣSaturates	31.1	29.6	31.7	29.9	30.0	28.8	33.3	32.6	28.9	25.3	25.6	35.9	31.2	31.5	30.1	30.8	32.2
14:1(n-7)	tr	tr	tr	tr	tr	0.06	0.11	0.06	0.08	0.06	0.05	0.06	0.09	0.05	0.07	tr	tr
14:1(n-5)	0.04	0.05	0.14	0.07	0.03	0.05	0.11	0.14	0.13	0.05	0.06	0.05	0.10	0.20	0.06	0.12	0.19
15:1(n-8)	0.02	tr	tr	tr	tr	tr	0.08	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.06
16:1(n-9)	tr	tr	tr	tr	tr	tr	0.12	tr	tr	0.05	0.06	tr	tr	tr	tr	tr	tr
16:1(n-7)	5.48	5.30	12.0	9.76	6.20	5.62	4.60	10.6	11.4	6.39	6.19	8.05	8.34	10.9	8.99	5.06	2.79
16:1(n-5)	0.12	0.14	0.25	0.30	0.18	0.16	0.26	0.24	0.27	0.16	0.17	0.24	0.25	0.17	0.26	0.17	0.19
17:1(n-10)	tr	tr	0.36	0.16	0.25	tr	tr	tr	tr	tr	tr	0.20	0.15	0.24	0.16	tr	tr
17:1(n-8)	0.69	0.64	0.02	0.35	0.20	0.58	0.32	0.43	0.31	0.86	0.75	0.19	0.31	0.48	0.26	0.50	0.37
18:1(n-11)	tr	tr	0.84	tr	tr	tr	0.15	tr	tr	tr	tr	tr	tr	0.06	tr	tr	tr
18:1(n-9)	22.2	18.8	15.9	18.2	19.8	16.1	9.36	18.0	19.2	20.4	20.0	12.6	18.7	13.1	21.0	13.0	7.46
18:1(n-7)	3.29	3.28	5.50	4.73	3.96	3.20	3.46	4.42	5.21	4.27	3.9	3.95	4.27	4.21	4.34	3.25	2.68
18:1(n-5)	0.15	0.17	0.21	0.31	0.33	0.17	0.17	0.31	0.35	0.20	0.24	0.25	0.22	0.11	0.33	0.15	0.10
20:1(n-11)	0.58	0.71	0.34	1.03	0.89	0.42	1.30	1.76	0.85	1.95	0.72	0.20	0.67	0.14	1.22	0.91	0.20
20:1(n-9)	2.10	2.39	0.48	1.61	1.80	2.03	1.09	tr	1.66	tr	1.83	0.69	1.43	1.05	1.95	1.87	0.83
20:1(n-7)	0.22	0.23	0.16	0.19	0.17	0.32	0.71	0.23	0.18	0.22	0.2	0.26	0.14	0.24	0.16	0.25	0.25
22:1(n-11)	1.48	1.68	tr	tr	1.00	0.96	tr	tr	tr	0.64	1.03	tr	tr	tr	tr	1.21	0.26
22:1(n-9)	0.35	0.44	tr	1.08	0.34	0.47	0.56	0.37	1.10	0.28	0.33	0.53	1.29	tr	1.50	tr	0.11
22:1(n-7)	0.09	0.08	tr	0.24	tr	tr	0.45	0.24	0.32	tr	0.07	0.12	0.26	0.11	0.34	tr	tr
24:1(n-11)	tr	tr	tr	tr	tr	tr	0.51	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
