Short Communication

Levels of Omega 3 fatty acids in Australian seafood

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The aim of this study was to determine the quantity of omega 3 (n–3) fatty acids in commonly consumed species of South Australian fish. Omega 3 fatty acids ranged from 17.7% to 53.7% of total fat with docosahexaenoic acid (DHA, 22:6n–3) as the major omega 3 fatty acid in all 26 species tested (range 9.5 % to 47.1% of total fat). The levels of total omega 6 (n–6) fatty acids ranged from 2.3% to 20.2% of total lipids, chiefly as arachidonic acid (AA, 20:4n–6). Fatty fish such as Gemfish, Atlantic Salmon and Swordfish were found to be good sources of omega-3 fatty acid (1360, 2252 and 2571 mg/100g fish respectively), while low fat fish such as Ling, Deep Sea Bream (Blue Warhou) and Blue Grenadier (0.5, 0.7 and 0.7% fat) had low levels of omega 3 fatty acid (222, 257 and 247 mg/100g). Because most white table fish consumed by Australians are so low in fat they are actually a limited source of omega 3 fats. The amount of fish required to be consumed to provide 1 g of omega 3 fatty acid per day ranged from 40 to 450 g.

Key Words: omega 3 fatty acids, dietary fats, fish, fish oils, diet

INTRODUCTION

Fish is a highly nutritious food and is an excellent source of high quality protein, vitamin D, iodine, taurine and omega 3 fatty acids[1]. Epidemiological studies suggests that dietary consumption of eicosapentaenoic acid (20:5 n–3, EPA) and docosahexaenoic acid (22:6n–3, DHA) that are commonly found in fish or fish oil may modify the risk for certain degenerative or neuropsychiatric disorders. As evidence, decreased blood concentrations of omega 3 fatty acid have been associated with several neuropsychiatric conditions, including Alzheimer disease, schizophrenia and depression[2] and Morris et al[3], reported that subjects who eat fish once a week or more had a 60% lower risk of developing Alzheimer disease than those who consumed fish less frequently. Dietary intake of fish and omega 3 fatty acids have been associated with lower risk of Alzheimer disease and stroke.[4] Several studies have found an inverse association between fish and omega 3 fatty acid consumption and incidence of Coronary Heart Disease (CHD)[5,6,7,8] and higher intake of DHA has been associated with decreased systolic and diastolic blood pressure.[9] Mozafferian and Rimm[10], reported that consumption of 1-2 serving/week of fish, especially of species higher in omega 3 fatty acids EPA and DHA, reduced coronary death by 36% and mortality by 17%. Omega 3 fatty acids are also reported to be effective in the treatment of hyperlipidemia, hypertension and rheumatoid arthritis.[11, 12] Recently a study suggested that dietary omega 3 fatty acids have the potential to improve calcium absorption in the intestine, reduce bone demineralization and inflammatory factors.[13]

The American Heart Association[14] has recommended consumption of two servings of fish per week for people with no history of CHD and at least one serving of fish daily for those with known CHD or an intake of at least 1 g omega 3 fatty acids from fish and fish oil per day. The National Heart Foundation of Australia[15] has recommended consumption of fish at least twice a week to reduce CHD. General recommendations for daily dietary intake of DHA/EPA are: 0.5 g/day for infants, an average of 500 mg/day for healthy adults, an average of 1 g/day for patients with CHD and 2-4 g/day for management of hyperglyceridemia with medical consultation.[16] The aim of this study was to determine the total fat, omega 6 and omega 3 fatty acid levels in a variety of commonly consumed Australian fish to provide consumers with guidance as to the potential benefit they can expect to get the from eating various fish species.

MATERIALS AND METHODS

Materials

Fillets from twenty-six species of fish were purchased from local markets in the Adelaide area at separate times during the period September – October 2007. Chloroform, methanol, heptane, sodium sulfate anhydrous and butylated hydroxyanisole (BHA) were purchased from Sigma Company Aldrich Pty. Ltd. 12 Anella Avenue. Castle Hill

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NSW 2154. Solvents were AR grade and the antioxidant BHA was added at a concentration of 5 mg/l.

