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Review Paper

Therapeutic Benefits Of Ω-3 Fatty Acids from Fish

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Abstract

Fatty acids play important roles in human nutrition and disease management. Fish are rich in Omega-3 Long Chain Polyunsaturated Fatty Acids (LC-PUFAs). Marine fish are the best source of these fatty acids. They typically include eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The major health maintenance and prevention of diseases recognized in EPA and DHA. These forms of fatty acids have excellent body usability component: Reduces heart attack risks, Reduce stroke risks, Brings down blood pressure, Manages heart rhythms and hence reducing possible heart failures. Further, Omega-3 fatty acids from fish supplements could also be useful in preventing a number of diseases including: Diabetes, Arthritis, Heart disease, Cancer, Depression, Hyperactivity. Factors underlying the popularity of ω-3 fatty acids, their recommended daily indices, clinical trials showing their benefits on cardiovascular health, and prevention of arthritis, inflammation, and allergy, child development, mental alertness, cognitive function and mood have been pointed out in this review Diseases that may be prevented or ameliorated with Omega-3 fatty acids, in descending order of the strength of the available evidence.

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INTRODUCTION

The recent scientific advances have blurred the line of demarcation between food and medicine, as scientists identify bioactive food components that can reduce the risk of chronic disease, improve the quality of life, and promote proper growth and development [1]. A Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases met in Geneva from 28 January to 1 February 2002 has adopted a resolution regarding

the primary and secondary prevention of chronic diseases and the reduction of their impact[2]. Nutritional superiority of aquatic food is well established. Fish offer scope for use as functional food and as sources of nutraceuticals. Fish are very rich and varied (32,100 species) either in marine or freshwater are favorite food and people love to eat. The holistic approach to link medicine and diet has ascertained that the fish, because of the presence of specific biochemical ingredients in addition to their nutritive values, can have a positive impact on an individual's health including his physical well-being and mental state. Fish also contains some health-promoting components beyond the traditional nutrients serve to prevent diseases. Marine fish and fish oil are the best source of these Omega-3 essential fatty acids[3]. Hundreds of clinical trials support the efficacy of fish oil's omega-3 essential fatty acids in preventing, mitigating, and remedying an incredible range of health conditions [4]. Fatty acids are straight chain carboxylic acids. Fatty acids with chain length of 10 carbon atoms or less are referred to as short-chain fatty acids, and they are all saturated. Fatty acids having up to 14 carbon atoms are medium-chain fatty acids and those with more than 14 carbon atoms are long-chain fatty acids, which may be saturated or unsaturated. The position of the first double bond is given by the (n-x) notation, counting the number of carbon atoms from the methyl end, according to the international nomenclature. For example, ω-3 and ω-6 (also referred as n-3 and n-6 fatty acids) denote fatty acids, in which the first double bond starts at 3 and 6 carbons from the methyl end, respectively. The symbol, 18:4 ω-3 identifies a fatty acid, with 18 carbon atoms and four double.

The aim of this communication is to offer a comprehensive review of ω-3 fatty acids from fish as therapeutics and their functional role in healthcare. The fish nutraceuticals and functional ingredients from fatty acids have been highlighted.

