Research on Flaxsead

Flax Council of Canada

FLAX AND THE LOW-CARBOHYDRATE DIET

Introduction

Millions of people have chosen low-carbohydrate diets for rapid weight loss. As a result, the eating patterns of one in five households have changed. Sales of carbohydrate-rich foods like rice, pasta, potatoes and orange juice dropped between 4% and 8% in 2003, while sales of high-protein, low-carbohydrate foods like meat snacks, cheese and nuts increased 4% to 9%. The United States and Canada led the world in introducing new low-carbohydrate foods in early 2004 – the United States with 661 and Canada with 49 new low-carbohydrate food products.[1]

While nutrition experts continue to debate the merits of these diets, consumers are asking a question about flax: What benefits does flax offer to consumers of low-carbohydrate diets? Plenty, as it turns out. The health benefits that make flax good in regular diets make it good in low-carbohydrate diets. Here are six reasons to add flax to low-carbohydrate diets.

Six Reasons to Add Flax to Low-carbohydrate Diets

1. Flax Is Low in Digestible Carbohydrates

Low-carbohydrate diets count only the "digestible" or "available" carbohydrates like simple sugars and starch in food. These carbohydrates are digested and absorbed by the body. They supply energy to the brain, organs and muscles. By comparison, dietary fibre – what our grandparents commonly called roughage – resists being digested by bacteria in the gut and helps keep the gut working properly.

Table 1. Nutrient Content of Flax[a]

Nutrient	*Ground Flax (1 tbsp)*	*Flax Oil (1 tbsp)*
Total calories (kcal)	36	124
Total carbohydrate (g)	2.3	—
Available carbohydrate (g)	0.1	—
Total dietary fibre (g)	2.2	—
Total fat (g)	3.3	14
Saturated fat (g)	0.3	1.3
Omega-3 fat (g)	1.8[b]	8.0
Omega-6 fat (g)	0.5	2.2
Omega-6/omega-3 ratio	0.3:1	0.3:1

[a] *Source: Flax–A Health and Nutrition Primer. Winnipeg, MB: Flax Council of Canada, 2003.*

[b] *Omega-3 fat = alpha-linolenic acid (ALA).*

The Atkins diet is a popular low-carbohydrate diet. It allows 20 g of "digestible carbs" per day during the early weight-loss phase and 60-90 g daily during weight maintenance.[2] Similarly, the Zone diet calls for a carbohydrate intake of about 70 g to 105 g daily.[3] Flax is very low in available carbohydrates. Because one tablespoon of ground flax contains only 0.1 g of available carbohydrate, flax fits in the low-carbohydrate diet.

2. Flax Is a Low GI Food

The glycemic index (GI) is a scale that rates carbohydrate-rich foods based on how much they raise blood glucose compared with a standard food. Foods rated high on the GI scale, like boiled potatoes and puffed rice cakes, are quickly digested and absorbed, causing blood glucose and insulin levels to rise quickly. Lower GI foods like chickpea hummus and beans, take longer to be digested and absorbed and cause blood glucose and insulin levels to rise slowly.

Low-carbohydrate diets limit the intake of high GI foods but allow for a few low GI foods. Small portions of low GI foods like vegetables, beans, nuts and some fruits are included in low-carbohydrate diets. Because flax is low in available carbohydrate, it would be expected to have a low GI value like meat, poultry, fish, cheese, eggs, avocados and salad vegetables, which also contain little or no carbohydrate.[4]

3. Flax Is a Good Source of Dietary Fibre

One criticism of low-carbohydrate diets is their low dietary fibre content. Indeed, the typical daily menu for the Atkins diet plan provides about 11 g of dietary fibre per day,[2] as shown in Table 2. This intake is roughly one-third to one-half of the recommended intake for adults.[5] Ground flax contains 2.2 g of dietary fibre per tablespoon and can add a significant amount of dietary fibre to low-carbohydrate diets.

Table 2. Nutrient Value of a Sample Menu from the Atkin's Diet Plan[a]

Total calories (kcal)	1942
Atkins digestible carbohydrate (g)	25
Dietary fibre (g)	11
Total fat (g)	122
Saturated fat (g)	27
Omega-3 fat (g)	2
Omega-6 fat (g)	31
Omega-6/omega-3 ratio	16:1

[a] *Source: Atkins RC. Dr. Atkins' New Diet Revolution. New York: HarperCollins, 2002, pp. 71-72 (menu plan) and pp. 492-502 (digestible carbohydrate values). Nutrient values, except for Atkins' digestible carbohydrate, were calculated using the U.S. Department of Agriculture's Nutrient Database, available at www.usda.gov/fnic/foodcomp.*

4. Flax Is Low in Saturated Fat

Because low-carbohydrate diets include ample portions of meat, poultry, eggs, dairy products and other animal foods, they are rich in saturated fat. Two studies – one in 53 healthy, obese women[6] and one in 10 normal weight men[7] – found significant increases in saturated fat intakes when volunteers ate a low-carbohydrate diet. In a typical Atkins diet, a daily meal plan might provide as much as 27 g of saturated fat obtained mainly from animal foods and salad dressings.[2]

Flax is low in saturated fat. One tablespoon of ground flax provides 0.3 g of saturated fat. One tablespoon of flax oil provides 1.3 g of saturated fat. Adding a little flax to a low-carbohydrate diet will not increase saturated fat intake appreciably.

5. Flax Is Rich in Omega-3 Fats

People who follow low-carbohydrate diets can get the recommended amount of omega-3 fats, even if their diet is based on beef, pork and chicken. For example, the Atkins sample menu plan provides a typical intake of about 2 grams of omega-3 fat. The recommended intake of omega-3 fat is 1.1 g daily for women and 1.6 g daily for men.[5]

Some experts believe the recommended intake is too low to achieve the health benefits linked with omega-3 fats. Adding flax to the diet is an easy way to increase omega-3 fat intake. One tablespoon of ground flax provides 1.8 g of omega-3 fat. One tablespoon of flax oil provides 8 g of omega-3 fat. An adult can get the full daily recommended amount of omega-3 fat from 1 tablespoon of ground flax or 1 teaspoon of flax oil.

6. Flax Improves the Omega-6/Omega-3 Ratio

Even though omega-6 and omega-3 fats are both important to good health, many North Americans eat diets that are too rich in omega-6 fats and low in omega-3 fats. The omega-6/omega-3 ratio of these unbalanced diets is often greater than 10:1 – meaning the diet contains 10 times more omega-6 fats than omega-3 fats. For some people, the ratio may be greater than 20:1. The recommended omega-6/omega-3 ratio is between 4:1 and 10:1.[8]

Adding flax to the diet improves the omega-6/omega-3 ratio. The typical Atkins diet plan has an omega-6/omega-3 ratio of 16:1, as shown in Table 2. Adding 1 tablespoon of ground flax daily to the Atkins diet nearly doubles the omega-3 fat intake and moves the omega-6/omega-3 ratio down to about 8:1 – well within the recommended range.

Go with Flax

The jury is still out on the safety and effectiveness of low-carbohydrate diets. Significant weight loss has been reported among obese volunteers on low-carbohydrate diets, but the outcome may have been due more to decreased caloric intake and diet duration than to the diet's carbohydrate content.[9] Low-carbohydrate diets appear to achieve greater short-term (six months), but not long-term weight loss (12 months).[10] What's needed now is more evidence showing that low-carbohydrate diets are safe and help people keep excess weight off in the long-term. Regardless of the carbohydrate content of the diet, there are good reasons to eat flax.

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Printed in Canada

New FLAX FACTS

OMEGA-3 FATS IN FLAX AND FISH ARE SIMILAR IN MANY WAYS

by Dr. Diane H. Morris

Introduction

Consumers want to know: Are the omega-3 fats in fish the same as those found in flax? The answer is that omega-3 fats are like siblings – they are alike in some ways and different in others.

What Are the Major Omega-3 Fats?

Alpha-linolenic acid (ALA) is the essential omega-3 fat. The word "essential" means that we must eat ALA in our diets because our bodies cannot make it. In other words, ALA is an essential nutrient just like vitamin C and calcium. The human body needs ALA to be healthy. Two other omega-3 fats are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA are vital for health, but they are not strictly "essential" because our bodies make them from ALA. In one study, for instance, the blood level of EPA increased 60% when 56 African-American adults with chronic illness consumed 3 grams of ALA daily for 12 weeks. The source of ALA in this study was flax oil capsules.[1]

Which Foods Are Rich in Omega-3 Fats?

Omega-3 fats are found in a variety of foods. Plants, fish, and omega-3-enriched eggs and dairy products are the main sources of these important fats.

ALA

ALA is found mainly in flax seeds and walnuts and in plant oils like flax, canola and soybean oils. Flax seeds and flax oil are the richest sources of ALA in the North American diet.[2] Flax-based omega-3-enriched eggs and dairy products enriched with flax oil, along with some fish like Atlantic salmon and canned sardine, are good sources of ALA. Small amounts of ALA can be found in cereals, breads, bagels, spaghetti, energy bars and cookies made with added flax. Beef, pork and chicken also contain small amounts of ALA.

EPA and DHA

EPA and DHA are found mainly in fatty fish like herring, salmon, mackerel and bluefin tuna and the fish oil supplements made from them. White fish like haddock, cod, flounder, sole and orange roughy, along with the fried fish fillets made from these white fish, contain small amounts of EPA and DHA.

Algae are rich sources of DHA, but contain little EPA. Plants do not contain EPA and DHA.

Nutrient Content Claims for Omega-3 Fats

Canada and the United States allow food processors to identify foods that are good sources of omega-3 fats. In Canada, the nutrition label can state that a food like novel pork meat (derived from pigs fed a ration enriched with flax) is a "source of omega-3 fat".[3,4] In the United States, flax oil, flax seeds, and flax-based omega-3-enriched eggs and some dairy products qualify for a label claim as a "high" source of ALA omega-3 fat.[5] (See Table 1 below.) White fish like haddock and cod do not qualify for a label claim because they are relatively low in omega-3 fat.

