

Omega-3 Fatty Acids

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Introduction

Polyunsaturated fatty acids are one of the four basic types of fat derived from food, along with Cholesterol, saturated fat, and monounsaturated fat. Polyunsaturated fatty acids include the omega-3s, which are important to human health.

Omega-3s are essential fatty acids, meaning your body cannot manufacture them. Hence, they have to come from a dietary source. Omega-3s have an important role in maintaining the cellular integrity, in the brain cells and in the arterial linings. An average American diet does not contain enough omega-3s to provide the maximum nutritional

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benefits. Select special vegetables or seafoods that are rich in omega-3s or take supplements if you do not want to eat fish.

Classification of Omega-3 Fatty Acids

All fatty acids contain carbon, oxygen, and hydrogen atoms. Fatty acids consist of a hydrogen and carbon (hydrocarbon=CH) backbone (varying in length), with a carboxyl acid (COOH) group at one end and a methyl group (CH₃) at the other.

Fat is saturated, when every one of its carbon atoms has a hydrogen atom attached. Polyunsaturated fatty acids contain two or more double bonds (missing hydrogen links) in the middle of their chain. The Omega nomenclature describes the position of the first double bond in the hydrocarbon.

All fatty acids utilize and compete for the same metabolic enzymes, resulting in alternating steps of de-saturation and chain elongation. These metabolic steps occur only toward the carboxyl end of the molecule, keeping the first double bond from the methyl end the same. Mammals cannot insert a double bond at either the third or the sixth carbon position, nor can they convert omega-6 fatty acids to omega-3 series and vice versa. Thus, both omega-6 and omega-3s must be supplied in the diet.

In omega-3s, the missing hydrogen on the third carbon atom creates a double bond between the third and fourth carbon atoms. The fatty acids chains' ability to bend and stay liquid at very low temperatures depends on the number of missing hydrogen atoms. It is essential for the body fluid to remain liquid in very cold climates such as seawater in the north.

Omega-3s are classified into groups based on the number of missing hydrogen atoms and the length of their fatty acid chains.

1. Alpha Linolenic Acid (ALA) 18:3w3
2. Eicosapentanoic Acid (EPA) 20:5w3
3. Docosahexaenoic Acid (DHA) 22:6w3
4. Linolenic Acid (LA) 18:3w3

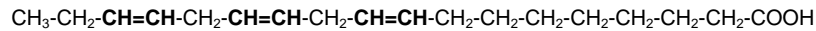
Alpha Linolenic Acid (ALA): ALA has a double bond at the third carbon position. Flaxseed capsules or flaxseed oil is a rich source

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of ALA. Dark green, leafy vegetables and certain vegetable oils also contain ALA. Walnuts are another source of ALA. Your body has the ability to convert ALA to EPA. ALA acts as an anti-inflammatory agent, prevents arterial wall damage, and boosts your immune system.

People with either diabetes or schizophrenia may lack the ability to convert ALA to EPA or DHA-- the forms that are readily utilized by the brain cells. Therefore, people with these conditions should also obtain omega-3s rich in EPA and DHA, in addition to foods that contain ALA.

Alpha-linolenic acid (ALA)



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

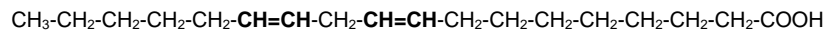
18:3n3; Eighteen-carbon backbone, **three** double bonds, and the first double bond in the third carbon position. Hence, the name, **omega-3**.

Eicosapentanoic Acid (EPA): The EPA is a major omega-3 fatty acid component of fish oil and the deep-sea fish-- salmon, mackerel, rainbow trout, and tuna. EPA, being an important part of the brain cell membrane, maintains the brain cell membrane's integrity.

Docosahexaenoic Acid (DHA): Another omega-3 DHA also an important component of fish or fish oil, maintains the integrity of the brain cell membrane. Since, the human body cannot produce DHA, it has to come from dietary sources.

Linoleic Acid (LA): The omega-6 essential fatty acid LA is found in most vegetable oils. According to experts, our current consumption of this fatty acid has doubled from what it was in 1940. Excess intake of omega-6s increases water retention, raises blood pressure, and augments blood clotting.

Linoleic acid



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

18:2n6; Eighteen-carbon backbone with **two** double bonds.

The first double bond is between the sixth and the seventh carbon positions. This is an **omega-6**.

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(**Oleic Acid (OA)** is an omega-9 fatty acid. It is the main fatty acid present in olive oil. Flaxseed contains a small percentage of oleic acid. Many other polyunsaturated fats also contain this fatty acid.)

