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Fish as a health food

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Abstract
Fish is a food of excellent nutritional value, rich in quality animal proteins, polyunsaturated fatty acids especially the (ω)-3 eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and micronutrients. It is generally a good source of the B group of vitamins. Fish also has a non-protein nitrogen fraction that plays a major role in its quality. In addition, fish are more available and affordable than other sources of animal proteins in most countries. Aquaculture, which is one of the fastest growing food production sectors, could play a big role in eradicating malnutrition and nutrient-deprivation globally. Epidemiological evidence suggesting a protective effect of fish intake on cardiovascular diseases dates back to ecological studies from the 1970s. Intermediary physiological benefits of fish intake via EPA and DHA include lowering plasma triglycerides, reducing heart rate and blood pressure, improving myocardial filling and efficiency, decreasing inflammation, and anti-arrhythmic effects. Various prospective observational studies have consistently found that fish intake is associated not only with these intermediary benefits but with major reductions in several cardiovascular disease outcomes, most notably coronary heart disease mortality.

Keywords: fish intake, eicosapentaenoic acid, docosahexaenoic acid, protein, antioxidants

1. Introduction
Overall health is achieved through a combination of physical, mental emotional and social well being; commonly referred to as the *health triangle* (Ayyappan, 2011) [5]. One of the principal determinants of maintaining good physical health is to have nutritionally balanced diet. Fish often referred to as 'rich food for poor people' provides quality proteins, fats, vitamins and minerals. Nutrient profiling of fish show that they are superior in terms of nutritive value and numerous health benefits are associated with routine fish consumption. Nutritionists recommend that fish should be eaten at least 2-3 times a week.

The market for fish has grown significantly world over in recent years largely fuelled by the image of fish as a healthy component of the diet (Kinsella, 1986; Anon., 2001) [26, 4]. Fish and fish products are increasingly promoted as functional foods (Gormley, 2006) [18], and Alasalvar and Taylor (2002) [1] have reviewed applications of marine nutraceuticals to food and health. Many health benefits have, and are, being attributed to fish which include risk reduction/alleviation in relation to a number of diseases/conditions: cardiovascular health and blood pressure; blood clotting; cancer; arthritis; vitamin and mineral deficiencies (Gormley, 2006) [18]. The composition of the eatable portion of fish varies as a function of many factors, such as species, sex, sexual maturity degree, size, place of capture, water temperature, type of feeding and season (Botta and Siquires, 1986; Armstrong *et al*., 1991) [7, 3]

Dietary patterns that typically include good amounts of fish, such as the Mediterranean diet, are generally associated with lower risk of obesity. Studies have generally shown a protective effect of fish intake on risk of cardiovascular disease (CVD), including stroke & have been found to decrease coronary heart disease (CHD) mortality. Nutrients present in fish, including protein, calcium and vitamin D play a critical role in bone health and development. Oil-rich fish is an important source of vitamin D, and fish that are consumed with bones are a good source for dietary calcium. A role for long-chain n-3 PUFAs in bone metabolism has also been suggested. There is some evidence from cohort and cross-sectional studies that fish intake may be associated with better bone health, though not all studies have found such an association.

The beneficial effects of polyunsaturated fatty acids (PUFAs) in fish oils have been widely discussed (Holub, 1988) [22]. The PUFAs' beneficial effects relate to their role in the integrity maintenance of biological membranes, their capability to reduce the amount of serum lipids and their conversion to compounds called eicosanoids, which show direct influence on the vascular physiology and vascular system (Murphy, 1990) [31]. These effects have been more noticeable in populations presenting low fat intake diets, such as Japanese communities of fishermen that show low incidence of heart problems, as well as the Eskimos (Kinsella, 1986) [26].

The ω-3 PUFAs from fish oils may also enhance the removal of VLDL in peripheral tissues and increase the excretion of cholesterol (Harris *et al*., 1983) [20]. They may also reduce the fatty acids synthesis in living cells (Yang and Williams, 1978) [39].

