omega-3 fatty acids

What can high-omega-3 foods do for you?

- Reduce inflammation throughout your body
- Keep your blood from clotting excessively
- Maintain the fluidity of your cell membranes
- Lower the amount of lipids (fats such as cholesterol and triglycerides) circulating in the bloodstream
- Decrease platelet aggregation, preventing excessive blood clotting
- Inhibit thickening of the arteries by decreasing endothelial cells' production of a platelet-derived growth factor (the lining of the arteries is composed of endothelial cells)
- Increase the activity of another chemical derived from endothelial cells (endothelium-derived nitric oxide), which causes arteries to relax and dilate
- Reduce the production of messenger chemicals called cytokines, which are involved in the inflammatory response associated with atherosclerosis
- Reduce the risk of becoming obese and improve the body's ability to respond to insulin by stimulating the secretion of leptin, a hormone that helps regulate food intake, body weight and metabolism, and is expressed primarily by adipocytes (fat cells)
- Help prevent cancer cell growth

What conditions or symptoms indicate a need for more high-omega-3 foods?

- Depression
- Cardiovascular Disease
- Type 2 Diabetes
- Fatigue
- Dry, itchy skin
- Brittle hair and nails
- Inability to concentrate
- Joint pain

Salmon, flax seeds and walnuts are excellent food sources of omega-3 fatty acids.

Research indicates that omega-3s may be better absorbed from food than supplements. Norwegian researchers compared 71 volunteers' absorption of omega-3s (EPA and DHA) from salmon, smoked salmon, cod (14 ounces of fish per week) or cod liver oil (3 teaspoons per day). Cooked salmon provided 1.2 grams of omega-3s daily, while cod liver oil provided more than twice as much: 3 grams of omega-3s per day.

Despite the fact that the salmon group got less than half the amount of omega-3s as the cod liver oil group, blood levels of omega-3s increased quite a bit more in those eating salmon than those taking cod liver oil. After 8 weeks, EPA levels had risen 129% and DHA rose 45% in those eating cooked salmon compared to 106% and 25%, respectively, in those taking cod liver oil.

In the group eating smoked salmon, blood levels of omega-3s rose about one-third less than in the salmon group. In those eating cod, the rise in omega-3s was very small.

Concurrent with the rise in omega-3s in those eating salmon, a drop was seen in blood levels...
of a number of pro-inflammatory chemicals (TNFalpha, IL-8, leukotriene B4, and thromboxane B2). Researchers think omega-3s may be better absorbed from fish because fish contains these fats in the form of triglycerides, while the omega-3s in almost all refined fish oils are in the ethyl ester form. Once absorbed, omega-3s are converted by the body from their triglyceride to ester forms as needed. Lipids. 2006 Dec;41(12):1109-14.

<table>
<thead>
<tr>
<th>World’s Healthiest Foods rich in Omega 3 Fatty Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Flaxseeds</td>
</tr>
<tr>
<td>Walnuts</td>
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<tr>
<td>Salmon, chinook</td>
</tr>
<tr>
<td>Sardines</td>
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<tr>
<td>Soybeans, cooked</td>
</tr>
<tr>
<td>Halibut, baked/broiled</td>
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<tr>
<td>Shrimp, steamed/boiled</td>
</tr>
<tr>
<td>Tofu, raw</td>
</tr>
<tr>
<td>Snapper, baked/broiled</td>
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<tr>
<td>Scallops, baked/broiled</td>
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</tbody>
</table>

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**Description**

**What are omega-3 fatty acids?**

You've probably been hearing about omega-3 fatty acids in recent years. The reason? A growing body of scientific research indicates that these healthy fats help prevent a wide range of medical problems, including cardiovascular disease, depression, asthma, and rheumatoid arthritis.

Unlike the saturated fats found in butter and lard, omega-3 fatty acids are polyunsaturated. In chemistry class, the terms "saturated" and "polyunsaturated" refer to the number of hydrogen atoms that are attached to the carbon chain of the fatty acid. In the kitchen, these terms take on a far more practical meaning.

Polyunsaturated fats, unlike saturated fats, are liquid at room temperature and remain liquid when refrigerated or frozen. Monounsaturated fats, found in olive oil, are liquid at room temperature, but harden when refrigerated. When eaten in appropriate amounts, each type of fat can contribute to health. However, the importance of omega-3 fatty acids in health promotion and disease prevention cannot be overstated.

