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Omega-3 Fatty Acids from Walnuts

By Diane L. McKay, PhD and Donna Sibley, RD

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Learning Objectives

At the conclusion of this course, the student will be able to:

1. Identify the different types of fatty acids.
2. Distinguish between marine and plant sources of omega-3 fatty acids.
3. Explain the health benefits of omega-3 fatty acids.
4. State the recommendations for consuming omega-3 fatty acids.
5. Discuss key studies demonstrating the effects of omega-3 fatty acids on cardiovascular disease prevention.
6. Describe the health benefits of nut consumption.
7. Compare the nutrient composition of walnuts with other nuts.
8. Discuss the effects of walnuts on cardiovascular risk factors.
9. List recommendations for incorporating walnuts as a source of omega-3 fatty acids into the diet.

This course for health professionals, outlines the health benefits of omega-3 fatty acids in general, walnuts in particular, and discusses recommendations for relaying this information to patients, clients, and the public.

Most consumers are aware that too much fat in their diet can be detrimental to their health. However, many do not understand that certain types of dietary fat, particularly polyunsaturated omega-3 fatty acids, can be beneficial.

In recent years, the number of studies describing the health-promoting benefits of omega-3 fatty acids has increased substantially. Some of the reported activities attributed to the omega-3 fatty acids include improving serum cholesterol profiles, stabilizing arrhythmias, reducing inflammation, regulating endothelial cell function, improving insulin sensitivity in patients with Type 2 diabetes, and enhancing the immune response.

Evidence-based reviews of the scientific data linking the intake of omega-3 fatty acids to specific health benefits have prompted several government agencies and professional organizations, including the US Department of Agriculture (USDA), the US Food and Drug Administration (FDA), the Institute of Medicine (IOM) of the National Academy of Sciences (NAS), and the American Heart Association (AHA), to recommend increasing omega-3 and other healthy fats in the diet, while limiting the intake of foods high in harmful saturated fat and *trans* fatty acids. For example, one of the key messages contained in the 2005 USDA Dietary Guidelines for Americans, and the accompanying "MyPyramid Plan," states that consumers should strive to "keep total fat intake between 20 to 35 percent of calories, with most fats coming from sources of polyunsaturated and monounsaturated fatty acids, such as fish, nuts, and vegetable oils." Among these foods, fatty fish, walnuts, flaxseeds, canola oil, and soybean oil are the richest sources of omega 3 fatty acids in the American diet today.

Unfortunately, most adults in the US do not consume enough omega-3 fatty acids in their diet to reap the health benefits. Part of the reason for the inadequate intake of these fatty acids is a lack of knowledge on the part of consumers. Another major factor is individual dietary tastes and preferences. Due to the high levels of omega-3 fatty acids found in fatty fish, the popular media and many health professionals emphasize increasing marine food sources to enhance their intake. Fatty fish, such as salmon, herring, sardines, mackerel, and fresh tuna, or supplements containing fish oils are typically recommended. However, a large percentage of the population is apparently unwilling or unable to incorporate fish into their diets in sufficient amounts, or take fish-oil supplements on a regular basis. For many consumers, adding plant-based sources of omega-3 fatty acids, including walnuts, flaxseed, and canola oil, can be a more pleasant and feasible way to increase their intake. For those who do eat fatty fish on occasion, plant sources can provide a consistent daily dose of omega-3 fatty acids, and perhaps eliminate the need for supplements.

As with fish, the challenge is to find convenient, pleasant and familiar ways to add or increase plant sources of omega-3 fatty acids in the average American diet. Walnuts, the only tree nut that contains significant amounts of omega 3 fatty acids, are particularly attractive because they can be added to a variety of familiar foods, such as cereals, salads, baked goods and desserts, or they can be eaten by themselves as snacks.