FISH AND HUMAN NUTRITION

Fish remain a desired food for nutritional value and taste for the large majority of people in the world, particularly in developing countries. Fish is a fabulous food - lots of variety in taste and texture, versatile and low in saturated fat. It is also low in calories - the perfect healthy diet food. Fish contributes up to 180 kcal per capita per day, but reaches such high levels only in a few countries where there is a lack of alternative protein foods grown locally or where there is a strong preference for fish (examples are Iceland, Japan and some small island states). More typically, fish provides about 20-30 kcal per capita per day. Worldwide, about a billion people rely on fish as their main source of animal proteins. Dependence on fish is usually higher in coastal than in inland areas. About 20% of the world's population derives at least one-fifth of its animal protein intake from fish, and some small island states depend almost exclusively on fish. Fish supply 10% of total protein supply of world. Above 60% population gets 40% animal protein from fish in 3rd world. It has been calculated that fish provide about 55% of all the animal protein consumed in Asia[5]. Major fish species used in the production of fish oil include Anchovies, Capelin, Atlantic cod, Atlantic herring, Atlantic mackerel, Atlantic menhaden, Salmonids, and Sardines. Marine sources containing the highest content of Omega-3 fatty acids are fatty fish (e.g., mackerel, halibut, salmon, bluefish, mullet, sablefish, menhaden, anchovy, herring, lake trout, coho, sardines), which provide 1 g or more of omega fatty acids per 100 g of fish.. The protein calories of fish in average are 8-21 g/100g and proteins of fish have a high biological value. The per capita fin-fish demand was around 13.7 kg in 2010 and expected to go up to 14.3 kg in 2015. By 2030, annual fish consumption is likely to rise to some 150-160 million tones, or between 19-20 kg per person (WHO, 2002). . Fish is a low fat and/or good fat source of protein, essential for the healthy growth and maintenance of muscles and body tissues. Fish is

a good source of Vitamins helping to maintain healthy nerve tissues, strong bones and teeth and a glowing complexion. Medical studies have shown that Omega-3 oils play an important part in aiding the development of our brains. The fish protein powder are also good sources of potassium, phosphorus, magnesium, and amino acids[6, 7]. Fish has obvious nutritional advantages over products such as fruits and vegetables or even other non-vegetarian diets. Increasing fish intake is the most obvious way to increase n-3 Polyunsaturated Fatty Acids (PUFAs).

FATTY ACIDS FOR HEALTHCARE

Lipids are the body's greatest energy reserve essential for life. These are naturally and most widely occurring organic molecules obtained from animals fats and vegetable oils. Chemically, fats and oils are triacylglycerols, that is, triesters of glycerol with three long-chain carboxylic acids. The simplest sorts of lipids are the fatty acids. Thus, hydrolysis of a fat or oil with aqueous sodium hydroxide yields glycerol and three fatty acids. The three fatty acids of a specific molecule are not necessarily the same, and a fat or oil from a given source (e.g. fish) is likely to be a complex mixture of many different triacylglycerol. The Omega 3 is a fatty acid considered essential, which means that the human body is unable to produce it. Must be obtained from food. Fish are rich in Omega-3 Long Chain Polyunsaturated Fatty Acids (LC-PUFAs). Fish do not actually synthesize LC-PUFAs, they obtain them from their diet (micro algae at the bottom of the food web). Recognition of the presence of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in marine fatty fish species in significant amounts and their health benefits promoted isolation of ω-3 PUFA from these resources at commercial scale called "Fish Oil". A European Union has funded research aimed at identifying the scientific basis for improving health through diet, with a focus on understanding how PUFA from fish can be a protective component of diet against metabolic syndromes such as obesity and type 2 diabetes. The major health maintenance and prevention of diseases recognized in EPA and DHA The fatty acids found in fish and fish oils are lacking in plant foods and vegetable oils. During the last few decades, investigations on the nutritional aspects of fatty acids particularly, ω-3 PUFA have opened up great vistas for these compounds in health protection. This was more focused in the 1970s with the recognition of the role of diet in the health of native Greenland Eskimos. It was observed that the longevity and coronary health of Eskimos was related to their diet, which contained an average 450 g fatty fish per day[8]. High fish consumption is believed to contribute to several health benefits to the Japanese, who eat about 80g of fish and shellfish per day, providing approximately 1000–2000 mg/day of ω-3 PUFA. Because of the recognized health benefits, fatty fish species, which contain significant amounts of ω-3 PUFA were considered as functional food[9].

