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Health Related Fatty Acids in Some Pelagic Fishes in Sri Lanka

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Abstract

Fish lipids are the main sources of a special type of fatty acids, known as omega 3 type polyunsaturated fatty acids, recognized as an important pharmaceutical drug to prevent a number of coronary heart diseases. Some of the fatty acids are essential fatty acids in all diets. The lipid content and fatty acid profile of 20 very common fish species were analysed by gas chromatography. The lipid content was found to vary over a wide range (0.5 - 15% on wet basis), but most species contained less than 10%. The most abundant fatty acids in the fish examined were palmitic (C 16:0), oleic (C 18:1), eicosapentaenoic (C 20:5 n-3, EPA) and docosahexaenoic (C 22:6 n-3, DHA). Most small pelagics contained high levels (around 30% of total fatty acids) of omega 3 polyunsaturated fatty acids (omega 3 PUFA). Among these species, the highest amounts of omega 3 PUFA were present in Yellowstripe scad (*Selaroides leptolepis* (Suraparawa)), Dorab-wolf herring (*Chirocentrus dorab* (Katuwalla)), Spotted sardinella (*Amblygaster sirm* (Hurulla)), Blacktip sardinella (*Sardinella melannura* (Salaya)), Toothpony (*Gassa minita* (Mas karalla)), White sardinella (*Sardinella albella* (Sudaya)) and these levels were 34.4, 33.9, 32.3, 32, 31.3 and 30.4% respectively. The lowest level of omega 3 PUFA, 7.1%, was reported in Silver sillago (*Sillago sihama* (Kalanda)). In most species studied, the total amount of omega 3 PUFA contributed for around 90% of the total PUFAs. The two most important omega 3 PUFAs, namely EPA and DHA contributed for nearly 85% of the total omega 3 PUFAs.

Introduction

Fish and seafood play a very important role in human food and nutrition. They provide high quality protein, vitamins, minerals, lipids, and carbohydrates. Fish lipids, apart from being a food are also used as a medicine. They also serve as a rich source of energy and carriers of fat soluble vitamins. Some constituent fatty acids of fish lipids, such as linoleic acid, linolenic acid and arachidonic acid, are essential nutrients in the human diet. Omega 3 (n-3) polyunsaturated fatty acids (PUFA), which are high in fish lipids, are increasingly being recognised as pharmaceutical drugs for a number of patho-

physiological diseases. These fatty acids are reported to have the ability to decrease levels of cholesterol, triacyleglycerols, very low-density lipoproteins (VLDL) and low density lipoproteins (LDL) in blood. The omega-3 PUFAs also play a role in preventing excess production of a highly important series of hormone-like compounds known as prostaglandins. The prostaglandins are powerful metabolic and physiological regulators, but the excess production leads to a number of diseases (Kinsella 1986, 1988; Ackman 1988). Therefore, these acids provide prophylactic effects minimizing the development of a number of chronic degenerative diseases such as coronary heart disease, high blood pressure, thrombosis, arthritis, and some other pathophysiological diseases. Fish lipids mainly consist of triacylglycerols (nearly 90%) and minor quantities of diacylglycerols, monoacylglycerols, fatty alcohols, waxes, cholesterol and phospolipids. Most of these compounds may contain various types of fatty acids with different molecular structure. The omega 3 PUFAs, especially eicosapentaenoic acid (EPA, 20:5 n-3) and decosahexaenoic acid (DHA, 22:6 n-3), are reported to be responsible for these effects (Kinsella 1988).

According to the literature, the best sources for omega-3 PUFAs are the fish oils. In recent times, information regarding fatty acid composition of fish is reported from all over the world. Ackman (1974) reported a summary of fatty acid composition of sole, squid fish, herring, sable fish, cod, redfish, capline, rockfish, cohosalmon and three species of mackerels. Yusuf et al. (1993) investigated 12 species of fish from the Bay of Bengal. The fatty acid composition of thirty-five Icelandic fish were studied by Sigurgisladottir & Palmadottir (1993). Gibson (1983) studied 25 species of temperate fish and 4 species of invertebrates from Southern Australia. In addition to these, the work of Ackman & McLeod (1988), Kaitaranta (1980) and Low et al. (1994) also highlight the occurrence of omega 3 fatty acids in fish.