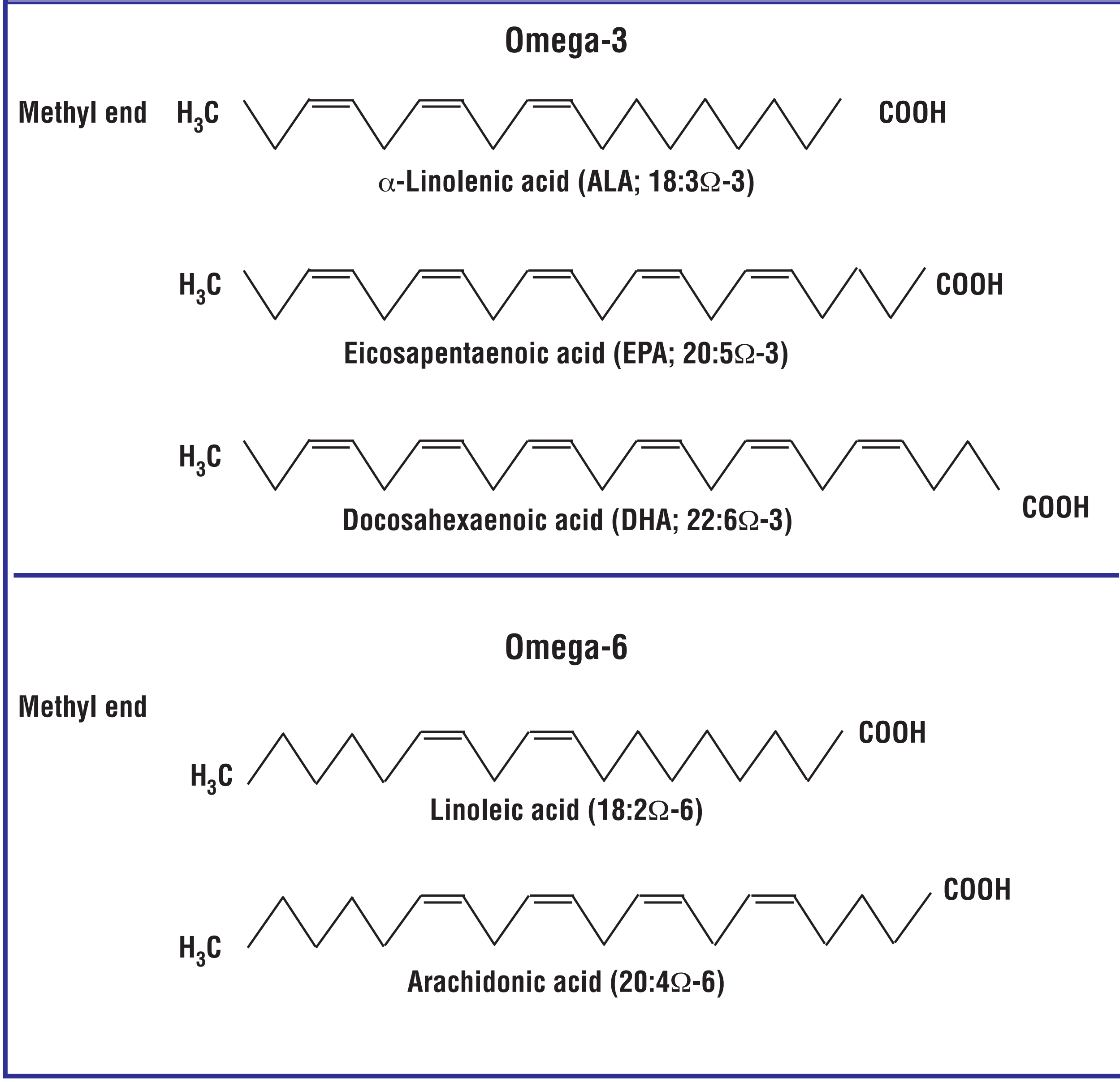
Terminology

A basic knowledge of the terminology and biochemistry of fatty acids is necessary in order to explain their importance to patients and clients.

Dietary fat, typically composed of a mixture of different fatty acids, is categorized according to the predominant type of fatty acid present. Fatty acids consist of a carbon and hydrogen chain with a methyl group at one end (CH_3) and a carboxyl group at the other end (COOH). The methyl end is also known as the omega end, while the carboxyl end is known as the delta end. Fatty acids are categorized by the number of double bonds present between the carbon atoms in their carbon chain. A fatty acid can be "saturated" (*i.e.*, it contains no double bonds between the carbon atoms and is, therefore, "saturated" with hydrogen atoms), "monounsaturated" (*i.e.*, contains one double bond), or "polyunsaturated" (*i.e.*, contains more than one double bond). The presence of double bonds directs most of the biologic activity of the molecule.

Polyunsaturated fatty acids (PUFA) can be further divided into omega-3 and omega-6 fatty acids based on the location of the first double-bond in the carbon chain, measured from the omega end, and further denoted by the total number of carbon atoms and double bonds in the chain. The first number represents the number of carbon atoms in the chain, the second number represents the number of double bonds, and the third number represents how far the first double bond is located from the omega (methyl) end. Diagrams of omega-3 and omega-6 PUFA structures are shown on the following page.

Omega-3 and Omega-6 Polyunsaturated Fatty Acids



Certain omega-3 and omega-6 PUFA are considered to be essential fatty acids because they are not manufactured by the human body, and must, therefore, be obtained through the diet. Alpha-linolenic acid (ALA), an omega-3 fatty acid, and linoleic acid (LA), an omega-6 fatty acid, are the predominant essential fatty acids in humans. ALA is the precursor or "parent" to two important long-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Significant plant sources of ALA include walnuts, flaxseed, flaxseed oil, canola oil, and soybean oil (see chart on the following page); EPA and DHA are found predominantly in fatty fish. LA is found in unmodified vegetable oils such as corn, safflower, cottonseed, sesame, and sunflower seed oils.

Top Plant Sources of Alpha-Linolenic Acid (ALA)

Whole foods	ALA (gm/100 gm raw material)	ALA (gm/serving)
Flaxseeds	22.81	2.35 gm/tbsp
Walnuts, English	9.08	2.57 gm/oz
Soybeans*	1.33	2.47 gm/cup
Pecans	0.99	0.28 gm/oz
Wheat germ	0.72	0.21 gm/ 1/4 cup
Oils	**ALA (gm/100 gm raw material)**	**ALA (gm/serving)**
Flaxseeds	53.30	7.25 gm/tbsp
Walnut oil	10.40	1.41 gm/tbsp
Canola oil	9.30	1.30 gm/tbsp
Soybean oil	6.80	0.93 gm/tbsp
Corn oil	1.16	0.16 gm/tbsp
Olive oil	0.76	0.10 gm/tbsp

*mature seeds, raw

When ALA and LA are metabolized, they interact with certain enzymes and are transformed in two ways. First, they become desaturated by losing hydrogen atoms, thereby increasing the number of double bonds they contain. Second, these fatty acids can become longer by having more carbon atoms added to the chain. These reactions enable ALA to be converted into EPA and DHA. These long-chain fatty acids eventually form chemical messengers known as eicosanoids. The table below shows how ALA and LA are desaturated and elongated to form longer-chain fatty acids and produce eicosanoids.