NUTRITIONAL VALUE OF FATTY ACIDS FROM FISH

Fatty acids play important roles in human nutrition. Mammals have two Essential Fatty Acids, which we must obtain from our diet: linoleic acid (LA) and α-linolenic acid (ALA). ALA can be converted to ω-3 fatty acids, EPA, and Omega-3 oils. The active ingredients are essential fatty acids known as Omega-3 fatty acids. They typically include eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). During the last few decades, investigations on the nutritional aspects of marine lipids particularly, ω-3 PUFA have opened up great vistas for these compounds in health protection. Marine fish are commonly classified according to the fat content of their fillets. They are grouped as lean (under 3% fat), medium (3–7% fat), and high fat (over 7% fat. Lean fish such as sole are usually whitish, whereas, fish with higher fat content (e.g., cod, haddock, halibut, and pollock, mackerel, tuna, salmon, sturgeon, mullet, bluefish, anchovy, sardines, herring, trout, and menhaden.) are white to

off-white. The flesh of high fat fish (e.g., herring, sardine, anchovy, and salmon) is usually pigmented (e.g., yellow, pink, and grayfish). In an individual fish, lipid content increases from tail to head, with higher level of fat deposition in the belly flap and dark muscle. Some of the fish species as sources of ω-3 fatty acids include sardine, mackerel, anchovy, cod, Atlantic herring, salmon, bluefin tuna, red snapper, swordfish, and silver hake. They provide about 1 gram of Omega-3 fatty acids in about 3.5 ounces of fish. However, not all fish may be created equal when it comes to Omega-3 content. When the researchers focused on the four most commonly farmed fish, they found high levels of Omega-3 fatty acids in trout and Atlantic salmon but low levels in the increasingly popular tilapia and catfish.

Therapeutic Benefits of ω-3 Fatty acids from fish:

The beneficial effects of ω-3 fatty acids can be classified into two main areas. First, these fatty acids sustain normal healthy life through the reduction of blood pressure and plasma triglycerides and cholesterol, together with increased blood coagulation time. EPA and DHA are important for maintenance of normal blood flow as they lower fibrinogen levels and prevent platelets from sticking to each other. Second they alleviate certain diseases such as blood vessel disorders and inflammatory diseases, and control an overactive immune function resulting in alleviation of autoimmune disease, such as arthritis and some types of dermatitis. Deficiency of these compounds causes several disorders such as restrictive growth, abnormality of skin and hair, damage of reproductive system, and abnormal composition of serum and tissue fatty acids. These benefits have been pointed out by several recent research in the field[10, 11, 12]. The advantages of consumption of PUFA in protecting health and addressing certain–diseases are as follows:

Cellular processes:

Polyunsaturated fatty acids are essential components in higher living organisms that confer fluidity, flexibility, and selective permeability to cellular membranes. DHA is a vital component of the phospholipids of human cellular membranes, especially those in the brain and retina[13].

Lowering of blood pressure:

A decrease of diastolic pressure by 3 mm Hg and systolic pressure by 6 mm Hg by regular consumption of EPA and DHA has been reported in a population-based intervention trial. The study, performed a Meta analysis of 40 studies testing the impact of ω-3 PUFA on blood pressure, which reported an intake of nearly 3 g EPA and DHA per day. The overall change in blood pressure was significant for systolic blood pressure only (a reduction of 1.0–1.5 mm Hg). However, the decline in blood pressure in the range of 3.5–5.5 mmHg in hypertensive patients was significant for both systolic and diastolic reduction. A recent study on 4000 men and women in the age group between 40 and 59 in Japan, China, United Kingdom, has shown that certain foods which are high in ω-3 fatty acids such as salmon oil and also ground flaxseed and walnuts may help to lower blood pressure[14].

Supports cardiovascular system:

The first recognition of the beneficial effect of these fatty acids on cardiovascular disease came from the observations on the longevity of Eskimos, which was later attributed to the high contents of fish-derived EPA and DHA in their diets[11, 16]. More evidences have shown that fish consumption favorably affected CHD mortality, especially non sudden death from myocardial infarction. Consumption of fish at least once per week could reduce the risk of sudden cardiac death in men. In addition, fish intake was associated with a reduced progression of coronary artery atherosclerosis in postmenopausal women with CHD[17, 18]. DHA shown to reduce cholesterol particle size in children[19]. Moreover, the higher fish intakes in the Japanese diet relative to that of the United States have been associated with considerably lower rates of heart attacks, other ischemic heart disease and atherosclerosis despite only moderately

lower blood cholesterol levels in the Japanese[20]. A European study of the effect of dietary Omega-3 fatty acids - such as cod liver oil and fish oil - on coronary atherosclerosis (measured with coronary angiography) in people with cardiovascular disease using a randomized, double-blind, placebo-controlled trial showed improved health from the Omega-3[21].