Role of Omega-3 Fatty Acids

Omega-3 fatty acids are an important component of cell membranes and their phospholipids. Every cell membrane consists of two layers of phospholipids (Omega-3s and other lipids) and cholesterol. Between these two layers are proteins acting as receptors, transporters, and enzymes. The phospholipid composition determines the physical and functional properties of cell membranes and has critical implications for cell integrity, growth, immunity, and anti-inflammatory properties.

Polyunsaturated fatty acids (with twenty carbon atoms), found in the phospholipids of cell membranes, are precursors of **eicosanoids**. These eicosanoids include the prostaglandins, leukotrienes, thromboxanes, and prostacyclins that perform a number of key physiological functions: control of vascular tone, cell membrane permeability, blood pressure, chemotaxis, adhesion, leucocytes degranulation, immune system regulation, platelet aggregation, cell division, and cell differentiation. Eicosanoids also are involved in gastric acid production, gastrointestinal motility, renal blood flow, and salt excretion. In addition, they take part in neurotransmission regulation, neuromuscular activity, and control of body temperature at the brain level.

Benefits of Omega-3 Fatty Acids

Cardiovascular: Omega-3s lower blood cholesterol levels and reduce arterial damage by their anti-inflammatory action. In addition, they lower the LDL (bad) cholesterol level, increase the HDL (good) cholesterol, and decrease the platelet adhesiveness (that leads to clot formation). In the absence of polyunsaturated omega-3s, your body has use saturated fats in its cell membranes, resulting in less elastic membranes. This condition can have a negative effect on the heart muscle, by making it harder for the heart muscle to return to a resting

state (relaxed state). Cardiac arrhythmias, which can lead to sudden cardiac death, is less common among people who consume omega-3s on a regular basis. Omega-3s decrease the rate of plaque growth in the arterial lining.

Studies of heart attack survivors have found that daily omega-3 supplements dramatically reduce the risk of death, subsequent heart attacks, and strokes. Likewise, people who eat an ALA-rich diet are less likely to suffer a fatal heart attack.

Following a review of several long-term clinical trials, Oliver et al. concluded that omega-3-rich diet regimens consistently showed a decrease in cardiovascular disease incidence. These results were even better when compared to the results of other people who were on a strict low fat diet alone without omega-3 supplements.

High Blood Pressure: Large-scale studies have discovered that people who consume more omega-3s have lower blood pressure readings (as noted in the Greenland and Inuit Eskimos who consume plenty of oily, cold-water fish). Avoid certain fish sources (such as tuna) that are high in mercury, since mercury has been shown to increase blood pressure.

Stroke: Strong evidence from population-based studies suggests that omega-3s (primarily from fish) help protect against strokes caused by plaque buildup and blood clots in the arteries. In fact, eating at least two fish servings per week has been shown to reduce the risk of stroke by as much as 50%. Nevertheless, people who eat more than three grams of omega-3s per day (equivalent to 3 fish servings per day) may be at an increased risk for hemorrhagic stroke, a potentially fatal type of stroke in which a brain artery ruptures or leaks. However, the Alaskan Inuit Eskimos who consume as much of fourteen grams of omega-3s per day have not exhibited an increased hemorrhagic stroke incidence. Please note that a combination of high omega-3s and other blood thinners may increase bleeding risk, especially in the elderly population with weak, brittle arterial linings.

Neurological: If someone says you have a fat brain, they literally are speaking the truth because sixty percent of your brain contains fatty tissue. The brain cell membranes are rich in omega-3s. In fact, the omega-3s (especially the EPA & DHA) are believed to keep the brain's entire traffic pattern of thoughts, reactions, and reflexes running

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smoothly and efficiently. When the brain cells cannot get enough omega-3s, they have to use other fatty acids as part of their membranes, making both of them less functional. Adequate omega-3 intake reduces symptoms of depression, dementia, general anxiety, schizophrenia, and mood disorders. They also improve cognitive and behavioral functions.

Children: Omega-3s are vital for infant's health. Pregnant mothers, who do not consume enough omega-3s, increase the potential risk of vision and nerve problems in their unborn babies.

Immune System: Omega-3s seem to improve rheumatoid arthritis, diabetes mellitus, psoriasis symptoms, and increase the life span of people with autoimmune diseases--due to their anti-inflammatory properties. They also improve insulin sensitivity. The human body can convert EPA and DHA to natural anti-inflammatory substances called prostaglandins and leukotrienes that decrease inflammation and pain. People on high omega-3 diets have less joint stiffness, swelling, tenderness, and overall fatigue. Omega-3s also reduce the amount of pain medications needed by these patients.