Methods

Triplicate samples (0.5 g) were taken from fresh fish fillets and homogenized in 1.75ml 0.9% cold saline. Tissue was then extracted according to method of Bligh and Dyer.[17] The resulting lipid fraction was weighed and then converted to fatty acid methyl esters in 1% H2SO4 in methanol in a sealed tube at 70 ºC for 3 hr. After cooling and adding 750µl distilled water the esters were extracted with 2ml heptane and separated by gas chromatography (GC) on 50 m capillary columns (0.32 mm internal diameter SGE, Victoria) coated with 70% cyanoproply polysilphenyene – siloxane (BPX-70, 0.25 µm film thickness) in a Hewlett- Packard 6890 GC fitted with a flame ionization detector. The carrier gas used was helium set at a flow rate of 1.8 ml/min and the split-ratio was 20:1. The injection temperature was 250˚C and the FID detector temperature was 300˚C. Initial oven temperature was set at 140˚C then programmed to rise to 220˚C at a rate of 5˚C/min and then held for 3 min. The oven temperature was then increased to 260˚C at a rate of 8˚C/min and then held for 8 min.[18] Identification of compounds was based on the retention time of standards obtained from Nucheck prep Inc. (Elysian, MN). SPSS windows version 14 was used to calculate the means and standard deviation (SD) from three replicates.

RESULTS

The level of fat in Australian fish was generally low and ranged from 0.5 to 2.7 g/100g (Table 1). The exceptions were Ocean Trout, Gemfish, Atlantic Salmon and Swordfish that contained 4.5, 6.3, 11.2 and 14.4 g/100g respectively. Seventeen of the species sampled contained *ca*. 1 g/100g fat or less [Barramundi, Boar, Flake, Prawn (shrimp), Rainbow Trout, Australian Salmon, Skate, Snook, Squid, Tommy Ruff and Northern Whiting, Blue Grenadier, Coral Trout, Deep Sea Bream (Blue Warehou), Flathead, Southern Bluefin Tuna, Red Snapper (Bight Redfish)].

The level of saturated fatty acids in the lipid of most Australian fish was about 30% (range, 26.3 % to 42.4%) of total fat (Table 1). Atlantic Salmon, Swordfish, Rainbow Trout, Flake, Deep Sea Bream (Blue Warehou) and Ling contained the lowest percent of saturated fat (26.3, 27, 27, 27.1, 28.8 and 29.1 % respectively). European Carp contained the highest percent of saturated fat (42.4%).

Monounsaturated fatty acids in lipids of Australian fish ranged from 7.6 to 50.7% of total fat (Table 1). Squid, Australian Salmon and John Dory contained lower than 10% monounsaturated fat. Snook, Tommy Ruff (Australian Herring), European Carp, Skate, Deep Sea Cod (Ribaldo), Coral Trout, Ling, Northern Whiting, Boar, Red Snapper (Bight Redfish), Flathead, Garfish and Prawn contained levels ranging from 10-20% monounsaturated fat. The highest levels of monounsaturated were found in Gemfish and Swordfish (40-50% monounsaturated fat).

Arachidonic acid (20:4n–6, AA) was found to be the major omega 6 fatty acid (Table 1) and there was little linoleic acid (18:2n–6, LA) in any of the samples assayed. The concentration of AA ranged from 0.1 to 14.2%. Prawn, Ocean Trout and Swordfish contained the lowest level of AA (0.1, 0.9 and 0.9 % respectively). On the other hand Flake (Blue Shark), Northern Whiting, Barramundi and Skate contained the highest concentration of arachidonic acid (11.4, 11.4, 13.2 and 13.3% respectively).

The long chain omega 3 fatty acids EPA, docosapentaenoic acid (22:5n–3, DPA) and DHA were present in high concentration in most of species examined (Table 1). In general EPA was present in lower concentration than DHA. The concentration of EPA ranged from 1.3 % to 13.4 %, while that of DHA ranged from 9.5 % to 47.1%. Deep Sea Cod (Ribaldo) and Squid contained more than 50% of total fat as omega 3 fatty acid, mostly as DHA (47.1 and 42.6% respectively). Seventeen out of twenty six species of fish contained *ca*. 30 – 50% of the total fat as omega 3 fatty acid. There was an inverse relationship between monounsaturated fatty acid and PUFA (n–3 + n–6) in the different species of fish (Fig 1).

The omega 3 fatty acid content of various fish as well as the amount required to be consumed each day to provide 1 g/day of omega 3-fatty acid are shown (Table 2). Gemfish, Atlantic Salmon and Swordfish contained the highest concentration of omega 3 fatty acid (1360, 2252 and 2571 mg/100g fish respectively) and consequently represented the lowest quantity of fish needed to provide 1 g/day omega 3 fatty acid (74, 44 and 39 g fish respectively).