Eicosanoid Production

Omega-6 Family	Omega-3 Family
Linoleic Acid (found in vegetable oils, seeds & nuts) C18:2 Ω-6	Alpha-Linolenic Acid (found in flaxseeds, walnuts, soybeans, and some vegetable oils) C18:3 Ω-3
Gamma-Linolenic Acid (found in meat) C20:4 Ω-6	Eicosapentaenoic Acid (found in fish oil) C20:5 Ω-3
Arachidonic Acid (found in meat) C20:4 Ω-6	Docosahexaenoic Acid (found in fish oil) C22:6 Ω-3
Omega-6 derived Eicosanoids	**Omega-3 derived Eicosanoids**

Role of eicosanoids

The eicosanoids play a critical role in immune and inflammatory responses. Eicosanoids, like hormones, exert specific physiological effects on target cells. However, eicosanoids are different from most hormones in that they react near their sites of synthesis where they are catabolized rapidly. Thus, eicosanoids are considered to be locally acting hormones. Omega-3-derived eicosanoids are considered beneficial, compared to omega-6-derived eicosanoids, which may be harmful in certain circumstances.

While some studies have suggested that the conversion of the omega-3 fatty acid ALA to the longer-chain fatty acids, EPA and DHA, could be below 10 percent in humans, it is generally thought that this conversion may depend on available levels of LA, since ALA and LA are competitive substrates for the same enzyme. This suggests a potentially wide variation in the rate of conversion. Vegetable oils, high in the omega-6 PUFA LA, are often recommended as a substitute for saturated fats; however, high levels may also impede the conversion of ALA to EPA and DHA.

The ratio of omega-6 to omega-3 fatty acids in the typical American diet is about 10:1 (Kris-Etherton, *et al*., 2000; Moshfegh, *et al*., 2005). In order to increase the conversion rate of ALA to EPA and DHA, some research scientists suggest a ratio closer to 3:1 or 2:1 (Masters, 1996; Simopoulos, *et al*., 1999; Simopoulos, 2008). This recommendation is based on the different eicosanoids that each of the essential fatty acids produce. The omega-6-derived eicosanoids appear to be pro-inflammatory and prothrombotic, while the omega-3-derived eicosanoids tend to be anti-inflammatory and antithrombotic.

Health benefits of omega-3 fatty acids

Most of the research on the health benefits of the omega-3 fatty acids has centered on their role in cardiovascular disease (CVD) prevention. Epidemiological and clinical studies have shown that the consumption of omega-3 fatty acids can reduce the incidence of CVD, and substantially benefit individuals at risk of coronary heart disease (CHD) (Kris Etherton, *et al*., 2003). These benefits have been primarily attributed to marine sources of omega-3 fatty acids, *i.e*., EPA and DHA found in fish and fish oils. However, plant sources, *i.e*., ALA found in canola and soybean oils, flaxseed and walnuts, also have cardioprotective effects. Determining the different potential mechanisms through which both marine and plant sources confer these benefits is an active area of investigation.

Marine sources

The evidence supporting an inverse relationship between the intake of omega-3 fatty acids from marine sources and CHD is quite strong (Kromhout, *et al.,* 1985; Hu, *et al.,* 2002). Studies have shown that consuming EPA and DHA can lead to a reduction in sudden death (Albert, *et al.,* 1998; Siscovick, *et al*., 2000), decrease risk of arrhythmia (Kang and Leaf, 1994), lower plasma triacylglycerol (TG) levels (Harris, 1997), and reduce blood-clotting tendency with EPA (Mori, *et al*., 1997) and DHA (Agren, *et al*., 1997). In secondary prevention studies, including The Diet and Reinfarction Trial (DART) (Burr, *et al*., 1989) and the GISSI-Prevenzione Trial (Group, 1999) fish and fish oil have been shown to reduce all cause mortality and CVD in patients who previously suffered myocardial infarction (MI).

Plant sources

Evidence supporting the use of plant-derived omega-3 fatty acids in reducing the risk of CVD continues to emerge (deDeckere, *et al.,* 1998; Djousse, *et al*., 2001). Large scale epidemiological studies have reported that ALA intake is associated with a lower risk of MI (Ascherio, *et al*., 1996), fatal ischemic heart disease (Hu, *et al*., 1999), mortality from CHD (Dolecek, 1992), and total mortality (Folsom and Demissie, 2004). One report from the Health Professionals Study cohort suggested that omega-3 PUFA from plants may be particularly helpful in lowering CHD risk among men who consume little or no fish (Mozaffarian, *et al*., 2005).

Among the intervention trials conducted, the most convincing evidence supporting the protective effects of dietary ALA intake on heart disease comes from the Lyon Diet Heart Study (deLorgeril, *et al.,* 1994, 1999). The Lyon Study was the first secondary prevention trial designed to test the hypothesis that a diet rich in ALA may improve prognosis in survivors of a first MI. Survivors were randomly assigned to follow either a prudent Western-type diet (the control diet) or an experimental Mediterranean-type diet in which the primary sources of fat were olive oil, canola oil, and a canola oil-based margarine. Compared to the control diet, the ALA content of the experimental diet was 68 percent higher. After 27 months, a 73 percent reduction in either cardiac death or nonfatal MI was observed in the high ALA diet group compared to the control group (deLorgeril, *et al.,* 1994). Interestingly, this protective effect was achieved without a reduction in serum total cholesterol (TC), TG levels, or an increase in HDL compared to controls. The protective effect of the high ALA diet was maintained up to four years after the first infarction (deLorgeril, *et al*., 1999).

