



Chemical characteristics and nutritional potentials of unsaturated fatty acids

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ABSTRACT

The oil has wide range of therapeutic and culinary applications. Saturated (SFAs), unsaturated (USFAs) like monounsaturated (MUFAs) and polyunsaturated fatty acids (PUFAs). It also contains the ω -3 fatty acid i.e. linolenic acid (ALA), ω -6 i.e. linoleic acid (LA) and ω -9 i.e., oleic acid (OA). These PUFAs are most beneficial to human health and in prevention and control of various diseases. The seeds oil contains SFAs, USFAs (MUFAs and PUFAs). Unsaturated oil has most beneficial to human health and in prevention and control of various diseases such as cancer, inflammation, rheumatoid arthritis, cardiovascular disorders, coronary heart disease (CHD), specifically for its ability to reduce blood pressure and low-density lipoprotein (LDL) cholesterol and other health benefits.

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Capsule Summary: The chemical characteristics of different types of fatty acids and their nutritional potentials and health benefits in cancer, inflammation, rheumatoid arthritis, cardiovascular disorders, CHD, blood pressure and LDL cholesterol and other health benefits are reviewed.

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INTRODUCTION

The vegetable fixed oils are mostly light yellow clear and transparent liquid and animal fats are semi solid light yellow color and slight soluble in ethanol. Major fatty acids (FAs) of the oil are unsaturated fatty acids [(UFAs) both monounsaturated and polyunsaturated FAs (MUSFAs & PUSFAs) that contained mainly linolenic acid (LA), oleic acid (OA), linoleic acid and also contains saturated fatty acids (SFAs). Seed oil is transparent without foreign flavour and is slightly soluble in ethanol. Seed oil is used as cooking oil. It is dry oil used as in paint, varnish and ink manufacturing. The seed cakes are used as animals and birds feed. Seeds contain various % of oil. Oil is used as cooking oil. It is also used in paint, varnish and ink manufacturing. UFAs revealed linked to a reduced incidence of degenerative diseases, particularly coronary heart disease (CHD), cancers, inflammation, arthritis, asthma etc. However, UFAs in the as the

diet is associated with a low incidence of cancer and CHD, despite the high fat intake, it has been suggested the type of fat is more important than the total amount consumed. Although the composition of UFAs is complex, the major groups of compounds thought to contribute to its observed health benefits include MUFAs and PUFAs (Asif, 2011; Asif, 2015a-g, Ashraf et al., 2015; Mensah et al., 205; Erasmus, 1986; Food and Nutrition Board, Institute of Medicine of the National Academies 2005).

Cooking with edible oil

In the various edible oil (animal or vegetable fats) are consumed in foods and some vegetable oil are used cold as a dressing for salads and pasta and frying. Therefore, cold FAs used in diet, it is important to determine the stability of the identified active components when subjected to heat. The major process contributing to the instability of oil when stored or heated is fat

oxidation (Stoll, 2001). Sufficient exposure and degradation can lead to significant changes in the composition of oil, and these changes affect its biological properties (Visioli et al., 2002). Cooking with oil produces a number of degradation products, with lipid peroxidation occurring to a limited extent. The heating method also affects degradation. Lipid peroxidation products have been linked to cancer and cardiovascular disease. Compared with other oils used for cooking, oil has MUFAs and PUFAs. This means fewer targets for reactive oxygen species (ROS), making MUFAs more stable than PUFAs and less likely to undergo peroxidation. In addition, vegetable oil contains many antioxidants that reduce lipid peroxidation. Although antioxidants protect oils from thermal degradation, frying reduces the oil's antioxidative capacity, a particularly important fact when the same oil is used repeatedly. Deep fat frying has both advantages and disadvantages related to oil degradation (Asif and Kumar, 2010; Asif, 2010). The low oxygen exposure of the oil and a short cooking time reduce the potential for lipid peroxidation. However, because the oil is more likely to be re-used, accumulation of polymeric compounds occurs as the antioxidant capacity is being reduced. Compared to other oils, olive oil has a relatively long deep-fat frying "shelf-life" and is comparatively more stable than other oils for repeated frying. Because exchange between lipids in the food and the oil occurs during cooking, the type of food fried also plays a role. For example, frying fish increases the oil's instability because the oil becomes enriched with PUFAs, which are more susceptible to oxidative degradation than MUFAs. Although frying foods with high protein content such as meat, fish, and eggs can potentially produce carcinogenic heterocyclic amines (HCAs), the antioxidants present in vegetable oil (such as olive oil) limit the formation of HCAs (Green et al., 2007; Alonso et al., 2006; Bastida and Sanchez-Muniz, 2001).

History

Although ω -3 FAs have been known as essential to normal growth and health since the 1930s, currently awareness of their health benefits has dramatically increased. New versions of ethyl esterized ω -3 FAs, such as EPA and combinations of EPA and DHA, have drawn attention as more effective products than the traditional ones. The health benefits of the long-chain ω -3 FAs DHA and EPA are the best known. The Greenland people consumed large amounts of fat from seafood (high level of ω -3 FAs), but displayed virtually no cardiovascular disease. The high level of ω -3 FAs consumed by the Eskimos reduced triglycerides, heart rate, BP, and atherosclerosis. The health claim status showed that consumption of EPA and DHA n -3 FAs may reduce the risk of coronary heart disease (Simopoulos et al., 2000; Simopoulos, 2003). The importance of DHA ω -3 FAs and permits the biological role claim for DHA, an ω -3 FA, supports the normal development of the brain, eyes and nerves (Azcona et al., 2008).

Biological significance

The biological effects of the n -3 FAs are largely mediated by their interactions with the n -6 FAs. The 'essential' fatty acids

(EFAs) are essential to normal growth in young children and animals. A small amount of n -3 FAs in the diet (~1% of total calories) enabled normal growth, and increasing the amount had little to no additional effect on growth. Likewise, n -6 FAs (such as γ -LA and AA) play a similar role in normal growth. However, they also found that n -6 FAs was "better" at supporting dermal integrity, renal function, and parturition. The n -6 AA was converted by the body into pro-inflammatory agents called prostaglandins (PGs). The eicosanoids: TXs, prostacyclins and the LTs. The eicosanoids, which have important biological functions, typically have a short active lifetime in the body, starting with synthesis from FAs and ending with metabolism by enzymes. However, if the rate of synthesis exceeds the rate of metabolism, the excess eicosanoids may have deleterious effects. The n -3 is also converted into eicosanoids, but at a much slower rate. Eicosanoids made from n -3 fats are often referred to as anti-inflammatory, but in fact they are just less pro-inflammatory than those made from n -6 fats. If both n -3 and n -6 are present, they will "compete" to be transformed, so the ratio of n -3: n -6 directly affects the type of eicosanoids that are produced. This competition was recognized as important when it was found that TX is a factor in the clumping of platelets, which leads to thrombosis. The LTs were similarly found to be important in immune/inflammatory-system response, and therefore relevant to arthritis, lupus, and asthma. These discoveries led to greater interest in finding ways to control the synthesis of n -6 eicosanoids. The simplest way would be by consuming more n -3 and fewer n -6 FAs. The ω -3 FA EPA forms in the body potent antiinflammatory nanomolecules, called resolvins. Later his team found that omega-3s also turn into other antiinflammatory molecules called maresins and ω -3-oxylipins, which partly explain the versatile health effects of fish oil (Beckermann et al., 1990; Darlington and Stone, 2001; Fortin et al., 1995; James et al., 2000; Jantti et al., 1989; Lee et al., 1994; Patrick and Uzick, 2001; Scher and Pillinger, 2005; Soeken et al., 2003).