There are hundreds of varieties of fish around Sri Lanka and most of them are edible. The chemical characteristics of some Sri Lankan fish species were recorded earlier. Most of the earlier work was limited to the analyses of proximate composition of fish (Lantz & Gunasekara 1957; Peiris & Grero 1972, 1973; De Silva & Rangoda 1979). The fatty acid composition of edible parts of ten marine fish species and three prawn species were reported Jayasinghe (1994). Edirisinghe et al. (1997) investigated the fatty acid composition of twenty low value marine fish species. However, there is still lack of information on the fatty acid composition of fish commonly available in Sri Lanka. The present study was therefore, carried out to investigate the fatty acid composition of twenty small low value fish species commonly available in Sri Lanka.

Materials and Methods

Twenty low value common fish species from ten different families were purchased from Chilaw and Negombo fish landing sites. These fish samples were packed in polythene and were immediately transferred to the laboratory of the National Aquatic Resources Research & Development Agency in ice and the samples were kept in a freezer at -18°C until use.

A set of four fish from each species was taken for the analysis and the length and weight of these species were measured. The amount of lipids present in the whole fish was extracted and determined by modified Bligh & Dyer method (Hans & Olly 1963). The fatty acid methyl esters (FAME) of these lipids were prepared by base hydrolysis followed by transesterification (Anon. 1990) and these FAME were separated

by gas chromatography using hydrogen flame ionisation detector and helium as a carrier gas (Shimadzu GC-14A gas chromatograph using GP 10% SP2330 on chromasob WAW, 100-120 mesh, packed glass column, 2.1m*3.2mm, with temperature programming: column initial temp. 175°C; initial time 20 min; temperature increasing rate 1,3°C/min; column final temp. 190, 240°C; final holding time 10, 3.5 min, flow rate of carrier gas : 35ml/min). The obtained peaks were identified and quantitatively determined by comparing retention times of methyl esters in a standard mixture from Larodane Fine Chemicals AB, Sweden, In-house FAME, Denmark, and Neu-Chek pack, USA.

Results

Total lipid content

Most of the fish species contained low levels of total lipids (< 5%) on wet basis, but Hilsa shad (*Tenualosa ilisha*) and Long-finned herring (*Opisthopterus tardoore*) contained 14.6% and 10.0% total lipids respectively. The lowest amount of lipid, 1.4%, was recorded in White sardine (*Escualosa thoracata*) (Table 1).

Fatty acid composition

The most abundant fatty acids were palmitic acid (C 16:0), palmitoleic acid (C 16:1), stearic acid (C 18:0), oleic acid (C 18:1), eicosapentaenoic acid (C 20:5 n-3, EPA) and docosahexaenoic acid (C 22:6 n-3, DHA), but the most predominant acid was palmitic acid which contributed to 25-30% of total fatty acids (Table 2). Of the three groups of fatty acids, i.e., saturated, monounsaturated and polyunsaturated fatty acids, the omega 3 (n-3) group of the polyunsaturated fatty acids are important in human health. The concentration of fatty acids in fish is dependent on the percentage of individual fatty acids as well as the total lipid content of fish. Most of these species contained very low amount of fat (<4%) and therefore the amount of fatty acids present is also very low. The concentrations of individual fatty acids (mg/100g fish) are shown in Table 3.

Saturated fatty acids

Saturated fatty acids (SFAs) contributed to the major part of the fatty acid profile and ranged from 40.8% (in Yellowstripe scad, *Selaroides leptolepis*) to 49.7% (in Bhestripe herring, *Herklotsichthys quadrimaculatus*) of the total fatty acids. This SFA group consisted of myristic acid (C 14:0), pentadecanoic acid (C 15:0), palmitic acid (C 16:0), heptadecanoic acid (C 17:0) and stearic acid (C 18:0), with palmitic acid contributing for the largest proportion (25-30%) of the total fatty acids. Myristic acid and stearic acid also contributed to a considerable proportion but the contribution from pentadecaenoic acid and heptadecaenoic acid was comparatively low (Table 2). The highest amount of saturated fatty acids was recorded in Hilsa shad (*Tenualosa ilisha*, 5844.5mg/100g fish) and palmitic acid contributed the main proportion (3345 mg/100g fish) to these high saturates. White sardine (*Escualosa thoracata*) record the lowest amount of saturated fatty acids , 230.3 mg/100g fish (Table 3).