2. Nutrient profile of fish

Fish is an important component of human diet. Fish contains proteins and other nitrogenous compounds, lipids, minerals and vitamins & low level of carbohydrates. Fish protein contain the essential amino acids in the required proportion & thus improve the overall protein quality of a mixed diet. The superior quality of fish lipids has been well documented; they greatly differ from the mammalian lipids as they include up to 40% long chain fatty acids that are highly unsaturated. Fish is generally a good source of Vitamin B complex and minerals like Calcium, Phosphorous, Iron, Copper, Selenium & Zinc. (Ayyappan, 2011) [5]

2.1 Proteins: role in growth & development of the body

Proteins provide both essential and non-essential amino acids, which are building blocks for protein synthesis. The amino acids also act as the precursors of hormones, porphyrins, other bio-molecules & secondary metabolites besides contributing to the daily energy requirement of the body by oxidation of their Carbon skeletons. Proteins are important for growth & development of the body, maintenance & repair of worn out tissues and for production of enzymes & hormones for many body processes. The importance of fish in providing easily digested protein of high biological value is well documented. In comparison to other sources of dietary proteins of animal origin such as chicken, mutton, beef etc., the unit cost of production of fish is much cheaper. A portion of fish provides one third to one half of one's daily protein requirement. (Ayyappan, 2011) [5]

2.2 Polyunsaturated fatty acids (PUFAs): role in cardiovascular health and brain development/cognitive function

2.2.1 Cardiovascular health

PUFAs, notably EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), are among the most researched group of compounds in sea foods with over five thousand scientific publications on their health-promoting effects (Bahri *et al*., 2002) [6]. ω-3 PUFAs have been cited as beneficial in alleviating, preventing, or reducing the incidence/severity of a number of diseases including: cardiovascular disease (Burr *et al*., 1989; Ness *et al*., 2002) [8, 33], high blood pressure (Morris *et al*., 1993) [29]; blood clotting (Murphy *et al*., 1999) [32]; cancer (Wolk *et al*., 2006) [38] and improved cognitive function (Kalmijn *et al*., 2004) [25]. The beneficial effects of ω-3-PUFAs from fish and fish oil on human health is derived from their role in modulating membrane lipid composition and affecting metabolic and signal-transduction pathways (Huang *et al*., 2009) [23].

2.2.2 Brain development/cognitive function

Neurodevelopment relates to the growth and development of the brain and Central Nervous System and includes brain function, emotion, learning ability, memory and long-term cognition. DHA is essential for this development and expectant mothers have an increased need for DHA which they can get from a combination of supplementation (e.g. capsules) and eating oily fish (Nys and Debruyne, 2011). For pre-term infants, DHA supplementation has a beneficial effect early in life on cognitive development at greater than 12 months of age. Evidence suggests a protective effect of ω-3 PUFAs against dementia. A study in the Nehru Science Centre, Mumbai has shown that DHA decreases progression of neurodegenerative disorders in older age.

2.3 Bioactive peptides

Elevated blood pressure is a significant risk factor for cardiovascular diseases. Fish contain anti-hypertensive peptides known as angiotensin I-converting enzyme (ACE) inhibitors (Gormley, 2006) [18]. ACE inhibitory peptides lower blood pressure by limiting the vaso-constrictory effects of Angiotensin II and potentiating the vaso-dilatory effects of bradykinin (De Leo *et al*., 2009) [12]. Matsufuji *et al*. (1994) [28] isolated thirteen ACE inhibitors from sardine mussel and most were competitive inhibitors of ACE with the potential to lower blood pressure.

2.3.1 PEP inhibitors: PEP inhibitors block the action of the enzyme prolyl endopeptidase (PEP). High levels of this enzyme in the blood are associated with neuro-degeneration, disturbance in memory and cognition (Husain & Nemeroff, 1990) [24], and with disorders such as depression, schizophrenia and autism. Altered blood PEP activity is related to psychiatric disorders and Alzheimer's patients have abnormally high levels of PEP activity. The presence of PEP inhibitors is therefore important and they have been isolated from cod, salmon and trout flesh (Sorensen, *et al*., 2004). PEP inhibitors are also found in other foods and plant materials including red wine, green tea and herbal extracts. While PEP inhibitors have not received the level of attention given to EPA/DHA for brain health/function, nevertheless in time they may be proven to be important.

2.3.2 Taurine: The effect of taurine on cardiovascular health has been demonstrated by a number of authors (Hayes *et al*., 1989; Liu and Li, 2000) [21, 27]. Fennessy *et al*. (2003) [14] have shown that taurine modifies endothelial dysfunction in young smokers and restores normal flow-mediated dilation in the brachial artery. The extensive data on the physiological effects of taurine do not match the corresponding data on the taurine content of foods. However, papers have been published on the taurine content of seafoods and other products (Gormley *et al*., 2007; Murata *et al*., 1998) [19, 30]. Selected studies (Gillum *et al*., 1996) [17] have shown that white and fatty fish consumption is beneficial for human health and this could be due, in-part, to their taurine content and to other similar compounds. Zhao *et al*. (1998) [40] reported a range in taurine content from 41 to 851 mg/100 g edible portion in 29 aquatic products.