Table 1

Foods Qualifying for a Label Claim of "High" Source of Omega-3 Fats, Ranked by Omega-3 Fat Content[a,b]

OMEGA-3 FAT CONTENT PER REFERENCE AMOUNT[c]

ALA	EPA	DHA
Flax oil	Herring	Salmon, Atlantic, wild
Flax seeds	Salmon, coho, wild	Tuna, bluefin
Walnuts	Mackerel	Herring
Walnut oil	Salmon, Atlantic, wild	Salmon, coho, wild
Canola oil	Tuna, bluefin	Striped bass
Soybean oil	Sardine, canned in oil	Mackerel
Flax-based omega-3 enriched egg[d]	Menhaden oil capsules[e]	Sea bass
Atlantic salmon	Shark	Shark
Sardine, canned in oil	Striped bass	Sardine, canned in oil
	Sea bass	Menhaden oil capsules
		Omega-3 enriched egg[f]

[a] Source: O'Flaherty MJ (5).
[b] Omega-3 fat content ranked from highest to lowest within each column, based on grams of fatty acid per reference amount of food. Values are for cooked fish. Sources of data: flax, flax oil and omega-3 enriched eggs (2); all other foods – U.S. Department of Agriculture, Nutrient Database for Standard Reference, Release 18, available at www.ars.usda.gov/nutrientdata.
[c] Reference amount = the amount customarily consumed. For fats and oils like flax oil, the reference amount is 1 tablespoon.
[d] Flax-based omega-3 enriched eggs are derived from laying hens fed flax.
[e] Values are for 2 capsules; data obtained from www.fishoilcapsules.com.
[f] Omega-3 enriched eggs are derived from laying hens fed a variety of feed supplements.

Do All Omega-3 Fats Have the Same Health Benefits?

Just like siblings, omega-3 fats are alike in some ways and different in others. ALA, EPA and DHA are alike in keeping the body's cell membranes flexible and elastic to help cells work properly, and they block the actions of some compounds that cause inflammation.[6] Chronic diseases like heart disease, diabetes, cancer and arthritis are marked by inflammation. Omega-3 fats help reduce chronic disease risk by blocking inflammation.

In a clinical study involving adults with moderate high blood cholesterol, eating a diet rich in ALA from walnuts, walnut oil and flax oil reduced the blood level of one marker of inflammation by 75%.[7] In the Nurses' Health Study, the greater the ALA intake, the lower the concentration of the inflammatory markers in

the blood.[8] These findings suggest that ALA helps reduce inflammation and thereby lowers chronic disease risk.

DHA is unique in its health effects. Because it helps the eye, brain and nervous system develop properly, infants have a special need for DHA. Aging adults may need DHA, too. A study of 815 elderly people living in Chicago found that those with the highest DHA intake had the most protection against Alzheimer Disease.[9]

Why Eat Flax?

Flax seeds are a rich source of ALA, lignans and dietary fibre. Lignans are phytoestrogens – plant compounds that can have estrogen-like actions in animals and humans. Through the actions of the lignans and ALA, flax blocks tumour growth in animals and may help reduce cancer risk in humans.[2]

Flax lowers blood cholesterol levels and helps reduce the risk of heart attacks and stroke, partly through the actions of ALA.[10] ALA may be especially important to vegetarians and people with low intakes of fatty fish. Findings from the Health Professionals Follow-up Study of 45,722 men indicated that each one gram of ALA in the daily diet was associated with a 47% lower risk of heart disease among men with low intakes of EPA and DHA (< 100 mg per day).[11] Eating flax every day increases the daily ALA intake.

Flax dietary fibre promotes laxation and helps the bowel work properly. The pleasant, nutty taste of flax makes it an ideal addition to hot and cold cereals, fruit smoothies, cookies and other baked goods, meatloaf, pasta and soup.

Looking for flax lignans and dietary fibre?

Lignans are found in the fibre fraction of the flax seed. For this reason, flax oil does not naturally contain lignans, although some processors add purified lignans to the oil to enhance its nutritional value.

Flax seeds, but not flax oil, are a good source of dietary fibre. One tablespoon of whole flax seeds contains as much total dietary fibre as 1/2 cup of cooked oat bran. One tablespoon of milled flax contains as much total dietary fibre as 1 slice of whole wheat bread; 1/3 cup of cooked, chopped broccoli; 1/3 cup of cooked pearled barley; 1/2 cup of cooked, long-grain brown rice; or 1/4 cup of cooked oat bran.[16]

Why Eat Fish?

Fish is valued for its high-quality protein and nutrient content, including omega-3 fats. Populations with high fish intakes, like the Japanese and Inuit, have low rates of some chronic diseases like heart disease.[12]

Is it safe to eat fish? Federal health agencies in Canada[13] and the United States[14] conclude that the benefits of eating fish outweigh concerns about traces of mercury in fish. However, both countries advise pregnant and nursing women, women who may become pregnant and young children to avoid eating certain fish.

What about fish oil supplements? Fish oil capsules are the most concentrated form of omega-3 fats, but they may contain polychlorinated biphenyls (PCBs). PCBs are chemicals used in industrial processes and may cause cancer in humans. Consumers who follow the label recommendation on some fish oil supplements can take in up to 43% of the daily upper limit of PCBs. Consumers who take fish oil capsules and eat PCB-contaminated fish may increase their risk of PCB toxicity.[15] Besides safety, the main factors to consider are price, convenience, dietary preference and tolerance of a fishy aftertaste experienced with some fish oil capsules.

Flax and Fish – Both Offer Good Nutrition

Flax is rich in ALA, the essential omega-3 fat, and contains dietary fibre and lignans. Fish contain high-quality protein and omega-3 fats. Fatty fish are rich in DHA. Both flax and fish contain important nutrients and belong in a healthy eating plan.

One key difference is sustainability. Flax is a sustainable crop. Fish may not be. Today's North American consumers can eat fish when they want to – a situation that may change in the coming years if the global demand for fish continues. The pressures on global fish stocks may eventually force the global community to ration the world's ocean fish. For the time being, consumers can enjoy both.

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New FLAX FACTS

FLAX – A SMART CHOICE

by Dr. Diane H. Morris

Humans have been eating flax for thousands of years. Flax is a founding crop, being one of the first domesticated plants. Its cultivation likely began in the fertile valleys of the so-called Fertile Crescent in Mesopotamia about 8,000 to 10,000 years ago. Flax was valued in Ancient and Early Modern times as both a food and medicine.[1]

Today, consumers turn to flax for its pleasant, nutty flavour and many health benefits. Clinical and large-scale population studies show that flax improves laxation, lowers blood cholesterol, aids in blood glucose control, and blocks inflammation.[2] Because it has an anti-inflammatory effect,[3,4] eating flax regularly may help prevent and treat chronic diseases in which inflammation plays a role – chronic diseases like heart disease, stroke, diabetes, cancer, obesity, the metabolic syndrome, and Alzheimer disease. Here are good reasons to eat flax.

Major Nutritional Components of Flax

The major nutritional components of flax are oil (fat), protein, and dietary fibre, as shown in Table 1. Milled flax provides about 36 kcal/tbsp. Flax oil provides about 124 kcal/tbsp. Ground flax is very low in carbohydrates (sugars and starches), providing only 0.1 g/tbsp – one reason why flax is popular with people following a high-protein, low-carbohydrate weight-loss diet.[2]

TABLE 1
Composition of Flax As a Food

Fat[a]	41%
Total dietary fibre	28%
Protein	20%
Moisture	7%
Ash	4%

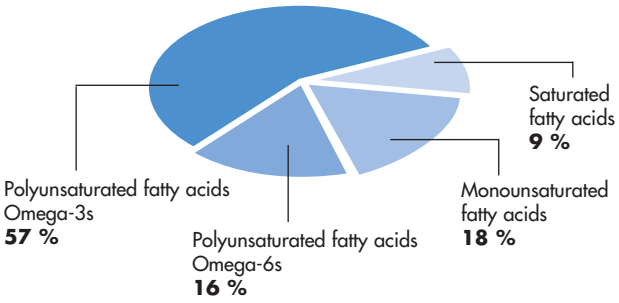
[a]Analysed by the American Oil Chemists' Society's (AOCS) Official Method Am 2-93, which is based on the Federation of Oils, Seeds and Fats Associations Ltd. (FOSFA) Official Method. The American Organization of Analytical Chemists (AOAC) Method 996.06 will produce a lower fat content.

Additional information about the nutrient content of flax, including its vitamin and mineral content and amino acid profile, can be found in the Flax Council of Canada's book, *Flax – A Health and Nutrition Primer*. The book is available in PDF format on the Council's website at **www.flaxcouncil.ca**

A Unique Mix of Fatty Acids

Flax is naturally low in saturated fat and has a moderate amount of monounsaturated fat (see Figure 1). Most of the fatty acids in flax are polyunsaturated. Flax is particularly rich in alpha-linolenic acid (ALA), the essential omega-3 fatty acid. As little as one tbsp of ground flax provides 1.8 g ALA, more than enough to meet the daily recommended intake for this nutrient.[5]

FIGURE 1
Fatty Acid Composition of Flax Oil



A Low Omega-6/Omega-3 Fatty Acid Ratio

Because of its high ALA content, flax has an omega-6/omega-3 fatty acid ratio of 0.3:1. Consuming flax, flax products, and omega-3 enriched eggs derived from hens fed flax or other similarly enhanced foods increases the omega-3 fatty acid content of the diet and improves the dietary omega-6/omega-3 fatty acid ratio. Consumers are advised to increase their omega-3 fat intake because the typical Western-type diet is high in omega-6 fats and low in omega-3 fats compared with the Paleolithic diet on which humans evolved.[6] Eating less omega-6 fats and more omega-3 fats may help lower the risk of chronic diseases like heart disease, stroke, and cancer.

Essential Fatty Acids

Flax contains two essential fatty acids (EFAs) – alpha-linolenic acid (ALA), the parent fatty acid of the omega-3 family, and linoleic acid (LA), the parent fatty acid of the omega-6 family. EFAs are required for maintaining the structure of cell membranes and the health of the skin, and they are involved in cholesterol transport and metabolism. EFAs can be converted to compounds called eicosanoids, which play a role in inflammatory reactions.[2]

Lignans

Lignans are both antioxidants and phytoestrogens. Antioxidants are compounds that work to keep oxygen from reacting with and damaging proteins, fats and other compounds in our tissues. Phytoestrogens are

compounds found in plants that can have weak estrogen activity in animals and humans.

The main lignan in flax is secoisolariciresinol diglycoside (SDG). The SDG found in flax and other foods is converted by bacteria in the gut to the lignans found in humans and other mammals – enterodiol and enterolactone.

