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Mixed EFAs

A carefully designed blend of seed and nut oils that includes walnut oil, sesame seed oil, apricot kernel oil and hazel nut oil.

Functions of Unsaturated Fatty Acids

Dietary Polyunsaturated Fatty Acids (PUFA)

Dietary PUFA supply essential fatty acids, (EFAs). EFAs fall into two broad categories, N-6 and N-3. The ratio of N-6/N-3 is an important consideration in establishing N-3 requirements. Animal products differ with respect to prevalence of N-6 and N-3 PUFA. Marine animals, marine algae and certain seed oils are enriched in N-3, while meat and cooking oils, such as corn oil and safflower oil, contain primarily N-6 PUFA. In contrast, the typical Western diet supplies 10-fold or more N-6 PUFA than N-3, and the single most common PUFA in such a diet is linoleic acid with 18 carbons and 2 double bonds (designated as C18:2n-6).[1] It is metabolized to longer chain PUFA by the body. It is estimated that 20 g linoleic acid/day would supply 1 g or more/day of gamma linoleic acid and higher metabolites via metabolism. Arachidonic acid (C20:4n-6) is the most abundant metabolite of linoleic acid in most foods; especially meats, eggs and seafood. American diets supply between 50-600 mg arachidonic acid daily, depending on the amount of meat and dairy products consumed.

Human plasma reflects dietary intake and typically contains the following average concentrations: linoleic acid 1500 mg/L; gamma linoleic acid 25 mg/L; dihomogamma linoleic acid 100 mg/L and arachidonic acid 400 mg/l.[2] These four N-6 PUFA are capable of reversing most physiologic effects of EFA deficiency in animals. Linoleic acid can restore water-barrier properties of the skin, while most of the other functions are best served by metabolites of linoleic acid. However, certain abnormal functions of the CNS, retina and platelets are corrected only by administering N-3 PUFA.[2]

N-6 PUFA

Linoleic acid is a major constituent of Mixed EFAs. As the simplest member of this family, linoleic acid, possesses two double bonds because the body cannot create double bonds in the N-6 family, linoleic acid is designed as a dietary essential fatty acid. Linoleic acid is converted to gamma linoleic acid (GLA, C18:3n-6) via delta 6 desaturase. GLA is elongated to dihomo GLA (C20:3n-6), then a fourth double bond is created by delta 5 desaturase, yielding the eicosanoid precursor, arachidonic acid, C20:4n-6.

N-3 PUFA

These fatty acids possess a double bond at the 3rd carbon atom of the fatty acid chain. The simplest member of this family, alpha linoleic acid (ALA), C18:2n-3, is considered a second essential fatty acid, due to the body's inability to create unsaturated fatty acids at the 3 position of the fatty acid chain. Delta 6-and delta-5 desaturases and elongases convert ALA to eicosapentaneoic acid (C20:5n-2, EPA) and this is the preferred substrate for these enzymes.

Polyunsaturated Fatty Acids (PUFA) for Membrane Synthesis.

Polyunsaturates play several important roles. As components of membrane phospholipids, they are required for all cell membranes-including those of mitochondria, nuclei, endoplasmic reticulum and plasma membranes. PUFA increase the fluidity of membranes, where they help regulate membrane-associated phenomena, such as mediated transport, hormone binding and intercellular communication.

The lipid bilayer model of membranes describes the arrangement of phospholipids with the hydrophilic fatty acid "tails" pointed inward and the polar "head" groups oriented to the membrane surfaces, where they interact with water molecules. The fluidity of the lipid layer is regulated by the degree of unsaturation of the fatty acids of the phospholipids. Their "cls" configuration of double bonds dictates a kink in the fatty acid chain, which prevents the fatty acid carbon chains from stacking together easily. This is the reason non-processed vegetable fats are liquids (oils) at room temperature. In contrast, saturated fatty acids possess straight chains, which allows them to stack together in ordered arrays and to solidify at room temperature.

Therefore, saturated fatty acids of phospholipids stiffen membranes.

Trans fatty acids are produced when PUFA are partially hydrogenated during processing. In trans fatty acids, the double bond has been "straightened." Consequently, trans fatty acids behave like saturated fatty acids and they harden, rather than soften, cell membranes. They do not function as precursors of prostaglandins.

