



## Review Article

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### CONSUMING FISH FOR NUTRITION AND MEDICINE IS BOON OR DOOM: A REVIEW ON SCIENTIFIC PERSPECTIVE

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#### ABSTRACT

Fish are known to be rich source of proteins, minerals and certain vitamins including low saturated fatty acids comprising of omega-3 fatty acid. These dietary sources are considered not only healthy but also nutritious diet for proper growth and development of bones and proper physiological functioning of a healthy body. The fish oil which is consumed worldwide for eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) has its own merits. These advantages are masked by the pollution and ill effects of consuming fish. It has also been reported that accumulation of toxins and other xenobiotic compounds are major concern when discussing the consumption of fish. This is scientific study which highlights both the sides of coin i.e. unbiased projection of benefits verses harmful effects. The health benefits which are discussed elaborately are equi-balanced by deleterious effects leading to the conclusion on this long-debated topic.

**Key words:** Fish, Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA), Mercury, Xenobiotic Compounds

#### INTRODUCTION

##### Fish is inevitable dietary food

Fish is an important dietary part in food all over the world because it is reported medically as one of the richest source of proteins, energy, and high content of vitamins (A, D, E and K). It also provides essential minerals, fatty acids, particularly omega-3 fatty acids required for proper growth and development of body. Eating fish not only play a vital role in maintaining healthy functioning of the body but also benefits bone development<sup>1</sup>, improving rickets (in children) and reduces risks of osteoporosis<sup>2,3</sup> coronary heart diseases and osteomalacia (in elderly people).

Fish is also used in form of medicine as an ancestral home made remedy to cure asthma. Bathini family from Hyderabad in south India have reported that chronic inflammatory disease like asthma, respiratory problems are being cured by swallowing the small live fish (Figure 1) known as 'Fish Prasadam'<sup>4</sup>, which is filled with a yellow colored medical formulation which contains its magical ingredients, which cures the disease beyond doubt.



Figure 1: Swallowing of the live fish with the medicine in fish mouth<sup>4</sup>.

Lovaza<sup>5</sup> which contains 465 milligrams of EP and 375 milligrams of DHA per gram of capsules, was one of the first fish oil supplements, approved by the FDA to lower triglycerides. Daily consumption of fish oil and Naproxen (Naprosyn) has been found to cure Rheumatoid arthritis. Fish oil with combination of Vitamin E or Vitamin B12 is helpful in reducing menstrual pain (dysmenorrhea)<sup>6-9</sup>. Fish oil in combination with calcium and Evening Primrose Oil increases bone density or slows bone loss rate particularly during treatment of osteoporosis in elderly people<sup>2,3</sup>. Few research evidence has been reported that specific fish oil supplement, 6 grams daily (Hi-DHA, NuMega), providing 260 mg DHA/gram and 60 mg EPA/gram, when combined with exercise decreases body fat and reduces blood sugar level in over-weight people. Fish oil taken orally, in combination with evening primrose oil, thyme oil, and vitamin E improves dyslexia and dyspraxia (movement disorders in children)<sup>10</sup>. Fish oil in combination with evening primrose oil has been evaluated to be beneficial in the treatment of chronic mastalgia and breast pain in premenopausal women<sup>11</sup>.

The voluminous literatures are available to support these health benefits, but it is not always true. The health benefits surpass the ill effects of consuming the fish like nervous system and allergies. This paper is an effort to pool all the deleterious effects as well as beneficial effects of consuming fish to help fish eaters to get complete picture of the scenario.

#### Beneficial Effects

Fish contains galaxy of compounds which are extremely useful for humans. Fish is preferred over other animal meet as it has proteins in additions to low saturated fatty acids<sup>12</sup> like omega-3 fatty acids (present mainly in pelagic or oily fishes). Consuming fish helps in bone development<sup>1</sup>, prevents rickets in young children<sup>1</sup> and cures arthritis and psoriasis<sup>13</sup>. It is reported that not all variety of fish supply these health benefits. Preference

should be given to few species of fishes which contains high omega-3 fatty acids (polyunsaturated fats). Few aquatic organisms which are recommended for health benefits are salmon (*Salmo salar*), cat fish (*Siluriformes*), shrimp (*Caridea*), sardines (*Sardina pilchardus*), canned light tuna (*Thunnus*

*alalunga*), Pollock (*Pollachius*), lake trout (*Salvelinus namaycush*), anchovies (*Engraulidae*), blue fish (*Pomatomus saltatrix*), oysters (farmed) (*Ostreidae*), water coho salmon (*Oncorhynchus kisutch*), arrow squid (*Nototodarus sloanii*), gem fish (*Rexea solandri*).