The level of enterodiol and enterolactone in blood and urine reflects the lignan content of the diet. In one study of nine healthy young women, for example, eating milled flax for seven days produced significant increases in the plasma and urinary concentrations of enterolactone and enterodiol.[7]

Lignans protect against cancer by blocking certain enzymes involved in hormone metabolism and interfering with the growth and spread (metastasis) of tumour cells.[8,9] Indeed, populations with high intakes of lignans, antioxidants and phytoestrogens from fruits, vegetables, nuts and whole grains have low rates of cancer of the ovaries[10,11] and the Gastrointestinal (GI) tract – including cancer of the mouth, esophagus, stomach, colon and rectum[12-18] – compared with those who have low intakes of these foods.[19]

In addition to having anticancer effects, a new study suggests that postmenopausal women who have a high intake of lignans perform better on tests of memory than women with low intakes. The intake of lignans, but not isoflavones (found in soy products, beans, peas, nuts), was related to better cognitive function in this study.[20]

Other Phytochemicals

Flax contains several phytochemicals. ("Phyto" means "plant.") In addition to the lignans, which are abundant in flax, flax contains phenolic acids, cinnamic acids, flavonoids, and lignins. These compounds are antioxidants and affect cell growth and viability – actions that may increase their potential use as agents which protect against cancer and heart disease.[21,22]

Dietary Fibre

Flax is a source of dietary fibre, providing about 2.2 g/tbsp of ground flax. It contains both insoluble and soluble fibre. Insoluble fibre helps improve laxation and prevent constipation, mainly by increasing fecal bulk and reducing bowel transit time.[13] In a recent study of elderly residents in a long-term care facility, adding 1 tbsp of milled flax to the daily diet resulted in a 32% increase in bowel frequency by the end of the 4-month intervention. The use of suppositories decreased 50% in this population over the course of the study.[23]

The water-soluble fibre fraction of flax makes up about one-third of total dietary fibre. The main soluble fibre in flax is mucilage gum. Water-soluble fibre helps maintain blood glucose levels and lower blood cholesterol levels.[2]

North Americans are advised to eat more fibre-rich foods,[24,25] as diets rich in fibre appear to protect against cancers of the GI tract and the lung. A protective effect of fibre-rich diets for cancers of the breast and prostate has not been established conclusively. Even so, diets rich in fibre from fruits, vegetables, and whole grains are less likely to promote obesity – itself a risk factor for cancer – because these foods tend to be low in fat.[13,26]

It Tastes Good, Too!

Flax is rich in ALA, the essential omega-3 fat; lignans, which are phytoestrogens and antioxidants; and dietary fibre, which helps maintain bowel function. Just as important as its nutrient content is its taste – flax has a mild, nutty flavour. It can be mixed into salads, soups, stews, chilies, hamburgers, vinaigrettes, hot and cold cereals, fruit smoothies, cookies, muffins and bread dough. Indeed, it can be added to just about any recipe!

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Printed in Canada

New FLAX FACTS

OMEGA-3 FATS ARE ESSENTIAL FOR INFANTS

by Dr. Diane H. Morris

Infants have a high requirement for essential fats. During pregnancy, the mother's diet is the source of essential fats for the developing fetus. After birth, breast milk or infant formula supplies a variety of essential fats for newborn growth.[1]

Essential Fats for Infants

Two families of fats – the omega-3 family and the omega-6 family – are vital for people of all ages, including infants. Alpha-linolenic acid (ALA) is the parent compound of the omega-3 family. ALA is essential in our diets because the human body cannot make it. The human body can convert ALA to the long-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

The parent compound of the omega-6 family is linoleic acid. Like its cousin (ALA), linoleic acid is essential for infants and adults because it cannot be made in the human body. Linoleic acid can be converted to a long-chain omega-6 fatty acid that goes by the tongue-twisting name of arachidonic acid.

Although all of these omega-3 and omega-6 fats are important in human nutrition, infants have a unique need for two of them – DHA and arachidonic acid. It is not clear whether ALA has a unique role in infant nutrition, other than its recognized role in preventing an omega-3 fatty acid deficiency.[2] The uncertainty about ALA's unique contribution to infant health may have arisen because most clinical research over the past decade has focused on understanding the unique role of DHA in infant nutrition.

ALA in Infant Nutrition

- ALA is the essential omega-3 fatty acid, being required in our diets because our bodies cannot make it.
- Infants need ALA to grow and develop properly.
- ALA is the main omega-3 fatty acid in human breast milk.
- A unique role for ALA in infant nutrition, other than being needed to prevent an omega-3 fat deficiency, has not been determined, possibly because most research has focused on the role of DHA in infant health.

Omega-3 Fats Are Needed *in utero*

The growing fetus draws its supply of essential fatty acids from the mother through the placenta. For this reason, pregnant women must eat a diet containing ample amounts of omega-3 and omega-6 fats for her own needs and also for those of the developing fetus.[3]

As the fetus grows *in utero*, essential fatty acids are needed for the production of compounds called eicosanoids, which control the immune system. The DHA and arachidonic acid derived from essential fatty acids are especially vital, as they are building materials for the structure of nervous tissue, including the brain.[1] DHA, for example, is laid down rapidly in the grey matter of the brain and in the retina of the eye during the last trimester of pregnancy and the first year of life.[4] In these tissues, the DHA concentration can exceed 50% of total fatty acids.[5]

Infants Need Omega-3 Fats to Grow

After birth, infants obtain omega-3 and omega-6 fatty acids from breast milk or infant formula. Preterm infants, because of their earlier-than-expected births, appear to have a greater need for essential fatty acids than full-term infants.

Omega-3 Fats in the Diets of Pregnant Women

Suggested intakes of flax for pregnant and lactating women are described in the Flax Council of Canada's book, *Flax – A Health and Nutrition Primer*, which is available on the Council's website at www.flaxcouncil.ca.

Cautions regarding the eating of some species of fish during pregnancy are posted on the websites of Health Canada (www.hc-sc.gc.ca) and the U.S. Food and Drug Administration (www.fda.gov).[27,28]

ALA Is the Main Omega-3 Fat in Breast Milk. ALA is the main omega-3 fatty acid in breast milk. ALA constituted 1.2% to 1.9% (% weight of total fatty acids) in breast milk samples taken from women in Canada (1.2%),[6] Brazil (1.4%),[7] and Nepal (1.9%).[8] Breast milk contains 3-10 times more ALA than DHA, depending on the mother's diet.[6-10] The breast milk of vegetarians contains less DHA than that of omnivores.[2]

Breast Milk is Best. Experts agree that breast milk is best for preterm and term infants. Breast milk provides calories, essential fatty acids, vitamins and other important nutrients.[2,11,12]

Infants who are breast-fed have greater amounts of DHA in their blood, red blood cells and brain tissue than formula-fed infants. Some studies found that breast-fed infants performed better on tests of vision and cognitive development than formula-fed ones.[13-15] In one study, children born to mothers who took cod liver oil (a source of DHA) during pregnancy and lactation scored higher on IQ tests at 4 years of age compared with children whose mother's diets were supplemented with corn oil.[16]

ALA Content of Infant Formula. In Canada, infant formula must contain not less than 500 mg of linoleic acid. A minimum amount of ALA has not been specified.[17] In 2002 Health Canada allowed the use of an oil blend containing DHA and arachidonic acid in infant formula.[18]

In the United States, the Life Sciences Research Office (LSRO) set a range for the ALA content in infant formula of 1.75% to 4% of total fatty acids. These levels apply to infant formula for both preterm and term infants.[2,11]

The LSRO endorsed a ratio of linoleic acid to ALA of not more than 16:1, and not less than 6:1. Upper and lower limits for the ratio were set to prevent inappropriate combinations of linoleic acid and ALA that would prevent their conversion to their respective long-chain essential fatty acids.

The source of ALA for most infant formulas is a polyunsaturated vegetable oil such as corn oil, safflower oil, or soybean oil. Canola oil is a component of some European infant formulas.[2] Canola and soybean oils contain modest amounts of ALA.

DHA Content of Infant Formula. The LSRO recommended a maximum concentration of DHA of 0.35% of total fatty acids in preterm infant formula. LSRO did not specify a minimum DHA content for preterm infant formula. Egg yolk, fish oils and oils produced by single-cell organisms (that is, microalgal and fungal oils) are sources of DHA and arachidonic acid in infant formulas.[2]

Benefits of Omega-3 Fat-Enriched Infant Formula. Some infant formulas have been modified to contain ALA, DHA and other essential fatty acids. As a result, studies have aimed to determine whether changes in infant formula composition improve growth and developmental outcomes in formula-fed preterm and term infants.

A recent meta-analysis of clinical studies – 5 involving term infants and 3 involving preterm infants – found that infants fed an infant formula supplemented with ALA had significantly higher blood and red blood cell levels of DHA than infants fed a regular formula without ALA.[19] The findings suggest that ALA-supplemented formula improves the DHA status of infants.

The findings related to DHA-supplemented formula are surprisingly mixed. Some studies have shown a benefit of supplementing formula with DHA in terms of visual acuity,[15,20,21] while others found no evidence to support adding DHA to formulas.[22-25]

Omega-3 Fats in the Feeding of Infants

Many questions about the roles of omega-3 fats in infant nutrition remain unanswered. What is the unique role of ALA in infant nutrition? What is the optimum mix of essential fatty acids in infant formula? For pregnant and nursing women, which diet pattern achieves the best omega-3 fat status in their growing infants? So far, research suggests that infant formula is not as good for babies as breast milk.[26] For pregnant women and nursing mothers, the best approach is to eat a varied diet containing ample amounts of ALA, DHA and other omega-3 fats.

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New FLAX FACTS

FLAX FAVOURABLY AFFECTS THE IMMUNE SYSTEM

by Dr. Diane H. Morris

SUMMARY

Flax is rich in ALA, which has been shown to decrease inflammatory reactions in humans. Lignans have anti-inflammatory effects in rats.

- ALA-rich diets increase the omega-3 fat content of cell membranes and decrease the production of agents that promote inflammation.
- ALA-rich diets decrease blood levels of CRP, a biomarker of inflammation and tissue damage. In a clinical study, CRP blood levels decreased 75% in volunteers who ate an ALA-rich diet containing a combination of walnuts, walnut oil, and flax oil. In a cohort of women participating in the Nurses' Health Study, CRP levels in blood decreased as their ALA intake increased.
- Lignans decrease levels of pro-inflammatory cytokines like TNFα in rats.

Flax is rich in alpha-linolenic acid (ALA), the essential omega-3 fatty acid, and lignans, which are phytoestrogens. ALA and lignans modulate immune reactions and may play a beneficial role in the prevention and management of atherosclerosis, obesity, the metabolic syndrome, and other chronic diseases in which chronic inflammation is a key feature.

Features of Chronic Inflammation

In healthy tissue there is a balance between agents that promote inflammation and those that block it. When there is an infection or injury, the pro-inflammatory agents rally to eliminate the infection or repair the injury and return the tissue to health. When health is restored after a few days or weeks, the number of pro-inflammatory agents returns to normal. In some cases, however, the immune system switches from an acute mode to a chronic, low-grade inflammation that can persist for months or years.[1]

In both acute and chronic inflammation, immune cells release a variety of pro-inflammatory agents, including cytokines such as tumor necrosis factor α (TNFα), interleukin-1β (IL-1β), and interleukin-6 (IL-6). These cytokines are part of a large network of cell signaling agents. One of their key actions is to stimulate the release of C-reactive protein (CRP).