Walnuts vs. fatty fish

Incorporating both plant and marine sources of omega-3 fatty acids into a healthy diet can favorably affect CHD risk. In a randomized crossover study (Rajaram, *et al.,* 2009) 25 normal and mildly hyperlipidemic subjects received either a control diet (about 30 percent total fat, less than 10 percent saturated fat), a diet incorporating 42.5 gm of walnuts (per 2400 kcal) on six days per week, or a diet including two servings of salmon per week. Each diet provided the same amount of total calories. After four weeks, subjects on the walnut diet showed a reduction in both TC (5 percent) and LDL (9 percent) compared to the control diet, but no change in HDL or TG levels. Conversely, subjects on the fatty fish diet had increased HDL (4 percent) and decreased TG (11 percent) compared to both the control and walnut diets. Although the walnut diet did not influence HDL levels, it did significantly reduce the ratios of TC:HDL and LDL:HDL, which are important predictors of CHD. Each of the omega-3 fatty acid rich foods used in this study was provided in the amount recommended for the primary prevention of CHD.

Walnuts are unique among nuts

Benefits of nut consumption

In general, nuts are a rich source of unsaturated fatty acids (MUFA, PUFA) contain no cholesterol or sodium, and are low in saturated fatty acids (Kris-Etherton, *et al.,* 2001). Nuts also contain dietary fiber, protein, essential micronutrients, plant sterols, and other potentially beneficial phytochemical compounds.

Five large epidemiological studies, including cohorts from the Nurses' Health Study (Hu, *et al*., 1998), the Physicians' Health Study (Albert, *et al.,* 2002), the Iowa Women's Health Study (Prineas, *et al.,* 1993) the Adventist Health Study (Fraser, *et al.,* 1992, 1997, 199) and the Cholesterol and Recurrent Events (CARE) study (Brown, *et al.,* 1999), have all shown that frequent nut consumption is associated with a decreased risk of CHD. Compared with people who ate nuts fewer than once a week, it was estimated that consuming a 1 oz serving of nuts more than 5 times per week resulted in an 18 to 51 percent reduction in CHD risk (Kris-Etherton, *et al.,* 2001).

Clinical trials have consistently shown that including nuts as part of a cholesterol-lowering diet improves lipid and lipoprotein profiles (Sabate, *et al.,* 1993; Abbey, *et al.,* 1994; Chisholm, *et al.,* 1998; Zambon, *et al.,* 2000; Spiller, *et al.,* 1992; O'Byrne, *et al.,* 1997; Kris-Etherton, *et al.,* 1999; Curb, *et al.,* 2000; Morgan and Clayshulte, 2000; Edwards, *et al.,* 1999). A systematic review of well-designed nut intervention studies estimated that consuming a moderate fat diet (approximately 35 percent of calories) including 1.5 to 3.5 servings (50 to 100 gm) of nuts per day, especially almonds, peanuts, pecans, or walnuts, significantly lowered TC (2 to 16 percent) and LDL cholesterol (2 to 19 percent) levels in normo- and hypo-lipidemic individuals compared to control diets without nuts or diets with a different fatty acid profile (Mukuddem-Petersen, *et al.,* 2005).

Similarly, in their review, Griel and Kris-Etherton (2006) concluded that tree nuts, *i.e*., walnuts, almonds, macadamias, pecans, pistachios, and hazelnuts, reduced LDL cholesterol 3 to 19 percent when compared with Western and lower-fat diets.

However, the LDL cholesterol-lowering response shown in these intervention studies is greater than expected based on equations derived from dietary fatty acid profiles, and may not be solely due to the fatty acid composition of nuts. Thus, other bioactive compounds present in nuts, including micronutrients, fiber, and phytochemicals, may contribute to their cardioprotective effect through additional mechanisms such as reducing inflammation, improving vascular reactivity, and lowering oxidative stress (Kris-Etherton, *et al.,* 2008). Evidence from the Multi-Ethnic Study of Atherosclerosis (MESA) suggests that frequent nut consumption is inversely correlated with biomarkers of inflammation and endothelial dysfunction, including C-reactive protein (CRP) and interleukin-6 (IL-6) (Jiang, *et al.,* 2006). In the PREDIMED primary prevention trial, adults at risk for CVD who adhered to a Mediterranean diet supplemented with mixed nuts (30 gm/day) for three months had reduced concentrations of inflammatory molecules, improved insulin resistance, and lower blood pressure when compared with a low fat control diet (Estruch, *et al.,* 2006). After one year, incidence of the metabolic syndrome, a cluster of well-documented risk factors for CVD, was reduced by 14 percent among subjects in the nut group compared with a 2 percent reduction among control subjects (Salas-Salvado, *et al.,* 2008).

Walnuts are the only nut that contain a significant amount of omega-3

Walnuts are unique compared to other nuts because they are predominantly composed of PUFA (both omega-3 and omega-6) rather than MUFA, which predominate in most other nuts. Per serving, walnuts contain a higher amount of omega-3 fatty acids than any of the other tree nuts (almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios) or peanuts (see tables on pages 8 and 9). In fact, the omega-3 fatty acid content of walnuts is nearly 10 times greater than pecans, the next highest nut, and 40 to 500 times greater than most other nuts. Peanuts contain negligible amounts, and almonds contain no omega-3 fatty acids.

One ounce (about 1/4 cup) of walnuts contains 190 calories and 18 gm of fat, 90 percent of which is unsaturated. Although they are energy dense, clinical dietary intervention studies have shown that regular walnut consumption does not cause a net gain in body weight when eaten as a replacement food (Tapsell, *et al.,* 2004; Garcia-Lorde, *et al.,* 2003; Morgan, *et al.,* 2002; Almario, *et al.,* 2001).