Dietary Omega-3 fatty acids seem to stabilize the myocardium electrically, resulting in reduced susceptibility to ventricular arrhythmias, thereby reducing the risk of sudden death. The use of Omega-3 fatty acids should be considered as part of a comprehensive secondary prevention strategy post-myocardial infarction. It is increasingly recognized that regular consumption of fish or dietary supplementation of fish oils rich in long-chain Omega-3 polyunsaturated fatty acids (n-3 PUFAs) lowers the risk of coronary heart disease (CHD) and protects against sudden cardiac death.

Prevents various cancers:

The Omega-3 fatty acids in fish may reduce the risk of many types of cancers by 30 to 50 per cent, especially of the oral cavity, oesophagus, colon, breast, ovary and prostate. Several studies have shown the effects of ω-3 PUFA against cancer. Scientists at the Paterson Institute for Cancer Research, Manchester, United Kingdom, found that the fatty acids found in salmon, mackerel, and fresh tuna can help prevent the spread of prostrate cancer to other parts of the body, which was attributed to ω-3 fatty acids [22]. In addition, EPA and DHA have also been reported to act positively against cancer effects such as cachexia (abnormal weight loss) or survival rate in end-stage cancer. In a population-based study involving 61,433 women without previous diagnosis of cancer, scientists from the Karolinska Institute, Sweden, found that consumption of fish with high content of ω-3 fatty acids reduced the risk of renal cell carcinoma (RCC), a common form of kidney cancer, in women by 74%, compared to those who did not take fatty fish. During a mean of 15.3 years of follow-up between 1987 and 2004, incidence of 150 RCC cases were diagnosed, which showed an inverse association of fatty fish consumption with the risk of RCC. It showed that women who consumed one or more servings of fatty fish per week had a decreased risk of RCC by 44% compared with women who did not consume any fish. Women who reported consistent long-term consumption of fatty fish at baseline had a 74% lower risk 10 years later [23]. Judicious selection of dietary fat has been suggested to prevent colon cancer[24].

Improves brain functions in children:

Recent research has shown that DHA display a variety of beneficial effects in fetal development. The content of DHA in human brain increases almost four times during the first 3 months of pregnancy as well as post-natal life EFAs, especially, AA and DHA, play an important role in maternal health and neonatal development. Several studies have clearly indicated significantly higher levels of intellectual capabilities (in terms of IQ) in children who have received DHA during their initial years. Children deficient in DHA may exhibit behavioral problems. A relationship between hostility and consumption of whole fish, ω-3 and ω-6 fatty acids has been indicated by a recent study. Using a sample of ~3600 adolescents, it was found that consuming DHA and whole fish were independently related to lower hostility rate compared to those who had not consumed DHA or fish. However, it may not be valid to equate whole fish consumption with fish oil consumption since fish generally are a much better source of DHA. While fish has a DHA: EPA ratio of 3.0:4.1, the contents of DHA is lower in fish oil, with a DHA: EPA ratio of 1:2. Eating fish twice or thrice a week could provide the required DHA. Supplementation of mother's diet with sardines and other fish oils at a level of 2.6 g ω-3 fatty acids per day resulted in an increase in DHA in maternal red blood cells from 4.6 to 7.2%, with a corresponding increase in maternal plasma. This subsequently enhanced DHA level in infant red blood cells[25].

Pregnancy and infancy (Prematurity):

Western diets are often deficient in ω-3 PUFA, and premature infants lack the important transfer of ω-3 PUFA from the mother to the infant, which normally occurs in the third trimester of pregnancy. Eating fish during pregnancy may help to reduce the risk of delivering a premature baby. Recent research has shown that DHA display a variety of beneficial effects in fetal development. During pregnancy, EFAs, especially AA and DHA, play an important role in maternal health and neonatal development. During pregnancy, and 2 years of postnatal life, the infant gets DHA and also EPA through mother, since the infant is unable to synthesize these EFAs[26].

