Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Watters et al., J Nutr Food Sci 2012, 2:8
DOI: 10.4172/2155-9600.1000159
Research Article
Open Access

A Cost Analysis of EPA and DHA in Fish, Supplements, and Foods

Corilee A. Watters[1]*, Christopher M. Edmonds[2], Lee S. Rosner[3], Karl P. Sloss[3] and PingSun Leung[4]

[1]Assistant Professor, Department of Human Nutrition, Food and Animal Science, University of Hawaii at Manoa, 1955 East-West Road, Agricultural Science 314 J, Honolulu, HI 96822, USA
[2]Senior Economist, Asian Development Bank, Pacific Department, 6 ADB Ave., Mandaluyong City, 1550 Manila, Philippines
[3]Research Assistant, Department of Human Nutrition, Food and Animal Science, University of Hawaii at Manoa, 1955 East-West Road, Agricultural Science 314 J, Honolulu, HI 96822, USA
[4]Professor,Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, 3050 Maile Way, Gilmore 111, Honolulu, HI 96822, USA

Abstract

Long-chain omega-3 polyunsaturated fatty acids (n-3 LC-PUFAs) are important components in healthy diets. Adequate intake of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) maintains proper neurodevelopment and reduces the risk of heart disease. Long-chain omega-3 polyunsaturated fatty acids are found primarily in fish, seafood, eggs, supplements, and fortified foods. The cost of food is a major influence on food choices. This study sought to determine the cost of 500 mg of EPA + DHA (the recommended intake) in seafood, food and supplements in order to identify the most economical sources. Stores from five retail grocery chains in Honolulu, Hawaii were visited in June and July 2010 to collect data on the price of foods and supplements containing significant amounts of EPA or DHA. The analysis used information from a nutrient database comprising fourteen food composition databases detailing the omega-3 content of a wide variety of fish and seafood products. While fish oil supplements provided 500 mg of EPA + DHA at the lowest cost, relatively low-cost sources of EPA and DHA were available in fish with a variety of consumption characteristics, such as salmon and pelagic marine fishes. The most expensive sources of 500 mg of EPA +DHA were demersal marine fishes, milk and soy milk, and seaweeds. Strategies to increase intake of EPA and DHA include educating consumers on health benefits and sources, encouraging the consumption of seafood, improving the fatty acid profile of farmed seafood, and increasing the number of foods with EPA and DHA fortification.

Keywords: Cost; Omega-3 fatty acids; Fish; Seafood

Introduction

The long-chain omega-3 fatty acids EPA and DHA, which are obtained in the human diet primarily from seafood, are important components of health. Intake of DHA is especially important in childhood because DHA is a major component of the brain, eyes, and neural tissues [1]. DHA intake is also associated with increase in gestation length and reduction in the incidence of preterm births [2]. Mozaffarian and Rimm [3] determined that consumption of 250 mg/d of EPA + DHA was associated with a 36% decreased risk of coronary heart disease (CHD) mortality compared to little or no intake. Studies of populations with high fish intake such as Greenland Eskimos [4] and the Japanese [5] suggest that long-term consumption may further reduce the risk of CHD. Intake of EPA and DHA may also inhibit carcinogenesis [6], reduce risk of type-1 diabetes [7], reduce risk of non-alcoholic fatty liver disease [8], and improve clinical outcomes in inflammatory diseases [9]. The Academy of Nutrition and Dietetics (formerly the American Dietetics Association) recommends consuming two 4-oz (113 g) servings of fatty fish each week, providing about 500 mg of EPA + DHA per day [10].

Seafood is not the only dietary source of EPA and DHA. Eggs average 58 mg of DHA per 100 g (3.53 oz) [11]. Hens have the ability to elongate shorter chain omega-3 fatty acids in order to enrich their eggs with DHA; feeding hens a 20% flaxseed diet can increase the DHA content by more than 70% [12]. Seaweeds are another dietary source of n-3 LC-PUFAs. Dawczynski et al. [13] tested the fatty acid composition of 34 varieties of brown and red macroalgae and found high concentrations of EPA, upto 42.4% of total fatty acids in the case of *hijiki* (*Sargassum fusiforme*), although the total fat concentration was low for all varieties. Fortified foods are an increasingly available source of long-chain omega-3s. Much of the DHA supplied for use in fortified food products is provided by algal oil derived from heterotrophically grown microalgae [14]. Advantages of algal-derived DHA include acceptability to vegetarians, improved palatability and smell, increased stability, and reduced risk of contamination [15].