Many of the most popular eating fish are poor sources of omega 3 fatty acid including the low oil fish such as Ling, Southern Bluefin Tuna, Blue Grenadier, Deep Sea Bream (Blue Warehou), Coral Trout, Barramundi and Skate and the amount of fish required to provide 1 g/day omega 3 fatty acid was large (450, 435, 405, 389, 370, 362 and 346 g respectively). These amounts represent 2-3 times the average daily serve size.

DISCUSSION

The present study emphasizes that most of the Australian fish examined contained low levels of fat. These results are in agreement with our earlier report[19] that most Australian and Malaysian species of fish contained low levels of fat (0.5 to 7.2% of fresh weight).[20] Our results are also in agreement with those of Nichols et al[21], Sinclair et al[22], Wang et al[23] and Nichols et al[24] who reported that the lipid content of Australian seafood was low (range 0.4 to 7.7%). Our conclusions are also in agreement with Hearn et al[25] and Kris-Etherton et al[16] who reported that fish containing lower fat are a poor source of omega 3 fatty acids including Northern hemisphere species such as Atlantic cod, Whiting, Snapper and Shark. Our results suggest that the fat content of fresh water fish are also low (ca. 1 g/100g) which is in general agreement with Komprda et al[26] and Barrado et al.[27] There is some variation in fat content of both fresh water and marine fish in Australian markets as many species are now farmed and farming can raise the fat content of fish. For example, two samples of farmed Tuna recently obtained had fat contents of 2.4% and 29.4%, which is considerably higher than the wild Tuna levels reported in Table 1. There is a need to examine in detail the level of fat in farmed versus wild

Table 1. Fatty acid Composition of Seafood samples (% total fat, means ±SD)