The three most nutritionally important omega-3 fatty acids are alpha-linolenic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

Alpha-linolenic acid is one of two fatty acids traditionally classified as "essential." The other fatty acid traditionally viewed as essential is an omega 6 fat called linoleic acid. These fatty acids have traditionally been classified as "essential" because the body is unable to manufacture them on its own and because they play a fundamental role in several
physiological functions. As a result, we must be sure our diet contains sufficient amounts of both alpha-linolenic acid and linoleic acid.

Dietary sources of alpha-linolenic acid include flaxseeds, walnuts, hemp seeds, soybeans and some dark green leafy vegetables. Linoleic acid is found in high concentrations in corn oil, safflower oil, sunflower oil, and canola oil. Most people consume a much higher amount of linoleic acid than alpha-linolenic acid, which has important health consequences. For more information on the proper ratio of these fatty acids in the diet, see our FAQ entitled, A New Way of Looking at Proteins, Fats, and Carbohydrates

The body converts alpha-linolenic acid into two important omega-3 fats, eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA). These fats can also be derived directly from certain foods, most notably cold-water fish including salmon, tuna, halibut, and herring. In addition, certain types of algae contain DHA. EPA is believed to play a role in the prevention of cardiovascular disease, while DHA is the necessary for proper brain and nerve development.

How it Functions

What are the functions of omega-3 fatty acids?

Every cell in our body is surrounded by a cell membrane composed mainly of fatty acids. The cell membrane allows the proper amounts of necessary nutrients to enter the cell, and ensures that waste products are quickly removed from the cell.

Promoting Healthy Cell Membranes

To perform these functions optimally, however, the cell membrane must maintain its integrity and fluidity. Cells without a healthy membrane lose their ability to hold water and vital nutrients. They also lose their ability to communicate with other cells. Researchers believe that loss of cell to cell communication is one of the physiological events that leads to growth of cancerous tumors.

Because cell membranes are made up of fat, the integrity and fluidity of our cell membranes is determined in large part by the type of fat we eat. Remember that saturated fats are solid at room temperature, while omega-3 fats are liquid at room temperature. Researchers believe that diets containing large amounts of saturated or hydrogenated fats produce cell membranes that are hard and lack fluidity. On the other hand, diets rich in omega-3 fats produce cell membranes with a high degree of fluidity.

In addition, recent in vitro (test tube) evidence suggests when omega-3 fatty acids are incorporated into cell membranes they may help to protect against cancer, notably of the breast. They are suggested to promote breast cancer cell apoptosis via several mechanisms including: inhibiting a pro-inflammatory enzyme called cyclooxygenase 2 (COX 2), which promotes breast cancer; activating a type of receptor in cell membranes called peroxisome proliferator-activated receptor (PPAR)-α, which can shut down proliferative activity in a variety of cells including breast cells; and, increasing the expression of BRCA1 and BRCA2, tumor suppressor genes that, when functioning normally, help repair damage to DNA, thus helping to prevent cancer development.

Animal and test tube studies published in the November 2005 issue of the International Journal of Cancer suggest yet another way in which the omega-3 fatty acids found in cold water fish-docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)-help protect against breast cancer development.

All dietary fatty acids are incorporated into cell membranes, and the type of fatty acids dictates how a cell responds and grows. Researchers found that omega-3 fatty acids affect cell growth by activating an enzyme called sphingomyelinase, which then generates the release of ceramide, a compound that induces the expression of the human tumor suppressor gene.
gene p21, which ultimately causes cancer cell death.

In the animal experiments, mice were fed diets rich in either omega-3 (fish oil) or omega-6 (corn oil) fatty acids after which breast cancer cells were implanted. Three weeks later, tumor volume and weight was significantly lower in mice on the omega-3 rich diet. In the lab culture experiments, when cells were treated with DHA or EPA, sphingomyelinase activity increased by 30-40%, and breast cancer cell growth dropped 20-25%.

**Prostaglandin Production**

Omega-3 fats also play an important role in the production of powerful hormone-like substances called prostaglandins. Prostaglandins help regulate many important physiological functions including blood pressure, blood clotting, nerve transmission, the inflammatory and allergic responses, the functions of the kidneys and gastrointestinal tract, and the production of other hormones.

In essence, all prostaglandins perform essential physiological functions. However, depending on the type of fat in the diet, certain types of prostaglandins may be produced in large quantities, while others may not be produced at all. This can set up an imbalance throughout the body that can lead to disease.