Supplemental EPA and DHA are available as fish oil, cod liver oil, omega-3-6-9 oil (fish oil plus vegetable oils), and algal-oil. One of the rationales for the use of supplements is safety, since consumption of seafood is associated with concerns about methylmercury and organochlorine (PCBs and dioxins) contamination. Consumption of fish and sea mammals, especially those on the top of the food chain, is the only known route of human exposure to methylmercury [16]. PCBs and dioxins are synthetic carcinogenic compounds that also bioaccumulate in animals; human exposure is associated with dietary intake, although not exclusively from seafood [17].

Intake of EPA and DHA in the US in 1999-2000 was about 100 mg/day [18] or about one fifth of recommended intakes [19]. Strategies are needed to increase intake. In addition to the need for consumer education regarding the health benefits of long-chain omega-3s, consumers need information on the price of EPA and DHA found in

***Corresponding author:** Corilee A. Watters,Assistant Professor, Department of Human Nutrition, Food and Animal Science, University of Hawaii at Manoa, 1955 East-West Road, Agricultural Science 314 J, Honolulu, HI 96822, USA, Tel: 808-956-7581; Fax: 808-956-4024; E-mail: cwatters@hawaii.edu.

Received Aug 01, 2012; **Accepted** August 24, 2012; **Published** August 27, 2012

Citation: Watters CA, Edmonds CM, Rosner LS, KP Sloss, Leung PS (2012) A Cost Analysis of EPA and DHA in Fish, Supplements, and Foods. J Nutr Food Sci 2:159. doi:10.4172/2155-9600.1000159

Category	N	Cost/500 mg of EPA + DHA ± SD	Minimum	Minimum Item	Maximum	Maximum Item
Fish /Cod Liver Oil Supplements	11	$0.19 ± 0.10	$0.03	fish oil	$0.20	cod liver oil
Omega 3-6-9 Supplement	2	$0.44 ± 0.08	$0.39	fish, plant oils[a]	$0.50	fish, plant oils[b]
Prenatal DHA Supplement	3	$0.97 ± 0.13	$0.87	prenatal vitamin	$1.11	prenatal vitamin
Salmon	25	$1.17 ± 1.27	$0.23	pink, C[c]	$4.91	Atlantic, D/S
Pelagic Marine Fishes	30	$1.35 ± 1.24	$0.09	sardines, Fo	$4.72	mahimahi, Fo
Other Marine Fishes	9	$2.15 ± 1.48	$0.19	scad, Fe	$3.89	opakapaka, Fo
Eggs (Enriched)	2	$3.15 ± 0.53	$2.77	eggs, 12ct	$3.52	eggs, 12 ct
Eggs (Non-Enriched)	4	$3.64 ± 1.67	$2.11	eggs, xl, 18 ct	$5.74	eggs, 18 ct
Cephalopods	11	$4.43 ± 5.55	$0.49	squid, PF	$17.56	octopus, D/S
Mollusks	44	$4.88 ± 4.58	$0.53	mussels, Fo	$26.39	abalone, C
Crustaceans	33	$5.46 ± 3.69	$1.34	shrimp, Fo	$14.54	shrimp, D/S
Fresh Water Fishes	11	$6.97 ± 5.62	$0.45	trout, Fe	$16.38	catfish, Fe
Milk and Soy Milk	3	$10.40 ± 1.77	$8.38	fortified milk	$11.70	fortified milk
Demersal Marine Fishes	6	$10.68 ± 16.49	$1.80	flatfish, Fo	$44.07	orange roughy, Fo
Seaweeds (dried)	13	$11.40 ± 8.86	$2.25	wakame	$28.72	nori

[a]fish, flax, borage oils
[b]flax, fish, evening primrose, borage oils
[c]C=canned, Fe=fresh, Fo=frozen, PF=previously frozen, D/S=dried/smoked

Table 1: Mean cost of 500 mg of EPA + DHA by category of supplements and foods

commonly available foods. The objective of this study was to determine the cost of 500 mg of EPA + DHA in various seafood, food and supplement sources in order to identify the most economical sources of EPA and DHA in commonly available foods.