Cardiovascular health benefits of walnuts

The effects of walnut intake on biomarkers of atherosclerotic CVD or on disease outcomes were evaluated in several controlled intervention studies with normo- or hyperlipidemic human subjects (Sabate, *et al.,* 1993; Abbey, *et al.,* 1994; Chisholm, *et al.,* 1998; Zambon, *et al.,* 2000; Almario, *et al.,* 2001; Iwamoto, *et al.,* 2002; Ros*, et al.,* 2004). Measurements were made on serum/plasma lipids and lipoproteins, plasma total fatty acid and lipid classes, and RBC fatty acids. The results from these intervention trials were consistent in showing decreases in total cholesterol and LDL with intakes equivalent to 2 to 3 oz of walnuts daily with no significant adverse effects reported (Ros*, et al.,* 2004).

Results from a clinical trial conducted at Loma Linda University (Sabate, *et al*., 1993) showed that incorporating 84 gm/day of walnuts (per 2500 kcal) into a cholesterol-lowering diet (as snacks, mixed in salads and breakfast cereals, or cooked with dinner entrees), and thereby replacing fatty foods (such as potato chips and meat, and visible fat like oils, margarine, and butter) significantly lowered serum TC (12 percent) and LDL cholesterol (16 percent) levels in healthy men after 1 month when compared to the reference diet recommended by the National Cholesterol Education Program (NCEP Step 1 diet). Although HDL cholesterol levels also decreased (5 percent) during this trial, the ratios of LDL:HDL and TC:HDL were significantly decreased. In this study, walnuts contributed 55 percent of total fat, 14 percent of protein, and 10 percent of fiber in the experimental diet. The major differences between the walnut diet and the NCEP Step 1 diet, respectively, included a slightly lower MUFA content (7.4 percent vs 8.8 percent of energy), a higher amount of total PUFA (16.5 percent vs 9.5 percent of energy) and nearly triple the amount of the omega-3 fatty acid ALA (9.2 gm vs. 3.3 gm/100 gm fatty acid). It is interesting to note that the effects were observed despite the relatively low base-line cholesterol levels of the study subjects.

Nutrients in 1 oz of Tree Nuts*

Nutrients	Units	Walnuts	Almonds	Brazil Nuts	Cashews	Hazel Nuts
# of nuts/oz		14 halves	23	6-8	18	21
Energy	kcal	185	165	190	160	180
Protein	gm	4	6	4	5	4
Total fat	gm	18	14	19	12	17
Saturated fat	gm	1.7	1.1	4.3	2.2	1.3
Monounsaturated fat	gm	2.5	9.1	7.0	6.7	12.9
Polyunsaturated fat	gm	13	3.5	5.8	2.2	2.2
Ω-6, linoleic acid	gm	10.8	3.5	5.8	2.2	2.2
Ω-3, alpha-linolenic acid	gm	2.6	0	0.01	0.02	0.03
Cholesterol	mg	0	0	0	0	0
Total carbohydrate	gm	4	6	3	9	5
Dietary fiber	gm	1.9	3.3	2.1	0.9	2.7
Calcium	mg	28	70	45	10	32
Iron	mg	0.82	1.22	0.69	1.89	1.33
Magnesium	mg	45	78	107	83	46
Phosphorus	mg	98	134	206	168	82
Potassium	mg	125	206	187	187	193
Sodium	mg	1	0	1	3	0
Zinc	mg	0.88	0.95	1.15	1.64	0.69
Copper	mg	0.45	0.32	0.50	0.62	0.49
Manganese	mg	0.97	0.72	0.35	0.47	1.75
Selenium	mg	1.4	0.8	544	5.6	0.7
Vitamin C	mg	0.4	0	0.2	0.1	1.8
Thiamin	mg	0.10	0.07	0.18	0.12	0.18
Riboflavin	mg	0.04	0.23	0.01	0.02	0.03
Niacin	mg	0.32	1.11	0.08	0.30	0.51
Pantothenic acid	mg	0.16	0.10	0.05	0.25	0.26
Vitamin B_6	mg	0.15	0.04	0.03	0.12	0.16
Folate	mcg	28	8	6	7	32
Vitamin B_{12}	mcg	0	0	0	0	0
Vitamin A	IU	6	1	0	0	6
Vitamin K	mcg	0.8	0	0	9.7	4.0
Vitamin E/Alpha-tocopherol	mg	0.20	7.33	1.62	0.26	4.26
Beta-tocopherol	mg	0.04	0.12	0	0.01	0.09
Gamma-tocopherol	mg	5.91	0.25	2.23	1.51	0
Delta-tocopherol	mg	0.54	0.07	0.22	0.10	0
Stiamasterol	mg	0	1	n/a	n/a	0
Campesterol	mg	2	1	n/a	n/a	2
Beta-sitosterol	mg	18	31	n/a	n/a	25
Alpha-carotene	mcg	0	0	0	0	1
Beta-carotene	mcg	3	1	0	0	0
Beta-cryptoxanthin	mcg	0	0	0	0	0
Lutein + zeaxanthin	mcg	3	0	0	6	26

*All of the nuts are unsalted; almonds, Brazil nuts, hazelnuts, and walnuts are raw; cashews are dry roasted.