24:1(n-9)	0.80	0.26	0.21	0.34	0.87	tr	tr	0.45	0.58	tr	tr	0.59	0.46	0.15	0.51	tr	0.43
24:1(n-7)	tr	0.09	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.32	0.16
ΣMonoenes	36.8	33.9	36.2	38.0	35.2	30.2	23.4	36.8	41.1	35.5	35.6	27.4	36.2	31.0	40.7	26.5	15.5
16:2(n-6)	tr	tr	tr	tr	tr	tr	tr	0.11	0.09	tr	tr	tr	tr	tr	tr	tr	tr
16:2(n-4)	0.84	tr	0.12	0.29	0.32	tr	0.29	0.19	0.22	0.98	0.94	0.29	0.56	0.29	0.25	1.06	0.84
16:3(n-3)	tr	0.76	tr	tr	tr	tr	tr	tr	tr	0.09	0.08	tr	tr	tr	tr	tr	tr
16:4(n-3)	tr	tr	0.16	0.05	0.08	0.07	0.29	0.09	0.08	0.06	0.05	0.14	tr	0.28	0.05	tr	0.29
16:4(n-1)	tr	tr	0.04	0.09	0.23	0.08	0.15	0.07	0.08	0.06	0.09	0.16	0.11	0.15	0.12	0.09	0.14
17:2(n-8)	0.21	0.24	0.11	0.17	0.10	0.22	0.32	0.15	0.13	0.27	0.22	0.17	0.19	0.25	0.12	0.21	0.18
18:2(n-9)	tr	tr	0.08	0.16	0.19	tr	tr	0.24	0.21	0.10	0.17	tr	tr	tr	0.19	tr	tr
18:2(n-7)	tr	tr	tr	tr	tr	tr	tr	0.09	0.10	tr	tr	tr	tr	0.07	0.08	tr	tr
18:2(n-6)	1.73	1.97	0.88	2.99	4.64	1.88	0.67	1.07	2.52	1.84	3.11	0.73	2.38	0.76	3.37	3.96	1.13
18:2(n-4)	0.12	0.14	0.1	0.15	0.19	0.14	0.23	0.11	0.18	0.15	0.19	0.12	0.11	0.15	0.16	0.15	0.10
18:3(n-6)	tr	tr	tr	tr	0.10	tr	tr	tr	tr	tr	tr	tr	tr	0.09	tr	tr	tr
18:3(n-4)	0.22	0.23	0.12	0.15	0.18	0.23	0.26	0.18	0.16	0.22	0.21	0.10	0.12	0.20	0.11	0.21	0.20
18:3(n-3)	0.56	0.83	0.95	0.82	0.56	0.69	0.20	0.42	0.55	0.99	0.96	0.33	0.87	0.24	0.64	0.69	0.16
18:4(n-3)	0.53	0.80	0.39	1.11	0.53	0.6	0.25	0.53	0.68	1.19	1.14	0.63	1.61	0.28	0.7	0.77	0.17
18:4(n-1)	tr	tr	tr	tr	0.14	0.06	tr	tr	tr	tr	tr	tr	tr	0.08	0.09	tr	tr
20:2NMID(5,11)[g]	tr	tr	0.1	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
20:2(n-9)	tr	tr	tr	tr	0.23	0.07	tr	0.1	0.06	tr	tr	tr	tr	0.14	0.14	tr	tr
20:2(n-6)	0.20	0.22	0.62	0.15	0.15	0.24	0.26	0.2	0.15	0.22	0.22	0.19	0.13	0.27	0.15	0.27	0.16
20:3(n-6)	0.05	0.08	0.14	0.05	0.11	0.11	0.11	0.08	tr	0.09	0.08	tr	tr	0.18	0.03	0.06	tr