Methods

Branches of five large chain supermarkets (Costco, Foodland, Safeway, Times, and Walmart) in the Honolulu metropolitan area were visited in June and July 2010 to record prices of raw, prepared, frozen, and canned seafood, as well as fortified food products and supplements containing EPA and DHA. The method of processing of fish and seafood, the source (country of origin) and whether the item was wild-caught or farm-raised were also recorded. The price survey covered common food products for which EPA and DHA content is available.

When similar products were found at the same store location, we selected the product with the lowest price for evaluation. This treatment is consistent with the study's focus on identifying the most economical sources of EPA and DHA in common foods available in Hawaii. Both the savvy and budget-minded consumer can be expected to choose the lowest-priced product of each type. Supplements and other types of non-seafood products were also assessed in relation to their cost of EPA + DHA. We grouped priced items in categories to organize the analysis. Analysis considered a total of fifteen categories: nine types of fish and seafood (cephalopods, crustaceans, demersal marine fishes, fresh-water fishes, mollusks, other marine fishes, pelagic marine fishes, salmon and seaweed), three types of supplements (fish/cod liver oil, omega-3-6-9 and prenatal DHA supplements), and three non-seafood categories (eggs, omega-3 enriched eggs and fortified milk/soymilk). The means and standard deviations of the cost of EPA + DHA were calculated for each category.

Nutrient data was compiled from product labels, the USDA Nutrient Database Laboratory [11] and the Composite Seafood Database [20], which is comprised of fourteen food composition databases detailing the scientific name, type of processing, EPA and DHA content of a wide variety of fish and seafood species, except for a few sources of long chain omega-3s. For the locally caught wild species, bigeye tuna, albacore tuna, wahoo, swordfish, mahi-mahi, opakapaka, and onaga, data from the Hawaii Seafood Council [21] was used. Fatty acid reference values for frozen and previously frozen shrimp items were based on data from Krzynowek and Panunzio [22]. Farmed and wild tilapia EPA and DHA contents were based on values from Karapanagiotidis et al. [23]. Trout and Atlantic salmon fatty acid data were taken from Blanchet et al. [24]. Fatty acid profiles of dried seaweeds (wakame, hijiki, nori and kombu) used in this study are described by Dawczynski et al. [13].

When specific information on the EPA and DHA content of a frozen fish item was not available, data for the raw form of the fish was used. This treatment is validated by the fact that observations from the USDA Nutrient Database Laboratory show there is not a significant difference in the EPA and DHA content of similar fish in fresh or frozen form [11]. In some cases, it was not possible to distinguish whether a seafood product was farm-raised or wild-caught or to identify the species. In these cases, the most commonly available species/source based on the country of origin and all other available information was used.

Results

Supplements, in particular fish oil supplements, are the most economical source of long-chain omega-3s, with the lowest cost of 500 mg of EPA + DHA (Table 1). Salmon, pelagic marine fishes, and other marine fishes are the three food categories providing 500 mg of EPA + DHA at the lowest cost. Within the salmon and pelagic marine fishes categories, there was a wide range of EPA + DHA costs, with 500 mg costing less than $0.25 for canned pink salmon and frozen sardines, and nearly $5.00 for smoked Atlantic salmon and fresh mahi-mahi. Eggs and omega-3 enriched eggs offer a lower cost of 500 mg EPA +

Product[a]	Category	Cost / 500 mg EPA +DHA
Fish oil supplement	Fish Oil Supplements[b]	$0.03
Sardines, Fo[c]	Pelagic Marine Fishes	$0.16
Scad, Fe	Demersal Marine Fishes	$0.19
Wild pink salmon, C	Salmon	$0.23
Farmed Atlantic salmon, Fe	Salmon	$0.26
Albacore tuna, C	Pelagic Marine Fishes	$0.38
Fish, flax, borage oil supplement	Omega-3-6-9 Supplements	$0.39
Farmed trout, Fe	Fresh-Water Fishes	$0.45
Mullet, Fo	Other Marine Fishes	$0.47
Squid, PF	Cephalopods	$0.49
Wild sockeye salmon, Fo	Salmon	$0.51
Mussels, PF	Molluscs	$0.53
Anchovies, C	Pelagic Marine Fishes	$0.55
Bigeye tuna, Fe	Pelagic Marine Fishes	$0.70

[a] Only the lowest cost data point is listed for each product.
[b] Includes cod liver oil supplements
[c] Fo=frozen, C=canned, Fe=fresh, PF=previously frozen

Table 2: Products with the lowest cost per 500 mg of EPA + DHA.