Nutrients in 1 oz of Tree Nuts and Peanuts*

Nutrients	Units	Macadamia	Peanuts	Pecans	Pine Nuts†	Pistachios
# of nuts/oz		10-12	28	20 halves	167	49
Energy	kcal	200	160	200	190	160
Protein	gm	2	7	3	4	6
Total fat	gm	21	14	20	19	13
Saturated fat	gm	3.4	1.9	1.8	1.4	1.5
Monounsaturated fat	gm	16.7	6.9	11.6	5.3	6.6
Polyunsaturated fat	gm	0.4	4.4	6.1	9.7	3.8
Ω-6, linoleic acid	gm	0.4	4.4	5.85	9.4	3.74
Ω-3, alpha-linolenic acid	gm	0.06	0	0.28	0.05	0.07
Cholesterol	mg	0	0	0	0	0
Total carbohydrate	gm	4	5	4	4	8
Dietary fiber	gm	2.4	2.4	2.7	1.0	2.9
Calcium	mg	24	26	20	5	30
Iron	mg	1.05	1.30	0.72	1.57	1.18
Magnesium	mg	37	48	34	71	34
Phosphorus	mg	53	107	79	163	139
Potassium	mg	104	200	116	169	291
Sodium	mg	1	5	0	1	0
Zinc	mg	0.37	0.93	1.28	1.83	0.62
Copper	mg	0.21	0.32	0.34	0.38	0.37
Manganese	mg	1.17	0.55	1.28	2.50	0.34
Selenium	mg	1.0	2.0	1.1	0.2	2.0
Vitamin C	mg	0.3	0	0.3	0.2	1.4
Thiamin	mg	0.34	0.18	0.19	0.10	0.25
Riboflavin	mg	0.04	0.04	0.04	0.06	0.05
Niacin	mg	0.70	3.42	0.33	1.24	0.37
Pantothenic acid	mg	0.22	0.50	0.25	0.09	0.15
Vitamin B_6	mg	0.08	0.10	0.06	0.03	0.48
Folate	mcg	3	68	6	10	14
Vitamin B_{12}	mcg	0	0	0	0	0
Vitamin A	IU	0	0	16	8	157
Vitamin K	mcg	n/a	0	1.0	15.3	n/a
Vitamin E/Alpha-tocopherol	mg	0.15	2.36	0.40	2.65	0.65
Beta-tocopherol	mg	0	n/a	0.11	0	0
Gamma-tocopherol	mg	0	n/a	6.93	3.16	6.41
Delta-tocopherol	mg	0	n/a	0.13	0	0.23
Stiamasterol	mg	0	n/a	1	n/a	1
Campesterol	mg	2	n/a	1	n/a	3
Beta-sitosterol	mg	31	n/a	25	n/a	56
Alpha-carotene	mcg	n/a	0	0	0	0
Beta-carotene	mcg	n/a	0	8	5	94
Beta-cryptoxanthin	mcg	n/a	0	3	0	0
Lutein + zeaxanthin	mcg	n/a	0	5	3	n/a

*All of the nuts are unsalted; macadamia, peanuts, pecans and pine nuts are raw. †Pignolia variety

Anti-inflammatory effects of walnuts

Researchers at Penn State University found that substituting walnuts (37 gm) and walnut oil (15 gm) for half the fat found in the average American diet (typically 35 percent total fat, 13 percent saturated fat, 8 percent PUFA) not only lowered cholesterol, LDL, and TG, it also produced cardioprotective anti-inflammatory effects after six weeks (Zhao, *et al.,* 2004, 2007). In hypercholesterolemic men and women this walnut-rich, ALA-containing diet high in PUFA (13 percent of calories) and low in saturated fat (8 percent of calories) reduced levels of CRP, pro-inflammatory cytokines, and key cell adhesion molecules involved in the atherogenic process. No changes were observed when the same subjects followed a control diet comparable to the average American diet. The MUFA composition of the control and intervention diets was kept constant (13 percent of calories).

Antioxidant capacity of walnuts

Since PUFA are more susceptible to oxidation than MUFA, there is some concern that increasing PUFA levels in the diet might also increase the resistance of LDL cholesterol to oxidative damage (*in vitro* peroxidation) (Gardner and Kraemer, 1995). Oxidized LDL play a key role in atherogenesis, however, data on the effect of PUFA on LDL oxidation are conflicting. This does not appear to be the case with walnuts.

At high intake levels (2 to 3 oz/day), walnuts have been shown to raise levels of LA and ALA in plasma fatty acids (Abbey, *et al.,* 1994; Almario, *et al.,* 2001), LDL cholesterol ester fatty acids, LDL phospholipids and TG (Zambon, *et al.,* 2000). In many of these studies plasma levels of oleic acid, palmitic acid and arachidonic acid decrease after the walnut intervention. In the Barcelona Walnut Trial (Albert, *et al.,* 2002), even though LDL particles were enriched with PUFA from walnuts, their resistance to oxidation was preserved. Other intervention studies comparing a walnut-enriched, high PUFA diet with a walnut-free, lower PUFA diet similarly showed no differences in LDL ability to oxidize (Iwamoto, *et al.,* 2002; Ros, *et al.,* 2004; Munoz, *et al.,* 2001) or other measures of oxidative biomarkers (Tapsell, *et al.,* 2004; Ros, *et al.,* 2004) between diets.

It is plausible that this lack of effect may be due to the high antioxidant capacity of walnuts. Among dietary plants used worldwide, walnuts were ranked second only to rose hips (*Rosa canina*) in their antioxidant activity (Halvorsen, *et al*., 2002). In the same analysis, sunflower seeds were shown to have 25 percent of the activity of walnuts, while other nuts (hazelnuts, almonds, cashews, and peanuts) exhibited less than 4 percent of the activity. Based on typical serving sizes, walnuts and blackberries were ranked the highest in antioxidant content among 1,113 common US foods (Halvorsen, *et al.,* 2006).

Polyphenolic phytochemicals isolated from walnuts have been shown to be effective inhibitors of plasma and LDL oxidation in ex vivo experiments (Anderson, *et al.,* 2001), and can significantly decrease in vivo markers of oxidative stress in diabetic mice (Fukuda, *et al*., 2004). Melatonin, which was identified as one of the antioxidant constituents present in walnuts, was positively correlated with increased plasma antioxidant capacity in animal studies (Reiter, *et al*., 2005). A limited number of human feeding trials indicate that walnuts improve some measures of antioxidant status (Canales, *et al.,* 2007), but not others (Davis, *et al.,* 2007).