CRP is an acute phase pro-inflammatory protein formed mainly in the liver in response to acute injury, infection, hypersensitivity reactions, inflammatory diseases, malignancy, and trauma. CRP is a sensitive biomarker of systemic inflammation and tissue damage. It is strongly associated with atherosclerosis, insulin resistance, and the metabolic syndrome.[2,3]

When immune cells switch to a chronic inflammatory mode, they produce more cytokines and CRP than are needed. The result is that healthy tissue becomes inflamed. Indeed, chronic inflammation has been said to result from the failure of normal wound healing.[1]

Chronic Inflammation and Chronic Disease

Low-grade chronic inflammation is a feature of many chronic diseases. In atherosclerosis, for example, TNFα, IL-1β, and IL-6 are released by macrophages (a type of immune cell) and foam cells found within vascular cell walls.[4] In rheumatoid arthritis, IL-1β and TNFα are major pro-inflammatory cytokines found in affected joints.[1] In one study of 74 patients with rheumatoid arthritis, blood concentrations of IL-1β and TNFα were 5- and 15-fold greater, respectively, in arthritis patients than in healthy adults.[5]

Obesity can also be viewed as a state of chronic inflammation.[2] The presence of excess adipose tissue, particularly in the abdominal area, is marked by increased blood levels of CRP and also of TNFα, IL-6 and other pro-inflammatory cytokines.[2,6,7] The abundance of these cytokines in adipose tissue and CRP in the bloodstream is believed to contribute to insulin resistance – a major risk factor for type 2 diabetes, hypertension, and blood lipid disorders, and possibly a risk factor for coronary heart disease.[8-10] Indeed, even in a group of healthy Japanese men and women, there was an association between CRP and increased fasting insulin levels, fasting glucose levels, and insulin resistance.[11]

Flax Effects on the Immune System

Flax contains ALA and lignans, both of which decrease inflammatory reactions. New research provides insights on their anti-inflammatory effects.

ALA. One way in which ALA influences immune reactions is by changing the fatty acid composition of membrane phospholipids. For example, in a clinical study, the ALA content of red blood cell membranes increased 225%, and their content of eicosapentaenoic acid (EPA) increased 150%, in healthy men who ate a diet enriched with flax oil (about 2 tbsp daily or 15 g ALA/day) for 12 weeks.[12]

This increased omega-3 fatty acid content of cell membranes decreases the production of the cytokines TNFα and IL-1β. In a study of 28 healthy men, for example, consuming flax oil (about 1 2/3 tbsp daily

providing 13.7 g ALA/day) for 4 weeks resulted in a decrease in TNFα and IL-1β production of nearly 30% in mononuclear cells (a type of immune cell).[13]

Diets rich in ALA have also been shown to decrease the blood concentration of CRP. A clinical study conducted in 23 men and women with high blood cholesterol found that serum CRP concentration decreased 75% when the volunteers consumed an ALA-enriched diet compared with when they consumed an average American diet.[14] Dietary ALA was obtained by eating a combination of walnuts, walnut oil, and flax oil in this study. [The ALA-rich diet provided about 17 g ALA/day, based on a 2,400 kcal diet, and can be achieved by consuming roughly 2 tbsp flax oil daily.] The average American diet in this study provided about 2 g of ALA per 2,400 kcal. In the Nurses' Health Study, ALA intake was inversely related to plasma CRP concentrations.[15]

Lignans. Lignans have been shown to decrease the production of TNFα and IL-6 in microglial cells of rats.[16] (Microglial cells are found in the brain.) The anti-inflammatory effects of lignans have not been studied in humans.

Flax Has Favourable Effects on the Immune System

Flax favourably influences immune reactions. ALA and lignans block the release of pro-inflammatory cytokines. ALA-rich diets decrease blood CRP levels. Through these effects, flax consumption may help prevent and treat disorders characterized in part by an over-stimulated immune system. Such disorders include atherosclerosis, obesity, the metabolic syndrome, diabetes mellitus, rheumatoid arthritis, multiple sclerosis and systemic lupus erythematosus.[17]

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New FLAX FACTS

ALA AND OTHER OMEGA-3 FATS MAY PROTECT AGAINST ARRHYTHMIA

by Dr. Diane H. Morris

Arrhythmias or dysrhythmias, as they are sometimes called, are abnormal rhythms of the heart muscle. There are many different types of arrhythmias. Some are disconcerting because they cause the heart muscle to skip a beat or add an extra beat, but they are not dangerous. Others are serious, resulting in dizzy spells, shortness of breath, chest pain and other complications.[1] The large number of sudden cardiac deaths from coronary heart disease – estimated at about 8-10% of all deaths in Canada in 1999[2] and 335,000 deaths per year in the United States[3] – are due mainly to arrhythmia.

Growing evidence suggests a simple dietary change – increasing the dietary intake of omega-3 fats – may help prevent sudden death from arrhythmias. The major omega-3 fats are alpha-linolenic acid (ALA), the essential omega-3 fatty acid, and its long-chain cousins, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

The omega-3 fatty acids prevent arrhythmias in heart cells grown in test tubes and also in laboratory animals. In humans, omega-3 fats have been shown to reduce the risk of arrhythmias in most,[4-7] but not all,[8] clinical studies.

How Arrhythmias Occur in the Heart

The heart is a muscle that pumps blood throughout the body. The pumping action of the heart is controlled by electrical signals, which are formed by a special group of cells located in the heart's right upper chamber. These special cells are known collectively as the sinus node.

The sinus node is a natural pacemaker for the heart. Its electrical signals travel first through the upper chambers of the heart (the atria), then through a switching station called the AV node, and finally to the lower chambers of the heart (the ventricles). The ventricles route the electrical signal through special nerve cells, and the end result is a contraction of the heart muscle, which pumps blood through the body.

Arrhythmias occur when the heart's natural pacemaker, the sinus node, develops an unnatural rhythm. In some cases, the sinus node may beat too fast, producing a condition known as tachycardia. In other cases, the sinus node's electrical signal is totally disorganized, causing the atria to contract too quickly. Both conditions are very serious.[1]

Omega-3 Fats Protect against Arrhythmia in Test Tube Studies

Omega-3 fats may protect against arrhythmia by helping heart muscle cells remain stable electrically and by preventing them from becoming "hyperexcitable".[9] In test tube studies of rat heart cells, for example, omega-3 fats decreased the electrical excitability of the heart cells, making them less likely to develop abnormal heart rhythms.[10,11]

A test tube study of adrenal gland cells taken from cows had similar findings – the major omega-3 fats (ALA, EPA and DHA) reduced the electrical excitability of cells. The omega-3 fats worked by blocking the entry of calcium into the adrenal gland cells. DHA and ALA were better than EPA at blocking calcium entry into these cells.[12] (Calcium works like a pacemaker for cells, much like the sinus node is a pacemaker for the heart.) These findings suggest that the antiarrhythmic effect of omega-3 fats is partly due to their ability to control the electrical activity of cells.

Alpha-Linolenic Acid Is As Effective as EPA and DHA in Animals

Pure preparations of ALA, EPA and DHA are equally good at protecting against fatal arrhythmias in dogs. In one study, pure solutions of ALA, EPA and DHA were infused separately. All three omega-3 fats reduced significantly the occurrence of ventricular fibrillation and protected a majority of dogs from fatal arrhythmias. Infusion of a control fat (soybean oil) failed to protect any animals from fatal arrhythmias.[13] These findings suggest that omega-3 fats help regulate heart function.

Flax Protects against Ventricular Fibrillation in Rabbits

Rabbits have long been used for the study of diet and coronary heart disease. A recent study tested the cardioprotective effects of flax in rabbits.[14] Rabbits were fed a regular rabbit diet, a regular rabbit diet + milled flax, a regular diet + added cholesterol, or a cholesterol diet + milled flax for up to 16 weeks.

The diets containing milled flax increased the ALA content of heart tissue 3- to 4-fold and lowered the omega-6/omega-3 ratio in heart tissue. Ventricular fibrillation was prevented in rabbits fed the regular

diet + milled flax and reduced in the group fed a cholesterol diet + milled flax. Indeed, there was a negative correlation between the ALA content of heart tissue and the incidence of arrhythmias. That is, rabbits with the greatest amount of ALA in their heart tissue had the fewest arrhythmias.

Rabbits fed milled flax, with or without added cholesterol, also had shorter QT intervals than rabbits fed diets without flax. In these rabbits, the flax diet resulted in a shortened QT interval, meaning that flax had an antiarrhythmic effect.[14]

What is a QT Interval?

The QT interval reflects the heart's electrical activity during an electrocardiogram (ECG or EKG). Electrical activity is recorded during the ECG as a pattern of waves. The parts of each wave are labeled by certain letters: P, Q, R, S and T. The QT interval is the time it takes for the electrical signal to pass through the lower chambers of the heart. If the time is longer than normal, a person (or animal) is said to have a long QT interval.[1]

Human Studies of Omega-3 Fats and Arrhythmia

Heart disease can be prevented by being active, not smoking, and eating a diet high in fruits, vegetables, nuts, and whole grains and also rich in omega-3 fats from plants and fish.[15] Diets containing fatty fish or at least one fish meal per week are associated with reduced risk of primary cardiac arrest,[16] death from all causes,[17] or sudden death from a heart attack.[18]

Now there is evidence that people who eat diets rich in omega-3 fats from fish and plants appear to be protected against fatal arrhythmia. Elderly adults in one study, for example, who regularly ate tuna or other broiled or baked fish had a lower incidence of atrial fibrillation than those who rarely ate such fish. Eating fried fish or fish sandwiches was not linked with a lower risk of atrial fibrillation.[5] In another study – the Family Heart Study[6] – men and women who had the highest intakes of plant omega-3 fats had shorter QT intervals than those with the lowest plant omega-3 fat intakes. These findings suggest that omega-3 fats from fish and plants have important benefits for the heart.

Healthy Diets for Healthy Hearts

Omega-3 fats appear to enhance the electrical stability of the heart muscle and to protect against fatal arrhythmia in animals and humans. Evidence suggests that making a small dietary change – namely, regularly eating foods rich in omega-3 fats from flax, other plants and broiled or baked fish (but not fried fish) – helps protect against arrhythmia.

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New FLAX FACTS

FLAX REDUCES INFLAMMATION LEADING TO ATHEROSCLEROSIS

by Dr. Diane H. Morris

SUMMARY

The findings of one large cohort study – the Nurses' Health Study – and two clinical studies suggest that diets rich in flax omega-3 fat (ALA) decrease blood levels of cell adhesion molecules. Cell adhesion molecules are biomarkers of early events in the development of atherosclerosis or hardening of the arteries.

Flax is rich in alpha-linolenic acid (ALA), the essential omega-3 fatty acid, and lignans, which are phytoestrogens and antioxidants. These flax components decrease inflammatory factors associated with atherosclerosis – also called "hardening of the arteries" – and may help prevent heart attacks and strokes.