2.4 Vitamins

Fish is a rich source of vitamins, particularly vitamins A, D and E from fatty species as well as thiamin, riboflavin, & niacin. Vitamin A from fish is more readily available to the body than from plant foods. Fatty fish contain more Vitamin A than lean species. Vitamin A is required for normal vision and bone growth. Vitamin D present in fish liver and fish oils is crucial for bone growth since it helps in the absorption and metabolism of Calcium. It also plays a major role in immune function. Fish being a very good source of B group of Vitamins act as an important part of diet. The B group of vitamins help in conversion of food to energy in the cells of body and play an important role in function of nerve tissue. If eaten fresh, fish also contain little Vitamin C which is

important for proper healing of wounds, normal health of body tissues and aids in the absorption of Iron in the body. (Ayyappan, 2011) [5].

2.5 Minerals

The minerals present in fish include Iron, Calcium, Zinc, Phosphorous, Selenium and Fluorine in general and Iodine in particular in marine fish. These minerals are highly bio-available as they are easily absorbed by the body. Iron is important in the synthesis of haemoglobin in red blood cells which transport oxygen to all parts of the body. Deficiency of Iron is associated with anaemia, impaired brain function and poor learning ability in infants. Calcium is important for strong bones (formation and mineralization) and for normal functioning of muscles and nervous system. It also plays an important role in blood clotting process. Fluorine also has an important role for maintaining strong bones and teeth. Zinc plays an important role in growth and development as well as in the proper functioning of immune system and healthy skin. (Ayyappan, 2011) [5].

2.5.1 Selenium

Selenium is an important trace element for human health and is linked to protection against cancer (Careche *et al*., 2008, Finley, 2003) [10, 15]. The concentration of selenium in fish is not influenced by cooking, or by cooking method (Fox *et al*., 2004) [16]. The Recommended Dietary Amount (RDA) for selenium is 55 μg (EC Directive 90/496/EC). Many soils are deficient in selenium and consumers in these regions are, therefore, likely to be deficient in selenium. This can be overcome to an extent by enriching the soil with selenium-containing compounds, and by growing plants known for their ability to readily absorb selenium such as garlic and feeding these to fish (Schram *et al*., 2008; Cotter *et al*., 2008) [36, 11].

2.6 Antioxidants

Antioxidants in fish have the potential to influence human health positively (Gormley, 2006) [18]. Antioxidants protect the body against oxidation by scavenging biologically toxic reactive oxygen species. Ekanayake *et al*. (2005) [13] screened potential antioxidant compounds in the skin and flesh extracts of the two eel species (*Anguilla japonica and Conger myriaster*) and all extracts of Anguilla japonica showed dose dependent DPPH (2,4-dipicrylhydrazine) free-radical scavenging, and also significant hydroxyl radical-scavenging activities. Noguchi (2003) [34] examined the biological activity in halibut skin and found that an alkaline extract showed inhibition of proliferation of some tumour cells in-vitro. It was concluded that fish skin components have significant biological activity and are valuable for functional foods and drugs.

3. Conclusion

Due to the appearance of several human health disorders, such as obesity, hypertension and heart problems, there has been increasing interest in the study of foods presenting functional components or substances, that is, those that act on the physiological system, not only improving human health but also preventing diseases (Byrne, 1994; Arai, 1996). Fish is an important dietary constituent of different populations across the globe, being a source of components of significant nutritional value, such as high quality proteins, vitamins, minerals and lipids, besides being the largest source of ω-3 series polyunsaturated fatty acids, especially the eicosapentaenoic (EPA) and docosahexaenoic (DHA), which have several benefits for humans. The ω-3 and ω-6 fatty acids found in fish are helpful in the prevention of cardiovascular diseases, as they decrease cholesterol amounts and blood pressure. They are also correlated with the cerebral and visual development. Therefore, a balanced diet, in which fish is consumed at least 2 or 3 times per week, supplies the daily needs of ω-3 polyunsaturated fatty acids, and keeps the integrity of cellular membranes and nervous tissues, as well as, ensures good functionality of the organism as a whole.

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