**Table 1: Depicts advantages of eating fish**

S. No.	Fishes & Products	Provides	Scientific names	Beneficial effects
1	Salmon (Salmon oil)	Omega-3 fatty acid, high proteins.	<i>Salmo salar</i>	Reduces formation of clots & heart attacks, helps in brain development, increment in memory, good eyesight. Reduces triglycerides and coronary heart diseases; it's also beneficial for skin and joints health.
2	Halibut (white fish)	High in proteins, minerals, vitamin A, D, E, K	<i>Hippoglossus stenolepis</i>	Proper growth and development of young children, helps in curing rickets.
3	Sardines	Omega-3 fatty acid	<i>Sardina pilchardus</i>	Reduces stroke and heart inflammation.
4	Pollock	Vitamin D, omega-3 fatty acid	<i>Pollachius</i>	Reduces the risk of osteoporosis, arthritis.
5	Haddock	Low saturated fats, omega-3 fatty acid, vitamin D.	<i>Melanogrammus aeglefinus</i>	Reduces risk of heart disease, helps in bone development, rickets improvement in young children.
6	Cat fish	High proteins, omega-3 fatty acid.	<i>Siluriformes</i>	Good eyesight, prevents from certain cancers, reduces risk of Alzheimer's disease and reduces depression.
7	Seer	Omega-3 fatty acid	<i>Cybium</i>	Reduce the risk of heart disease.
8	Tuna -fish oil -Baked -Broiled	Omega-3 fatty acids	<i>Thunnus</i>	Reduces the risk of atrial fibrillation in patients aged 65 or older. Helpful in inflammation problems, maintains blood pressure imbalances, improves improper heart functioning, improves memory and joint health problems.
9	Lake trout	Omega-3 fatty acid, high proteins.	<i>Salvelinus namaycush</i>	Less likely to form clots & reduce heart attacks, brain development, increment in memory, good eyesight.
10	Hoki (NZ whiting) oil	Low in Saturated Fat, also a good source of Calcium, and a very good source of Protein, Magnesium, Phosphorus, Potassium and Selenium.	<i>Macruronos novaezelandiae</i>	Helpful in inflammation problems, maintains blood pressure imbalances, improves improper heart functioning, improves memory and joint health problems.
11	Marine fish (cod liver oil)	Omega 3 and omega 6 nutrients		Efamol Marine (combines fish oil and evening primrose oil), -reduce the symptoms CFS (Chronic fatigue syndrome)
12	Herring	Omega-3 Fatty Acids and herring as a pickle is one of the best sources of natural vitamin D3, also an excellent source of selenium and vitamin B12.	<i>Clupea</i>	Helps people to overcome obesity, helpful in bones or joints health.

And also included that serving fish twice a week is good for health in various aspects such as asthma, brain development or increment in memory, good eyesight, reduce the risks of cancer<sup>14</sup> (includes oral cavity, oesophagus, prostate, ovary, breast, colon), reduces stroke and heart inflammation, lowering blood pressure, lowers the risk of osteoporosis<sup>2,3</sup>, osteomalacia (in elderly people) and developing dementia in elderly people including Alzheimer's disease<sup>15</sup>, diabetes (manage blood sugar levels), lowers depression, curing rheumatoid arthritis<sup>16,17</sup>.