Cancer: A recent study showed that participants who consumed fish oils as part of their diet produced fewer quantities of carcinogens, associated with colon cancer, than those who were on a regular diet. There is also increasing scientific evidence that omega-3s help maintain healthy breast tissue and prevent breast cancer.

The Mediterranean Diet: The Mediterranean diet consists of a healthy balance between omega-3s and omega-6s. Many studies have discovered that people who follow this diet are less likely to develop heart disease. The Mediterranean diet, which does not contain much meat (meat is high in omega-6s), does include whole grains, fresh fruits and vegetables, fish, olive oil, garlic, foods rich in omega-3s, and moderate wine consumption.

Diabetes: People with diabetes tend to have high triglycerides and low HDL levels. Since, omega-3s lower triglycerides and raise HDL, diabetic people may benefit from eating foods or taking supplements that contain EPA and DHA. However, ALA, an omega-3 found in flaxseed, may not provide the same benefit as the EPA or DHA, found in fish sources, because some diabetic people lack the ability to efficiently convert ALA to EPA or DHA.

Weight Loss: Omega-3s combined with low calories and low carbohydrates will improve insulin sensitivity and sugar control, aiding weight loss.

Osteoporosis: Omega-3s (such as EPA) increase the body and bone calcium level, leading to improved bone strength. People deficient in EPA suffer from bone loss. A three year study of women over sixty-five with osteoporosis, who received EPA and ALA supplements, demonstrated less bone loss and increased bone density than those who did not.

Eating Disorders: Men and women with anorexia nervosa have less than optimal levels of polyunsaturated fatty acids (including ALA and GLA). To prevent the complications associated with these essential fatty acid deficiencies, experts recommend that treatment programs for anorexia nervosa should include ample omega-3s in their diets.

Asthma: Omega-3 supplements (in the form of flaxseed) may improve lung function in adults with asthma, due to their anti-inflammatory properties. In contrast, omega-6s (found in most vegetable oils) tend to increase inflammation and worsen respiratory functions. In a small, well-designed study of twenty-nine children with asthma, those who took fish oil supplements (rich in EPA and DHA) for 10 months had improvement in their symptoms compared to those children who took a placebo pill (an inert or innocuous substance).

Inflammatory Bowel Disease (IBD): Omega-3s, when combined with the standard IBD medications like sulfasalazine or others, may reduce symptoms of Crohn's disease and ulcerative colitis (two types of IBD). More studies exploring these preliminary findings are under way. In animals, it appears that ALA works better than EPA and DHA at decreasing bowel inflammation. However, symptoms such as flatulence and diarrhea of IBD may also be related to fish oil consumption. Time-release preparations may help reduce these unwanted effects.

Burns: Essential fatty acids have been used to reduce inflammation and promote wound healing in burn victims. Omega-3s may promote a healthy balance of proteins in the body that is vital for healing following a burn.

Macular Degeneration: Several retrospective studies showed that people who regularly consumed omega-3s in the form of fish or fish oil capsules were less likely to have macular degeneration (a grave age-

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related eye condition that may lead to blindness) than those who did not consume fish on a regular basis. Another study revealed less muscular degeneration in those people who consumed fish (EPA and DHA) four or more times per week. On the other hand, the same study, noted that ALA (found in flaxseed) might increase the risk of macular degeneration.

Menstrual Pain: A Danish study showed that women with the highest dietary intake of omega-3s had the mildest symptoms during menstruation.

Colon Cancer: Consuming a significant amount of omega-3s appear to reduce the risk of colorectal cancer. Eskimos, for instance, who consume fish, rich omega-3s, have a lower colorectal cancer rate. Daily consumption of EPA and DHA also has been shown to slow or even reverse the colon cancer progression in people in the early stages of the disease.

Breast Cancer: Women who regularly consume omega-3 rich foods over many years may be less likely to develop breast cancer. In addition, people who eat omega-3 rich fish and brown-kelp seaweed (common in Japan) have been shown to have a significantly less fatality risk from breast cancer. The balance between omega-3s and omega-6s appears to play an important role in the development and growth of breast cancer. Several researchers hypothesize that omega-3s combined with other nutrients (namely: vitamin C, vitamin E, beta-carotene, selenium, and coenzyme Q10) may be important in treating and preventing breast cancer.