Brain function and eye-sight:

Fish may have earned its reputation as "brain food" because some people eat fish to help with depression, psychosis, attention deficit-hyperactivity disorder (ADHD), Alzheimer's disease, and other thinking disorders. Fish rich in Omega-3 fatty acids can contribute to the health of brain tissue and the retina (the light sensitive tissue lining the inner surface of the eye). Breastfed babies of mothers who eat fish have better eyesight, perhaps due to the Omega 3 fatty acids transmitted in breast milk. Consumption of ω-3 PUFA could also offer protection against blindness resulting from abnormal blood vessel growth in the eye, according to a study on the influence of ω-3 and ω-6 PUFAs on vascular loss, vascular regrowth after injury, and hypoxia-induced pathological neovascularization in a mouse model that had acquired oxygen-induced retinopathy. It was shown that increasing ω-3 PUFA tissue levels by dietary or genetic means decreased the vascular area of the retina by increasing vessel re-growth after injury, thereby reducing the hypoxic stimulus for neovascularization[27]. Supplementing ω-3 PUFA intake may be of benefit in preventing retinopathy.

Mental benefits:

Elderly people who eat fish at least once a week may have a lower risk of developing dementia, including Alzheimer's disease. Fish-derived PUFA, particularly DHA are beneficial against mental disorders such as schizophrenia, ADHD, Alzheimer's disease, and dementia. Consumption of fish prevented such neurological disorders[28]. People who regularly eat fish have a lower incidence of depression (depression is linked to low levels of Omega-3 fatty acids in the brain[29]. Previous studies have suggested that the balance of Omega-3 fatty acids in the brain may be skewed in people with depression, and earlier studies have shown that cod liver oil and fish oil supplements can help alleviate the symptoms of depression and schizophrenia. Research has found that people who suffer from depression who received a daily dose of 1 gram of an Omega-3 fatty acid such as cod liver oil for 12 weeks experienced a decrease in their symptoms, such as anxiety, sadness and sleeping problems[30].

Behavioral pattern:

PUFAs appear to be a major determinant of membrane fluidity in brain cells, and this could play a major role in the maintenance of normal cognition and mood, as shown in a study involving 24 patients with a history of substance abuse, some of who exhibited aggressive behavior. The adult male subjects were randomly assigned into two groups, one receiving 3 g of ω-3 fatty acids (2250 mg EPA, 500 mg DHA, and 250 mg others) in the form of purified fish oil in capsules, whereas the other received a placebo. In order to assess changes in anger level, a modified version of profiles of mood states (POMS) questionnaire was administered at baseline and every month thereafter for a period of 3 months. Thirteen patients who received the fish oil showed a clinically significant and progressive decrease in their POMS anger subscale scores, whereas in the other patients no change was observed. The study revealed that low levels of ω-3 EFAs, particularly EPA and DHA, played a significant role in the path physiology of anger as well as depressive, suicidal, and aggressive behavior [31]. According to a study conducted at Scotland, two-thirds of children are likely to have fatty acid

deficiency, which may be responsible for some of the behavioral patterns and symptoms of autism. Supplementation of diet of this den with fish oil can result in improvement in their behavior.

Anti-inflammatory effects:

Regular fish consumption may relieve the symptoms of rheumatoid arthritis, psoriasis and autoimmune disease. Omega-3 essential fatty acids may be at least as effective as pharmacological anti-inflammatory, and they are much safer. These fatty acids also have potent anti-inflammatory effects, and may also be antithrombotic and anti-atherogenic.

Besides the various benefits accrued from consumption of ω-3 fatty acids, as discussed above, other functions include anti-inflammatory and immune-modulating properties. Consumption of high dose of ω-3 supplements daily has been reported to decrease the severity of symptoms associated with enclosing spondylitis (ASA), a chronic disease that mostly affects joints of the spine and hips[32]. It reduces overweight, and in patients with inflammatory diseases such as rheumatoid arthritis and inflammatory bowel disorders, supplementation result in significant relief, due to improved joint tenderness and grip strength.