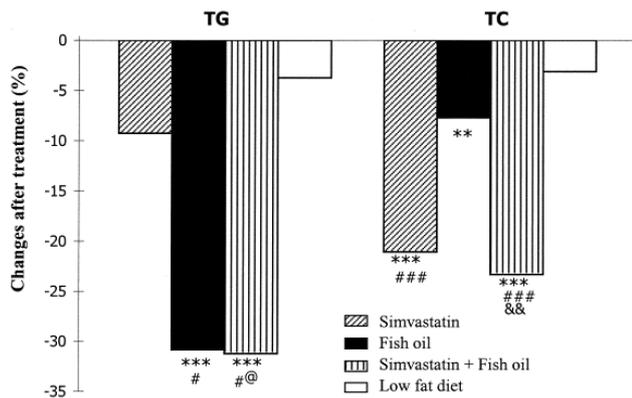
### Fish Oil

Fish oil lowers the blood pressure or triglycerides level, prevents heart diseases and strokes<sup>18</sup>. Its usefulness is also noted in dry eyes, glaucoma, and age related macular degeneration (AMD)<sup>19</sup>. Sometimes women are also suggested to intake fish oil to avert painful periods, breast pain and also difficulties related with pregnancy such as miscarriage, high blood pressure, late pregnancy and early delivery<sup>20</sup>. Fish oil is also useful as an antioxidant stress<sup>21</sup> which helps in preventing weight loss triggered by certain cancer drugs as well as beneficial for diabetes, asthma, developmental coordination disorders,

movement disorders, dyslexia, obesity, kidney disease, weak bones and psoriasis.

In order to foil high blood pressure and kidney injury after heart and liver transplant surgery, fish oil is sometimes recommended as to lessen the rejection risks. It also keeps the blood vessels from clotting and clogging protecting it from closing. The beneficial effect is due to omega -3-fatty acids contained in fish oil are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). This essential fatty acid is an omega-3 fat, which is found in cold water fish. EPA & DHA are highly unsaturated fat because they contain 6 and 5 double bonds on their long structural chain<sup>20</sup>.

These polyunsaturated fats play a very important role with the function of our bodies. Fish oil is adjuvant with many useful compounds like lycopene, Astaxanthin<sup>21</sup> which is useful in aids of eye health and anti-inflammation. It is also reported to suppress the risk of obesity, diabetes, atherosclerosis, hyperlipidemia and hypertension<sup>22</sup>. Fish oil in combination with a drug named Simvastatin may lower the cholesterol level<sup>23</sup> as shown in Graph 1.



**Graph 1: Effect of treatment of high cholesterol related disease with only Simvastatin, only Fish oil, combination of Simvastatin + Fish oil and Low fat diet on triglycerides (TG) and total cholesterol (TC)<sup>23</sup>.**

### Cardiovascular and respiratory disorder

Coronary heart diseases (CHD), suspected fatal myocardial infarction, and sudden death from heart diseases<sup>18</sup>, are reduced by consumption of fish or fish oil<sup>24, 25& 45</sup>. Across different studies, compared with little or no intake, modest consumption (250-500 mg/D of EPA and DHA lowers relative risk by 25% or more. Higher intakes further do not substantially lower CHD mortality, suggesting a threshold effect<sup>24</sup>. Consumption of fish oil containing EPA and DHA as it possesses omega-3 fatty acids (including  $\alpha$ -linolenic acid) in fish oil proved to be beneficial in treating circulatory problems, lung complications and cardiac arrhythmias and hence reduces the risks of cardiac death<sup>26,18</sup>. Moreover fish oil supplementation (containing EPA and DHA) also proves to be worthwhile for sports athletes which eases the severity of exercise-induced bronchoconstriction (EIB)<sup>27</sup>.

**Table 2: Ayurvedic formulation in the mouth of two medically important fish species**

Fish	Cure for
Chinook Salmon	Asthma
Murrel fingerlings	Bronchitis and related respiratory problems