Monounsaturated fatty acids

Monounsaturated fatty acids (MUFAs) consisted mainly of palmitoleic acid (C 16:1) and oleic acid (C 18:1) and minor quantities of myristoleic acid (C 14:1),

Table 1 The total length, weight, and the total lipid content of the species studied
(mean ± standard deviation ; n =4)

No.	Date	Family	Common name	Scientific name	English name	Weight (g)	Total length (cm)	Total lipid content (%)
1	96/08/22	*Caesionidae*	Angaya	*Pterocaesio digramma*	Double-lined fusilier	55 1 ± 6.1	14 00 ± 3 1	2 17 ± 0 3
2	96/09/12	*Caesionidae*	Angaya	*Pterocaesio chrysozona*	Gold band fusilier	47 93 ± 2 8	13 1 ± 0 7	3 43 ± 0 5
3	96/07/25	*Carangidae*	Suraparawa	*Selaroides leptolepis*	Yellowstripe scad	17 4 ± 1 2	10 2 ± 0 4	2 1 ± 0 3
4	96/09/12	*Chirocentridae*	Katuwalla	*Chirocentrus dorab*	Dorab-wolf herring	60.91	24 5	2 03 ± 0 2
5	96/08/22	*Clupeidae*	Sudaya	*Sardinella albella*	White sardinella	18 4 ± 2 1	10 15 ± 0 5	5 24 ± 0 3
6	96/08/22	*Clupeidae*	Salaya	*Sardinella melanura*	Blacktip sardinella	22.0 ± 1 3	13 1 ± 1 4	1 91 ± 0 2
7	96/08/22	*Clupeidae*	Hurulla	*Amblygaster sirm*	Spotted sardinella	68 33 ± 5 8	17 72 ± 2 1	3 03 ± 0.5
8	96/08/22	*Clupeidae*	Wella Sudaya	*Escualosa thoracata*	White sardine	5 30 ± 0 3	20 8 ± 2 5	0 69
9	96/09/23	*Clupeidae*	Koramburuwa	*Herklotsichthys quadrimaculatus*	Bluestripe herring	23 18 ± 2.5	11 2 ± 0 9	5 51 ± 0 4
10	96/09/23	*Clupeidae*	Thonda Huralla	*Dussumieria acuta*	Rainbow sardine	32.5	13 7	3 2
11	96/10/10	*Clupeidae*	Tottawa	*Opisthopterus tardoore*	Long-finned herring	10 0	10 5	10 0
12	96/10/10	*Clupeidae*	Katukottya	*Tenualosa ilisha*	Hilsa shad	43 01 ± 3 8	38 7 ± 6 8	14.6 ± 2 8
13	96/09/12	*Leiognathidae*	Karalla	*Secutor insidiator*	Pugnose ponyfish	7 64 ± 0 6	6.83 ± 0 2	5 35 ± 0 3
14	96/09/12	*Leiognathidae*	Karalla	*Gazza minuta*	Toothpony	17 3 ± 1 9	10 4 ± 0 4	1 84 ± 0 1
15	96/08/12	*Sillaginidae*	Kalanda	*Sillago sihama*	Silver sillago	38.75 ± 3 5	16 0 ± 2.8	2 41 ± 0 2
16	96/07/11	*Mugilidae*	Godaya	*Liza melanoptera*	Oronchoa mullet	70.24 ± 5 2	17 0 ± 1.2	2 59 ± 0 3
17	96/10/10	*Scombridae*	Kumbalawa	*Rastrelliger kanagurta*	Indian mackerel	78 4	16.8	1 7
18	96/09/12	*Engraulidae*	Lagga	*Thryssa malabarica*	Malabar thryssa	18 1 ± 3 1	11 5 ± 0 9	1 60 ± 0 2
19	96/09/12	*Engraulidae*	Halmassa	*Stolephorus commersonii*	Commerson's anchovy	2 8	6 65	1 6 ± 0 1
20	96/08/22	*Siganidae*	Orawa	*Siganus canaliculatus*	White spotted spinefoot	146 7 ± 8 1	29.6 ± 2 7	0.83

Table 2. Percentage of saturated, monounsaturated and polyunsaturated fatty acids of the fish species studied