Botanical sources

Flax seeds produce linseed oil, which has a very high n -3 content. Six times richer than most fish oils in n -3 flax (or linseed) (*Linum usitatissimum*) and its oil are most widely available botanical source of n -3. Flaxseed oil consists of approximately 55% ALA (alpha-linolenic acid). Flax, like chia, contains approximately three times as much n -3 as n -6. 15 grams of flaxseed oil provides ca. 8 grams of ALA, which is converted in the body to EPA and then DHA at an efficiency of 5–10% and 2–5%, respectively (Asif, 2011; Bousquet et al., 2008).

Fish

The most widely available source of EPA and DHA is cold water oily fish such as salmon, herring, mackerel, anchovies and sardines. Oils from these fish have a profile of around seven times as much n -3 as n -6. Other oily fish such as tuna also contain n -3 in somewhat lesser amounts. Consumers of oily fish should be aware of the potential presence of heavy metals and fat-soluble pollutants like PCBs and dioxin which may

accumulate up the food chain. The benefits of fish intake generally far outweigh the potential risks. As fish oil supplements are bought for their healthful ω -3 FAs content, it is therefore vital that manufacturers and suppliers of these products ensure that they do not contain high levels of dioxins and other toxics. Even some forms of fish oil may not be optimally digestible. The compare bioavailability of the triglyceride form of fish oil vs. the ester form, two have concluded that the natural triglyceride form is better, and the other two studies did not find a significant difference. Although fish is a dietary source of n -3 FAs, fish do not synthesize them; they obtain them from the algae or plankton in their diet or from any other source (William, 1992; William 2003).

Meat

The n -6 to n -3 ratio of grass-fed beef is about 2:1, making it a more useful source of n -3 than grain-fed beef, which usually has a ratio of 4:1. In most countries, commercially available lamb is typically grass-fed, and thus higher in n -3 than other grain-fed or grain-finished meat sources. In the United States, lamb is often finished (i.e. fattened before slaughter) with grain, resulting in lower n -3. The ω -3 content of chicken meat may be enhanced by increasing the animals' dietary intake of grains that are high in n -3, such as flax, chia, and canola.

Seal oil

Seal oil is a source of EPA, DPH, and DPA. It helps to support the development of the brain, eyes and nerves in children up to 12 years of age. Other sources: Milk and cheese from grass-fed cows may also be good sources of n -3. One UK study showed that half a pint of milk provides 10% of the recommended daily intake (RDI) of ALA, while a piece of organic cheese the size of a matchbox may provide up to 88%. The microalgae *Cryptocodinium cohnii* and *Schizochytrium* are rich sources of DHA (22:6 n -3) and can be produced commercially in bioreactors. This is the only source of DHA acceptable to vegans. Oil from brown algae (kelp) is a source of EPA. Walnuts are one of few nuts that contain appreciable n -3 fat, with approximately a 1:4 ratio of n -3 to n -6. Acai palm fruit also contains n -3 FAs. The ω -3 is also found in softgels in pharmacies and nowadays it is also found in combination with ω -6, ω -9 and shark liver oil. Some vegetables, too, contain a noteworthy amount of n -3, including strawberries and broccoli (van de Rest et al., 2008; Stone, 1996).

Eggs

Eggs produced by chickens fed a diet of greens and insects produce higher levels of n -3 FAs (mostly ALA) than chickens fed corn or soybeans. In addition to feeding chickens insects and greens, fish oils may be added to their diet to increase the amount of fatty acid concentrations in eggs. The addition of flax and canola seeds to the diet of chickens, both good sources of ALA, increases the ω -3 content of the eggs (Trebunová et al., 2007; Tribole 2006; Tribole, 2007).

CHEMISTRY

Chemical structure of α -linolenic acid (ALA) (Fig. 1, Table 1), an essential n -3 FA, (18:3 Δ 9c,12c,15c, which means a chain of 18 carbons with 3 double bonds on carbons numbered 9, 12 and 15). The n end is almost never changed during physiologic transformations in the human body, as it is more stable energetically. The term n -3 (ω -3 or omega-3) signifies that the first double bond exists as the third C-C bond from the terminal methyl end (n) of the carbon chain. The n -3 FAs which are important in human nutrition are: α -linolenic acid (18:3, n -3; ALA), eicosapentaenoic acid (20:5, n -3; EPA), and docosahexaenoic acid (22:6, n -3; DHA) (Fig. 1, Table 1). These three polyunsaturates have either 3, 5 or 6 double bonds in a carbon chain of 18, 20 or 22 carbon atoms, respectively. All double bonds are in the *cis*-configuration; in other words, the two hydrogen atoms are on the same side of the double bond. Most naturally-produced FAs are in *cis*-configuration where they are more easily transformable. The *trans*-configuration results in much more stable chains those are difficult to further break or transform, forming longer chains that aggregate in tissues and lacking the necessary hydrophilic properties. Natural transforms in plant or animal cells more rarely affect the last n -3 group itself. However, n -3 compounds are still more fragile than n -6 because the last double bond is geometrically and electrically more exposed, notably in the natural *cis* configuration. The n -3 fatty acids (ω -3 or omega-3 FAs) are a family of USFAs that have in common a final C-C double bond in the n -3 position; that is, the third bond from the methyl end of the FA. Important nutritionally essential n -3 FAs include ALA, EPA, and DHA, all of which are PUFAs. The human body cannot synthesize n -3 FAs *de novo*, but it can form 20-C n -3 USFAs (like EPA) and 22-C n -3 USFAs (like DHA) from the eighteen-carbon n -3 FA ALA. These conversions occur competitively with n -6 FAs, which are essential closely related chemical analogues that are derived from LA. Both the n -3 ALA and n -6 LA are essential nutrients which must be obtained from food. Synthesis of the longer n -3 FAs from LA within the body is competitively slowed by the n -6 analogues. Thus accumulation of long-chain n -3 FAs in tissues is more effective when they are obtained directly from food or when competing amounts of n -6 analogs do not greatly exceed the amounts of n -3.

Nomenclature and chemistry of oil

Edible fatty acids contain both SFAs and USFAs (MUFAs & PUFAs) fatty acids. Fatty acids, those having saturated carbon chain called saturated fatty acid (SFAs), those having single double bond called monounsaturated fatty acids (MUFAs) and those having more than one double bond are called polyunsaturated fatty acids (PUFAs). Commonly present SFAs are palmitic acid (PA), stearic acid (SA), MUFAs is oleic acid (OA), and PUFAs are linoleic acid (LA), γ -linolenic acid (GLA), α -linolenic acid (ALA), icosanoic acid (IA). USFAs are having lower melting point than SFAs.