Role of Cell Adhesion Molecules in Atherosclerosis

Atherosclerosis begins in infancy and childhood when the earliest lesions, called fatty streaks, begin to develop in arteries.[1] In the early stages of fatty streak development, white blood cells (leukocytes) begin sticking to the inner lining of blood vessels (the endothelium).

The sticking of leukocytes to the endothelium is controlled by a group of compounds called cell adhesion molecules. Cell adhesion molecules are stirred into action in response to signals from pro-inflammatory compounds such as C-reactive protein (CRP) and cytokines such as tumor necrosis factor α (TNFα), interleukin-1β (IL-1β), and interleukin-6 (IL-6). CRP and cytokines are themselves released in response to inflammation.[2-4]

Refer to the Flax Council of Canada's fact sheet titled *Flax Favourably Affects the Immune System* for a review of how flax components decrease the blood levels of C-reactive protein and cytokines.

The actions of cell adhesion molecules enhance the formation of fatty streaks and plaques. Plaques are advanced lesions that can block the flow of blood in the artery. If a plaque ruptures, it can cause a thrombosis that may result in a heart attack (myocardial infarction) or stroke.[4] (Consult the table for a description of compounds that promote inflammation and atherosclerosis.)

Clinical Importance of Cell Adhesion Molecules

Cell adhesion molecules include E-selectin, vascular cell adhesion molecule type 1 (VCAM-1), and intercellular adhesion molecule type 1 (ICAM-1). They are responsible for attaching leukocytes tightly to the endothelium.[5]

Soluble forms of these adhesion molecules appear in the bloodstream. High blood levels of cell adhesion molecules occur in several inflammatory disorders. For example, blood levels of VCAM-1 and ICAM-1, but not E-selectin, were increased significantly in patients who had had an acute heart attack or who had either stable or unstable angina, but they were low in patients with normal coronary arteries.[6] Blood levels of VCAM-1 and ICAM-1 were increased significantly in patients with rheumatoid arthritis – who have a high risk of coronary events – compared with healthy adults.[7] (E-selectin was not measured in this study.) These and other findings suggest that blood levels of cell adhesion molecules may serve as important clinical biomarkers of inflammation and atherosclerosis.[6-8]

Table

Active Agents in Atherosclerosis

Agent	Actions
C-reactive protein (CRP)	An acute phase inflammatory protein; high blood levels of CRP indicate the presence of systemic inflammation or infection.[3]
Cytokines	Proteins released by immune cells; they both start and amplify inflammatory reactions.[1] Examples: interleukin-1β (IL-1β), interleukin-6 (IL-6), tumor necrosis factor α (TNFα)
Cell adhesion molecules	Respond to signals received from cytokines; they promote the sticking of white blood cells (leukocytes) to the inner lining of blood vessels (the endothelium) and their blood levels may help predict risk of heart attack and stroke.[6] Examples: E-selectin, vascular cell adhesion molecule type 1 (VCAM-1), intercellular adhesion molecule type 1 (ICAM-1)

ALA-Rich Diets Decrease Blood Levels of Cell Adhesion Molecules

Several recent studies suggest that flax and its essential omega-3 fatty acid, ALA, decrease the blood levels of soluble cell adhesion molecules. These findings provide evidence that diets containing flax may help prevent or slow the progression of atherosclerosis.

Cohort Study. In the Nurses' Health Study, a cohort of 727 women reported their usual dietary intake and provided a blood sample in 1989-1990. The Nurses' Health Study is a prospective cohort study that began in 1976; follow-up data have been collected every 2 years since then.

In these women, plasma concentrations of VCAM-1 and E-selectin tended to decrease as ALA intake increased. Plasma concentrations of E-selectin, ICAM-1, and VCAM-1 were all inversely related to the intake of total omega-3 fatty acids. Plasma VCAM-1 concentrations were lowest in women with ALA intakes of 1.2-2.4 g/day or total omega-3 fat intakes of 1.4-3.3 g/day.[9] [An ALA intake of 1.2-2.4 g/day can be achieved by eating 2-4 tsp of milled flax or 1/2-1 tsp of flax oil daily.]

Clinical Studies. In a clinical study, men and women with moderate hypercholesterolemia were assigned to eat 3 test diets on a rotating basis. One diet was an average American diet; one diet was rich in ALA provided by a combination of walnuts, walnut oil, and flax oil; and one diet was rich in linoleic acid, the essential omega-6 fatty acid. The ALA-rich diet significantly decreased serum ICAM-1, E-selectin, and VCAM-1 concentrations compared with the average American diet. In this study, the ALA-rich diet had the largest beneficial effects on these markers of endothelial activation.[10] However, the ALA intake in this clinical study was high – 6.5% of energy or about 17 g ALA/day. [This intake level can be achieved by consuming flax oil, which provides 8 g ALA/tbsp, in addition to other ALA-containing foods.]

A clinical study conducted in Greece recruited 90 men with high blood cholesterol who ate a typical Greek diet. They were randomized to eat for 12 weeks a diet rich in ALA obtained from flax oil or a diet rich in linoleic acid obtained from safflower oil. The ALA diet decreased VCAM-1 levels 18%.[2]

Regular Flax Consumption May Help Prevent Atherosclerosis

New research suggests a role for flax in reducing blood levels of cell adhesion molecules. Blood levels of cell adhesion molecules may predict risk of heart attacks and stroke.[6] A regular intake of flax may help prevent heart attacks and stroke by reducing inflammatory reactions associated with atherosclerosis.

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Flaxseed – STORAGE AND BAKING STABILITY

Flaxseed is recognized as a "functional food" because of its generous content of the essential fatty acid, alpha-linolenic acid (ALA) and the precursor of mammalian lignans, secoisolariciresinol diglycoside (SDG). Each promises to play a positive role in reducing the risk of a major health threat: ALA in coronary heart disease[1], and lignans with respect to cancer[2]. Health professionals have raised the question of how well these components survive the hazards of oxidation and heat under common conditions of flax storage and food preparation. The answer is, surprisingly well.

Alpha-linolenic acid

ALA, in isolated form or as a component of an extracted purified oil, is generally considered susceptible to oxidation[3] because it is highly unsaturated; that is, it has three double bonds in its 18-carbon chain. Oxidation is encouraged by both warmth (autoxidation) and light (photo-oxidation)[4]. However, ALA in the intact seed of flax has proven remarkably resistant to oxidation despite the fact that it makes up about 50-59% of the oil in flaxseed which in turn is normally 35-45% of the seed weight[3]. Why this is so remains a question but the facts are clear, as represented by current research.

Storage effects:

Flaxseed, either whole or coarsely ground, appears stable to long-term storage at room temperature. Even after 308 days at 22°C (72°F) there was essentially no change in peroxide value as a measure of oxidation by-products or in the percentage of ALA in fat extracted from the stored flaxseed samples[5]. This demonstration of oxidative stability in common storage was later confirmed by direct measurement of oxygen consumption. One gram samples of whole flaxseed, milled flaxseed and extracted flax oil were held in individual sealed glass tubes for 280 days at room temperature with 12h alternating dark/light cycles. All three preparations showed little change in headspace oxygen during this time although the flax oil sample was more variable. The fatty acid composition of all three samples remained unchanged, suggesting that flaxseed ALA was stable to both heat and light[6].

These stability results with small samples have been corroborated by studies on l kg lots of milled flaxseed which were stored in closed packages at 23°C for 128 days. The samples were examined initially and at approximately thirty-day intervals. The packages were triple-layer paper bags with plastic liners, much like those used in the 60 lb. bags normally supplied to commercial bakers. Sensory tests by a trained panel showed no difference in the aroma intensity of water slurries of fresh and stored samples at any of the four storage intervals. Changes in chemical indices of oxidation (peroxide values, free fatty acids and volatile compounds) were negligible[7]. As further evidence of flaxseed's storage stability, 36 consumers could not tell the difference between the taste of yeast breads baked with the either fresh or stored milled flaxseed included as 11% of flour weight in the recipe[8].

Baking effects:

ALA in whole and milled flaxseed also appears to be stable to heat equal or greater than the temperatures involved in baking batters and doughs such as muffins and yeast bread. Thermal stability was shown in 1992 by the absence of significant changes in peroxide values and fatty acid composition when both forms of flaxseed were heated for 60 minutes at either 100°C (212°F) or 350°C (662°F). Furthermore, gas liquid chromatography showed no signs of new *trans* isomers of ALA or of cyclic fatty acid formation in samples subjected to these degrees of heat[5]. In a follow-up study the proportion of ALA in the fat of a muffin mix, where 28.5% of the formula was milled flaxseed, was virtually unchanged after baking at 178°C (350°F) for 2h (45.1% ALA before:45.0% after). This stability was observed even though oxygen consumption of the flaxseed muffin mix was considerably greater than that of the control muffin mix[6]. A subsequent study confirmed the stability of ALA in baked muffins containing the same amount of milled flaxseed and noted that thiobarbituric acid values, as estimates of ALA oxidation were also unaffected by baking[9].

On reflection, the baking stability of ALA should not be surprising considering that the internal temperature of a muffin approaching doneness would not be expected to exceed the gelatinization temperature of starch. Wheat flour in the presence of sugar, or honey in this instance, would gelatinize around 95°C (203°F), much lower than the temperature of hot air in the oven from which heat is transferred to the baking product. A further margin of safety for the ALA-conscious consumer is the fact that muffins are usually baked for only 20-25 min. at 204-208°C (400-425°F) in contrast to some experimental conditions[4].

Biological evidence also supports the stability of ALA to baking temperatures. Nine college women included 50g flaxseed in their daily diet for four weeks in one of two ways. Five of them added milled

flaxseed, uncooked, to the food of their choice such as breakfast cereal, soup, juice or yogurt. The other four consumed bread baked with milled flaxseed (250g/kg) rather than their usual bread. Plasma fatty acid profiles during the four-week study were not significantly different between the women eating raw milled flaxseed and those eating the same amount of flaxseed baked in bread. Both subject groups exhibited a lowering of serum total cholesterol and low-density-lipoprotein cholesterol[10]. The implication is that baking had no effect on the bioavailability of flaxseed fatty acids.

Lignans

SDG, the precursor of mammalian lignans in flaxseed, is a phenolic substance associated with the plant fibre[11]. Because phenolic structures are common to a number of commercial antioxidants[4] and because purified lignans as well as flaxseed extracts have shown antioxidant effects *in vitro* and/or *in vivo* [12], it is tempting to speculate that SDG may play a role in the storage and/or baking stability of ALA. The amounts of SDG in flax appear to vary with the variety of flax, its growing location and harvest year[13]. Each of these variables has been found to affect the amount of mammalian lignans produced from flax ingestion[14].