Name of Fish	Percentage fatty acids																						
	Saturated fatty acids						Monounsaturated fatty acids							Polyunsaturated fatty acids									
	14 0	15 0	16 0	17 0	18 0	Total	14 1	16 1	18 1	20 1	22 1	24:1 w 9	Total	16 2 w4	18 2 w6	18:4 w3	20 2 w6	20 4 w3	20:5 w3	22 4	22 5 w3	22 6 w3	Total	omega-3 PUFA
Double-lined fusilier	6 3	1 0	25 6	1 6	7 0	**41.5**		6 2	9.1			2.4	**17.7**	1 3	0 8	1 4		0 6	9.0	0 8	1 3	20 0	**35.2**	**32.3**
Gold band fusilier	7 6	0 7	27 3	0 9	8 6	**45.1**		7 2	12.3	0 7		1 9	**22.2**	0 5	0 9	1 1		0 5	7.0	0 5	2 5	15 3	**28.4**	**26.5**
Yellowstripe scad	3 9	0 6	26	1 5	8 7	**40.8**		4 6	11.4	0 3		1	**17.2**		0 6	0 9		0 2	11	0 7	2 9	19 1	**35.7**	**34.4**
Dorab wolf herring	6 4	0 7	26 4	1 2	9 1	**43.8**		6 2	8 7			1 3	**16.2**		1 2	1 1			7.7	0 6	1 5	23 7	**35.7**	**33.9**
White sardinella	10 1	1 0	24 1	1 4	6 4	**43**		9 2	6.5			1 5	**17.2**	1 3	1 0	2 4		0 4	10.9	0 8	1 7	15 5	**34.0**	**30.9**
Blacktip sardinella	8 6	0 9	25 4	1 7	6 0	**42.7**		7 7	6.9	0 7		1 9	**17.1**	1 2	0 9	1 1		0 4	10.0	0 6	1 9	18 7	**34.7**	**32.1**
Spotted sardinella	6 3	1 0	25 6	1 6	7 0	**41.5**		6 2	9.1			2.4	**17.7**	1 3	0 8	1 4		0 6	9.0	0 8	1 3	20 0	**35.2**	**32.3**
White sardine	6 1	0 7	26 2	1 9	9 0	**43.9**		6	6 0	0 8		1 6	**14.4**		0 3	1 2		0 4	9 0	0 8	2 3	17 5	**31.5**	**30.4**
Bleeding herring	6 6		32 7	2 1	8 3	**49.7**	1 1	6 5	11 5			1 2	**20.4**	0 8	0 8			0 4	7 5		1 8	11 9	**23.3**	**21.6**
Rainbow sardine	6	0 9	27 7	2 7	9 0	**46.2**	0 1	6 3	7 9			1 5	**15.9**	0 8	1 0	1 7		0 2	8 9	0 3	1 2	18 4	**32.6**	**30.4**
Long-finned herring	5 3	0 6	32 4	1 1	7 3	**46.6**		8	22.6	0 8		1 6	**31.9**	0 6	1 1			0 4	4 9	0 6	2 4	8 3	**18.3**	**16.0**
Hilsa shad	12 6	0 5	26 5		6 7	**46.2**		14 6	8 4	0 6		0 5	**24.0**	1 0	0 5	1 5	0 3	0 3	13 9	0 7	1 4	6 7	**26.2**	**23.8**
Pugnose ponyfish	6 4	0 7	28 2	2 0	8 2	**45.5**		8 5	8 9	0 4		1 4	**19.2**	1 1	1 1	0 7		0 4	9 4	0 6	1 7	15 1	**30.2**	**27.3**
Toothpony	3 8	0 6	25	2 1	10	**41.5**	0 7	5	10 9			1 2	**17.9**	2 1	1				7 3	0 2	2 3	21 7	**34.6**	**31.3**
Silver nillago	3 5	1	28 9	2	9 6	**45**		10 8	14 9	2 7	0 6	0 4	**29.5**	0 9	1 6				2 6	4 7	2 1	2 4	**14.3**	**7.1**
Oceanbora mullet	10 5	1 9	22.2	0 9	7 5	**43**		13 5	6			0 8	**20.3**	3 6	1 4	2 4	0 3	0 7	12	1 1	2 1	7 1	**30.6**	**24.2**
Indian mackerel	10 9	0 2	24 1	1 3	8 0	**44.6**	0 6	14 2	6 1	1 4		0 7	**23.1**	1 6	0 5				10.7		1 0	12 7	**27.0**	**25.0**
Malabar thryssa	5	1 1	29.2	1 7	10 8	**47.7**	0 1	6 3	11 8			1 5	**19.8**	1 7	1 7	0 1	0 5	0 3	7.1	0 5	1 3	12 2	**25.4**	**21.0**
Commerson's anchovy	6 8	1 3	28.0	0 9	8 2	**45.3**		9 1	7 2	0 4		0 9	**17.7**	0 9	1 3	2 2		0 2	7.6		1 2	16 8	**30.3**	**28.1**
White spotted spanefoot	4 9	1 9	20.7	2 7	11.5	**41.7**	0 4	4 3	8 8	1 4		0 8	**21.7**	1 4	0 9		0 3	0 5	1 9	1 6	3 8	12 1	**22.5**	**18.4**