Obesity control:

Obesity is a risk factor for many diseases, including heart disease, high blood pressure, diabetes, and some cancers [33]. Experimental evidence supports the role of ω-6 fatty acids as being potent promoters of both adipogenesis *in vitro* and adipose tissue development *in vivo* during the gestation/lactation period [34]. It was proposed that unnoticed changes in fatty acid composition of ingested fats over the last decades have been important determinants containing ω-3 fatty acids, combined with moderate exercise such as walking can in weight loss[35].

Reduce symptoms in asthma patients:

Fish containing more than 2% fat has been found to have a reduced risk of airway hyper responsiveness. Supplementation of diet with ω-3 fatty acids confirmed their benefit in the reduction of breathing difficulties and other symptoms in asthma patients. More recently, it has been demonstrated that PUFA are also beneficial in the treatment of other lung diseases such as cystic fibrosis and emphysema[36, 37]. ω-3 fatty acid supplements shown to protect against exercise-induced bronchoconstriction (EIB) in asthma sufferers[38]. Children who regularly eat fresh, oily fish have a four times lower risk of developing asthma than children who rarely eat fish.

Beneficial for diabetic patients:

Epidemiologic studies have reported a lower prevalence of impaired glucose tolerance and type 2 diabetes in populations consuming large amounts of ω-3 PUFA. Evidence also suggests that increased consumption of ω-3 PUFAs with reduced intake of saturated fat may reduce the risk of conversion from impaired glucose tolerance to type 2 diabetes in obese persons[39]. Expected health benefits and public health implications of consuming 1–2 g ω-3 PUFA per day as part of lifestyle modification in insulin resistance and type 2 diabetes have been reported. Controlled clinical studies have shown that consumption of PUFAs has cardio protective effects in persons with type 2 diabetes without adverse effects on glucose control and insulin activity [40]. Fish may help people with diabetes to manage their blood sugar levels.

Provides bone health:

The beneficial effects on bone health in 23 subjects, who consumed one of three specific PUFA-rich diets for 6 weeks, reported by determine line phosphates (BSAP) as markers. The diets were (i) average American diet, consisting of 34% total fat, 13% saturated fatty acids, 13% monounsaturated fatty acids, 9% PUFA (7.7% LA, 0.8% ALA); (ii) LA diet (37% total fat, 9% saturated fatty acid, 12% monounsaturated fatty acid, and 16% PUFA [12.6% LA, 3.6% ALA]), and (iii) ALA diet containing 38% total fat, 8% saturated fatty acids, 12% monounsaturated fatty acid, 17% PUFA (10.5% LA, 6.5% ALA). Walnuts and flaxseed oil were the predominant sources of ALA. Nix levels were

significantly lower in subjects who consumed the ALA diet (13.20 + 1.21 nM), in comparison to those who received average American diet (15.59 + 1.21 nM). There was no change in levels of BSAP across the three diets. Concentrations of NTx were positively correlated with the pro-inflammatory cytokine TNF-α. The results indicated that dietary ω-3 PUFA could have a protective effect on bone metabolism through a decrease in bone resorption in the presence of consistent levels of bone formation[41, 42]. The study employed walnuts and flaxseed, whereas the potential exists for extrapolation of the study to consumption of fatty fish.

Other benefits:

The protective effect of ω-3 PUFAs and their bioactive metabolites was mediated, in part, through suppression of tumor necrosis factor-α. Increasing the sources of ω-3 PUFA or their bioactive products reduced pathological angiogenesis. A diet rich in fish oils may slow the progression of metabolic syndrome. It was shown that increasing ω-3 PUFA tissue levels by dietary or genetic means decreased the vascular area of the retina by increasing vessel regrowth after injury, thereby reducing the hypoxic stimulus for neovascularization[43, 44]. Supplementing ω-3 PUFA intake may be of benefit in preventing retinopathy[45].