PUFA and Vitamin E Requirements

Increased consumption of PUFA raises the requirement for vitamin E, due to an increased risk of lipid peroxidation. A ratio of 0.4 mg vitamin E/gram of PUFA has been suggested.[3] Thus, the availability of PUFA in the body is affected by the need for ample antioxidants, as well as by the intake of unsaturated fatty acids.

N-6 PUFA and Cardiovascular Disease

An increased intake of linoleic acid lowers plasma cholesterol, although amounts required to achieve this are relatively high. Conversely, low levels of adipose tissue linoleic acid increase the risk of coronary heart disease and related mortality.[4] In addition, N-6 PUFA affects other risk factors for cardiovascular disease, such as platelet aggregation and hypertension.[4] A diet that is high in N-6 PUFA depresses all lipoprotein fractions, including HDL, which is protective against coronary heart disease.[4] Many studies suggest that PUFA slow down intra-arterial blockage. This inhibitory effect may be related to increased fluidity of platelet membranes. In addition, PGE, from N-6 PUFA is an inhibitor of platelet aggregation.

N-6 PUFA and the Immune System

High intake of linoleic acid can suppress the immune system of laboratory animals, but oleic acid does not have this effect.[5]

PUFA for Eicosanoid Synthesis

PUFA are required to synthesize eicosanoids, hormone-like lipids that regulate many processes. These include leukotrienes, prostaglandins and thromboxanes. Whether the PUFA belongs to the N-6 or the N-3 class of essential fatty acids, determines the final eicosanoid structure (see Note on Fatty Acid Nomenclature and Biosynthetic Relationships).

Eicosanoids from N-6 PUFA

Arachidonic acid is the direct precursor for important eicosanoids. Arachidonic acid yields PG2 series of prostaglandins via cyclooxygenase. PG2 prostaglandins tend to raise blood pressure, increase platelet aggregation and stimulate macrophages. A second pathway, initiated by lipoxygenase, oxidizes arachidonic acid to straight chain lipid regulators called leukotrienes. The leukotrienes derived from arachidonic acid are among the most powerful inflammatory agents produced by the body.

Prostaglandins from Dihomo-gamma linoleic Acid

A branch pathway leading from dihomo-gamma linoleic acid to the PG1 family of prostaglandins is usually favored when N-3 PUFA, the other family of essential fatty acids, are processed. Due to higher affinities of the required desaturases for N-3 over N-6 fatty acids, and the sluggish nature of these reactions in humans, dihomo-gamma linoleic acid and arachidonic acid are formed very slowly from linoleic acid.[6] The PG1 prostaglandins counter inflammation and favor parasympathetic processes, thus they balance arachidonic acid derivatives.

Monounsaturated Fatty Acids

Fatty acids with a single double bond are classified as monounsaturates. They are readily synthesized in the body and are not dietary essentials. The most common example in the body is oleic acid (C18:1n-9), which is derived from stearic acid, while palmitoleic acid (C16:1n-7) is derived from palmitic acid.

Functions of Monounsaturated Fatty Acids

Diets rich in monounsaturated fatty acids (primarily oleic acid) can lower serum cholesterol and LDL-cholesterol levels, especially when substituted for high levels of saturated fats.[7] There is an inverse association between increased consumption of monounsaturated fat and decreasing risk of stroke.[8] A second advantage is that oleic acid does not lower HDL levels. Higher intake of monunsaturates at the expense of carbohydrate, as in the Mediterranean diet, is well tolerated. Populations consuming such a diet experience lower rates of coronary artery disease and lower rates of cancer, when compared to people eating a typical Western diet.[9] Monounsaturated fatty acid intake accounting or 15-16% of total calories has been suggested.[1] Variation of oleic acid consumption over a range of 10 to 20% of energy intake, adjusted for personal preferences, would yield ratios of oleic acid/linoleic acid ranging from 1:1 to 3:1.[1]

Although monounsaturated fatty acids have been regarded as neutral fatty acids, in fact they are not. Both olive and fish oil lowered high baseline levels of fibrinogen.[10] Olive oil may benefit patients with rheumatoid arthritis.[11] Consumption of monounsaturated fatty acids was recently found to lower the level of intercellular adhesion molecule-1 (ICAM-1) in peripheral (up to 20%) mononuclear cells without altering natural killer cell activity.[12] ICAM-1 plays a key role in the growth of atherosclerotic plaque.