Fatty acid	Scientific Name	% Fat ± SD	Total Saturated	Total Mono-unsaturated	18:2n–6 † LA	20:4n–6 ‡ AA	Total n–6	18:3n–3 § ALA	20:5n–3 §§ EPA	22:5n–3 ¶ DPA	22:6n–3 †† DHA	Total n–3
Atlantic Salmon	Salmo Salar	11.2 ± 0.28	26.3±0.54	34.3±0.18	0.2±0.00	1.2±0.21	7.3±0.02	1.5±0.01	8.6±0.15	5.2±0.05	17.1±0.47	31.8±0.73
Barramundi	Lates Calcarifer	1.2 ± 0.19	30.7±0.09	22.3±0.56	0.3±0.01	13.2±0.34	20.2±0.27	1.0±0.03	7.2±0.17	4.1±0.09	9.5±0.18	23.6±0.32
Boar	Pentaceropsis recurvirostris	0.9 ± 0.05	34.2±0.21	10.2±0.23	0.1±0.00	14.2±0.32	18.1±0.27	0.1±0.01	4.6±0.09	2.4±0.05	29.5±0.27	36.7±0.25
Blue Grenadier	Macruronus novaezelandiae	0.7 ± 0.01	30.0±0.03	27.9±2.46	0.2±0.02	2.1±0.18	3.8±0.02	0.3±0.04	4.5±0.08	2.4±0.05	31.4±2.47	37.9±2.47
European Carp	Cyprinus carpio	2.7 ± 0.08	42.4±0.39	17.7±0.56	0.1±0.02	5.8±0.37	8.2±0.40	0.1±0.03	4.7±0.13	2.1±0.08	23.8±0.60	30.8±0.39
Coral Trout	Plectropomus leopardus	0.7 ± 0.02	32.5±0.30	12.0±0.83	0.2±0.00	9.5±0.31	14.0±0.39	0.1±0.10	3.5±0.15	2.2±0.21	34.4±0.78	40.6±1.02
Deep Sea Bream (Blue Warehou)	Seriolella brama	0.7 ± 0.02	28.8±1.18	27.4±5.62	0.2±0.02	3.0±0.42	4.4±0.31	0.1±0.01	10.4±1.17	2.2±0.10	25.8±3.08	38.9±4.25
Deep Sea Cod (Ribaldo)	Mora moro	0.6 ± 0.01	32.0±0.09	10.8±0.38	0.1±0.01	2.8±0.06	3.9±0.18	0.1±0.02	4.6±0.14	1.2±0.02	47.1±0.46	53.1±0.58
Flake (Blue Shark)	Prionace glauca	1.3 ± 0.09	27.1±0.63	22.3±0.10	0.2±0.01	11.4±0.08	14.7±0.26	0.1±0.00	2.3±0.53	2.1±0.06	29.9±0.49	34.5±0.27
Flathead	Platycephalus bassensis	0.7 ± 0.02	36.0±0.26	12.0±0.86	0.1±0.01	4.0±0.04	5.5±0.02	0.1±0.02	3.2±0.05	1.1±0.04	41.5±0.69	46.1±0.64
Garfish	Hyporhamphus melanochir	0.8 ± 0.04	32.0±0.24	12.7±1.74	0.3±0.02	7.0±0.23	15.9±0.47	3.8±0.14	3.8±0.06	3.1±0.03	27.2±0.62	38.8±0.76
Gemfish	Rexen Solandri	6.3 ± 0.34	34.5±0.11	40.1±2.03	0.2±0.01	1.2±0.14	3.8±0.08	0.8±0.07	3.3±0.10	2.0±0.04	14.4±2.01	21.4±1.97
John Dory	Zeus faber	0.6 ± 0.06	34.1±0.22	9.2±0.34	0.1±0.01	4.3±0.07	6.9±0.04	0.1±0.00	2.8±0.04	1.1±0.04	45.1±0.48	49.3±0.45
Ling	Genypterus blacodes	0.5 ± 0.01	29.1±0.05	17.8±0.15	0.2±0.02	5.1±0.05	6.5±0.07	0.1±0.01	4.7±0.03	1.5±0.01	39.9±0.29	46.3±0.25
Ocean Trout	Oncorhynchus mykiss	4.5 ± 0.30	37.2±1.35	37.2±1.35	0.2±0.01	0.9±0.14	10.5±0.30	0.8±0.03	5.2±0.11	2.0±0.03	12.2±1.47	20.7±1.54
Prawn (shrimp)	Metapenaeus SPP	1.2 ± 0.19	32.4±0.20	20.9±1.30	0.2±0.00	0.1±0.02	14.2±0.62	0.3±0.02	13.4±0.61	1.4±0.02	15.4±0.20	30.7±0.61
Rainbow Trout	Oncorhynchus mykiss	1.7 ± 0.05	32.9±0.23	39.0±0.45	0.2±0.00	1.4±0.02	8.5±0.08	0.5±0.01	5.5±0.10	1.3±0.01	17.0±0.39	24.9±0.48
Red Snapper (Bight Red Fish)	Centroberyx gerrardi	0.7 ± 0.05	32.9±0.23	12.5±0.20	0.1±0.01	3.3±0.05	5.3±0.52	0.2±0.01	3.6±0.08	1.7±0.02	43.3±0.83	49.3±1.26
Australian Salmon	Arripis trutta	1.0 ± 0.06	34.0±0.17	9.1±0.19	0.2±0.02	4.8±0.07	7.4±0.15	0.3±0.00	5.7±0.09	4.1±0.01	38.2±0.18	48.6±0.26
Skate	Irolita Waitii	1.0 ± 0.13	38.5±0.21	15.1±0.27	0.3±0.00	13.3±0.09	17.7±0.12	0.1±0.01	3.1±0.05	2.4±0.02	22.0±0.07	27.8±0.05
Snook	Sphyraena novaehollandiae	1.5 ± 0.55	35.4±0.23	12.3±0.41	0.1±0.03	4.6±0.07	6.7±0.26	0.5±0.01	1.3±0.01	1.3±0.01	37.6±0.28	45.0±0.29
Squid	Sepioteuthis australis	1.1 ± 0.07	36.2±0.14	7.6±0.18	0.1±0.01	1.7±0.03	2.3±0.07	0.1±0.01	10.2±0.10	0.5±0.03	42.6±0.17	53.7±0.05
Swordfish	Xiphias gladius	14.4± 0.34	27.0±0.44	50.7±0.73	0.3±0.02	0.9±0.01	3.6±0.02	0.4±0.03	2.0±0.18	3.4±0.01	11.5±0.07	17.7±0.31
Tommy Ruff (Australian Herring)	Arripis georgianus	1.2 ± 0.08	36.0±0.21	17.6±1.14	0.2±0.01	3.5±0.16	6.2±0.10	0.5±0.07	5.2±0.13	1.9±0.05	29.3±0.32	39.4±1.14
Southern Bluefin Tuna	Thunnus maccoyii	0.7 ± 0.01	34.4±0.64	22.6±0.22	0.1±0.03	4.2±0.01	7.2±0.28	0.3±0.02	3.8±0.05	1.7±0.15	29.3±0.32	35.4±0.19
Northern Whiting	Sillago Sihama	1.0 ± 0.07	32.9±0.21	19.6±0.94	0.2±0.01	0.1±0.03	16.9±0.41	0.4±0.01	10.8±0.33	4.3±0.54	13.8±0.39	29.1±0.65