Possible mechanisms of action

Various mechanisms have been proposed to explain the cardioprotective effects of walnuts. Their unique fatty acid composition and favorable effect on serum lipids and lipoprotein levels is certainly one possibility. Their phytochemical constituents may lower oxidative stress, reduce inflammation, and improve endothelial function. Still, other constituents present in walnuts including fiber, beta-sitosterol, ellagic acid, L-arginine, gamma-tocopherol, vitamin B_6, folate, potassium, magnesium, copper, or manganese may also play a role.

Did You Know?

Walnuts were the first whole food to receive a health claim from the FDA. In July 2004, the FDA approved the following claim:

"Supportive but not conclusive research shows that eating 1.5 oz of walnuts per day, as part of a low saturated fat and low cholesterol diet, and not resulting in increased caloric intake may reduce risk of coronary heart disease."

Guidelines for incorporating walnut omega-3 fatty acids into the diet

Dietary guidelines from the American Heart Association (AHA)

Evidence-based dietary guidelines from the AHA recommend including both marine and plant sources of omega-3 fatty acids as part of an overall healthful diet (Munoz, *et al.,* 2001).

- To prevent heart disease, patients without documented CHD should be advised to consume 2 servings of fish per week, with an emphasis on fatty fish, and include ALA-rich vegetable oils (canola, soybean, and flaxseed oils) and foods (flaxseed and walnuts).
- Patients with known coronary disease should be encouraged to consume at least 1 daily serving of fatty fish, or take a fish oil supplement providing up to 1 gm/day of omega-3 fatty acids.

Although the ideal intake of omega-3 fatty acids is unclear at this time, dietary dosages of up to 3 gm/day from marine sources are generally regarded as safe (GRAS). The acceptable macronutrient distribution range (AMDR) of ALA is estimated to be 0.6 to 1.2 percent of energy, or 1.3 to 2.7 gm/day on the basis of a 2000 kcal diet, according to the Dietary Reference Intake (DRI) report by the Food and Nutrition Board of the IOM (Institute of Medicine, 2002). In May 2004, the FDA used the evidence presented in this report to set a DV for ALA at 1.3 gm/day.

Walnuts as a food source of omega-3 fatty acids

A one ounce (30 gm) serving of walnuts, the equivalent of 10 to 14 walnuts halves, a small handful or 1/4 cup, provides 2.6 gm of the omega-3 fatty acid ALA. Complete nutrition information on walnuts, as well as other tree nuts and peanuts, can be found in the tables on pages 8 and 9 (USDA, 2008).

• **Walnut storage and handling.** Walnuts kept in their shell have a shelf life of 12 months when stored in a cool, dry environment. An unopened package of shelled walnuts has a similar shelf life. Opened packages and chopped walnuts should be kept refrigerated or frozen in an airtight container for no longer than 6 to 12 months.

• **Walnut usage.** In the US, consumers use walnuts most often in baking (49 percent), as snacks (25 percent), in cooking (11 percent), salad dressings (11 percent), and as ice cream toppings (4 percent) (Ravai, 1995). When incorporated with other foods, walnuts can add and intensify flavor. They also have rising or puffing properties, and can lighten foods by fluffing or foaming when used in place of egg whites as finely ground walnut meal.

Walnuts and weight concerns

One concern many consumers and health professionals have about adding walnuts to the diet is increased caloric intake and the potential for subsequent increased body weight. A limited number of studies have specifically looked at the impact of nut consumption on body weight and body composition changes, and all concluded that daily nut consumption posed no risk of significant weight gain. In the most recent study, free-living subjects were instructed to incorporate moderate amounts of walnuts (35 gm/day on average) into their regular diet for six months, but given no other dietary advice (Sabate, *et al.,* 2005). After adjusting for energy differences between the control and walnut-supplemented diets, no significant changes in body weight or composition were observed. Although the walnut-supplemented diet resulted in a mean increase of 133 kcal/day, which theoretically should have led to a weight gain of 3.1 kg over six months, the average amount of weight gained among all participants was only 0.4 kg. Subjects maintained the same level of physical activity throughout the study. Therefore, it is likely that the walnuts partially displaced certain other foods in their diet, perhaps due to the increased satiety levels. Or, they may have affected the rate of energy expenditure.

While this study demonstrates that patients may make caloric substitutions on their own when adding walnuts to their diet, they should still be counseled to substitute walnuts for other high calorie, low nutrient density foods (*e.g*. candy bars, donuts, potato chips, etc.). In a different study, patients with Type 2 diabetes were given specific advice to regularly include as little as one serving of walnuts each day in the context of the total diet, these patients were able to achieve optimal fatty acid intake proportions without adversely affecting their total fat or energy (calorie) intake (Gillen, *et al.,* 2005).

Advice for promoting walnut consumption

The healthcare professional encounters many challenges when advising clients to make dietary changes. Carefully framing the intended message in a positive, health enhancing way has been shown to be successful in improving compliance, especially when the patient's perceived barriers to change (*e.g.,* weight gain) are also addressed (McKay, *et al.,* 2004). For example, when advising patients to add a specific food or supplement to their diet, present it as a highly effective way to improve their health, and a very easy thing to do. With regard to presenting specific dietary advice on walnut consumption, emphasize how effective walnuts are in enhancing omega-3 fatty acid intake and reducing heart disease risk factors, how simple it is to incorporate them into meals and snacks, and how weight gain can be avoided if they are used as a substitute for certain other foods.