Table 3 Amounts of saturated, monounsaturated and polyunsaturated fatty acids (mg/100g fish) in the fish species studied (mean ± standard deviation, n = 4)

Name of fish	Amount of fatty acids (mg/100g fish)												
	Saturated fatty acids						Monounsaturated fatty acids						
	14:0	15:0	16:0	17:0	18:0	Total	14:1	16:1	18:1	20:1	22:1	24:1w 9	Total
Double-lined mullet	113.5 ±5.2	17.2 ±1.6	459.8 ±18.2	29.6 ±3.0	125.7	745.8		111.5 ±4.5		20.6		42.3 ±2.1	317.3
Gold band fusilier	228.3 ±9.4	20.7	815.9 ±25.3	26.7 ±2.1	255.4 ±17.6	1347.0		216.0 ±8.6	366.9 ±14.0	8.7 ±2.1		58.2 ±3.1	661.7
Yellowstripe scad	66.2 ±5.1	10.3 ±0.8	437.1 ±17.2	25.9 ±1.6	147.0 ±4.9	686.5		77.0 ±5.1	191.1 ±12.2			16.4	290.2
Dumb-scad herring	97.1 ±4.8	10.6 ±1.4	403.5 ±20.1	19.0 ±2.4	138.7 ±17.6	668.9		94.5 ±3.9	132.7 ±3.5			20.0 ±1.0	247.2
White sardinella	420.9 ±21.3	40.2 ±1.5	1008.4 ±23.8	60.1 ±4.8	265.3 ±8.0	1794.9		386.3 ±14.5	271.6 ±5.9	10.0		60.9 ±2.4	718.8
Blacktip sardinella	126.9 ±5.6	13.6 ±1.0	373.0 ±7.6	25.7 ±2.5	87.5 ±7.6	626.7		112.6 ±6.1	100.9 ±4.5			27.9 ±0.5	251.4
Spotted sardinella	179.8 ±9.2	27.3 ±2.4	728.5 ±24.9	46.8	199.1 ±8.0	1181.6		176.7 ±8.4	258.9 ±9.0	4.2		67.1 ±2.9	502.7
White sardine	32.1 ±4.2	3.7 ±0.2	137.4 ±17.6	9.7	47.3 ±2.5	230.3		31.3 ±3.4	31.6 ±2.1			8.5	75.6
Rhestrope herring	299.1 ±6.8		1473.5 ±53.2	94.3 ±8.0	373.3	2240.2	50.7 ±4.3	294.1 ±6.8	519.6 ±15.2			54.3 ±2.1	918.6
Rainbow sardine	178.3 ±14.2	28.2 ±5.3	826.5 ±35.2	79.2 ±5.7	269.0 ±17.6	1381.2	3.3 ±0.2	188.7 ±7.5	236.7 ±7.2	72.6		45.0 ±5.0	473.9
Long-finned herring	489.3 ±31.2	51.0 ±4.9	2987.9 ±68.2	100.8 ±6.4	671.2 ±23.1	4300.1		735.9 ±16.5	2085.0 ±24.0	71.2 ±4.0		55.7 ±3.8	2949.3
Fitch shad	1597.5 ±54.9	58.8 ±8.1	3345.1 ±92.4		843.1 ±45.2	5844.5		1843.8 ±57.3	1060.4 ±20.5	15.5 ±1.2		57.9 ±3.4	3033.4
Pugnose ponyfish	249.6 ±16.5	28.4 ±1.2	1101.3 ±54.3	78.3 ±5.9	319.7 ±24.1	1777.3	-	331.9 ±14.2	346.3			54.6 ±2.8	748.3
Toothpony	62.8 ±5.8	10.2 ±0.7	411.8 ±28.0	34.8 ±11.5	164.2 ±10.0	683.7	11.7 ±0.4	82.9 ±5.3	180.1 ±8.1	55.4 ±1.4		20.3 ±1.2	295.1
Silver silago	71.8 ±4.6	20.9 ±1.2	584.0 ±36.2	40.9 ±2.4	193.7 ±5.9	911.3		219.3 ±17.2	301.3 ±14.2		13.0	8.6	597.7
Ehrenbergs mullet	211.8 ±2.4	39.1 ±2.3	448.4 ±24.8	18.2 ±1.1	151.4 ±10.2	868.9		273.2 ±20.0	120.4 ±4.9	18.3		17.1 ±2.1	410.6
Indian mackerel	139.8 ±8.7	3.1 ±0.4	307.2 ±23.4	16.8 ±1.2	102.0 ±7.3	568.9	8.0 ±0.5	181.6 ±8.6	77.8 ±5.7			9.6	295.2
Malabar thryssa	52.6 ±.2	11.4 ±0.7	308.9 ±14.2	17.8 ±1.5	113.8 ±8.0	504.4	1.4	66.5 ±3.9	125.0 ±5.8	5.3		16.3 ±1.3	209.3
Commerson's anchovy	86.7 ±7.8	16.7 ±0.8	356.1	11.2 ±0.8	104.7 ±14.2	575.5		116.2 ±7.1	91.6 ±5.2	9.0		11.4 ±0.5	224.5
White spotted spinefoot	32.1 ±2.4	12.7 ±0.6	135.7 ±4.6	17.6	75.4 ±5.0	273.4	2.8	28.0 ±0.9	57.7 ±2.1			44.7 ±2.5	142.2