Storage and baking effects:

While there is currently little information on SDG stability to common storage, several studies suggest that there is no significant loss of SDG from flaxseed during the baking process. Muir and Westcott[15] reported in 1996 that the amounts of SDG measured chemically in both the crust and centre of a loaf of bread agreed well with measurements of SDG in flaxseed added to the dough. As well, the levels of SDG that they detected in four loaves of flaxseed bread purchased at local bakeries were within the range of values likely from the original addition of 7% flaxseed. In 1998, Rickard and colleagues[16], using *in vitro* fermentation[17], assessed total lignan production from a number of commercial breads and homemade products. Bread, muffins and pizza dough containing 6.9, 8.0 and 13.2% flaxseed respectively, were baked at 190°C (375°F). In both commercial and homemade categories, lignan production reflected the amount of flaxseed added. This was also the case in pancakes enriched with 6.2% flaxseed which were griddle-baked at 205°C (400°F). Furthermore, urinary lignan levels from nine women who ate 25g flaxseed daily for eight days were similar whether the flaxseed was eaten raw in applesauce or baked in muffins or bread[16]. It appears that the lignan availability from the SDG in flaxseed is stable to customary baking temperatures.

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New FLAX FACTS

METABOLISM OF ALPHA-LINOLENIC ACID

by Dr. Diane H. Morris

Alpha-linolenic acid (ALA) is the true essential omega-3 fatty acid, being required in our diets because our bodies do not make it. ALA has important roles in human health. It dampens inflammation, which is a feature of many chronic diseases like heart disease, stroke and cancer. It is incorporated into cell membranes, promotes the health of blood vessels and is converted to long-chain omega-3 fatty acids. Young women appear to convert more ALA to long-chain omega-3 fatty acids than men do, possibly because of their greater need for omega-3 fats during pregnancy and lactation. The efficiency of ALA conversion by both women and men is affected by diet. Our bodies use ALA to make energy for work and play and to form ketone bodies, which may help preserve cognition in elderly adults. Excess ALA is stored in adipose tissue to meet future energy needs.

Alpha-linolenic acid (ALA) constitutes about 57% of the total fatty acids in flax, making flax one of the richest sources of ALA in the diet.[1] The sections below describe the metabolism of ALA and its roles in human health.

ALA Is the True Essential Omega-3 Fatty Acid

ALA is the parent compound of the omega-3 fatty acid family. It must be obtained from our diets because our bodies do not make it.[2] In this regard, ALA is an essential nutrient just like vitamin C and calcium.

ALA Is Needed for Good Health

ALA has important biologic effects and helps prevent and manage chronic diseases like heart disease, stroke, type 2 diabetes, kidney disease and certain types of cancer.[1] ALA dampens inflammation, which is a feature of many chronic diseases,[3] and it helps promote the proper functioning of blood vessels, which reduces the risk of heart attacks and stroke.[4]

ALA constitutes 75-80% of total omega-3 fatty acids in breast milk, underscoring its importance for infant growth and development.[5,6] ALA is also required for maintaining the nervous system. A deficiency of ALA in humans causes poor growth, numbness, pain in the legs, difficulty walking and blurred vision.[7] These deficiency symptoms can be alleviated by adding ALA to the diet.[1]

Metabolic Fates of ALA

Dietary ALA has several metabolic fates. The list below describes how ALA is used by the human body.

- ***Increases the omega-3 fat content of cell membranes.*** ALA is incorporated into the triacylglycerols (triglycerides) and phospholipids of cell membranes, where it affects how nutrients are transferred into and out of the cell and how cells communicate with one another. In one study, healthy men who consumed about 2 tbsp of flax oil daily for 12 weeks showed a 225% increase in the ALA content and a 150% increase in the eicosapentaenoic acid (EPA) content of red blood cell membranes.[8] Increasing the omega-3 content of cell membranes makes them more flexible and decreases inflammation.[9]
- ***Is converted to long-chain omega-3 fatty acids.*** ALA is converted to the long-chain omega-3 fatty acids, particularly EPA and docosapentaenoic acid (DPA).[10]
- ***Produces energy.*** ALA undergoes ß-oxidation to produce energy for the work of muscles, the digestion of food, breathing, and the like. About 24-33% of an ingested dose of ALA undergoes ß-oxidation in men; in women, the figure is 19-22%.[1,10]
- ***Is used to make ketone bodies.*** ALA appears to be preferred over linoleic acid (an omega-6 fatty acid) as a substrate for ketogenesis – the process of making ketone bodies. Ketone bodies serve as an alternate energy source for the brain during starvation or fasting. This function of ALA may be important in maintaining healthy cognition in elderly adults.[11]
- ***Is stored for future energy needs.*** ALA is stored in adipose tissue, where it serves as a reserve supply of energy. Women store more ALA in their adipose tissue than men because of their greater fat mass.[12]

ALA Metabolism

The metabolic pathways of the omega-3 and omega-6 fatty acids are shown in the figure below. The discussion that follows focuses on the metabolism of the omega-3 family of fatty acids.

Desaturation and elongation. ALA is converted to long-chain fatty acids by a series of alternating desaturations and elongations. The desaturations add a double bond by removing hydrogen, while the elongations add two carbon atoms.

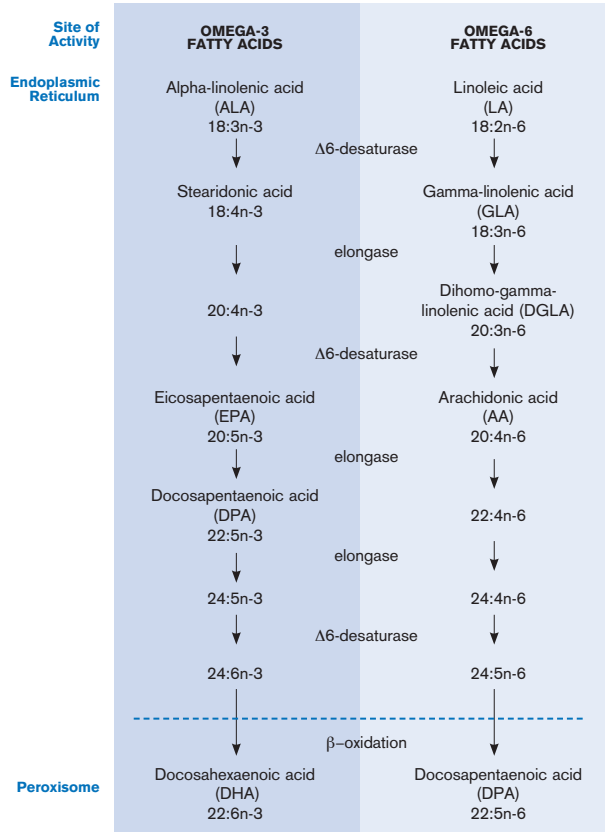
A more in-depth discussion of the metabolism of omega-3 and omega-6 fatty acids, along with information about their roles in human health, can be found in the Flax Council of Canada's book, Flax–A Health and Nutrition Primer. The book is available on the Council's website at www.flaxcouncil.ca

The first step in ALA metabolism is desaturation, catalysed by delta-6-desaturase. This step is considered rate-limiting, as it is most affected by nutritional, hormonal and metabolic factors.[13]

The desaturation and elongation steps occur in the endoplasmic reticulum of the cell. The desaturation steps tend to be slow, while the elongation steps are rapid. For this reason, the tissue concentration of stearidonic acid tends to be low, because it is formed slowly by desaturation and then quickly elongated to other metabolites.[14]

Competition between fatty acid families. Mammals cannot interconvert the omega-3 and omega-6 fatty acids. That is, omega-3 fatty acids cannot be changed into omega-6

Metabolic Pathways of the Omega-3 and Omega-6 Fatty Acids[a]



[a] The conversion pathway shown is the "Sprecher pathway", which is believed to be the major route. Conversion of DPA to DHA via Δ4-desaturase occurs in bacteria and some microorganisms. The exact method by which DHA is moved out of the peroxisome is not known, and the factors that affect its translocation have not been identified. New research suggests that regulation of DHA synthesis may be independent of the other steps in the omega-3 pathway (10).

fatty acids, or vice versa. Furthermore, there is competition between the two families. An excess of one family of fatty acids can interfere with the metabolism of the other, changing their concentrations in tissues and their biological effects.[14]

Efficiency of Conversion of ALA. Estimates of the conversion of ALA to EPA range from 0.2% to 8%,[12,15] with young women showing a conversion rate as high as 21%.[16] Conversion of ALA to DPA is estimated at 0.13% to 6%,[10] with women showing a conversion rate on the higher end (6%).[16]

ALA conversion to DHA appears to be limited in humans, with most studies showing a conversion rate of about 0.05%,[10,17] although one study reported a figure of 4%.[18] Here again, young women appear to convert more ALA to DHA than men do – as much as 9% of ingested ALA may be converted to DHA in young women.[16]

Factors Affecting ALA Conversion

Various factors affect ALA's conversion rate. One innovative test tube study of human breast cells found less ALA converted to EPA and DHA when cigarette smoke was bubbled into the growth medium; the enzyme most affected by the concentration of cigarette smoke was delta-5-desaturase.[19] Two other factors affecting ALA conversion – gender and diet – are described below.

Gender. Young women convert more ALA to the long-chain omega-3 fatty acids, possibly because their unique hormonal profile makes them more sensitive to diet than men are. Their greater ability to convert ALA to DHA may be important during pregnancy and lactation.[20, 21]

Diet. A diet rich in linoleic acid decreases ALA conversion by as much as 40%.[18] A high maternal intake of linoleic acid lowers EPA and DHA levels in umbilical plasma, suggesting reduced ALA conversion and availability of omega-3 fatty acids to the developing fetus.[22] Saturated fat, oleic acid, *trans* fatty acids, and dietary cholesterol interfere with ALA desaturation and elongation. High intakes of EPA and DHA – and even of ALA itself – can decrease the conversion rate.[13]

ALA Metabolism: What's Needed Now

The fact that ALA conversion to EPA, DPA, and DHA is affected by gender, smoking, and diet suggests that people differ in their metabolic capacity for ALA conversion. Clearly, ALA conversion is more complex than was originally thought. Studies are needed to identify other roles of ALA in human health and determine the diet and lifestyle patterns that enhance ALA conversion to the long-chain omega-3 fatty acids.

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New FLAX FACTS

FLAX LIGNANS HAVE ANTICANCER EFFECTS IN BREAST TISSUE

by Dr. Diane H. Morris

Large-scale population studies show that diets rich in lignans are associated with a reduced risk of breast cancer. Flax and its lignans help protect against breast cancer by altering the metabolism of estrogen and by decreasing cell proliferation, according to findings from a small number of clinical studies. The animal data are strong – flax and its main lignans interfere with cancer processes and inhibit metastasis of mammary (breast) tumours to the lungs and other organs. One animal study found that the combination of flax and tamoxifen was better at decreasing tumour size in mice than tamoxifen alone. Eating flax regularly may reduce breast cancer risk and improve the clinical prognosis for women with breast cancer.