Prostrate Cancer: Omega-3s, specifically DHA and EPA, have been proved to inhibit prostate cancer growth in animal studies. Similarly, population based studies of men suggest that a low-fat diet combined with omega-3s from fish or fish oil can prevent prostate cancer development. As in breast cancer, the balance of omega-3s and omega-6s appears to be important in reducing prostate cancer rate. A recent study evaluating sixty-seven men with prostate cancer found that they had higher levels of ALA than men without prostate cancer. Hence, EPA and DHA are more beneficial in patients with prostate cancer than ALA. More research in this area is needed.

Lipids Levels: Cholesterol-lowering medications, atorvastatin, lovastatin, and simvastatin may be more effective when combined with

an adequate intake of omega-3s, and an Omega-6 to omega-3 ratio reduction.

Daily Recommended Dose of Omega-3 Fatty Acids:

There is no established, daily-recommended omega-3s allowance in our diet. However, a healthy diet containing a significant amount of omega-3 rich foods is a prudent choice. Experts believe that the omega-6 to omega-3 ratio in our diet should be 1:1. In reality, though, the average American diet has an omega-6 to omega-3 ratio in the range of 10:0 to 40:1. Don't fret it or give-up. Because you are reading this chapter, there is still plenty of hope for you. Since omega-6s are a major component of vegetable oils (canola, olive, sunflower etc) reducing their consumption while increasing omega-3 intake should help balance your fat ingestion.

Pregnant women need plenty of omega-3s to nourish the developing fetal brain. Omega-3s are also important for an infant's brain maturity.

If a pregnant woman's omega-3 intake is too low, the growing fetus will take all the available omega-3s from the mother's reserves, leading to possible depression in the mother.

The American Heart Association recommends that people with high triglycerides (blood fats) may benefit from a supplement of 2 to 4 grams of EPA and DHA (fish source) per day.

Evidence from prospective, secondary prevention studies suggests that taking EPA and DHA (0.5 to 1.8 g per day), either in fatty fish or supplemental form, can significantly reduce risk of death from heart disease, stroke, or other causes. Intake of 1.5 to 3 g of flaxseed (ALA) per day seems beneficial. People with high triglycerides, need two to four grams of omega-3s.

As mentioned earlier, the EPA and DHA works on your brain cell membranes and the nervous system while ALA works on maintaining arterial lining integrity. Therefore, we need to consume both types of omega-3s to get a maximum benefit.

Sources of Omega-3 Fatty Acids:

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Where do the omega-3s, EPA or DHA come from? Aside from fresh seaweed, most plant foods rarely contain EPA or DHA. Most oceanic fish--such as salmon, mackerel, or rainbow trout--get their omega-3s from feeding on seaweeds like algae. Then, these fish incorporate those omega-3s into their fatty tissue.

Increase your intake of fish or tuna that is rich in omega-3s. The American Heart Association recommends that people consume at least two servings of deep-sea fish per week.

Both, venison and buffalo are excellent animal sources of omega-3s for people craving red meat. If your supermarket does not carry these wild-game meats, you can purchase them through mail order sources.

Omega-3 fatty acid supplements: Consumption of two to three servings of deep-sea fatty fish per week provides three to four grams of omega-3s. Please refer to the omega-3 chart (on page ____) for details on other forms of fish that also can provide omega-3s.

Fish oil capsules are another good source of omega-3s for people who don't like fresh fish. Typically, a 1,000 mg fish oil capsule has 180 mg EPA and 120 mg DHA. Consumption of six fish oil capsules per day will give you approximately 1080 mg of EPA (Eicosapentanoic Acid) and 720mg of DHA (Docosahexaenoic Acid).

Flaxseeds are available in different forms. Ten grams of raw flaxseed (2 tsp) provides 2.28 g of ALA. You can get a pound of flaxseed for a couple of dollars (year 2003) from the whole food markets. You can use a teaspoon of flaxseeds in salads or cereals. You also can use a coffee grinder to grind the flaxseeds to a fine powder and then mix them with prepared foods. Grind just the amount you need, at any given time. Keep the seeds in a refrigerator to prolong its shelf life.

One gram of flaxseed capsule contains 1000mg of ALA, linolenic acid, and oleic acid. Take at least two to four flaxseed capsules per day.

Flaxseed oil can be purchased from nutritional or health food markets. Look for flaxseed oil rich in lignan. Please note that flaxseed oil is not suitable for cooking or seasoning, since heating will destroy its nutritional value. However, you can add flaxseed oil to cereals, salads, or already prepared foods.