The nomenclature of FAs is derived from the name of its parent hydrocarbon by replacing its final e by oleic acid. Thus the names of SFAs end with the suffix anoic acid and those of

USFAs with the suffix enoic acid. The numbering of carbon atoms in FAs is started at the carboxyl terminus and end methyl carbon is known as omega (ω) carbon atom. The names omega (ω -3/ ω -6/ ω -9) FAs refer to where a double bond occurs in the FA molecule. The terms "omega" or "n minus" refer to the position of the double bond of the FA closest to the methyl end of the molecule. Thus, oleic acid, which has its double bond 9 carbons from the methyl end, is considered a ω -9 (or an n-9) FA. Similarly, linoleic acid, is a ω -6 (n-6) fatty acid because its second double bond is 6 carbons from the methyl end of the molecule (i.e., between C-12 and C-13 from the carboxyl end). Various conventions are adopted for indicating the position of the double bonds. The most widely used are involve the use of the symbol delta (Δ) followed by superscript number. For example Δ^9 means that there is a double bond between C-9 and C-10. Lastly note that total number of carbon atoms and number of position(s) of double bond(s) is again indicated by convention. Examples, the symbol 18: 0 denote a C-18 fatty acid with no double bonds, the symbol 18: 1; 9 denote a C 18 FA with a double bond between carbon 9 and carbon 10 and the symbol 18: 2; 9, 12 denote a C-18 fatty acid with two double bonds between C-9 and C-10 and between C-12 and C-13. Thus, oleic acid, which has its double bond 9 carbons from the methyl end, is considered a ω -9 (or an n-9) FA. Similarly, linoleic acid, is a ω -6 (n-6) FA because its second double bond is 6 carbons from the methyl end of the molecule (i.e., between C-12 and C-13 from the carboxyl end) (Table 2) (Asif, 2011; Asif, 2015).

Importance of ω -3, ω -6 and ω -9 PUFAs

The ω -3 and ω -6 fatty acids are essential fatty acids (EFAs), because these FAs cannot synthesize by body itself. Instead, we must include them in our diet or through supplements to meet our body demands. ω -9 fatty acids are "conditionally essential", which means that if we have the other FAs in our diet, then our body can manufacture ω -9 fatty acids. Otherwise, omega 9 fatty acids must be consumed or supplemented as well. Among plant oils, the balance between ω -3, ω -6 and ω -9 FAs must dictate which oil is chosen. Oils which predominate in ω -3 component would be most likely to promote health. Most would actually contribute to the imbalance of ω -6 FAs because they contain more ω -6 than ω -3. Any amount of ω -9 is beneficial, but in balancing these FAs, the ω -3 component is the most important.

Uses of seed oil

The PUFAs ω -3, specifically α -linolenic acid (ALA), ω -6 and ω -9 are essential for human health, so these PUFAs must be obtained through diet or by supplementation. PUFAs suppresses the production of chemical mediator in the allergy and inflammatory responses. These EFAs have been associated with benefits in a wide range of inflammatory conditions, heart diseases, colitis/Crohn's disease, asthma, allergies, antimicrobial, anticancer, various skin conditions. It also prevent the formation of LTB₄, nephrotoxicity, asthma, rheumatoid arthritis, colitis, lupus, multiple sclerosis, and psoriasis etc.

IMPORTANCE OF UNSATURATED FATTY ACID

The ω -3 and ω -6 fatty acids (FAs) are essential fatty acids (EFAs), because they cannot synthesize in body itself. The ω -9 fatty acids are "conditionally essential", which means that if we have the other FAs in our diet, then our body can manufacture ω -9 fatty acids. Otherwise, ω -9 FAs must be consumed or supplemented as well. Among plant oils, the balance between ω -3, ω -6 and ω -9 FAs must dictate which oil is chosen. Oils which predominate in ω -3 FAs component would be most likely to promote health. Most would actually contribute to the imbalance of ω -6 FAs because they contain more ω -6 than ω -3 FAs. Any amount of ω -9 FAs is beneficial, but in balancing these FAs, the ω -3 component is the most important. The USFAs is unique the majority of seed oils are composed primarily of PUFAs and MUFAs, including EFAs, linoleic acid (PUFAs) and oleic acid (MUFAs). Compared to PUFAs, oleic acid (MUFAs), less susceptible to oxidation because it has one double bond and contributing to the antioxidant action, high stability, and long shelf life. The health benefits of OA are conflicting. It has been reported that OA plays a role in cancer prevention. Whether this is a secondary effect of the FAs on stability or a direct anticancer effect remains debatable. Beef and poultry fats contain 30-45 % OA, while oils such as palm, peanut, soybean, and sunflower contain 25-49 % OA. The effect of OA on colorectal neoplasia, MUFAs induces apoptosis and cell differentiation and down-regulates the expression of COX-2 and Bcl-2. The COX-2 plays an important role in colorectal cancer development, while Bcl-2 is an intracellular protein that inhibits apoptosis. The OA alone exhibited cell-line specific apoptotic induction, since HT-29 cells were affected but not Caco-2 cells and OA had no effect on the down-regulation of COX-2 and Bcl-2. The OA plays a minor role, if any, in colorectal chemo-protection and that other component of USFAs are involved in this protective process. The effect of OA on breast cancer cell lines causes down-regulates the over-expression of Her-2/neu, an oncogene over-expressed in breast carcinomas. The gene know as erb-B2, encodes for the p185Her-2/neu oncoprotein, a transmembrane tyrosine kinase orphan receptor that, under normal cellular conditions, is highly regulated because it controls many cell functions, such as differentiation, proliferation, and apoptosis. Deregulation of p185Her-2/neu greatly increases the risk of cancer development. The OA acts synergistically to enhance its action when used against cell cultures that over-express the Her-2/neu oncogene. The OA up-regulates PEA3. Low levels of PEA3 are found in cells over-expressing Her-2/neu; whereas, high levels of PEA3 are associated with low p185Her-2/ neu expression. The PUFAs are essential for human health, so these PUFAs must be obtained through diet or by supplementation. These USFAs suppresses the production of chemical mediator in the allergy and inflammatory responses. These EFAs have been associated with benefits in a wide range of heart diseases, colitis/Crohn's disease, asthma, antimicrobial, anticancer, various skin conditions, etc. Anti-inflammatory doses of PUSFAs have been shown to reduce the hypertensive and nephrotoxic effects. It prevent the formation of LTB₄ have been used in treating asthma, rheumatoid arthritis, colitis, lupus, multiple sclerosis, and psoriasis etc.