For example, EPA and DHA serve as direct precursors for series 3 prostaglandins, which have been called "good" or "beneficial" because they reduce platelet aggregation, reduce inflammation and improve blood flow. The role of EPA and DHA in the prevention of cardiovascular disease can be explained in large part by the ability of these fats to increase the production of favorable prostaglandins.

The omega 6 fats serve as precursors for series 1 and series 2 prostaglandins. Like the series 3 prostaglandins produced from omega-3 fats, series 1 prostaglandins are believed to be beneficial. On the other hand, series 2 prostaglandins are usually considered to be "bad" or "unhealthy," since these prostaglandins promote an inflammatory response and increase platelet aggregation. As a result, it is important to ensure proper balance of omega-3 and omega-6 fats in the diet.

**EPA Directly Anti-Inflammatory**

A recently identified lipid (fat) product our bodies make from EPA, called resolvins, helps explain how this omega-3 fat provides anti-inflammatory effects on our joints and improves blood flow.

Resolvins, which have been shown to reduce inflammation in animal studies, are made from EPA by our cellular enzymes, and work by inhibiting the production and regulating the migration of inflammatory cells and chemicals to sites of inflammation. Unlike anti-inflammatory drugs, such as aspirin, ibuprofen and the COX-2 inhibitors, the resolvins our bodies produce from EPA do not have negative side effects on our gastrointestinal or cardiovascular systems.

**Deficiency Symptoms**

**What are deficiency symptoms for omega-3 fatty acids?**

Recent statistics indicate that nearly 99% of people in the United States do not eat enough omega 3 fatty acids. However, the symptoms of omega-3 fatty acid deficiency are very vague, and can often be attributed to some other health conditions or nutrient deficiencies.

Consequently, few people (or their physicians, for that matter) realize that they are not consuming enough omega-3 fatty acids. The symptoms of omega-3 fatty acid deficiency include fatigue, dry and/or itchy skin, brittle hair and nails, constipation, frequent colds, depression, poor concentration, lack of physical endurance, and/or joint pain.
Toxicity Symptoms

What are toxicity symptoms for omega 3 fatty acids?

In its 2002 guidelines for omega-3 fatty acid intake, the Institute of Medicine at the National Academy of Sciences declined to establish a Tolerable Upper Intake Level (UL) for omega-3s. However, research was cited showing increased risk of bleeding and hemorrhagic stroke in a few studies following supplementation with omega-3s. Individuals who have disorders involving bleeding, who bruise very easily, or who are taking blood thinners should consult with a medical practitioner before taking supplemental omega-3 fatty acids.

Impact of Cooking, Storage and Processing

How do cooking, storage, or processing affect omega-3 fatty acids?

Polyunsaturated oils, including the omega-3 fats, are extremely susceptible to damage from heat, light, and oxygen. When exposed to these elements for too long, the fatty acids in the oil become oxidized, a scientific term that simply means that the oil becomes rancid.

Rancidity not only alters the flavor and smell of the oil, but it also diminishes the nutritional value. More importantly, the oxidation of fatty acids produces free radicals, which are believed to play a role in the development of cancer and other degenerative diseases.

Under most circumstances, the problem of rancidity only arises when the oils are removed from their natural food package. For example, the hard shell of the flaxseed protects the oil inside the seed from heat, light, and oxygen. Flaxseeds also contain antioxidant compounds, such as vitamin E, that provide additional protection against oxidation. But, when the seed is pressed to isolate the oil, the oil becomes vulnerable to the elements.

As a result, oils rich in polyunsaturated fatty acids should be stored in dark glass, tightly closed containers in the refrigerator or freezer. In addition, these oils should never be heated on the stove. So, instead of sautéing your vegetables in flaxseed or walnut oil, make a salad dressing using these oils.

Although less a problem with whole foods than processed oils, some foods containing omega-3 fatty acids appear to lose some of their health benefits (like heart protection) when the foods are fried. Fried fish is a good example in this area, since fried fish containing omega-3s have been shown to provide less heart protection than baked or broiled fish containing the same amount of omega-3s.

Factors that Affect Function

What factors might contribute to a deficiency of omega-3 fatty acids?

The conversion of alpha-linolenic acid to EPA and DHA involves a series of chemical reactions. One of the first reactions in this series is catalyzed by the enzyme delta-6 desaturase. Further down the line is a reaction that is catalyzed by the enzyme delta-5 desaturase. Unfortunately, it is now well-known that these enzymes do not function optimally in many people, and, consequently, only a small amount of the alpha-linolenic acid consumed in the diet is converted to EPA, DHA, and ultimately to the anti-inflammatory prostaglandins.