### Neurogenic Development

Fish oil and fish is nature's richest source of DHA. DHA is known to be an essential nutrient that promotes neural health of an inborn babies and pregnant or breast feeding mothers associated with cognitive development<sup>28</sup>, good IQ levels, high skills and sharp memories<sup>29</sup> and reduces the risks of obesity in children. DHA is preferentially incorporated into the rapidly developing brain during gestation<sup>30,31</sup> and first two years of infancy, concentrating in gray matter and retinal membranes. Infants can convert shorter chain N-3 fatty acids to DHA. Effects of maternal<sup>32</sup> DHA consumption or neurodevelopment have been investigated in observational studies on consumption of fish especially cod liver oil. It is estimated that increasing maternal intake of DHA by 100 mg/Day increased in child IQ by 0.13 points. Consumption of cod liver oil from onset of 18 weeks of pregnancy, until 3 months postpartum increased DHA levels in the cord blood by 50% which was reflected in raised mental processing scores. This is consistent with observational studies showing positive associations between maternal DHA levels or fish intake during pregnancy and behavioral attention scores, visual recognition memory and language comprehension in infancy. Thus, while dose responses and specific effects require further investigation, these studies together indicate that

maternal intake of DHA is beneficial for early neurodevelopment<sup>31-34</sup>.

### Anti-inflammatory effect

Effect of an enteric-coated fish oil preparation on relapses in crohn's disease has been extensively studied. Patients with crohn's disease may have phases of retardation, intermittent by relapses. Usefulness of fish oil extracts containing EPA has been reported in treating chronic inflammatory diseases as well as autoimmune diseases<sup>35</sup>. Fish oil eases the occurrence of relapses as it has an anti-inflammatory action, though its unpleasant taste, gastrointestinal side effects, indigestion, gassiness and diarrhoea is often poorly tolerated.

For treating few chronic inflammatory disorders<sup>36</sup>, fish oil has suggestive role. Due to the condensed production of Leukotriene B4 and Thromboxane A2, may play a role as an anti-inflammatory effect are raised up in the inflamed intestinal mucosa of patients thru crohn's disease or inhibition of the synthesis of cytokines such as interleukin-1 beta and tumour necrosis factor<sup>37</sup> and hence can also scavenge free radicals.

Besides inflammation, presence of multifocal gastrointestinal infarction has been recommended as a prompt pathogenic occurrence in crohn's disease, which may direct a key role in the pathogenesis of platelets and probably a powerful platelet-aggregating agent, i.e. Thromboxane A2. The production of Thromboxane A2<sup>13</sup> inhibited thru fish oil capacitance could be significant to the management of Crohn's disease, as treatment with N-3 fatty acids decline responsiveness of platelet in patients with these ailments. Enterocyte hyperplasia may get induced by fish oil, thus aggregating the mucosal surface area in correspondence increment in enteral absorption of nutrients and enhancement of nutrition.

### Traumatic brain injuries

Repetitive Mild Traumatic Brain Injuries (MTBI) may lead to irreversible brain damage due to the secondary effects that follow an MTBI (i.e. oxidative damage). Omega-3-fatty acids, DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid), have been shown to reduce the secondary effects of an MTBI by reducing oxidative damage, it helps to prevent and treat the cumulative effects of an MTBI<sup>38,39</sup>. So if a diet rich in omega-3-fatty acids, would reduce cognitive deficits and neuronal cell death<sup>39</sup>.

### Brain and Retina

DHA is a building block of tissue in the brain and retina of the eye. It helps with forming neural transmitters, such as phosphatidylserine, which is important for brain function. DHA is found in the retina of the eye and taking DHA may be necessary for maintaining healthy levels of DHA for normal eye function. In cardiovascular system-EPA and DHA are converted into hormone like substances called prostaglandins and regulate the cell activity and healthy cardiovascular function. Human brain is 60% fat (a large part of which is DHA) and fatty acids like omega 3 affect brain growth and its neural connectivities. It supports brain development during infancy and helps maintain healthy brains at all stages of life. DHA is the most important omega 3 during early infancy. It supports brain development during the third trimester of pregnancy and the first two years of life when the brain is growing<sup>30</sup>. DHA helps build healthy brain, eye and nerve cells. Babies in all stages of growth require omega 3 DHA to develop healthy, normal vision and brain/nervous system function<sup>33</sup>. Omega -3 DHA is a major

component of brain and nerve tissue and plays a vital role in brain and eye development and function throughout your life. Omega-3 fatty acid, EPA and DHA also helps the cells in our brain communicate at any age by increasing membrane fluidity, which is essential for optimal cell signaling.