One of the simplest ways to incorporate walnuts into the diet is to add them to foods eaten regularly such as breakfast cereals, yogurt, sandwiches, salads, pasta and rice, or have them readily available for snacking. Recipes using walnuts as an ingredient are available through the California Walnut Commission, and can be accessed at www.walnuts.org. Patients and clients without access to the internet, as well as those who prefer receiving their nutrition information in written form (particularly older adults), should be given a list of serving suggestions and recipes printed with a legible font type and size.

Summary

If you have patients or clients who you think may benefit from increased omega-3 fatty acid intake, there are a variety of both plant and marine food sources available. Walnuts are a convenient source of the omega-3 fatty acid ALA that can be readily added to favorite foods and recipes, or eaten out of hand as a snack. A 1 oz serving of walnuts provides 2.6 gm of omega-3 fatty acid, as well as other health-promoting nutrients and bioactive components. Numerous studies have shown that adding walnuts to the diet produces favorable health outcomes, including lowering LDL cholesterol, improving LDL:HDL ratios, and reducing inflammation associated with increased heart disease risk. Patients concerned about the caloric density of walnuts should be counseled to substitute walnuts for less nutrient-dense foods, and/or increase physical activity to offset potential changes in weight.

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Examination for WAL09

1. What two essential fatty acids are not manufactured by the human body and must be obtained through diet?
   a. Monounsaturated and oleic fatty acids
   b. Stearic and saturated fatty acids
   c. Linoleic and alpha-linolenic fatty acids
   d. None of the above

2. What landmark study provides convincing evidence that dietary alpha-linolenic acid (ALA) improves the prognosis of patients with a previous myocardial infarction (MI)?
   a. The Seven Countries Study
   b. Lyon Diet Heart Study
   c. GISSI-Prevenzione Trial
   d. The PREDIMED Study

3. Walnuts are unique among tree nuts and peanuts because _______________.
   a. They contain a significant amount of essential omega-3 fatty acids
   b. They contain only monounsaturated fat
   c. They contain less total fat
   d. All of the above

4. Inflammation is a newly-defined risk factor for heart disease. Walnuts have been shown to improve which biomarker of inflammation?
   a. RBC
   b. CRP
   c. Gamma globulin
   d. None of the above

5. Which of the following is the precursor or "parent" omega-3 fatty acid?
   a. Linoleic acid (LA)
   b. Alpha-linolenic acid (ALA)
   c. Eicosapentaenoic acid (EPA)
   d. None of the above

6. What bioactive compound(s) found in walnuts may help prevent the oxidation of LDL cholesterol?
   a. Folate
   b. Arginine
   c. Polyphenols
   d. None of the above

7. The typical American diet has a 10:1 ratio of omega-6 to omega-3 fatty acids. Research scientists suggest a ratio of ____ : ____ to be more efficient in converting ALA to EPA and DHA?
   a. 20:1
   b. 6:1
   c. 3:1
   d. None of the above

8. Studies conducted in humans have shown that walnuts can do which of the following:
   a. Reduce inflammation
   b. Lower total cholesterol levels
   c. Improve antioxidant status
   d. All of the above

9. Intervention studies demonstrate that including 2 to 3 oz/day of walnuts in the diet improves the blood lipid profile by ________________ levels.
   a. Reducing triglyceride
   b. Reducing LDL cholesterol
   c. Increasing HDL cholesterol
   d. All of the above

10. The AMDR for ALA is estimated to be ______ according to the DRI report by the Food and Nutrition Board of the National Academy's Institute of Medicine.
   a. 0.5 to 1.2 gm/day
   b. 1.5 to 3.0 gm/day
   c. 1.3 to 2.7 gm/day
   d. None of the above

11. The heart health benefits of consuming walnuts are due solely to their fatty acid consumption.
   a. True b. False

12. Reported health promoting activities attributed to increased omega-3 fatty acids in the diet to include all of the following EXCEPT:
   a. Stabilizing arrhythmias
   b. Reduced inflammation
   c. Decreased glaucoma incidence
   d. Enhanced immune response

13. A 1 oz portion of walnuts provides _______ grams of ALA?
   a. 2.6
   b. 2.0
   c. 1.4
   d. 0.8

14. Data from large epidemiological studies indicate that people who eat at least 5 oz of nuts per week have a __________ lower risk of CHD.
   a. 2 to 10 percent
   b. 15 to 28 percent
   c. 18 to 51 percent
   d. 75 to 98 percent

15. Walnuts are an excellent source of which form of Vitamin E?
    a. Alpha tocopherol
    b. Beta tocopherol
    c. Gamma tocopherol
    d. All the above

16. The Loma Linda University study showed that incorporating 84 gm of walnuts per day into NCEP diet reduced serum levels of total and LDL cholesterol by how much, respectively?
    a. 5 and 6 percent
    b. 12 and 16 percent
    c. 15 and 18 percent
    d. None of the above

17. Shelled walnuts should be kept refrigerated or frozen in an airtight container for up to:
    a. 1 month
    b. 2 months
    c. 6 months
    d. 12 months

18. Studies have shown that incorporating walnuts into subjects' diets does not necessarily cause weight gain. Researchers suggest that walnuts __________________, an important factor in successful dieting.
    a. Reduce satiety
    b. Increase satiety
    c. Increase hunger
    d. None of the above

19. In the PREDIMED study, subjects who consumed a diet supplemented with 30 gm of nuts daily for 1 year were less likely to develop:
    a. Metabolic syndrome
    b. Hypertension
    c. Angina
    d. Diabetes

20. When offering specific dietary advice on walnut consumption, emphasis should be on:
    a. How effective walnuts are in enhancing omega-3 fatty acid intake and reducing heart disease risk factors.
    b. How simple walnuts can be incorporated into meal and snacks
    c. How weight gain can be avoided if walnuts are used as a substitute for certain other foods in the diet
    d. All of the above

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