Cardio-vascular benefits

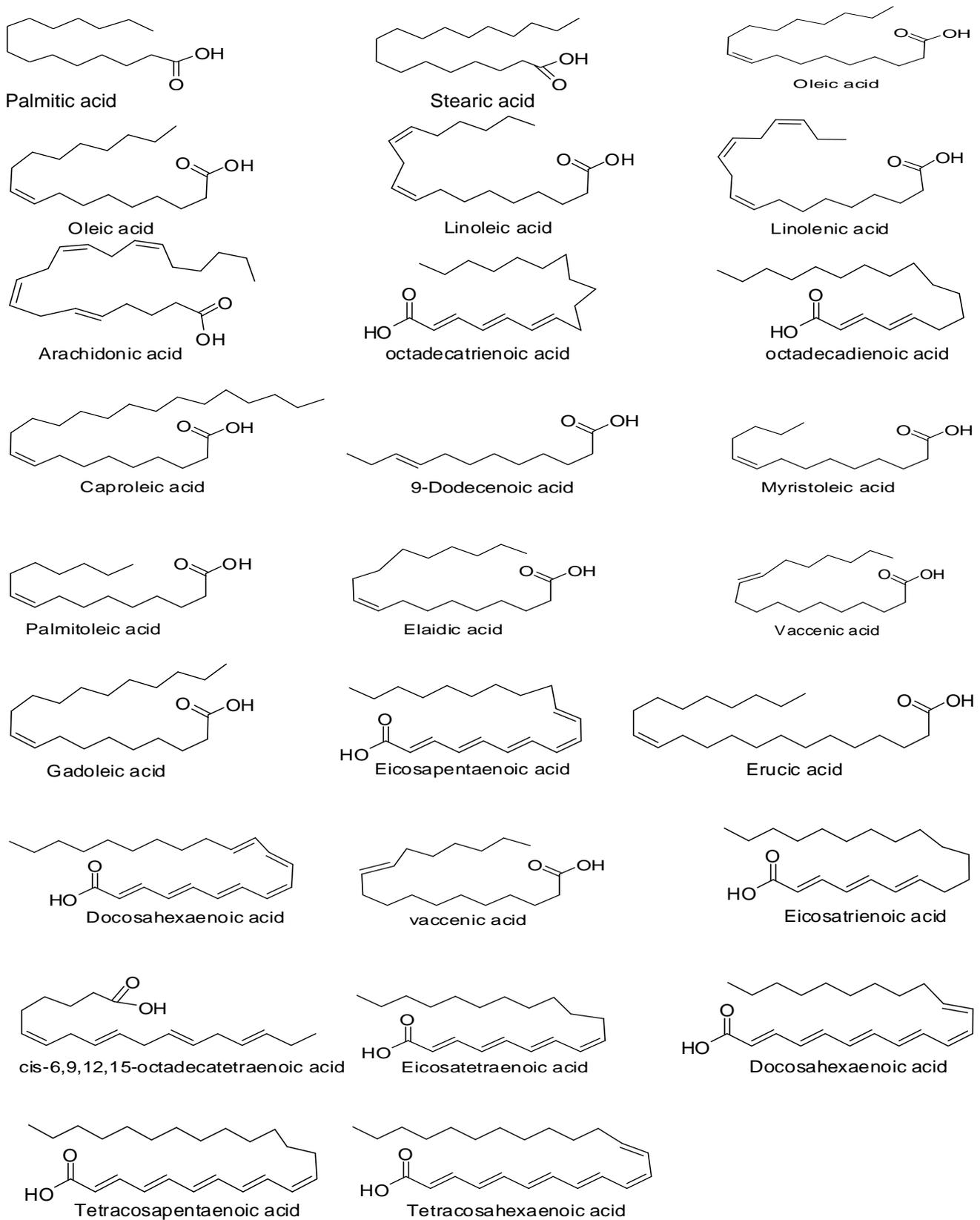


Fig. 1: Structure of some unsaturated fatty acids

In-vivo metabolism of ω -3PUFAs, it mainly exists in the form of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) at a rate of 7-10% that can help to prevent heart diseases. These two specific ω -3 FAs metabolites are inserted in cell membranes

throughout the body, where they convert into substances which prevent abnormal clotting, and relax blood vessels and improved ventilatory parameters. The ω -3 rich FAs may lead to prevention of coronary heart disease (CHD) and decrease blood clotting. In platelets, the cell products in the blood which aid in clotting, ω -6 FAs are converted to thromboxane-A2 (TX-A2). This makes the platelets more likely to burst or degranulate, releasing their clotting substances and cell messengers. These cell messengers constrict blood vessels and cause other platelets to burst-causing a clotting cascade. On the other hand, when ω -3 FAs are used in the same machinery in platelets, TX-A3 is made, which is inactive. In cut or injury, the bleeding is stop with the help of platelets. The ω -6 FAs make more inflammatory substances. These substances include leukotriene-B4, (LT-B4), which is a cell messenger responsible for inflammation throughout the body (Mozaffarian et al., 2005; Okuyama, 2001; Sanders et al., 1997; Schacky and Dyerberg, 2001). LT-B4 actually causes these WBC's to absorb oxidized LDL cholesterol (cholesterol plaque is formed). In contrast, when ω -3 FAs are used in the same cellular machinery, LTB5 is made. LTB5 is anti-inflammatory. Epidemiological studies demonstrate the MUFAs might help prevent atherosclerosis. Oxidation of LDL cholesterol has been identified as one of the first steps in the development of atherosclerotic lesions by promoting injury to the arterial wall through several mechanisms, including growth factor and chemotactic protein expression, inflammation, and increased local macrophages. Macrophages bind to and engulf oxidized LDL—an innate immune response to tissue damage. This engulfment produces a fatty foam cell, which, when combined with other cells, produces a fatty streak in the blood vessel. Oxidized LDL can also be taken up directly by endothelial and smooth muscles cells, leading to formation of fatty streaks, which is the first sign of atherosclerosis. The lesions forming atherosclerotic plaques are made up of lipids, endothelial and smooth muscle cells, and extracellular matrix. The plaque environment is proinflammatory. Inflammation occurring prior to the formation of fatty streaks and atherosclerotic lesions causes alterations to the endothelial cell wall, which increases the adhesion of leukocytes, LDL cholesterol, and platelets. This contributes to the development of atherosclerosis and cardiovascular diseases (Yokoyama et al., 2007; Zambón et al., 2000).

There is a reduced incidence of hypertension in populations that consume the UFAs diet, and adherence to the USFAs diet is inversely related to systolic and diastolic blood pressure (BP). Several studies have demonstrated the antihypertensive properties USFAs. These USFAs reduced systolic, diastolic, and mean arterial BPs in normo-tensive animals. Epidemiological studies suggested a protective effect for MUFAs. Compare a diet rich in PUFAs with a diet high in MUFAs in patients taking antihypertensive medications and found individuals who consumed MUFAs-rich diet were able to reduce the dosage of antihypertensive medication. The precise mechanism of action for BP reduction is unknown, although several theories have been proposed like Ca^{+2} channel antagonists, mimicking the effects of the Ca^{+2} channel blocker drugs (verapamil). Another suggested mechanism is via improved endothelial function. The OA may contribute to improved endothelial function by reducing

ROS. Other mechanisms have been suggested, including decreasing vascular tone and changes to the FAs and phospholipid composition of the aorta (Wang et al., 2006; Willett, 2007).