DHA than any of the remaining fish, seafood and food categories. Due to variability in egg size, number of eggs per carton, and production method (conventional versus free-range and/or organic), EPA + DHA prices overlapped between egg categories, with the lowest cost item in the non-enriched category costing less per 500 mg of EPA + DHA than the highest cost item in the enriched category.

After eggs, the next most economical categories for EPA + DHA were cephalopods, mollusks, and crustaceans (Table 1). Each of these categories offers economical sources of EPA + DHA as well as expensive sources. Items within a given category that were dried or smoked were invariably more expensive sources of EPA + DHA than fresh, frozen or canned items, as would be expected given the additional processing and greater density of the foods after reduction in water content. The cost of EPA + DHA in the two remaining fish categories, fresh-water fishes and demersal marine fishes, was generally high. However, within both categories, there were several inexpensive sources of EPA + DHA. For example, fresh-water trout was one of the least expensive fresh or frozen fish sources of EPA + DHA in our survey, whereas catfish was one of the most expensive.

Among demersal marine fishes, orange roughy was the most expensive fish source of EPA + DHA, and its inclusion raised the average cost of EPA + DHA in the category substantially. Fortified milk/soymilk products were relatively expensive sources of EPA + DHA compared to most of the seafood and fish categories. Two of the three products sampled were fortified with algal oil DHA, while one (the least expensive) was fortified with fish oil. Although seaweeds, as a category, were the most expensive source of omega-3 fatty acids surveyed, dried wakame and hijiki averaged $3.32 and $3.70 per 500 mg of EPA + DHA respectively, or about the same cost as the omega-3s in eggs. However, the standard serving size for dried seaweeds is only 8 g, since it must be reconstituted before being eaten, and more than 10 servings (84 g) of wakame or hijiki would need to be eaten to consume 500 mg of EPA + DHA.

There are numerous individual items from many categories of fish and seafood that were inexpensive sources of 500 mg of EPA + DHA—costing $0.70 or less (Table 2). Besides fish oil and Omega-3-6-9 supplements containing fish oil, all of the items on Table 2 are fish and seafood. Among categories of seafood, only crustaceans lacked a product providing 500 mg of DHA + EPA at $0.70 or less. None of the food products fortified with algal oil (e.g. milk, soymilk, prenatal supplements) made the list of most economical sources of EPA + DHA. This likely reflects the relatively high cost of algal oil as a source of DHA and the fact that these are specialty products for niche markets.

Salmon and pelagic marine fishes were among the least expensive sources of EPA and DHA because both categories of fish contain numerous species with very high EPA and DHA contents. Many species in both groups provide more than 1000 mg of EPA + DHA per 100 g (3.53 oz) serving, with canned mackerel (not shown) and sardines exceeding 2000 mg of EPA + DHA per 100 g (Figure 1). Outside of these two categories only two items surveyed had greater than 1000 mg of EPA + DHA per 100 g - scad (other marine fishes) and trout (fresh-water fish). Non-fish seafood categories (mollusks, crustaceans and cephalopods) had moderate but consistent levels of EPA + DHA, typically in the 200 to 400 mg range per 100 g, although Pacific oysters are a particular good source of long-chain omega-3s, with over 600 mg per 100-g serving. A serving of two eggs (100 g), whether enriched or not, contains insufficient EPA + DHA to achieve recommended levels, but does contribute a significant amount towards a day's recommended intake if combined with another source of EPA and/or DHA. For