DISCUSSION

Diet has been known for many years to play a key role as a risk factor for chronic diseases. The need for action to strengthen control and prevention measures to counter the spread of the chronic disease epidemic is now widely recognized by many countries, but the developing countries are lagging behind in implementing such measures. Because of the changes in dietary and lifestyle patterns, chronic NCDs including obesity, diabetes mellitus, cardiovascular disease (CVD), hypertension and stroke, and some types of cancer are becoming increasingly significant causes of disability and premature death in both developing and newly developed countries, placing additional burdens on already overtaxed national health budgets. In recognition of health benefits, fatty fish species, which contain significant amounts of ω-3 PUFA are considered as functional food so, consumption of fatty fish has risen by 10% since 2004. Importantly, people who have used Omega-3 supplements have shown positive results especially in the development of various body tissues as well as the general management of health. In view of the several therapeutic benefits as discussed marketing campaigns have been launched for many fish products, which tend to affirm that consumption of fish or supplements containing ω-3 PUFA is an appropriate method to satisfy consumer's need for a variety of nutritive foods. A dietary approach to increasing Omega-3 fatty acid intake is preferable. A good way to do this is to choose fish. The strongest evidence for the health benefits of fatty acids from fish is in the area of heart disease and its risk factors. Eating fish every week reduces the risk of heart disease and stroke by reducing blood clots and inflammation, improving blood vessel elasticity, lowering blood pressure, lowering blood fats and boosting 'good' cholesterol. Still, for patients with coronary artery disease, the dose of Omega-3 (≈1 g/d) may be greater than what can readily be achieved through diet alone. Clinical benefit is strongest for lowering the risk of coronary artery disease (CAD), decreasing serum triglycerides, and improving symptoms of rheumatoid arthritis. Ample evidence exists online and offline that support Omega-3 fish oil to be used for heart and diabetic patients. Omega-3 fatty acids found in fish and fish oils have been found to reduce cardiovascular morbidity and mortality.

The availability of natural fish has beneficially ensured that these supplements are not only within reach but are also easy to access and process for use. Aquacultured fish generally are not good sources of ω-3 fatty acids. However, it is possible to rear fish such as salmon to have significant levels of ω-3 PUFAs by selective feeding techniques. Natural fish

stocks are in major decline and suffer from pollution. Some species of fish may contain significant levels of methyl mercury, polychlorinated biphenyls (PCBs), dioxins, and other environmental contaminants. These substances are present at low levels in fresh waters and oceans, and they bioconcentrate in the aquatic food chain such that levels are generally highest in older, larger, predatory fish. Swordfish, shark, and tilefish (golden bass or golden snapper), for instance, are high in omega-3 fatty acids but may also contain high levels of mercury[44]. King mackerel, a lesser source of omega-3s, may also have high mercury levels. Unfortunately, there is no way for a consumer to know what might be present in any particular fish, although some fish are inclined to have higher levels of contamination than others.

One example of a significant area of Omega-3 research underway is in the development of non-fish sources that offer the same active fatty acids as fish oil, EPA and DHA. Recently there have been products introduced to the market derived from Omega-3 sources such as squid (calamari), as well as vegetarian options such as algae and Echium. These innovative Omega-3 sources offer the same benefits as fish oil.

CONCLUSION

Natural marine fish are excellent sources of Omega-3 fatty acids that are extremely beneficial for our health. The recent decline in certain fisheries together with preference of some sections of the populations to the foods of vegetable origin initiated search on alternate sources of these fatty acids, such as transgenic plants and micro-algae. The algae and Echium sources offer vegetarians a product that can significantly increase blood levels of EPA and DHA, something that is not possible with traditional flax seed oil. It is said that the food processors are locked in a “fish oil arms race”; many entrepreneurs are interested in development of genetically modified crops that could challenge the supremacy of fish as the best source of ω-3 fatty acids[45, 46]. Nevertheless, the supremacy of marine fish as sources of PUFA is difficult to challenge at least in the near future. However, some clinical data have produced conflicting results and areas of potential use include schizophrenia, respiratory diseases, and promotion of postnatal growth, development, memory and even mood require further more research.

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