[a] The data are represented as mean values of four determinations (two group×two determinations).
[b] W, wild fish. [c] C, cultured fish. [d] C(K), cultured fish in Korea. [e] C(J), cultured fish in Japan.
[f] tr, trace. [g] NMID, non-methylene interrupted diene. [h] ND, not detected.

Table 2. (continued)

Fatty acid	1. Yellow tail		2. Sea bass		3. Red sea bream			4. Striped beakperch		5. Rockfish		6. Black rock fish		7. Sevenband grouper		8. Bastard	
	W[b]	C[c]	W	C	W	C(K)[d]	C(J)[e]	W	C	W	C	W	C	W	C	W	C
20 : 3(n-3)	0.05	0.09	0.26	tr	tr	0.13	tr	0.11	tr	0.12	0.13	0.07	0.41	0.14	tr	0.16	tr
20 : 4(n-6)	1.39	1.36	2.1	1.15	0.93	1.67	4.03	1.41	0.82	1.65	1.51	1.26	0.91	4.16	0.72	1.79	4.11
20 : 4(n-3)	0.35	0.46	0.21	0.44	0.64	0.67	0.34	0.47	0.56	0.47	0.41	0.15	tr	0.44	0.52	0.32	0.11
20 : 5(n-3)	4.21	5.30	7.26	6.69	6.21	5.34	7.28	7.03	5.81	6.53	6.71	9.96	7.38	8.37	5.77	5.51	4.74
21 : 5(n-3)	0.16	0.20	0.18	0.16	0.24	0.22	0.34	0.15	0.15	0.23	0.24	0.19	0.16	0.23	0.16	0.2	0.12
22 : 2NMID(7,13)	tr	tr	0.28	tr	tr	tr	0.27	tr	tr	tr	tr	0.09	tr	tr	tr	tr	tr
22 : 2NMID(7,15)	tr	tr	tr	tr	tr	tr	0.26	tr	tr	tr	tr	0.12	tr	tr	tr	tr	tr
22 : 2NMID	tr	tr	tr	tr	tr	tr	0.14	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
22 : 4(n-6)	0.21	0.18	1.22		0.17	0.41	1.42	0.29	0.04	0.25	0.15	0.23	tr	0.99	0.06	0.24	0.63
22 : 4(n-3)	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	0.06	tr	tr	tr
22 : 5(n-6)	0.70	0.65	0.28	0.35	0.28	0.98	1.04	0.36	0.27	0.80	0.73	0.25	0.34	0.78	0.24	0.78	1.31
22 : 5(n-3)	2.34	2.15	2.97	1.65	3.44	3.28	3.93	2.21	1.71	1.86	1.66	1.12	1.06	5.03	2.03	2.87	3.34
22 : 6(n-3)	17.5	20.5	13.4	15.2	14.3	24.0	21.2	14.5	14.8	20.9	19.8	19.8	15.8	13.7	13.1	23.0	34.0
24 : 6(n-3)	ND[h]	ND	ND	ND	ND	ND	ND	ND	ND	0.12	ND	ND	ND	ND	ND	ND	ND
ΣPolyenes	31.4	36.2	31.9	31.9	34.0	41.1	43.3	30.2	29.4	39.2	38.8	36.1	32.2	37.3	28.8	42.4	51.8

[a] The data are represented as mean values of four determinations (two group×two determinations).
[b] W, wild fish. [c] C, cultured fish. [d] C(K), cultured fish in Korea. [e] C(J), cultured fish in Japan.
[f] tr, trace. [g] NMID, non-methylene interrupted diene. [h] ND, not detected.

n-6 PUFA content (24.4 ± 5.4% and 16.5 ± 4.5%, respectively) than the 11 species of Australian fish (Belling *et al.*, 1997). The different distribution patterns of n-3 and n-6 PUFA in fish muscle may be the result of differences (in terms of PUFA) in the marine food chain in the respective habitats (Sinclair, 1984). The prominent fatty acids in PUFA were DHA and EPA, accounting for about 85% of the n-3 PUFA. Wild fish samples of yellow tail, red sea bream, and sevenband grouper have been shown to be rich in 16 : 0. Cultured fish samples of the same species have been proved to be rich in 18 : 1(n-9) and DHA. On the other hand, seabass and black rockfish were rich in 16 : 0 and EPA when they were wild fish and rich in 18 : 1(n-9) when they were cultured fish. The proportions of DHA, EPA, 16 : 1(n-7), and 18 : 1(n-9) in bastard were high in cultured fish, while the proportion of 18 : 0 was high in wild fish. Wild and cultured striped beakperch and rockfish had similar fatty acid compositions. In addition, both fish species had almost the same TL content in the wild and cultured. Although, in this study, an analysis of the diet of the cultured fish was not carried out, it is accepted in principle that the fatty acid composition of the fish is affected by the fish's diet (Kim and Lee, 1986). Therefore, the results of the comparison of wild and cultured rockfish as well as striped beakperch suggest some similarity in their diets.

Table 3 shows the content (g/100 g muscle) of total fatty acids (TFA), n-3 PUFA including DHA and EPA, and n-6 PUFA of 8 species of wild and cultured fish. TFA mean content of the cultured fish was 5.44 ± 1.88 g/100 g muscle which is 1.6 times that of wild fish (3.33 ± 2.74 g). PUFA was the most prominent fatty acid group in cultured fish, 1.7 times as much as in wild fish. The DHA and EPA contents of cultured fish were 1.74 and 1.55 times higher than those of wild fish, respectively. Although rock fish and striped beakperch were slightly richer in n-3 PUFA as wild fish compared to cultured fish, the n-3 PUFA content of all fish, wild and cultured, were in proportion to their TFA content: $y=0.292x-0.0055$ ($R^2=0.9349$, $p<0.001$) (Fig. 2). In general, the lipid composition of fish diets is responsible for their muscle lipid composition, and thus cultured fish can be largely affected by the choice of diet. Furthermore, cultured fish have much higher lipid contents than wild fish. This could be due to the regular feeding schedule for cultured fish as well as to low energy expenditure due to their environmental confinement; cultured fish are reared in systems such as tank culture on land or cage culture in the open sea.