The major clinical study with a recent myocardial infarction (M.I). Treatment 1 gram per day of n -3 FAs reduced the occurrence of death, cardiovascular death and sudden cardiac death by 20%, 30% and 45% respectively. These beneficial effects were seen already from three months onwards. In 2006 studies into n -3 FAs, found in abundance in oily fish. It concluded that they do not have a significant protective effect against cardiovascular disease. Researches indicated that the decreases in total mortality and cardiovascular incidents associated with the regular consumption of fish and fish oil supplements. In 2007, patients with unhealthy blood sugar levels were randomly assigned to receive 1800 mg daily of eicosapentaenoic acid (EPA—an n -3 EFA from fish oil). The thickness of the carotid arteries and certain measures of blood flow were measured before and after supplementation. This went on for approximately two years. A total of patients completed the study. The EPA had a statistically significant decrease in the thickness of the carotid arteries along with improvement in blood flow. This indicated that administration of purified EPA improves the thickness of carotid arteries along with improving blood flow in patients with unhealthy blood sugar levels. In another study in 2007, patients with high triglycerides and poor coronary artery health were given 4 grams a day of a combination of EPA and DHA along with some MUFAs (Caponio et al., 2002; Carollo et al., 2007; Cunnane, 2006; Damsgaard et al., 2007; Davidson et al., 2007; Garrido-Sánchez et al., 2008)). Those patients with very unhealthy triglyceride levels (above 500 mg/dl) reduced their triglycerides on average 45% and their very low density lipid (VLDL) cholesterol by more than 50%. This VLDL is a bad type of cholesterol and elevated triglycerides can also be deleterious for cardiovascular health. Another study on the benefits of EPA in 2007, patients with unhealthy cholesterol levels. The patients were randomly assigned to receive either 1,800 mg a day of E-EPA with a statin drug or a statin drug alone. The trial went on for a total of five years. It was found at the end of the study those patients in the E-EPA group had superior cardiovascular function. Non-fatal coronary events were also significantly reduced in the E-EPA group. This concluded that EPA is a promising treatment for prevention of major coronary events, especially non-fatal coronary events. Similar to those who consume high amounts of n -3 FAs tend to have higher proportions of n -3, increased HDL cholesterol and decreased triglycerides (fatty material that circulates in the blood) and less heart disease. Eating walnuts (the ratio of n -3 to n -6 is 1:4) was reported to lower total cholesterol by 4% relative to controls when people also ate 27% less cholesterol. A study carried out on women showed serum level of EPA is inversely related to the levels of anti-oxidized-LDL antibodies. Oxidative modification of LDL is thought to play an important role in the development of atherosclerosis (Kris-Etherton et al., 2001; Lewis, 2000; Mita et al., 2007; Mori et al., 1993).

Cancer benefits: The ω -3 FAs may suppress cancer formation, but there is no direct evidence for protective effects in humans.

The EFA linoleic acid (LA) has both anticarcinogenic and antiatherogenic properties. Animal studies have indicated that LA reduces the incidence of tumors induced by carcinogens. The LA appears to be unique among FAs because low levels in the diet produce significant cancer protection (Ip et al., 1996; Thompson et al., 1997). Epidemiological evidence suggests people who consume the PUFAs diet have a lower incidence of certain cancers, including breast, skin, and colon. Oxidation of proteins, DNA, and lipids has been shown to contribute to cancer development, and consumption of antioxidants is believed to reduce the risk of mutagenesis and carcinogenesis. The exact contribution MUFAs makes to the apparent dietary chemoprotection. Saturated animal fats and plant SFAs in the diet have been implicated in colon, breast, prostate, and ovarian cancers. The substitution of USFAs may explain its apparent cancer-protective effect and accentuate the importance of the type, rather than the amount, of FAs consumed. MUFAs have a protective effect against colon cancer. The effect of plant FAs phenols on colorectal carcinogenesis, the FAs were shown to reduce DNA damage (initiation), increase barrier function (promotion), and reduce cell invasion of surrounding tissue (metastasis). In addition, OA is incorporated into the phospholipid membrane of breast tissue cells, resulting in a reduction in lipid peroxidation (Caughey et al., 1996; Caygill, and Hill, 1995; Chin et al., 1992; De Deckere, 1999). Epidemiological data showed women in the PUFAs diet have a lower incidence of breast cancer than women in higher PUFAs diets. Several studies report possible anti-cancer effects of *n*-3 FAs (particularly breast, colon and prostate cancer). The ω -3 FAs reduced prostate tumor growth, slowed histopathological progression, and increased survival. Among *n*-3 FAs, neither long-chain nor short-chain forms were consistently associated with breast cancer risk. High levels of DHA, however, the most abundant *n*-3 PUFA in erythrocyte membranes, were associated with a reduced risk of breast cancer. Supplement of EPA helped cancer patients retain muscle mass (de Lorgeril and Salen, 2006; Gillum et al., 1996; Griffin 2008; Iso et al., 2001; Keli et al., 1994).

Anti-inflammatory and rheumatoid arthritis benefits

Rheumatoid arthritis (RA) is an autoimmune disease characterized by chronic joint inflammation and damage. The initial autoimmune stimulus is unknown; however, joint and tissue damage occurs by a variety of mechanisms, many of which involve reactive oxygen species. ROS can cause destruction of hyaluronic acid and disruption to collagen, proteoglycans, protease inhibitors, and membrane function, the latter via oxidation of membrane fatty acids. The initiation of RA is believed to result in an increase in the concentration of macrophages and neutrophils in the synovial fluid and free-radical-producing enzymes. This leads to high levels of ROS in the joints, which increases and prolongs inflammation and damage. The antioxidant effect of UFAs oil has been found to reduce inflammation. In addition, dietary MUFAs, such as oleic acid, have been found to replace PUFAs in several aspects of cell metabolism. Reducing the competition between ω -6 and ω -3-PUFAs can lead to an increased use and incorporation of ω -3-

PUFAs. A number of studies that examined the benefits of fish oils (PUFAs) in RA used an olive oil (MUFAs) placebo for the control groups. Although results highlighted the benefits of fish oils, unexpected significant improvements were also seen in the control groups. Benefits including pain reduction, reduced morning stiffness, and improved patient evaluation of global disease were reported by patients receiving MUFAs. No explanation of the improvements shown by the olive oil groups were proposed, although changes in immune function may be responsible. MUFAs oil improved RA symptoms in patients already receiving fish oil (PUFAs). MUFAs appears to act synergistically with ω -3 fish oils to improve the symptoms of RA; the benefits are thought to be exerted through the oleic acid component. OA is converted to eicosatrienoic acid (ETA) and then LT-A₃. LTA₃ is a potent inhibitor of proinflammatory LT-B₄ synthesis and decreases the risk of developing RA (Lawson and Hughes, 1988).

The USFAs is rich in the ω -3 FAs, on metabolism gives EPA and DHA, which can displace arachidonic acid (AA) from cell membranes. These ω -3 FAs are also released with AA by phospholipases and act as substrate inhibitors of conversion of AA by cyclooxygenases (COX) and the terminal synthases to the pro-inflammatory oxygenated inflammatory mediators known as eicosanoids. The EPA is structurally identical to AA with the exception of its additional *n*-3 double bond and can be converted to eicosanoids that resemble eicosanoids. In addition to these effects on inflammatory eicosanoid synthesis, USFAs have been shown to reduce the production of the inflammatory cytokines IL-1 β and TNF- α by monocytes stimulated *in-vitro*. These cytokines are important effector molecules in inflammatory responses and TNF- α blocking agents are used widely to treat rheumatoid arthritis (RA) disease (Gediminas et al., 2008; Gilbert, 2008; Green et al., 2006). *In-vitro* studies have also shown inhibition of release of the metalloproteinases that are implicated in the tissue damage that is the hallmark of RA and other inflammatory diseases. The USFAs reduces recourse to NSAIDs for analgesia in RA and thereby reduces risk for upper gastrointestinal (GI) hemorrhage contrasts with the highly selective COX-2 inhibitor (Rofecoxib), which has been associated with increased serious cardiovascular risks. The result is fewer AA derived eicosanoids with production of homologous metabolites products such as PGE₁ (one less double bond than AA derived PGE₂). Research suggested that the *in-vitro* anti-inflammatory activity of *n*-3 FAs translates into clinical benefits. Cohorts of neck pain patients and of rheumatoid arthritis (RA) sufferers have demonstrated benefits comparable to those receiving standard NSAIDs. Those who follow a high PUFAs diet tend to have less heart disease, higher HDL (good) cholesterol levels and higher proportions of *n*-3 in tissue highly UFAs.