There are other advantages of dietary monounsaturated fatty acids: Higher consumption of monounsaturates at the expense of carbohydrate may decrease elevated serum triglycerides and high blood sugar for people with insulin resistance.[13] Monounsaturates are also less susceptible to oxidation than PUFA. Linoleic acid (N-6) lowers total cholesterol levels more than oleic acid. However, in experiments with lab animals large amounts of linoleic acid suppress the immune system.[15] Oleic acid does not have this affect. Therefore, a balance between oleic acid and linoleic acid is believed to be beneficial.

Properties of Individual Oils in Mixed EFAs

The average fatty acid compositions of key oils are summarized in table 1. Walnut oil and sesame oil contain proportionately more linoleic acid, while apricot kernel oil and hazelnut oil contain predominantly oleic acid.

Table 1. Comparison of average fatty acid compositions of oils as percentages

	GLA	ALA	Linoleic Acid	Oleic Acid	Palmitic Acid	Stearic Acid
Walnut Oil	0	10	60	21	8	2
Sesame Oil	0	0	45	40	10	5
Apricot Kernal	0	0	32	60	6	<1
Hazelnut Oil	0	0	12	80	6	3

Walnut Oil

Walnut oil is rich in linoleic acid (60%) and is moderately high in oleic acid (21%). It also contains low levels of alpha linolenic acid (ALA). The consumption of nuts is associated with a reduced risk of ischemic heart disease. When healthy men were fed a diet in which 20% of calories came from walnuts and which conformed to the Step 1, Cholesterol Education Program, there was a 12% reduction in total serum cholesterol, representing a 16% reduction in LDL and a 5% reduction in HDL.[14] The ratio of LDL cholesterol/HDL cholesterol decreased significantly. In a similar study, supplementing normolipidemic males with 68 g walnuts/day for 3 weeks lowered serum cholesterol by 5% and LDL cholesterol by 9%.[15] Allergic reactions to walnuts have been noted.[16] An early report suggested that walnuts may interfere with thyroxin secretion.[17]

Sesame Seed Oil

Sesame seeds yield 53% oil, depending upon the variety. Sesame seed oil contains a relatively large amount of linoleic acid (45%) and approximately equal amounts of oleic acid (40%). Sesame oil has long been used in Asian cooking, and Ayurvedic traditions recommend the use of topically applied sesame oil as a health-promoting procedure. The absorption of lymphatic cholesterol by rats fed a diet containing 24% sesame oil was 50% less than that of rats fed a control diet. Levels of LDL cholesterol and liver cholesterol were significantly lower as well.[18] Sesame oil did not alter the levels of HDL or serum triglycerides; however the level of liver lipids increased over controls. Sesame seeds and possible sesame seed oil contain lignan compounds, sesmol, sesaminol, sesaminolinol, pinoresinol, as well as tocopherols. These may contribute strong antioxidant activity.[19] Certain cultured cells are sensitive to sesame oil.[20] Sesame seed oil is reported to contain masked allergens, though allergies to sesame seeds are still rare.[21]

Apricot Kernel Oil

Apricot kernels contain 47% oil, which is 94% unsaturated. Apricot kernel oil is enriched in oleic acid (60%) and provides less linoleic acid (32%) then walnut or sesame oils. Although apricot kernels contain about 5% amygdalin, the oil is free of this compound.[22] Apricot kernel oil is used in foods and in cosmetics, such as skin creams. It is widely used as cooking oil in India. Apricot kernel oil is reported to contain 840 mg total tocopherols per kg oil, and it is a rich source of gamma tocopherol (794 mg/kg oil).[23]

Hazelnut Oil

Hazelnut oil contains large amounts of oleic acid (80%) and low levels of linoleic acid (12%). In this sense, hazelnut oil resembles olive oil. Hazelnut oil contains significant tocopherols, ranging from 335 to 520 mg alpha tocopherol per kg of oil.[24] Tocotrienols are absent in this oil. Allergies to hazelnuts have been reported.[25]

Note on Fatty Acid Nomenclature and Biosynthetic Relationships

Polyunsaturated fatty acids (PUFA). Fatty acids containing two or more double bounds are classified as polyunsaturates. There are two classes depending upon the number and position of double bonds. N-6 PUFA possesses double bonds beginning with the 6th carbon atom from the methyl end of the fatty acid chain.

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