In summary, we demonstrated here that cultured fish are the richer sources of n-3 polyunsaturated

Table 3. The contents of total fatty acid (TFA), saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) of 8 species of wild and cultured seawater fish in Korea

(g/100 g muscle)

Fish species	TFA	SFA	MUFA	PUFA	n-3 PUFA	n-6 PUFA	n-6/n-3	EPA	DHA
Wild fish									
1. Yellow tail	6.46	2.01	2.43	2.03	1.66	0.28	0.17	0.27	1.13
2. Sea bass	2.30	0.73	0.84	0.73	0.59	0.12	0.20	0.17	0.31
3. Red sea bream	1.00	0.30	0.36	0.34	0.26	0.06	0.25	0.06	0.14
4. Striped beakperch	5.74	1.87	2.14	1.73	1.47	0.20	0.14	0.40	0.83
5. Rockfish	7.32	1.85	2.60	2.87	2.38	0.36	0.15	0.48	1.53
6. Black rock fish	2.31	0.83	0.65	0.83	0.75	0.06	0.08	0.23	0.46
7. Sevenband grouper	1.05	0.33	0.33	0.39	0.30	0.08	0.25	0.09	0.14
8. Bastard	0.43	0.13	0.12	0.18	0.14	0.03	0.21	0.02	0.10
Mean	3.33	1.01	1.18	1.14	0.94	0.15	0.16	0.22	0.58
SD	2.74	0.78	1.03	0.96	0.80	0.12	0.15	0.16	0.53
Cultured fish									
1. Yellow tail	7.93	2.34	2.72	2.87	2.47	0.35	0.14	0.42	1.63
2. Sea bass	4.95	1.48	1.90	1.58	1.29	0.23	0.18	0.33	0.75
3. Red sea bream (K)[a]	4.77	1.37	1.44	1.96	1.67	0.25	0.15	0.25	1.14
Red sea bream (J)[b]	5.96	1.99	1.39	2.58	2.02	0.45	0.22	0.43	1.27
4. Striped beakperch	5.43	1.57	2.26	1.60	1.32	0.21	0.16	0.32	0.81
5. Rockfish	7.00	1.79	2.49	2.72	2.18	0.41	0.19	0.47	1.39
6. Black rock fish	6.16	1.92	2.26	1.98	1.68	0.23	0.14	0.45	0.97
7. Sevenband grouper	5.57	1.67	2.29	1.60	1.28	0.25	0.20	0.32	0.73
8. Bastard	1.18	0.38	0.19	0.61	0.51	0.09	0.17	0.06	0.40
Mean	5.44	1.61	1.88	1.94	1.60	0.28	0.17	0.34	1.01
SD	1.88	0.55	0.78	0.71	0.59	0.11	0.19	0.13	0.38

[a](K), cultured fish in Korea. [b](J), cultured fish in Japan.

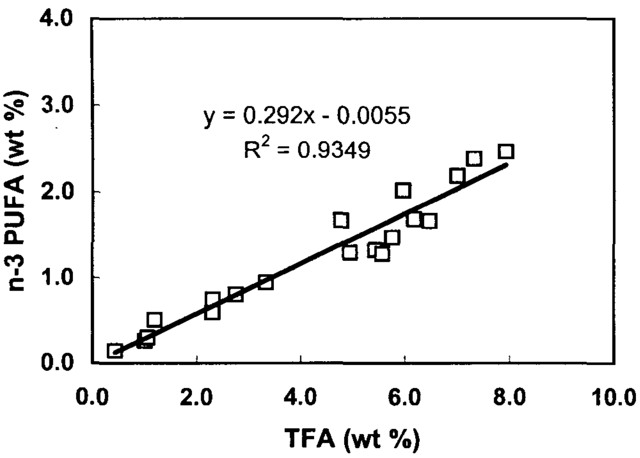

Fig. 2. Correlations between total fatty acid (TFA) and n-3 polyunsaturated fatty acid (n-3 PUFA) contents in 8 species of wild and cultured seawater fish in Korea.

fatty acids than wild fish.

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