n–6: Omega 6, n–3: Omega 3. † Linoleic acid, ‡ Arachidonic acid, § Alpha linolenic acid, §§Eicospentaenoic acid, §Docosapentaenoic acid, †† Docosahexaenoic acid

Table 2. Amounts of omega 3 fatty acids in fish and amount of fish consumption required to provide 1 g of omega 3 per day

Name of Fish	Amount of Omega 3 FA (mg/100g)	Amount of Omega 3 FA (mg/150g Serve)	Amount of fish consumption required to Provide 1 g Omega 3 FA per day
Ling	222	334	450
Southern Bluefin Tuna	230	345	435
Blue Grenadier	247	370	405
Deep Sea Bream (Blue Warehou)	257	385	389
Coral Trout	270	408	370
Barramundi	276	415	362
Skate	289	433	346
Northern Whiting	302	455	313
John Dory	315	473	317
Boar	319	506	313
Garfish	327	489	306
Flathead	337	505	297
Deep Sea Cod (Ribaldo)	340	510	294
Red Snapper (Bight Redfish)	357	533	280
Prawn (shrimp)	373	562	268
Rainbow Trout	415	627	241
Flake (Blue Shark)	456	684	219
Australian Salmon	476	714	210
Tommy Ruff (Australian Herring)	477	716	210
Squid	584	874	171
Snook	675	1012	148
European Carp	829	1244	121
Ocean Trout	921	1380	108
Gemfish	1360	2033	74
Atlantic Salmon	2252	3380	44
Swordfish	2571	3860	39

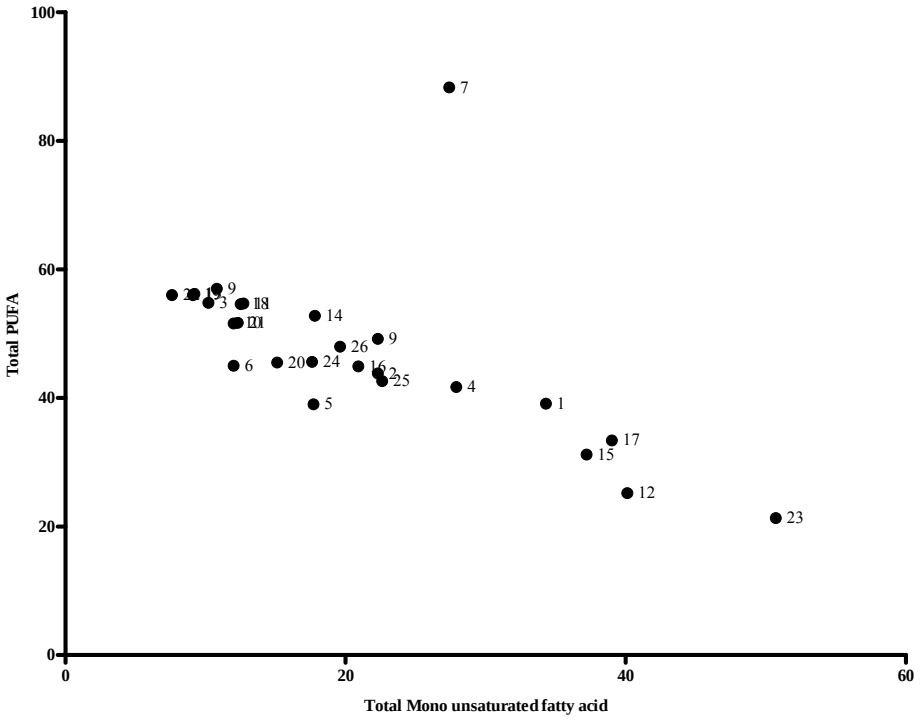

Figure 1. Relationship between monounsaturated fatty acid and PUFA in common Australia fish species (expressed as % total fatty acids)