Whole flax seeds and milled flax are excellent sources of lignans. Indeed, flax is the richest known dietary source of lignans.[1] Lignans are phytoestrogens – plant compounds that can affect estrogen metabolism in animals and humans. The main flax lignan is secoisolariciresinol diglucoside (SDG). SDG is converted to the enterolignans or mammalian lignans – namely, enterodiol and enterolactone – by the action of bacteria in the colon.[2] Human and animal studies support a role for flax and its lignans in breast cancer prevention and control.

Information about flax lignans, their roles as phytoestrogens and antioxidants, and their anticancer effects can be found in Chapters 4 and 6 of the Council's book, *Flax–A Health and Nutrition Primer*, which is available on-line at www.flaxcouncil.ca

Flax Helps Protect Against Breast Cancer by Influencing Estrogen Metabolism

Breast cancer is hormone-sensitive, meaning that in the early stages, tumour growth is influenced by the sex hormones, particularly estrogen and its metabolites.[3] The biologically active form of estrogen is estradiol, which is oxidized mainly in the liver to estrone. Estrone can be converted to two metabolites with different biologic effects – 2-hydroxyestrone has little biologic activity, while 16α-hydroxyestrone enhances estrogen activity and promotes uncontrollable tumour cell growth or cell proliferation, as it is called.[4] Women who produce more 16α-hydroxyestrone may have an increased risk of breast cancer.[5] Two clinical studies found that postmenopausal women who ate a diet supplemented with 10 g or 25 g of milled flax for 7 weeks[6] or 16 weeks[4] increased the excretion of 2-hydroxyestrone in their urine, without increasing the excretion of 16α-hydroxyestrone. In these studies, flax consumption shifted the balance toward production of the relatively inactive metabolite of estrogen, thus supporting a role for flax seed in breast cancer prevention.

Estrogen Receptors in Breast Tumours

Breast tumours that contain receptors for estrogen are estrogen receptor positive (ER+); tumours that lack estrogen receptors are called ER negative (ER–). Women with ER+ tumours are more likely to respond to hormone therapy than women whose tumours are ER–.[3]

Population Studies Suggest a Protective Effect of Dietary Lignans

According to two recent reviews of large-scale population studies published since 1997,[7,8] plant and mammalian lignans appear to protect against breast cancer, at least in premenopausal women. The cancer protective effects of lignans in this population may be determined by the type of estrogen receptor in women's breast tissue.

One prospective cohort study among 58,049 postmenopausal French women found that those with the highest dietary lignan intake (>1395 μg per day) had a significantly reduced risk of breast cancer.[9] The beneficial effect of dietary lignans in this study was limited to ER+ and progesterone-positive breast cancers, suggesting a strong role for hormone receptors in controlling the biologic effects of lignans.

Flax Interferes with Cancer Processes in Animal Studies

Flax fed to carcinogen-treated rats and mice reduced tumour incidence, number, and size at the initiation, promotion and progression stages of mammary (breast) cancer.[2] Milled flax fed to rats decreased tumour incidence, number and size and resulted in lower levels of cell proliferation in mammary tissue.[10-12] Feeding milled flax slowed tumour growth rate in mice implanted with an ER– human breast cancer cell line[13] and decreased tumour weight and volume in mice implanted with an ER+ human breast cancer cell line.[14]

Feeding pure SDG to rats appears to inhibit mammary tumour growth at the early promotion stage of cancer development.[12] Thus, pure SDG may affect new tumour development, whereas milled flax appears to exert its effects at later stages of tumour growth.[15]

Flax Enhances Tamoxifen's Anticancer Effects in Mice

Tamoxifen is widely used as adjuvant therapy for breast cancer, especially in women who have ER+ breast cancer. Despite its proven anticancer effects, tamoxifen has troubling side effects.[16,17] A question often asked by women with breast cancer is this: Do flax lignans interfere with or enhance the anticancer actions of tamoxifen?

A mouse study was conducted at the University of Toronto to answer this question.[14] The study assessed the effect of flax and tamoxifen, alone and in combination, on the growth of ER+ human breast cancer cells in mice.

Nude mice were injected with estrogen-dependent MCF-7 cells and then fed one of several diets. The diets contained 10% milled flax, a tamoxifen pellet (5 mg), or both. (A 10% flax diet is roughly equal to a human diet containing about 20-25 g or 2-3 tbsp of milled flax daily.) Tumour growth was monitored weekly.

In these mice, dietary flax inhibited the growth of human ER+ breast cancer cells. At low 17β-estradiol levels, flax regressed tumour size by 74%; at high 17β-estradiol levels, flax regressed tumour size by 22%. (17β-estradiol is a key human estrogen.) Furthermore, flax enhanced the anticancer effect of tamoxifen – that is, flax + tamoxifen achieved a tumour regression >53% compared with tamoxifen alone.

Flax Lignans Block Metastasis in Mice

SDG inhibited metastasis in two studies of implanted ER– human breast cancer cells in nude mice. One study found that feeding SDG to mice decreased metastasis to lung, lymph nodes and other organs. Its effects were greater when it was combined with flax oil – the combination decreased total metastasis by ~43%.[18]

Another study assessed the therapeutic effect of flax and its main components – alpha-linolenic acid (ALA) and SDG – on the recurrence and metastasis after surgical resection of established primary mammary tumours in nude mice.[19] The study was designed to mimic in mice the typical clinical situation in which there is a risk of tumour recurrence and metastasis in women who have had surgery to remove a breast tumour. The incidence of metastasis in nude mice was significantly lower in groups fed milled flax, pure SDG and SDG + flax oil. The study showed that dietary flax and its components (ALA and SDG) inhibited metastasis to lungs, lymph nodes and other organs, but had little effect on tumour recurrence in mammary tissue.

The researchers suggest that breast cancer patients who consume flax after surgery may experience reduced risk of metastasis and an improved clinical prognosis.[19] Furthermore, consuming milled flax rather than pure SDG appears to be preferable – mice fed milled flax had the lowest incidence of metastasis among all diet groups.

Mechanisms of Lignans' Anticancer Effects

Mammalian lignans appear to exert anticancer effects through both hormone and non-hormone-related actions. The mammalian lignans enterodiol and enterolactone inhibit two key enzymes involved in estrogen synthesis; both enzymes are associated with increased breast cancer risk. Mammalian lignans may also have non-hormone-related actions, such as antioxidant activity, inhibiting angiogenesis and cell proliferation, and/or altering the expression of growth factors that stimulate tumour development.[2,10,13,14]

More Clinical Studies of Flax and Cancer Are Needed

The findings of animal studies strongly suggest that flax and its lignans have anticancer effects. Although the clinical findings are promising, more clinical work is needed to confirm the anticancer effects of flax and the flax intake needed to achieve breast cancer protection.

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Printed in Canada

New FLAX FACTS

FOOD SOURCES OF ALPHA-LINOLENIC ACID

by Dr. Diane H. Morris

Alpha-linolenic acid (ALA) is the true essential omega-3 fatty acid, being required in our diets because our bodies cannot make it. ALA has important functions in the body. It is used for energy and converted to long-chain omega-3 fats such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). ALA helps prevent heart disease and stroke and reduces inflammation.[1]

Flax seeds are a renewable and rich source of ALA. Using flax in food preparation, whether at home or in commercial settings, increases the omega-3 fat content of popular foods.

Food Sources of ALA

Today's health-conscious consumers can choose among many different foods containing ALA. Some foods are naturally rich in ALA, while others have been enriched to increase their ALA and total omega-3 content. The main sources of dietary ALA are described below.

Flax and Flax Ingredients. Flax is the richest source of ALA in the North American diet. One tablespoon (8 g) of milled flax contains 1.8 g of ALA. One tablespoon (15 mL) of flax oil contains 8 g of ALA.

Various forms of flax are available in the consumer food market – whole flax seeds, milled flax, roasted flax and flax oil. Novel flax ingredients such as encapsulated flax and flax kernel (a dehulled flax product) are some ways in which food processors add flax to their food products. Food processors add milled flax and flax kernel to products as diverse as energy bars, salad dressings, soups, sausages, yogurt and baked goods.[2]

A Word about Flax Meal

Consumer products labeled "flax meal" are made by grinding whole flax seeds to produce traditional milled flax. Milled flax has all the goodness consumers expect – omega-3 fat, dietary fibre and lignans – in their proper proportions.

Other Oilseeds, Nuts and Plants. ALA is found in the fats and oils of canola, wheat germ and soybeans; in nuts such as butternuts and walnuts; and in red and black currant seeds. Leafy green plants like purslane contain a great deal of ALA, but because their overall fat content is low, leafy plants do not contribute significant amounts of ALA to our diets.[3]

Fish, Meat and Poultry. Fish contain trace amounts of ALA. Oily fish like salmon and herring contain more ALA (113-132 mg per 100 g portion) than do white fish like cod and haddock (1-3 mg per 100 g portion).[4]

Beef and pork generally contain more ALA than white fish. A broiled New York strip beef fillet contains 210 mg ALA per 100 g portion. A regular, all-beef large hamburger patty and roasted cured ham both contain about 25-45 mg ALA per 100 g portion. Chicken contains about 26 mg ALA per ½ roasted breast. Chicken with a milled flax seed breading is another tasty way for consumers to enjoy flax and chicken.[5]

Omega-3-Enriched Eggs. Omega-3-enriched eggs are derived from hens fed flax or other sources of omega-3 fats. Omega-3-enriched eggs are widely promoted for their DHA content, but they are also good sources of ALA. On average, one omega-3-enriched egg provides 340 mg of ALA – 10 times more than a regular egg and nearly one-third of the Adequate Intake of ALA for women aged 19 years and older.[6] A regular, large chicken egg contains about 20 mg of ALA.

Omega-3-Enriched Pork. Consumers in the Canadian, U.S. and Japanese markets can enjoy omega-3-enriched pork derived from hogs fed flax in their rations.[7] The pork product was developed by a company based in Winnipeg, Manitoba,[8] and contains between 400 mg and 2 g of ALA per 100 g serving. Traditional retail shoulder and loin cuts of pork contain about 20 mg of ALA per 100 g serving. [Canadian consumers can look for Prairie Orchard Farms Omega 3 Enriched Pork products; U.S. consumers can look for the product under the Verdancia Farms label.[9]]

ALA Content of Commonly Eaten Foods

If you are interested in the ALA content of other foods, consult the Flax Council of Canada's book, Flax–A Health and Nutrition Primer, which is available on the Council's website at www.flaxcouncil.ca. Table 11 in Chapter 3 of the Primer shows the ALA content of many leading food sources of this essential omega-3 fat.