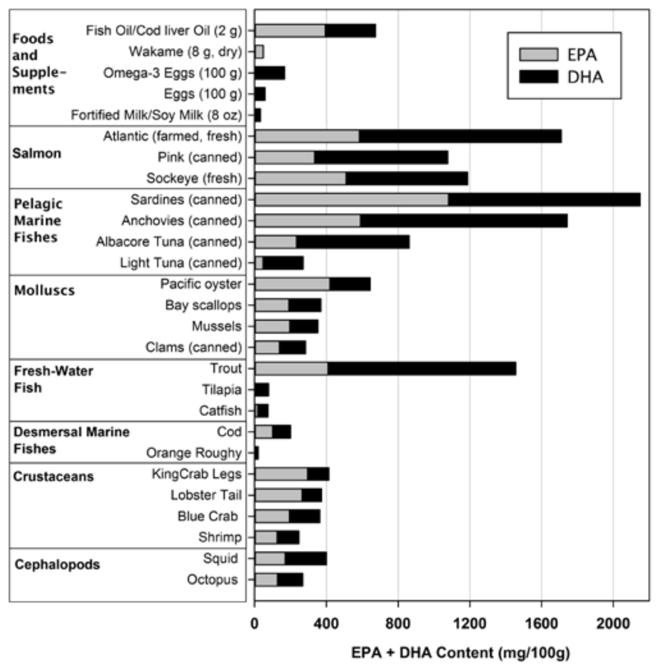

Figure 1: EPA and DHA content in selected foods, supplements and seafood items available in supermarkets in Honolulu, Hawaii. The EPA and DHA content for "Foods and Supplements" is in mg/serving, with the serving size listed for each item. All other items are listed on mg/100g (3.53 oz) basis. EPA and DHA data was compiled from the Composite Seafood Database [20] with the following exceptions: values for frozen and previously frozen shrimp items are based on data from Krzynowek and Panunzio [22]; values for farmed and wild tilapia are based on data from Karapanagiotidis et al. [23]; values for trout and Atlantic salmon are based on data from Blanchet et al. [24]. The processing method is specified only for items where different values were available based on the method of processing.

example, two omega-3 enriched eggs (providing 166 mg EPA + DHA) consumed the same day as a 100 g serving of either squid (400 mg), canned crab (363 mg), lobster (373 mg), or mussels (353 mg) provides more than 500 mg of EPA + DHA, although none of the items do so individually.

Discussion

Our results show that fish oil supplements offer the lowest cost of EPA and DHA, which is unsurprising since they are produced and marketed solely as a source of long-chain omega-3s.Considering consumption of fish, seafood, eggs, and milk from a hedonic perspective, as well as a broader nutritional perspective, these products offer attributes in addition to their EPA and DHA content that lead individuals to consume them. Fish is an excellent source of high-quality protein, minerals including calcium, iron, selenium, and zinc, water-soluble vitamins B3, B6, and B12, as well as fat-soluble vitamins A, E, and D [25,26]. Eggs are an excellent source of high quality protein, are rich in vitamin D, riboflavin, vitamin B12, biotin and iodine, and also contain significant levels of vitamin A, folate, choline, phosphorus, and selenium [27]. Milk (and fortified soy milk) is a good source of protein and also one of the best bio-available sources of calcium [28]. Seaweeds are high in soluble fiber and are excellent sources of calcium, potassium, iron, copper and iodine [29]. Wakame also has been shown to have antihypertensive properties [30] and may have antihyperlipidemic effects, especially in combination with fish oil [31]. Consumption of fish, eggs, milk, and seaweed would have value as part of a healthy diet even if these foods lacked long-chain omega-3s, which needs to be considered in assessing the value-for-money of alternative sources of long-chain omega-3s.

In the case of omega-3-enriched eggs, milk, and soymilk, an important question is whether the added DHA is worth the added cost. Omega-3 enriched eggs contain more than twice the DHA content of non-enriched eggs (Figure 1) but were priced at about twice the cost per egg while providing just 74 mg additional EPA + DHA in a serving of 2 eggs (100 g). Fortified milk and soymilk products provide only 32 mg of DHA per 8-ounce serving, a content that would require a weekly consumption of 456 ounces (over 3.5 gallons) to obtain 500 mg of EPA + DHA per day at a cost of over $11.00 per gallon. However, the added expense of obtaining n-3 LC-PUFAs in these fortified products may be justified for individuals unwilling or unlikely to consume fish, seafood, or supplements on a regular basis.