Table 3 (continued)
(mean ± standard deviation n = 4)

Name of fish	Amount of fatty acid (mg / 100g fish)										
	Polyunsaturated fatty acids										
	16 2w4	18 2w6	18 4w3	20 2w6	20 4w3	20 5w3	22 4	22 5w3	22 6w3	Total	Omega3 PUFA
Dotted-lined frailes	22 6 ±2 7	15 0 ±1 0	26 0 ±1 9		10 7 ±0 8	161 1 ±8 1	13 9 ±1 0	23 5 ±1 3	359 8 ±14 1	632 6	581 1
Gold-lined frailes	16 4 ±1 5	26 0 ±1 2	33 0 ±2 0		16 4 ±1 0	209 2 ±7.8	14 1 ±1 2	74 0 ±4.8	457 9 ±10 2	846.9	790 5
Yellowstripe scad	0 0	10 2 ±0 5	14 4 ±0 5		4 2	190 8 ±11 0	11 3 ±1 1	48 1 ±3.1	321 5 ±9 8	600.6	579 0
Dorab-wolf herring	0 0	17 7 ±1 2	16 3 ±1 3			117 4 ±6 8	8 9 ±0 1	23.0 ±1 0	361 2 ±13 1	544 4	517 9
White sardinella	52 2 ±3 2	41 2 ±4 5	101 1 ±6 1		18 2 ±1 8	453 5 ±15 4	33 9 ±3 5	70 3 ±3 4	648 8 ±14 1	1419 2	1291 8
Blacktip sardinella	17 3 ±2 1	13 4 ±0 8	16 1 ±0 8		5 3	147.0 ±6 1	8 4	27 5 ±2 1	275 1 ±10.0	510 1	470 9
Spotted sardinella	35 8 ±2 1	23 8 ±1 4	41 2 ±3 4		16 9 ±1 0	255.2 ±10.2	22 0 ±1 3	37 2 ±3 1	570 0 ±8 2	1002.2	920 6
White sardine		1 7	6 5		2 2	47 0 ±4 8	4 1	11 9 ±0 7	91 8 ±6 5	165.2	159 4
Dhera-pe herring	38 3 ±1 9	37 6 ±2 3			16 6 ±1 1	340 6 ±21 1		80 5 ±6.9	536 6 ±18 0	1050 1	974 2
Rainbow sardine	25 2 ±0 8	30 9 ±3 1	50 2 ±3 1		6 6	266 8 ±14 2	8 2	35 2 ±3 1	550 2 ±15 6	973 3	909.0
Long-finned herring	55 3 ±3 2	99 8 ±6 7			32.5 ±1 5	448 6 ±26 2	58 6 ±5 1	223.5 ±15 6	768.6 ±14 2	1686 9	1473 1
Hilsa shad	124 7 ±5 9	60 7 ±6 4	184 9 ±13 2	31 9 ±2 5	37 1 ±2 5	1753 5 ±32.1	88 7 ±7 5	178 3 ±8 7	850 9 ±21 3	3310.7	3004 7
Pugnose ponyfish	42 5 ±0 8	43 4 ±2 5	26 9 ±1 5		14 6 ±0 6	368.4 ±13 5	25 1	66 6 ±3 4	589 8 ±32 1	1177 3	1066 3
Toothpony	33 9 ±1 2	17 1 ±1 4				120 8 ±7 5	3 9	37 6 ±5 0	357 5 ±16 5	570 8	515 9
Silver sillago	18 2 ±1 4	33 2 ±2 1				53 2	94 1 ±5 8	42 5 ±4 1	48 7 ±3.9	289 8	144.3
Ommobon mullet	72 2 ±5 1	28 6 ±1 7	49 3 ±3 1	5 4	13 8 ±0 8	240 4 ±8 0	22 1 ±1 1	42 7 ±2 6	143 6 ±9 1	618 0	489 7
Indian mackerel	20 3 ±2 1	6 1				136 2 ±6 0		20 9 ±1 0	161 9 ±6 8	345 4	318 9
Malabar thryssa	18 0 ±1 5	18 1 ±1 4	1 2	5 4	2 7	75 2 ±4 5	5 3	13 7	128 6 ±5 1	268 3	221 4
Commerson's anchovy	11 0	16 9 ±0 7	27 9 ±0 8		2 6	97 2 ±5 7		14 9 ±0 8	214 1 ±17 2	384 5	356.6
White spotted spinefoot	8 9	6 0		2 0	3.5	12.4	10 2 ±0 3	25.3 ±1 2	79.5 ±5 8	147 8	120 6