Flaxseed oil turns rancid very quickly. Once opened, it can stay fresh up to a week or so in the fridge and must be kept away from light,

heat, and air. Commercial processing also destroys the flaxseed oil. Always buy *fresh cold pressed*. Finally, please note that pesticides often gather in fats and oils, so buy ORGANIC products whenever possible.

Other omega-3 sources include walnuts, and pumpkin. An ounce of walnuts supplies about 2 grams of plant-based omega-3, slightly more than that is found in 3 ounces of salmon. However, other nuts such as peanuts, cashews, or sunflower seeds, have a higher content of omega-6s (polyunsaturated fatty acids) that can add extra calories. Therefore, look for products with the highest amount of omega-3s, and the least amount of omega-6s per ounce.

Omega-3s Enriched Foods: One example of omega-3 enriched foods in the US is the enriched eggs. Since, omega-3 enriched eggs cost two to three times more than regular eggs, the best choice would be to get your omega-3s from the supplements mentioned above.

Precaution: Because omega-3s reduce platelet stickiness, omega-3s can enhance bleeding problems, especially in patients on blood thinners such as aspirin, Coumadin, and/or antiplatelet agents.

If you are taking more than three grams of omega-3 supplements along with blood thinners, you should do so only under a physician's supervision.

Certain fish (especially the older, larger, predatory fish) and marine mammals may contain high levels of mercury, PCBs (polychlorinated biphenyls), dioxins, and other environmental contaminants. Eating a variety of fish will help to minimize any potentially adverse effects from these pollutants.

From a caloric viewpoint, all oils are equal opportunity-fattening agents. Each teaspoon of oil contains 120 calories.

Fish oil, although beneficial, does have some unwanted side effects. For one, fish oils can cause flatulence and diarrhea. Time-release preparations may help reduce these side effects. The capsules also may leave an odd taste in your mouth, especially if they have been stored at room temperature over a long time. Keeping the fish oil capsules in a refrigerator may minimize this effect.

Recommended readings:

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AHA Scientific Statement: Fish Consumption, Fish Oil, omega-3s and Cardiovascular Disease, #71-0241 *Circulation*. 2002; 106: 2747-2757

AHA Scientific Statement: AHA Dietary Guidelines: Revision 2000, #71-0193 *Circulation*. 2000; 102:2284-2299; *Stroke*. 2000; 31:2751-2766

The Health Effects of Polyunsaturated Fatty Acids in Seafoods, Edited by Artemis P. Simopoulos, Robert R. Kifer, and Roy E. Martin, and published by Academic Press, Inc. in 1986.

Oliver MF et al. It is more important to increase the intake of unsaturated fats than to decrease the intake of saturated fats: evidence from clinical trials relating to ischemic heart disease. *Am J Clin Nutr* 1997 Oct; 66(4 Suppl): 980S-986S

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Omega-3 Contents of Various Foods

Deep sea fish 100g	O-6	O-3-g	LNA	EPA	DHA
Mackerel	1.1	2.2 g	0.1	0.9	1.6
Herrings	0.6	1.7g	0.1	1.0	0.7
Sardines		1.7g			
Bluefin tuna		1.7g	--	0.4	1.2
Trout		1.7g			
Salmon (Atlantic)	0.7	1.4g	0.2	0.3	0.9
Anchovies		1.4g			
Bluefish	0.4	1.3g	--	0.4	0.8
Halibut	0.5	0.9g	Tr	0.5	0.4
Rainbow trout		0.8g			
Bass stripped	--	0.8g	Tr	0.2	0.6
Shrimp	0.2	0.4g	Tr	0.2	0.1
Catfish	0.7	-	Tr	0.1	0.2
Sturgeon (Atlantic)	0.6	-	Tr	1.0	0.5
Conch	0.1	-	Tr	0.6	0.4

Oils 100g

flaxseed oil		15 g	58 g	-
Walnut oil		58 g	11.5 g	-
Canola oil		20 g	7.0 g	11.2
Soy bean oil		51 g	7.0 g	-
Hazelnut		4	Tr	-
Cashew		8	Tr	-
Butter		1.8	1.2	-

Seeds 100g

Flaxseeds		6	15-25	-
Pumpkin seeds		20 g	7-10	-
Sunflower seeds		30 g	Tr	-
Walnuts		34.2	3.3	-
Soybean kernels		11.2	1.5	-

O-6=Omega-6s, O-3=Omega-3s, g=grams, Tr= trace, LNA, EPA, DHA,