Concerns associated with fish consumption include the potential for health problems associated with contaminants such as methylmercury, polychlorinated biphenyls (PCB), and organochlorines. Testing of five over-the-counter brands of fish oil supplements revealed negligible (12 µg/L or less) levels of methylmercury [32], and undetectable levels of polychlorinated biphenyls (PCBs) and organochlorines [33]. Cod liver oil supplements were also found to contain levels of PCBs and organochlorines below WHO daily intake limits [34]. These findings may suggest an advantage of obtaining long-chain omega-3s from supplements rather than fish and seafood. However, numerous authors have compared the benefits associated with fish intake against the risks from co-ingested contaminants and have concluded that the benefits outweigh the risks under typical circumstances [3,16,26,35]. Due to concerns about gestational and early childhood mercury exposure, the FDA currently provides fish consumption recommendations for women who may become pregnant, pregnant women, nursing mothers, and young children, with guidelines intended to reduce methyl mercury intake while continuing fish consumption [3,36].

Conclusion

This study has produced detailed information on the relative cost of long-chain omega-3 fatty acids available from common fish, seafoods, supplements, and fortified foods. Results reveal the value-for-money of alternative sources of long-chain omega-3s, and show relatively low-cost sources of EPA and DHA are available in fish with a variety of consumption characteristics. Modifying the diets of farmed fish to improve their fatty acid profiles and incorporating algal oils into foods are two strategies that may improve the affordability and availability of long-chain omega-3s in the long-term. Providing information to consumers on the cost of long-chain omega-3s is one strategy to increase consumption given current market conditions.

Acknowledgements

Thanks to Skylar Fritz and Sheng-Ti Hung, research assistants at University of Hawaii, who participated in collection of price data, and to Dr. Isabelle Sioen, Ghent University, Ghent, Belgium, for sharing the composite seafood database.

References

1. Neuringer M, Anderson GJ, Connor WE (1998) The essentiality of n-3 fatty acids for the development and function of the retina and brain. Ann Rev Nutr 8: 517-541.
2. Jordan RG (2010) Prenatal omega-3 fatty acids: review and recommendations. J Midwifery Womens Health 55: 520-528.
3. Mozaffarian D, Rimm EB (2006) Fish intake, contaminants, and human health: evaluating the risks and the benefits. JAMA 296: 1885-1899.
4. Bang HO, Dyerberg J (1972) Plasma lipids and lipoproteins in Greenlandic west coast Eskimos. Acta Med Scand 192: 85-94.
5. Iso H, Kobayashi M, Ishihara J, Sasaki S, Okada K, et al. (2006) Intake of fish and n3 fatty acids and risk of coronary heart disease among Japanese: the Japan Public Health Center-Based (JPHC) Study Cohort I. Circulation 113: 195-202.
6. Larsson SC, Kumlin M, Ingelman-Sundberg M, Wolk A (2004) Dietary long-chain n-3 fatty acids for the prevention of cancer: a review of potential mechanisms. Am J Clin Nutr 79: 935-945.
7. Stene LC, Joner G (2003) Use of cod liver oil during the first year of life is associated with lower risk of childhood-onset type 1 diabetes: a large population-based, case-control study. Am J Clin Nutr 78: 1128-1134.
8. Oya J, Nakagami T, Sasaki S, Jimba S, Murakami K, et al. (2010) Intake of n-3 polyunsaturated fatty acids and non-alcoholic fatty liver disease: a cross-sectional study in Japanese men and women. Eur J Clin Nutr 64: 1179-1185.
9. Calder PC (2006) n-3 polyunsaturated fatty acids, inflammation, and inflammatory diseases. Am J Clin Nutr 83: 1505S-1519S.
10. Kris-Etherton PM, Innis S (2007) Position of the American Dietetic Association and Dietitians of Canada: dietary fatty acids. J Am Diet Assoc 107: 1599-1611.
11. U.S. Department of Agriculture, Agricultural Research Service. USDA National Nutrient Database for Standard Reference, Release 24. Nutrient Data Laboratory.
12. Ferrier LK, Caston LJ, Leeson S, Squires J, Weaver BJ, et al. (1995) alpha-Linolenic acid- and docosahexaenoic acid-enriched eggs from hens fed flaxseed: influence on blood lipids and platelet phospholipid fatty acids in humans. Am J Clin Nutr 62: 81-86.
13. Dawczynski C, Schubert R, Jahreis G (2007) Amino acids, fatty acids, and dietary fibre in edible seaweed products. Food Chem 103: 891–899.
14. Whelan J, Rust C (2006) Innovative dietary sources of n-3 fatty acids. Annu Rev Nutr 26: 75–103.
15. Spolaore P, Joannis-Cassan C, Duran E, Isambert A (2006) Commercial applications of microalgae. J Biosci Bioeng 101: 87-96.
16. Clarkson, TW, Magos L, Myers GJ (2003) The toxicology of mercury-current exposures and clinical manifestations. N Engl J Med 349: 1731-1737.
17. Schecter A, Cramer P, Boggess K, Stanley J, Päpke O, et al. (2001) Intake

of dioxins and related compounds from food in the US population. J Toxicol Environ Health A 63: 1–18.