To increase the activity of your desaturase enzymes, be sure that your diet includes a sufficient amount of vitamin B6, vitamin B3, vitamin C, magnesium and zinc. In addition, limit your intake of saturated fat and partially hydrogenated fat, as these fats are known to decrease the activity of delta-6 desaturase. Also, to be on the safe side, consider including a direct source of EPA and DHA if your diet, such as wild-caught salmon, halibut, or tuna.

Drug-Nutrient Interactions
What medications affect omega-3 fatty acids?

Fish oil supplements containing high amounts of omega-3 fatty acids have been shown to reduce high blood pressure in people taking cyclosporine, an immunosuppressive drug used to prevent rejection of transplanted organs.

In addition, a high dietary intake of omega-3 fats, especially from fish, may decrease blood pressure and thin the blood. People taking prescription blood pressure medications and/or anticoagulants should consult with their physician before taking fish oil supplements.

Nutrient Interactions

How do other nutrients interact with omega-3 fatty acids?

Vitamin E, the primary fat-soluble antioxidant, protects omega-3 fats from oxidation. Oxidation is a chemical process that produces free radicals.

Health Conditions

What health conditions require special emphasis on omega-3 fatty acids?

Omega-3 fatty acids may play a role in the prevention and/or treatment of the following health conditions:

- Alzheimer's disease
- Asthma
- Attention deficit hyperactivity disorder (ADHD)
- Bipolar disorder
- Cancer
- Cardiovascular disease
- Depression
- Diabetes
- Eczema
- High blood pressure
- Huntington's disease
- Lupus
- Migraine headaches
- Multiple sclerosis
- Obesity
- Osteoarthritis
- Osteoporosis
- Psoriasis
- Rheumatoid arthritis

Form in Dietary Supplements

What forms of omega-3 fatty acids are found in dietary supplements?

In supplemental form, omega-3 fatty acids are available as softgels (like a vitamin E capsule) or as bottled liquids. Flaxseed oil, a rich source of alpha-linolenic acid, and cod liver oil, a rich source of EPA and DHA, are among the most popular omega-3 supplements.

When purchasing an omega-3 fatty acid supplement, remember that these oils are highly sensitive to damage from heat, light and oxygen. Choose a certified organic product that has been refrigerated and is packaged in a dark brown or green glass jar and be sure to store the product in your refrigerator or freezer.

It is also advisable to choose a supplement that contains vitamin E. Vitamin E is a powerful
antioxidant, which is added to the oil to prevent the fatty acids from becoming oxidized (or rancid).

**Food Sources**

**Introduction to Nutrient Rating System Chart**

The following chart shows the World's Healthiest Foods that are either excellent, very good or good sources of this nutrient. Next to each food name you will find the following information: the serving size of the food; the number of calories in one serving; DV% (percent daily value) of the nutrient contained in one serving (similar to other information presented in the website, this DV is calculated for 25-50 year old healthy woman); the nutrient density rating; and the food's World's Healthiest Foods Rating. Underneath the chart is a table that summarizes how the ratings were devised. Read detailed information on our Nutrient Rating System.

**Introduction to Nutrient Rating System Chart**

In order to better help you identify foods that feature a high concentration of nutrients for the calories they contain, we created a Food Rating System. This system allows us to highlight the foods that are especially rich in particular nutrients. The following chart shows the World's Healthiest Foods that are either an excellent, very good, or good source of omega 3 fatty acids. Next to each food name, you'll find the serving size we used to calculate the food's nutrient composition, the calories contained in the serving, the amount of omega 3 fatty acids contained in one serving size of the food, the percent Daily Value (DV%) that this amount represents, the nutrient density that we calculated for this food and nutrient, and the rating we established in our rating system. For most of our nutrient ratings, we adopted the government standards for food labeling that are found in the U.S. Food and Drug Administration's "Reference Values for Nutrition Labeling." Read more background information and details of our rating system.