Brain health

The *n*-3 FAs study, a group of mice was genetically modified to develop accumulation of β -amyloid and τ -proteins in the brain similar to that seen in people with poor memory. The mice were divided into four groups with one group receiving a typical American diet (with high ratio of *n*-6 to *n*-3 FAs being 10 to 1).

Table 1: Some saturated and unsaturated fatty acids

Type of fatty acids	Molecular formula
Saturated fatty acid	
Palmitic acid	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
Stearic acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
Monounsaturated fatty acids	
Oleic acid	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Polyunsaturated fatty acids	
Linoleic acid	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Linolenic acid	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Arachidonic acid	$\text{CH}_3(\text{CH}_2)_3(\text{CH}_2\text{CH}=\text{CH})_4(\text{CH}_2)_3\text{COOH}$

Table 2: Several different names for the most common *n*-3 fatty acids found in nature

Common name	Lipid	Chemical name
n/a	16:3 (<i>n</i> -3)	<i>all-cis</i> -7,10,13-hexadecatrienoic acid
α -Linolenic acid (ALA)	18:3 (<i>n</i> -3)	<i>all-cis</i> -9,12,15-octadecatrienoic acid
Stearidonic acid (SDA)	18:4 (<i>n</i> -3)	<i>all-cis</i> -6,9,12,15-octadecatetraenoic acid
Eicosatrienoic acid (ETE)	20:3 (<i>n</i> -3)	<i>all-cis</i> -11,14,17-eicosatrienoic acid
Eicosatetraenoic acid (ETA)	20:4 (<i>n</i> -3)	<i>all-cis</i> -8,11,14,17-eicosatetraenoic acid
Eicosapentaenoic acid (EPA)	20:5 (<i>n</i> -3)	<i>all-cis</i> -5,8,11,14,17-eicosapentaenoic acid
Docosapentaenoic acid (DPA), Clupanodonic acid	22:5 (<i>n</i> -3)	<i>all-cis</i> -7,10,13,16,19-docosapentaenoic acid
Docosahexaenoic acid (DHA)	22:6 (<i>n</i> -3)	<i>all-cis</i> -4,7,10,13,16,19-docosahexaenoic acid
Tetracosapentaenoic acid	24:5 (<i>n</i> -3)	<i>all-cis</i> -9,12,15,18,21-docosahexaenoic acid
Tetracosahexaenoic acid (Nisinic acid)	24:6 (<i>n</i> -3)	<i>all-cis</i> -6,9,12,15,18,21-tetracosenoic acid

Table 3: *n*-3 content as the percentage of ALA in the seed oil

Common name	Alternative name	Linnaean name	<i>n</i> -3 (%)
Chia	chia sage	<i>Salvia hispanica</i>	64
Kiwifruit	Chinese gooseberry	<i>Actinidia chinensis</i>	62
Perilla	shiso	<i>Perilla frutescens</i>	58
Flax	linseed	<i>Linum usitatissimum</i>	55
Lingonberry	Cowberry	<i>Vaccinium vitis-idaea</i>	49
Camelina	Gold-of-pleasure	<i>Camelina sativa</i>	36
Purslane	Portulaca	<i>Portulaca oleracea</i>	35
Black Raspberry		<i>Rubus occidentalis</i>	33

The other three groups were given food with a balanced 1 to 1 *n*-6 to *n*-3 ratio and two additional groups supplemented with DHA plus long chain *n*-6 FAs. After three months of feeding, all the DHA supplemented groups were noted to have a lower accumulation of β -amyloid and τ -protein. Some research suggests that these abnormal proteins may contribute to the development of memory loss in later years. Other study, the children were given PUFAs (*n*-3 and *n*-6, 3000 mg a day), PUFAs plus multi-vitamins and minerals or placebo. After fifteen weeks, all groups crossed over to the PUFAs plus vitamins and mineral supplement. Parents were asked to rate their children's condition after fifteen and thirty weeks. After thirty weeks, parental ratings of behavior improved significantly in nine out of fourteen scales. The study is the largest PUFA trial to date with children falling in the poor learning and focus range. The results support those of other studies that have found

improvement in poor developmental health with EFA supplementation. A study examining whether ω -3 exerts neuroprotective action in Parkinson's disease found that it did, exhibit a protective effect (much like it did for Alzheimer's disease as well). The research exposed mice to either a control or a high ω -3 diet from two to twelve months of age and then treated them with a neurotoxin commonly used as an experimental model for Parkinson's. The high doses of ω -3 completely prevented the neurotoxin-induced decrease of dopamine that ordinarily occurs. Since Parkinson's is a disease caused by disruption of the dopamine system, this protective effect exhibited could show promise for future research in the prevention of Parkinson's disease (Nemets et al., 2006; Young and Conquer, 2005). The *n*-3 FAs are thought by some to have membrane-enhancing capabilities in brain cells. One medical explanation is that *n*-3 FAs play a role in the fortification of the

myelin sheaths (Su et al., 2003; Richardson et al., 2005; Richardson, and Ross. 2000). Not coincidentally, $n-3$ FAs comprise approximately eight percent of the average human brain. The EFAs, who gave $\omega-3$ its name, surmised how $n-3$ components are analogous to the human brain by stating that "DHA is structure, EPA is function." A benefit of $n-3$ FAs is helping the brain to repair damage by promoting neuronal growth. In a six-month study involving people with schizophrenia and Huntington's disease who were treated with E-EPA or a placebo, the placebo group had clearly lost cerebral tissue, while the patients given the supplements had a significant increase of grey and white matter. In the prefrontal cortex (PFC) of the brain, low brain $n-3$ FAs are thought to lower the dopaminergic neurotransmission in this brain area, possibly contributing to the negative and neurocognitive symptoms in schizophrenia. This reduction in dopamine system function in the PFC may lead to an over activity in dopaminergic function in the limbic system of the brain which is suppressively controlled by the PFC dopamine system, causing the positive symptoms of schizophrenia. This is called the $n-3$ PUFAs/dopamine hypothesis of schizophrenia (Ohara, 2007). This mechanism may explain why $n-3$ supplementation shows effects against both positive, negative and neurocognitive symptoms in schizophrenia. Consequently, the past decade of $n-3$ FAs research has procured *some* Western interest in $n-3$ FAs as being a legitimate 'brain food.' Still, recent claims that one's intelligence quotient, psychological tests measuring certain cognitive skills, including numerical and verbal reasoning skills, are increased on account of $n-3$ FAs consumed by pregnant mothers remain unreliable and controversial. An even more significant focus of research, however, lies in the role of $n-3$ FAs as a non-prescription treatment for certain psychiatric and mental diagnoses and has become a topic of much research and speculation. In 1998, placebo-controlled study in thirty patients diagnosed with bipolar disorder. Over the course of four months, who take capsules containing olive oil (MUFA), and another subject's capsule containing nine grams of EPA and DHA. The study showed that subjects in the $n-3$ group were less likely to experience a relapse of symptoms in the four months of the study. Moreover, the $n-3$ group experienced significantly more recovery than the placebo group. However, a study notes that the improvement in the $n-3$ group was too small to be clinically significant.^[74] "Several epidemiological studies suggest covariation between seafood consumption and rates of mood disorders. Biological marker studies indicate deficits in $\omega-3$ FAs in people with depressive disorders, while several treatment studies indicate therapeutic benefits from $\omega-3$ supplementation. A similar contribution of $\omega-3$ FAs to coronary artery disease may explain the well-described links between coronary artery disease and depression. Deficits in $\omega-3$ FAs have been identified as a contributing factor to mood disorders and offer a potential rational treatment approach."^[76] In 2004, a study found that 100 suicide attempt patients on average had significantly lower levels of EPA in their blood as compared to controls. "The preponderance of epidemiologic and tissue compositional studies supports a protective effect of $\omega-3$ EFA intake, particularly EPA and DHA, in mood disorders. Meta-analyses of randomized controlled trials demonstrate a statistically significant benefit in