cicosenoeic acid (C 20:1), erucateic acid (C 22:1) and nervoneic acid (C 24:1). The highest and the lowest percentage of MUFAs were recorded in Long-finned herring (*Opisthopterus tardoore*, 31.9%) and in White sardine (*Escualosa thoracata*, 14.41%) respectively (Table 2). Hilsa shad and White sardine records the highest (3033.4 mg/100g fish) and the lowest (75.6 mg/100g fish) amount of MUFAs respectively (Table 3).

Polyunsaturated fatty acids

The polyunsaturated fatty acids (PUFAs) were the second largest group, being slightly less than the monoenes only in two of the twenty fish species studied. The percentage of the PUFAs ranged from 14.3% (in Silver sillago, *Sillago sihama*) to 35.7% (in Yellowstripe scad, *Selaroides leptolepis*) and 12 species out of 20 contained more than 30% PUFAs of total fatty acids (Table 2). The highest and the lowest amount of polyunsaturated fatty acids was recorded in Hilsa shad (3310.7mg/100g fish) and White spotted spinefoot (147.8 mg/100g fish) respectively (Table 3). The PUFAs mainly consisted of two types of fatty acids, i.e., omega 3 and omega 6, based on their molecular structure.

Omega 3 Polyunsaturated fatty acids

Most species contained high levels, around 30%, of omega 3 PUFAs, but contained low levels of omega 6 PUFAs. Among the species studied, the highest amounts of omega 3 PUFAs were present in Yellow stripe scad (*Selaroides leptolepis*, 34.4%, 579mg/100g fish), Dorab-wolf herring (*Chirocentrus dorab*, 33.9%, 517.9 mg/100g fish), Spotted sardinella (*Amblygaster sirm*, 32.3%, 1002.2mg/100g fish), Double-lined fusilier (*Pterocaesio digramma*, 32.3%, 581.1mg/100g fish) and Blacktip sardinella (*Sardinella melannura*, 32.1%, 470.9mg/100g fish. The lowest percentage of omega 3 PUFAs, 7.1%, was reported in Silver sillago (*Sillago sihama*, 144.3 mg/100g fish) (Tables 2 and 3).