18. Ervin RB, Wright JD, Wang CY, Kennedy-Stephenson J (2004) Dietary intake of fats and fatty acids for the United States population: 1999–2000. Adv Data: 1-6.

19. Kris-Etherton PM, Grieger JA, Etherton TD (2009) Dietary reference intakes for DHA and EPA. Prostaglandins Leukot Essent Fatty Acids 81: 99-104.

20. Sioen I, De Henauw S, Verdonck F, Van Thuyne N, Van Camp J (2007) Development of a nutrient database and distributions for use in a probabilistic risk-benefit analysis of human seafood consumption. J Food Compost Anal 20: 662-670.

21. Hawaii Seafood Council (2012). Wild Hawaii Fish.

22. Krzynowek J, Panunzio LJ (1989) Cholesterol and fatty acids in several species of shrimp. J Food Sci 54: 237–239.

23. Karapanagiotidis IT, Bell MV, Little DC, Yakupitiyage A, Rakshit SK (2006) Polyunsaturated Fatty Acid Content of Wild and Farmed Tilapias in Thailand: Effect of Aquaculture Practices and Implications for Human Nutrition. J Agric Food Chem 54: 4304–4310.

24. Blanchet C, Lucas M, Julien P, Morin R, Gingras S, et al. (2005) Fatty Acid Composition of Wild and Farmed Atlantic Salmon (*Salmo salar*) and Rainbow Trout (*Oncorhynchus mykiss*). Lipids 40: 529-531.

25. Murray J, Burt JR (2001) The composition of fish. Torry Advisory Note No. 38.

26. Sidhu KS (2003) Health benefits and potential risks related to consumption of fish or fish oil. Regul Toxicol Pharmacol 38: 336-344.

27. Ruxton C (2010) Recommendations for the use of eggs in the diet. Nurs Stand 24: 47-55.

28. Titchenal CA, Dobbs J (2007) A system to assess the quality of food sources of calcium. J Food Compost Anal 20: 717-724.

29. MacArtain P, Gill CI, Brooks M, Campbell R, Rowland IR (2007) Nutritional Value of Edible Seaweeds. Nutr Rev 65: 535–543.

30. Satoa M, Obaa T, Yamaguchia T, Nakanoa T, Kaharab T, et al. (2002) Antihypertensive Effects of hydrolysates of wakame (*Undaria pinnatifida*) and their angiotensin-I-converting enzyme inhibitory activity. Ann Nutr Metab 46: 259-267.

31. Murata M, Sano Y, Ishihara K, Uchida M (2002) Dietary Fish Oil and *Undaria pinnatifida* (Wakame) Synergistically Decrease Rat Serum and Liver Triacylglycerol. J Nutr 132: 742-747.

32. Foran SE, Flood JG, Lewandrowski KB (2003) Measurement of mercury levels in concentrated over-the-counter fish oil preparations. Is fish oil healthier than fish? Arch Pathol Lab Med 127: 1603-1605.

33. Melanson SF, Lewandrowski EL, Flood JG, Lewandrowski KB (2005) Measurement of organochlorines in commercial over-the-counter fish oil preparations: implications for dietary and therapeutic recommendations for omega-3 fatty acids and a review of the literature. Arch Pathol Lab Med 129: 74–77.

34. Storelli MM, Storelli A, Marcotrigiano GO (2004) Polychlorinated biphenyls, hexachlorobenzene, hexachlorocyclohexane isomers, and pesticide organochlorine residues in cod-liver oil dietary supplements. J Food Prot 67: 1787-1791.

35. Sioen I, De Henauw S, Verbeke W, Verdonck F, Willems JL, et al. (2008) Fish consumption is a safe solution to increase the intake of long-chain n-3 fatty acids. Public Health Nutr 11: 1107-1116.

36. US Food and Drug Administration (2004) What You Need to Know about Mercury in Fish and Shellfish.