unipolar and bipolar depression. The results were highly heterogeneous, indicating that it is important to examine the characteristics of each individual study to note the differences in design and execution. There is less evidence of benefit in schizophrenia (Ohara, 2007). EPA and DHA appear to have negligible risks and some potential benefit in major depressive disorder and bipolar disorder, but results remain inconclusive in most areas of interest in psychiatry. Health benefits of $\omega-3$ EFA may be especially important in patients with psychiatric disorders, due to high prevalence rates of smoking and obesity and the metabolic side effects of some psychotropic medications." Another meta-analysis published 2007, based on 10 clinical trials, found that $\omega-3$ PUFAs significantly improved depression in patients with both unipolar and bipolar disorder (Pignier et al., 2007; Yehuda et al., 2005; Richardson, 2006; Roche and Gibney, 1996). However, based upon the heterogeneity of the trials, "more large-scale, well-controlled trials are needed to find out the favorable target subjects, therapeutic dose of EPA and the composition of $\omega-3$ PUFAs in treating depression". The E-EPA, as monotherapy, has an advantage over placebo in major depressive disorder.

Immune function

A study regarding to fish oil, sixty four healthy Danish infants from nine to twelve months of age received either cow's milk or infant formula alone or with fish oil. It was found that those infants supplemented with fish oil had improvement in immune function maturation with no apparent reduction in immune activation (Mozaffarian et al., 2006; Naliwaiko et al., 2004).

Antiallergic benefits

The USFAs suppressed a wide range of allergic mediators in experimental animals. These findings raise the potential USFAs to be effective in reducing allergic hypersensitivity in humans. The USFAs also showed benefits in terms of lung function, breathing parameters and may be useful for the treatment of asthma. The reduction in asthma symptoms due to the ALA effects on LTs (Talbot et al., 2006; Reisman et al., 2006).

Numerous other applications of unsaturated fatty acids

PUFAs ($\omega-3$ and $\omega-6$), MUFAs ($\omega-9$), plus multi-vitamins and minerals or placebo supplementation is useful in children with learning and behavioral problems. $\omega-3$ FAs exerts neuroprotective action in Parkinson's and Alzheimer's disease. The high doses of $\omega-3$ FAs prevented the neurotoxin-induced decrease of dopamine that ordinarily occurs. Since Parkinson's is a disease caused by disruption of the dopamine system, this protective effect exhibited could show promise for future research in the prevention of Parkinson's disease. PUFAs are rich source of antioxidant because plant FAs contained polyphenolic compounds such as rosmarinic acid, luteolin, chrysoeriol, quercetin, catechin and apigenin, etc. These antioxidants may also be involved in allergy, antimicrobial, cardiovascular and cancer prevention along with the USFAs. The 18 carbon ALA has not been shown to have the same cardiovascular benefits as

Table 4: *n*-3 content as the percentage of ALA in the whole food

Common name	Linnaean name	% <i>n</i> -3
Flaxseed	<i>Linum usitatissimum</i>	18.1
Butternuts	<i>Juglans cinerea</i>	8.7
Hempseed	<i>Cannabis sativa</i>	8.7
Walnuts	<i>Juglans regia</i>	6.3
Pecan nuts	<i>Carya illinoensis</i>	0.6
Hazel nuts	<i>Corylus avellana</i>	0.1

DHA or EPA. Currently there are many products on the market which claim to contain health promoting 'omega 3', but contain only ALA, not EPA or DHA. These products contain mainly higher plant oils and must be converted by the body to create DHA and therefore considered less efficient. DHA and EPA are made by microalgae that live in seawater. These are then consumed by fish and accumulate to high levels in their internal organs. If a person has ethical concerns about killing fish, or is concerned about mercury and ocean borne contaminants in fish, DHA can be produced directly from microalgae as a vegetarian source. People with certain circulatory problems, such as varicose veins, benefit from such supplements containing EPA and DHA which stimulate blood circulation, increase the breakdown of fibrin, a compound involved in clot and scar formation, and additionally have been shown to reduce blood pressure. There is strong scientific evidence that *n*-3 FAs reduce blood triglyceride levels and regular intake reduces the risk of secondary and primary heart attack. Some benefits have been reported in conditions such as RA and cardiac arrhythmias. There is preliminary evidence that *n*-3 FAs supplementation might be helpful in cases of depression and anxiety. Some research suggests that fish oil intake may reduce the risk of ischemic and thrombotic stroke. However, very large amounts may actually increase the risk of hemorrhagic stroke. Lower amounts are not related to this risk, 3 grams of total EPA/DHA daily are considered safe with no increased risk of bleeding involved and many studies used substantially higher doses without major side effects (for example: 4.4 grams EPA/2.2 grams DHA) (Harris, 1997; Harwood and Yaqoob, 2002; Holman, 1998; Kromann and Green, 1980; Levy and Hyman, 2005; Lin and Kuan-Pin, 2007).

Health risks

In 2000, noted that known or suspected risks of EPA and DHA *n*-3 FAs may include the possibility of: Increased bleeding if overused (normally over 3 grams per day) by a patient who is also taking aspirin or warfarin. However, this is disputed. Hemorrhagic stroke (only in case of very large doses). Reduced glycemic control among diabetics, subsequent advice from the FDA and national counterparts have permitted health claims associated with heart health.

Cardiac risk

Persons with CHF, chronic recurrent angina pectoris or evidence that their heart is receiving insufficient blood flow are advised to talk to their doctor before taking *n*-3 FAs. There have been concerns if such persons take *n*-3 FAs or eating foods that

contain them in substantial amounts. In a study, *n*-3 FAs on top of standard heart failure therapy produced a small but statistically significant benefit in terms of mortality and hospitalization. In CHF, cells that are only barely receiving enough blood flow become electrically hyper excitable. This, in turn, can lead to increased risk of irregular heartbeats, which, in turn, can cause sudden cardiac death. The *n*-3 FAs seem to stabilize the rhythm of the heart by effectively preventing these hyper excitable cells from functioning, thereby reducing the likelihood of irregular heartbeats and sudden cardiac death. For most people, this is obviously beneficial and would account for most of the large reduction in the likelihood of sudden cardiac death. Nevertheless, for people with congestive heart failure, the heart is barely pumping blood well enough to keep them alive. In these patients, *n*-3 FAs may eliminate enough of these few pumping cells that the heart would no longer be able to pump sufficient blood to live, causing an increased risk of cardiac death (Bucher et al., 2002; Calabrese et al., 1999; Calder, 2004; Longvah et al., 2000).