1.Atlantic Salmon, 2.Barramundi, 3.Boar, 4.Blue Grenadier, 5.European Carp, 6.Coral Trout, 7.Deep Sea Bream (Blue Warehou), 8.Deep sea Cod (Ribaldo), 9.Flake (Blue Shark), 10.Flathead, 11.Garfish, 12.Gemfish, 13.John Dory, 14.Ling, 15.Ocean Trout, 16.Prawn, 17.Rainbow Trout, 18.Red Snapper (Bight Redfish), 19.Australian Salmon, 20.Skate, 21.Snook, 22.Squid, 23.Swordfish, 24.Tommy Ruff (Australian Herring), 25. Southern Bluefin Tuna, 26.Northern Whiting.

fish since many more species sold in Australian markets are now farmed.

Because of the low level of fat in most table fish in Australia quite large servings would be required to achieve an adequate dietary intake of omega 3 LCPUFA. For many fish species the amount required is well over the 150 g recommended serving size for fish. This is important information for consumers who may believe that they are ingesting adequate amounts of omega 3 LCPUFA from a single serve of Tuna, for example, when in fact they would need to consume 3 times this amount to ingest 1 g omega 3 fatty acids per day. There is a need to provide adequate labeling to inform consumers about omega 3 levels in fish.

The omega 6 fat levels have previously been reported in Australian fish as high (9% to 23.1%)[19, 23] and this is confirmed by our current results (range from 2.3% to 20.2%) existing mainly in the form of AA. These results were confirmed by Sinclair et al[22] and Moony et al[28] who reported that arachidonic acid was the major omega 6 fatty acid of many species of Australian fish. The significance of these findings has not been addressed in any detail. Since one of the purposes of consuming fish is to redress the balance of AA to omega 3 LCPUFA in the cells of key tissues such as platelets, neutrophils and vascular/cardiac tissue, there is a need to uncover the clinical benefit (if any) of consuming Australian fish as opposed to oils from fish species that are rich in omega 3 LCPUFA and very low in AA. The opposing function of eicosanoids derived from AA compared with those derived from omega 3 LCPUFA provides a mechanistic rationale for such a study.

CONCLUSION

The fats of Australian fish are rich in omega 3 fatty acids but because many species that are commonly eaten are low in total fat, a large intake of seafood would be required if consumers were attempting to acquire their recommended daily omega 3 LCPUFA intake. Consumers need to be aware, that many fish, although excellent sources of high value protein are actually poor sources of omega 3 fats. For example, standard serves of Ling, a popular white fish or Tuna, will contribute only 340 mg of omega 3 fatty acid. Therefore 9 serves per week would be required to reach RDI to reduce CHD. This may be detrimental to health by increasing the risk of mercury consumption and is also an unrealistic target for fish consumption for the general population. Consumers have a right to know the relative value of the fish they purchase, as not all fish are equally rich in omega 3 fats.

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AUTHOR DISCLOSURES

This paper is an original work that has not been published elsewhere. No ethics approval was required for this research project.

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Short Communication

Levels of Omega 3 fatty acids in Australian seafood

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澳大利亞海鮮中 n–3 脂肪酸的含量

這個研究的目的是要測定南澳大利亞省常食用魚類中 n–3 脂肪酸的含量。在測試的 26 個樣本中，n–3 脂肪酸佔總脂肪的 17.7%到 53.7%，最主要為 DHA (22:6n-3) ，佔總脂肪的 9.5%至 47.1%。n–6 脂肪酸佔總脂肪的 2.3%到 20.2%，主要是花生四烯酸(AA,20:4n-6)。脂肪較多的魚類如 Gemfish、大西洋鮭魚及箭魚是 n–3 脂肪酸的良好來源(每 100 g 魚中分別含 1360、2252 及 2571 mg)。而低脂魚如 Ling、Blue Warhou 及 Blue Grenadier(含脂量為 0.5、0.7 及 0.7%)，則含較少的 n–3 脂肪酸(100 g 魚分別含 222、257 及 247 mg)。因為澳大利亞人常吃的大多數白色魚類中脂肪含量很低，能提供的 n–3 脂肪酸亦有限。每天必需攝取 40 至 450 g 的魚才能得到 1 g 的 n–3 脂肪酸。

關鍵字：n–3 脂肪酸、膳食脂肪、魚、魚油、飲食