EPA and DHA content

The omega 3 PUFAs mainly consisted of C 18:4 n-3, C 20:4 n-3, eicosapentaenoic acid (EPA, C 20:5 n-3), docosapentaenoic acid (C 22:5 n-3) and docosahexaenoic acid (DHA, 22:6 n-3). In most species the two most biologically active omega 3 PUFAs, namely EPA and DHA, contributed for nearly 85% of the total omega 3 PUFAs. The highest percentage of EPA, 13.9%, was recorded in Hisla shad (*Tenualosa ilisha*) and the lowest value, 1.9%, was recorded in Whitespotted spinefoot (*Siganus canaliculatus*). Generally, DHA content was greater than EPA except in very few species such as Hilsa shad, Silver sillago and Otomebora mullet. The highest (23.7%) and the lowest (2.41%) values of DHA were recorded for Dorab-wolf herring (*Chirocentrus dorab*) and Silver sillago respectively (Tables 2 and 3).

Discussion

The total lipid content of the fish studied varies between 0.69 - 14.6%. Nevertheless this lipid content is different when compared with the lipid content of edible portion of some fish such as Dorab-wolf herring, White sardinella and Spotted sardinella (Jayasinghe 1994). Lantz & Gunesekara (1957) have reported the total fat content of Indian mackerel (6%) to be higher than the values obtained from this study.

The work of Peiris & Grero (1972, 1973) showed that there were differences in lipid content in fish. These changes might happen due to a number of reasons. The lipid content of fish varies with species, season, physiological status, diet, location in the body, and age (Kensella 1988).

The high proportion of omega 3 PUFAs and low proportion of SFAs and MUFAs acids indicate the good quality of the lipids with respect to health benefits. The omega 3 PUFAs, known to provide a number of health benefits, originate in unicellular phytoplankton or in some seaweeds (Ackman 1979). When considering these quality parameters, Yelowstripe scad provides the highest health benefits with 34.4% omega 3 PUFAs, 17.2% MUFAs and 40.8% SAFs. In addition to this species, Spotted sardinella, Double-lined fusilier, Blacktip sardinella, White sardine, Toothpony, Dorab-wolf herring and White sardinella were found to contain of 30.4 - 33.9% omega 3 PUFAs, 14.4 - 17.9 % MUFAs and 40.8 - 43.9% SFAs and therefore provide good health benefits. Ackman (1979) showed that the SFAs, MUFAs and PUFAs of Capelin, Mackerel and Atlantic herring were in the range of 22.6 - 30.3%, 43.9 - 61.0% and 16.4 - 25.8% respectively. In this case, the percentages of MUFAs were higher and SFAs were lower when compared with the results from our study. The percentage of saturated, monounsaturated and omega 3 polyunsaturated fatty acids of Dorab-wolf herring is very much close to the results recorded by Jayasinghe (1994).

In most species of the current study, the total omega 3 PUFA content (14 out of 20 species) were higher than 24% of total fatty acid content. The omega 3 PUFA content of Australian fish were in the range of 9.6 - 48.2% (Gibson 1983), and the upper limit of this range is higher than in the present study. Yusuf et al. (1993) reported that the omega 3 PUFA content of marine fish in Bay of Bengal to vary from 8.9 - 35%.

Among the omega 3 PUFAs, EPA and DHA contributed a very high proportion (nearly 85%) of the total omega 3 PUFAs. The content of these two acids in seafood and fish oils varies immensely between species of fish and marine mammals (Ackman 1982; Kinsella 1987a) and largely determines the efficacy and dose required for different treatments. According to the results, DHA is the major fatty acid of this group and records higher values in Dorab-wolf herring and Toothpony than in other species. Studies in Australian and Bay of Bengal fishes also have shown that DHA is normally the abundant omega 3 fatty acid (Gibson 1983; Yusuf et al. 1993). Generally EPA content is lower than the DHA, but in a few cases such as Hilsa shad and Otomebora mullet EPA content is higher than the DHA content. Low et al. (1994) reported that longtail shad (Family: Clupeidae) had more EPA than DHA. The Icelandic fish, Capelin (*Mallotus villosus*), shows the same pattern. Herbivores and phytoplankton feeders tend to have more EPA than DHA (Sigurgisladottir & Palmadottir 1993).

The study shows that some of the fish species analysed are moderate sources of these fatty acids. Nevertheless a few species, such as Silver sillago, Long-finned herring and White spotted spinefoot, contained low proportion of omega 3 PUFAs (7.1 - 16%) with high proportion of SFAs (45.0 - 46.6%) and MUFAs (29.5 - 32%) and therefore to be poor sources of beneficial fatty acids.

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