### Harmful Effects

The well-established fact of consuming fish as dietary component leads to numerous health benefits is presently ambiguous. Consuming fishes like tuna, shark, king mackerel, sword fish, tile fish, has also resulted in poisoning due to mercury and dioxins, which accumulates from industry and water pollution<sup>40</sup>. These toxins and xenobiotic compounds directly or indirectly produced adverse effects in humans when consumed, as it induces blood clots, heart choking, heart attack, neural disorders in men, pregnant women, unborn babies and children<sup>41</sup>.

Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) abdicate the responsibilities for pregnant women, nursing mothers and young children to limit their intake of fishes and particularly predator fishes like shark, king mackerel etc., as these are exposed to high level of mercury, dioxins<sup>42</sup>, methylmercury, pesticide and other industrial pollutants, which adversely effects development of fetal brain and damage in the nervous system of young children and nursing mothers.

There is a great dilemma in human minds, whether to dine fish or not? Or particularly which species of fish should be restricted and eluded? Because of unsubstantiated claims of health risks due to intake of few species of fish, scientists have concluded based on evidence that almost all the species of fish are effected by mercury but few species of fish, mainly sea or oceanic fishes like king mackerel, shark, shell fish, albacore tuna, sword fish, Japanese puffer fish, tile fish, herring, flat fish, Atlantic mackerel, snapper, cod etc., particularly large, long lived predator fishes are highly effected and contains high level of mercury<sup>41,12</sup>.

The main heavy metal accumulated in the top predatory fish is mercury<sup>44</sup> which is produces by industrial effluents, burning of coal, farming and few manufacturing industries. It enters rivers, streams, lakes or any water bodies then it gets converted to methyl mercury which is readily absorbed and accumulated in the fish bodies by food chain.

Heavy metals like lead, cadmium, zinc, chromium, arsenic, selenium and other xenobiotic compounds like detergents, phthalate, PCB's, Dioxins, DDT, pesticide, synthetic dyes etc. enter the food chain and reach the humans (Figure 2)<sup>45</sup>.



These fishes consumed by man produces adverse effects to the health, mostly elderly people, young children, nursing mothers, pregnant women and unborn babies<sup>43</sup>. The person may experience nervous or neural system problems which includes<sup>37</sup> Multiple Sclerosis (chronic inflammatory disease which leads to plaques and tissue injuries in central nervous system). Hence, indicating that may be exposure of genotoxic pollutants through various mercury mechanisms is responsible for the DNA damage due to single or double strand breakages, leading to variants of adverse health effects entering to food chain and ultimately hampering human health and life<sup>46</sup>.

Methylmercury in fish also<sup>47</sup> hampers foetal brain development, memory loss in children, stress, tremors, headache, and changes in vision or hearing, insomnia, eye irritation. Cardiovascular related problems<sup>48</sup> such as increase in blood pressure or heart rate, breathing problems, blood clot or heart attack, choking etc<sup>49</sup>. Other problems were also noted as weakness, vomiting, nausea, diarrhoea, fever, abdominal pain which are most common symptoms found is allergies (mainly caused by fishes like shell fish, crabs, tuna etc.).

**Table 3: Harmful effects of consuming fish**

S. No.	Fishes	Scientific Names	Harmful effects
1	Japanese puffer fish	<i>Fugu rubripes</i>	Produces neurotoxin which causes fatal nervous system blockage or shuts down the nervous function.
2	Albacore tuna	<i>Thunnus alalunga</i>	Multiple sclerosis, hampers fetal brain development, memory loss, vision loss.
3	Sword fish	<i>Xiphias gladius</i>	Breathing problems, heart choke, tremors, headache.
4	Shark	<i>Selachimorpha</i>	Diarrhoea, vomiting, fever, abdominal pain etc.
5	Atlantic mackerel	<i>Scomber scombrus</i>	Insomnia and other neural effects.

### CONCLUSION

Despite scientific evidence, on beneficial effects of consuming fish, we concluded that harmful or adverse effects are more immense than benefits. The dietary requirement of essential minerals and vitamins can be fulfilled by various alternate sources but poisoning cannot be reversed. Fish medicine, can be consumed as a treatment for few diseases and disorders that too in limited quantities. It is mandatory to have fish from non-

polluted waterbodies, and should be consumed for healthy human growth and development.

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