**World's Healthiest Foods ranked as quality sources of:**

**omega 3 fatty acids**

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving Size</th>
<th>Cals</th>
<th>Amount (g)</th>
<th>DV (%)</th>
<th>Nutrient Density</th>
<th>World's Healthiest Foods Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flaxseeds</td>
<td>2 tbs</td>
<td>95.3</td>
<td>3.51</td>
<td>146.3</td>
<td>27.6</td>
<td>excellent</td>
</tr>
<tr>
<td>Cloves, dried, ground</td>
<td>2 tsp</td>
<td>14.2</td>
<td>0.20</td>
<td>8.3</td>
<td>10.6</td>
<td>very good</td>
</tr>
<tr>
<td>Walnuts</td>
<td>0.25 cup</td>
<td>163.5</td>
<td>2.27</td>
<td>94.6</td>
<td>10.4</td>
<td>excellent</td>
</tr>
<tr>
<td>Oregano, dried, ground</td>
<td>2 tsp</td>
<td>9.2</td>
<td>0.12</td>
<td>5.0</td>
<td>9.8</td>
<td>very good</td>
</tr>
<tr>
<td>Salmon, chinook, baked/broiled</td>
<td>4 oz-wt</td>
<td>261.9</td>
<td>2.09</td>
<td>87.1</td>
<td>6.0</td>
<td>excellent</td>
</tr>
<tr>
<td>Cauliflower, boiled</td>
<td>1 cup</td>
<td>28.5</td>
<td>0.21</td>
<td>8.8</td>
<td>5.5</td>
<td>very good</td>
</tr>
<tr>
<td>Sardines</td>
<td>3.25 oz can</td>
<td>191.4</td>
<td>1.36</td>
<td>56.7</td>
<td>5.3</td>
<td>very good</td>
</tr>
<tr>
<td>Mustard seeds</td>
<td>2 tsp</td>
<td>35.0</td>
<td>0.20</td>
<td>8.3</td>
<td>4.3</td>
<td>very good</td>
</tr>
<tr>
<td>Cabbage, shredded, boiled</td>
<td>1 cup</td>
<td>33.0</td>
<td>0.17</td>
<td>7.1</td>
<td>3.9</td>
<td>very good</td>
</tr>
<tr>
<td>Romaine lettuce</td>
<td>2 cup</td>
<td>15.7</td>
<td>0.08</td>
<td>3.3</td>
<td>3.8</td>
<td>good</td>
</tr>
<tr>
<td>Broccoli, steamed</td>
<td>1 cup</td>
<td>43.7</td>
<td>0.20</td>
<td>8.3</td>
<td>3.4</td>
<td>very good</td>
</tr>
<tr>
<td>Brussel sprouts, boiled</td>
<td>1 cup</td>
<td>60.8</td>
<td>0.26</td>
<td>10.8</td>
<td>3.2</td>
<td>good</td>
</tr>
<tr>
<td>Winter squash, baked, cubes</td>
<td>1 cup</td>
<td>80.0</td>
<td>0.34</td>
<td>14.2</td>
<td>3.2</td>
<td>good</td>
</tr>
</tbody>
</table>
**Public Health Recommendations**

What are current public health recommendations for omega-3 fatty acids?

In 2002, the Institute of Medicine at the National Academy of Sciences issued Adequate Intake (AI) levels for linolenic acid, the initial building block for all omega-3 fatty acids found in the body. For male teenagers and adult men, 1.6 grams per day were recommended. For female teenagers and adult women, the recommended amount was 1.1 grams per day. These guidelines do not seem as well-matched to the existing health research on omega-3 fatty acids as guidelines issued by the Workshop on the Essentiality of and Recommended Dietary Intakes (RDI) for Omega-6 and Omega-3 Fatty Acids in 1999 sponsored by the National Institutes of Health (NIH). This panel of experts recommended that people consume at least 2% of their total daily calories as omega-3 fats. To meet this recommendation, a person consuming 2000 calories per day should eat sufficient omega-3-rich foods to provide at least 4 grams of omega-3 fatty acids.

This goal can be easily met by adding just two foods to your diet: flaxseeds and wild-caught salmon. Two tablespoons of flaxseeds contain 3.5 grams of omega-3 fats, while a 4 ounce piece of salmon contains 1.5 grams of omega 3 fats. There's research evidence showing that two servings of non-fried fish per week-especially salmon, tuna, and halibut-can be enough to significantly increase the level of omega-3 fatty acids in your blood (including the level of both EPA and DHA).

Vegans and vegetarians relying on ALA as their only source of omega-3 fatty acids should increase their consumption of ALA-rich foods accordingly to ensure sufficient production its
important derivatives, EPA and DHA.

References