Developmental differences

The used EFAs supplements to treat children with autism spectrum disorders. The ω -3 FAs offer a promising complementary approach to standard treatments for ADHD and developmental coordination disorder. Fish oils appear to reduce ADHD-related symptoms in some children. Double blind studies have showed "medium to strong treatment effects of ω -3 FAs on symptoms of ADHD" after administering amounts around 1 gram for three to six months. There is very little scientific evidence supporting the effectiveness of ω -3 FAs for autism spectrum disorders. One randomized controlled trial found that ω -3 FAs did not significantly affect aberrant behavior in autistic children, and although the investigators noted reduced hyperactivity their later reanalysis reported that the reduction was not statistically significant. Low birth weight: women who ate fish once a week during their first trimester had 3.6 times less risk of low birth weight and premature birth than those who ate no fish. Low consumption of fish was a strong risk factor for preterm delivery and low birth weight. However, attempts by other groups to reverse this increased risk by encouraging increased pre-natal consumption of fish were unsuccessful.

Dietary sources and daily values

As macronutrients, fats are not assigned recommended daily allowances. Macronutrients have AI (acceptable intake) and AMDR (acceptable macronutrient distribution range) instead of RDAs. The AI for *n*-3 is 1.6 grams/day for men and 1.1 grams/day for women while the AMDR is 0.6% to 1.2% of total energy. "A growing body of literature suggests that higher intakes of ALA, EPA, and DHA may afford some degree of protection against coronary heart disease. Because the physiological potency of EPA and DHA is much greater than that for ALA, it is not possible to estimate one AMDR for all *n*-3 FAs. Approximately 10 percent of the AMDR can be consumed as EPA and/or DHA." There was insufficient evidence as of 2005 to set a UL (upper tolerable limit) for *n*-3 FAs. A perceived risk of fish oil *n*-3 supplementation has been heavy metal poisoning

by the body's accumulation of traces of heavy metals, in particular mercury, lead, nickel, arsenic and cadmium as well as other contaminants (PCBs, furans, dioxins, PBDEs), which potentially might be found especially in less-refined fish oil supplements. However, in reality, heavy metal toxicity from consuming fish oil supplements is highly unlikely. This is because heavy metals selectively bind with protein in the fish flesh rather than accumulate in the oil. The FDA recommends that total dietary intake of $n-3$ FAs from fish not exceed 3 grams per day, of which no more than 2 grams per day are from nutritional supplements (Lee et al., 2007; Marchioli, 2002; Herrera et al., 2001; Hibbeln et al., 2006; Kremer et al., 1985). The $n-3$ supplementation in food has been a significant recent trend in food fortification, with global food companies launching $n-3$ fortified bread, mayonnaise, pizza, yogurt, orange juice, children's pasta, milk, eggs, confections and infant formula.

THE $n-6$ TO $n-3$ RATIO

Essential fatty acid interactions

Clinical studies indicate that the ingested ratio of $n-6$ to $n-3$ (especially Linoleic vs α -Linolenic) FAs is important to maintaining cardiovascular health. Both $n-3$ and $n-6$ FAs are essential, i.e. humans must consume them in the diet. $n-3$ and $n-6$ compete for the same metabolic enzymes, thus the $n-6:n-3$ ratio will significantly influence the ratio of the ensuing eicosanoids (hormones), (e.g. PGs, LTs, TXs etc.), and will alter the body's metabolic function. Generally, grass-fed animals accumulate more $n-3$ than do grain-fed animals which accumulate relatively more $n-6$. Metabolites of $n-6$ are significantly more inflammatory (esp. AA) than those of $n-3$. This necessitates that $n-3$ and $n-6$ be consumed in a *balanced proportion*; healthy ratios of $n-6:n-3$ range from 1:1 to 4:1. Studies suggest that the evolutionary human diet, rich in game animals, seafood and other sources of $n-3$, may have provided such a ratio (Table 3 and 4). Typical Western diets provide ratios of between 10:1 and 30:1- i.e., dramatically skewed toward $n-6$. Here are the ratios of $n-6$ to $n-3$ FAs in some common oils: canola 2:1, soybean 7:1, olive 3-13:1, sunflower (no $n-3$), flax 1:3, cottonseed (almost no $n-3$), peanut (no $n-3$), grape seed oil (almost no $n-3$) and corn oil 46 to 1 ratio of $n-6$ to $n-3$ (Mattson and Grundy, 1985; McKenney et al., 2007; Menendez et al., 2006; Newmark, 1997).

Conversion efficiency of ALA to EPA and DHA

It has been reported that conversion of ALA to EPA and further to DHA in humans is limited, but varies with individuals. Women have higher ALA conversion efficiency than men, probably due to the lower rate of utilization of dietary ALA for β -oxidation. This suggests that biological engineering of ALA conversion efficiency is possible. The absolute amount of ALA rather than the ratio of $n-3$ and $n-6$ FAs which affects the conversion.

DISCUSSION

Research showed that the low incidence of heart attacks even their diet was so high in fat when the fats in the diet have high amount of PUFAs, especially $\omega-3$ FAs. ALA or $\omega-3$ FAs, *in-vivo* decreases the BP, cholesterol and glyceride contents in the blood. It also controls hematoblastic aggregation and thrombi reduction. The $\omega-3$ FAs has inhibitory action on the growth and metabolism of breast and colon cancer. The higher intakes of $\omega-3$ FAs ALA, EPA, and DHA may afford some degree of protection against coronary heart diseases. The physiological potency of EPA and DHA is much greater than that for ALA. Many health issues depend on a proper balance of $\omega-3$ and $\omega-6$ FAs. While $\omega-6$ FAs are necessary for normal immune function and clotting, too much $\omega-6$ FAs may promote abnormal clotting and an overactive immune system. It is believed that our ancestors evolved on a diet where these two ω FAs were approximately equal. However, modern diets usually have more $\omega-6$ FAs than $\omega-3$ FAs. Many of the chronic diseases are believed to have their origins in an imbalance of $\omega-3$ and $\omega-6$ FAs in diet. This necessitates that $\omega-3$ and $\omega-6$ is consumed in a balanced proportion; healthy ratios of $\omega-6$: $\omega-3$ range from 1:1 to 4:1. Considerable evidence indicates the USFAs diet is linked to a decreased incidence of cardiovascular disease and certain cancer types, despite the fact that this diet is higher in fat than other SFAs diets. Since PUFAs intake has a positive correlation with the risk of CHD and cancer. SFAs have been linked to unfavorable health outcomes; whereas, MUFAs have been found to be beneficial. The studies provide good evidence USFAs may be beneficial for reducing high B.P. and preventing breast and colon cancer (Sinn et al., 2007; Waterman and Lockwood, 2007; Odent et al., 2002; Perona et al., 2006; Renaud, 2002). However, evidence that the active compounds in FAs are capable of distribution throughout the body.

CONCLUSION

Although the PUFAs diet consumed is thought to be a significant, if not the primary, contributor to the reduced incidence of CHD and certain cancers seen in these populations, it may not be the only factor. USFAs are also not the only component of the diet that has been found to have biological benefits. The evidence indicates, however, that USFAs contribute significantly to the health benefits, with more of an effect on prevention than treatment. USFAs to be potentially benefits to prevent and cure different ailments like cardiovascular diseases, allergy, asthma, antioxidant, pain reliever, anti-inflammatory, constipation, etc, stimulate immune functions also but little health risk was also reported. Most important the $\omega-3$ FAs have been shown to improve cardiovascular activity to regulate and control of heart functions like BP, vascular resistance, lower triglycerides, abnormal heart rhythm, sudden cardiac death, and may reduce the risk of heart attack. Vegetable FAs also contain various polyphenols, these polyphenols have powerful impact on decreasing allergy symptoms and free radicals scavenging activity.

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