Adding Flax to Food Products Increases Their Omega-3 Fat Content

The food industry has turned to flax to meet consumers' demand for foods that taste good, are nutritious and provide health benefits. Food companies continue to be creative in developing new flax food products – for families and their pets.[1,10]

Baked Goods and Dry Mixes. Bakers add milled flax to hearth breads – that is, breads baked in open hearths, not in pans. Whole flax seed or milled flax is added to variety and multigrain breads, bagels, tortilla shells, muffins, crackers and cookies. Milled flax is added to dry mixes for muffins, waffles and pancakes.[2]

Beverages. Flax adds texture and omega-3 fat in the form of ALA to energy drinks and smoothies. Milled flax is added to dry beverage mixes.[2]

Cereals and Pasta. Both hot and cold cereals are made with flax. Flax combined with soy in a granola-type cereal appears to be popular. Pasta products made with flax are found in most supermarkets and health food stores.

Energy Bars. Energy bars containing milled flax are increasing in popularity. Consumers can enjoy energy bars made with flax seeds and other ingredients such as soy, hemp, nuts, berries and whole grains.[2]

Spreads and Salad Dressings. Mayonnaise-type and buttery spreads made with flax oil are convenient for delivering omega-3 fats. Both heart-healthy and vegan spreads made with flax oil are available in numerous outlets. Flax oil-based salad dressings have been marketed in North America for several years.

Dairy Products. An omega-3 fortified milk has been available in Canada since 2004. Its omega-3 fat source is flax oil. Other products available globally include soy-based beverages with added flax oil, providing 500 mg omega-3 fatty acids per 250 mL (1 cup). Milled and whole flax seeds are used as a source of omega-3 fat in yogurts, cottage cheese and cheese spreads. Flax adds texture to these products.

Meatless Meal Products. Interest in vegan meals has increased steadily in recent years. Vegans can now enjoy a meatless smoked bratwurst, soy-based ham, hamburger and chicken cutlets made with added flax seed or milled flax.[2]

Miscellaneous Food Products. Some snack foods are formulated with flax. Crisps, popcorn, rice cakes and confectionary like chocolate bars contain added flax.

Prepared Meals. Several classic dinner favourites such as pizza, meat pies and lasagna now contain added flax. Pizza crust formulated with milled flax was introduced in 2007.[2]

Pet Foods. Pet food manufacturers recognize the health benefits of flax for pets – after all, if it's good for the family, it must be good for the family's pet. Many premium dry dog and cat foods and treats contain added flax.

Flax at Home — An Easy Way to Increase Your ALA Intake

Increase your ALA intake by buying flax products at local supermarkets, health food stores or through the Internet. At home, use flax regularly in food preparation. Here are simple suggestions for enjoying the great taste of flax at home:

- Sprinkle whole flax seeds or milled flax on yogurt, hot or cold cereals and salads.
- Whisk a little flax oil (2 mL/1/2 tsp) into a homemade or store-bought salad dressing or vinaigrette.
- Add 8-16 g (1-2 tbsp) of milled flax to family soups, stews and chilies.
- Add milled flax to homemade quick breads, muffins and cookies.
- Mix whole flax seeds and/or milled flax into bread doughs.
- Mix milled flax with hamburger for meat loaf.

Not sure how to get started? Try this simple breakfast treat or snack – mix about 3 g (1 tsp) of milled flax with 15 mL (1 tbsp) of honey and spread on warm toast. There are as many ideas on how to cook with flax as there are people in the kitchen!

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Printed in Canada

New FLAX FACTS

FLAX HELPS PREVENT HEART ATTACKS AND STROKE

by Dr. Diane H. Morris

Flax helps protect against heart attacks and stroke by lowering blood lipids, maintaining healthy blood vessels, and decreasing inflammation. The main nutrients in flax – namely, alpha-linolenic acid (ALA), the essential omega-3 fat; dietary fibre; and the lignan secoisolariciresinol diglucoside (SDG) – all contribute to its heart healthy effects.[1] Milled flax and whole flax seeds contain ALA, dietary fibre and lignans. Flax oil is very rich in ALA but contains virtually no dietary fibre and lignans.

Risk Factors for Cardiovascular Disease

The term cardiovascular disease (CVD) refers to all diseases of the blood vessels and circulation system, including heart attacks and stroke.[2,3] CVD is the result of atherosclerosis or "hardening of the arteries," an inflammatory disease that begins in childhood and involves unhealthy changes in the lining of blood vessels or endothelium, as it is called.[4]

Diet and lifestyle factors such as smoking, diabetes, high blood pressure, and high blood cholesterol can promote undesirable changes such as increased oxidative stress and inflammation in the endothelium. When the endothelium becomes inflamed, cholesterol and other lipids accumulate in blood vessel walls. Eventually, blood platelets clump together and plaques form in blood vessel walls. If a plaque ruptures and blocks blood flow to the heart, it can cause a heart attack; if it blocks blood flow to the brain, it can cause a stroke.

Cardioprotective Effects of Flax

Flax helps lower CVD risk. In clinical studies, the heart healthy benefits of flax were achieved by consuming 15 to 50 g (2-6 tbsp) of milled flax or between 2 mL (1 tsp) and 35 mL (2 1/2 tbsp) of flax oil daily.[1] Flax favourably affects the following risk factors associated with increased CVD risk:

Blood Lipids. Eating 2-6 tbsp (15-50 g) of milled flax daily for as little as 4 weeks decreased blood total and LDL-cholesterol significantly in clinical studies. (LDL-cholesterol is the so-called bad cholesterol.) Blood total cholesterol decreased 6-13% and LDL-cholesterol decreased 9-18% in studies of healthy young adults,[5,6] men and women with moderately high levels of blood cholesterol,[7] and other groups.[8-11] HDL cholesterol (the so-called good cholesterol) and triglycerides did not change in these studies.

The beneficial effect of milled flax and whole flax seeds[8] may be due in part to the dietary fibre in flax. Flax contains mucilage gums, which are a type of soluble dietary fibre. Soluble dietary fibre helps lower blood cholesterol levels.[12] In a study of 29 adults with high blood cholesterol levels, blood total cholesterol decreased about 5.5% and LDL-cholesterol decreased 9.7% when the volunteers ate muffins made with partially defatted flax for 3 weeks compared with when they ate muffins made from wheat bran for 3 weeks. (Partially defatted flax contains less than 10% fat, compared with regular milled flax, which contains about 41% fat.) These findings suggest a role for flax mucilage gums in lowering blood lipids.[13]

Clinical studies show no effect of flax oil on blood total and LDL-cholesterol levels. Even so, flax oil is a rich source of ALA, reducing inflammatory reactions and having beneficial effects on blood vessels.[1]

A flax lignan complex providing 500 mg of SDG daily did not lower blood lipids in one clinical trial,[14] although it decreased total and LDL-cholesterol by 20% and 14%, respectively, and increased HDL-cholesterol by 30% in a rabbit study.[15] Research regarding flax lignans and heart health is in its infancy, and too few human studies have been conducted to provide guidance on the role of lignans in decreasing CVD risk. Nonetheless, SDG is a powerful antioxidant.[16] It may help protect against oxidative stress,[17] which contributes to atherosclerosis.[18]

All together, most clinical studies suggest that consuming milled flax, whole flax seeds or partially defatted flax decreases total cholesterol and LDL-cholesterol levels without decreasing HDL-cholesterol.

Blood vessels. When the lining of the blood vessels – the endothelium – becomes inflamed, it loses its ability to work properly. In other words, it becomes dysfunctional. Studies measuring endothelial function in adults with type 2 diabetes[19] and in obese adults[20] have found that consuming flax oil, ALA-rich vegetable oils and omega-3 fats in general improves endothelial function and blood flow.[21-23] In one study, a diet providing 3.7-6.0 g of ALA from walnuts, walnut oil and flax oil increased blood flow (vasodilation) by 64% compared with an olive oil diet.[24]

Another outcome of endothelial dysfunction is a tendency for white blood cells, called leukocytes, to stick to the endothelium. This process is controlled by cell adhesion molecules, which increase inflammatory reactions and the progression of atherosclerosis; a high level of soluble cell adhesion molecules in the bloodstream is associated with increased CVD risk.[25] In a study of Greek men with abnormal blood lipids, consuming 15 mL (1 tbsp) of flax oil daily for 12 weeks reduced the concentration of one type of cell adhesion molecule by 18.7%.[26]

Inflammation. ALA-rich diets decrease the production of inflammatory compounds such as eicosanoids and cytokines. For example, cytokine levels decreased 26-28% when volunteers consumed flax oil for 4 weeks.[27]

ALA-rich diets are also associated with lower blood levels of C-reactive protein (CRP). CRP is a protein released by the liver in response to infection or injury; it is strongly linked with clinical signs of CVD.[28] In a clinical study, CRP levels

decreased 75% when 23 men and women consumed a diet rich in ALA obtained from a combination of walnuts, walnut oil, and flax oil for 6 weeks.[29] A community study in Tuscany, Italy, found that adults with low plasma ALA levels – indicating low dietary intakes of ALA – had significantly higher levels of blood CRP.[30]

Population Studies Show Heart Healthy Effects of ALA

Several large-scale population or epidemiologic studies, listed in the table, suggest a role for ALA in decreasing CVD risk. The studies involved hundreds or even thousands of men and women living in various countries. Twelve studies found that diets rich in ALA were inversely associated with fatal ischemic heart disease, risk of heart attack, risk of recurrent heart attack and death, risk of stroke, and risk of death from CVD and all causes. In other words, the higher the ALA content of the diet, the less the risk of having or dying from a heart attack or stroke. Only one study – the Zutphen Elderly Study conducted in The Netherlands – failed to find a cardioprotective effect of ALA.[1]

Table

Summary of Population Studies of ALA and Cardiovascular Diseases*

Studies Suggesting a Benefit of ALA

Alpha-Tocopherol Cancer Prevention Study
Cardiovascular Health Study
Costa Rica Study
EURAMIC Study
Family Heart Study
Health Professionals Follow-up Study
India Study
Lyon Diet Heart Study
MARGARIN Study
Multiple Risk Factor Intervention Trial (MRFIT)
Nurses' Health Study
Singapore Heart Study

Study Suggesting No Benefit of ALA

Zutphen Elderly Study

**Complete citations for these studies can be found in Flax–A Health and Nutrition Primer, pages 66-67. (1)*

More information about flax, alpha-linolenic acid (ALA), inflammation, atherosclerosis and coronary heart disease can be found in the Flax Council of Canada's book, Flax–A Health and Nutrition Primer. The book is located under the Nutrition tab on the Council's website at http://www.flaxcouncil.ca

Flax and Heart Health

Including flax in the daily diet helps lower blood lipids, reduce inflammation and enhance the health of blood vessels. These actions help reduce CVD risk.

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