

Description and Composition of Flax

Flax is a good source of plant omega-3 fat, dietary fibre and other nutrients. Its nutrient composition differs from that of other major oilseeds such as canola and sunflower. The following discussion provides a basis for considering the health benefits of flax.

Description

The botanical name of flax is *Linum usitatissimum* of the family Linaceae. Flax is a versatile, blue-flowered crop. The seeds for food and feed uses are harvested and then sieved through fine mesh screens, resulting in a clean, uniform batch of whole seeds (considered 99.9% pure).

The seed itself is flat and oval with a pointed tip. It is a little larger than a sesame seed and measures about 4-6 mm (7). The seeds have a crisp and chewy texture and a pleasant, nutty taste (8).

Flax seeds range in colour from a deep brown to a light yellow (7). Seed colour is determined by the amount of pigment in the outer seed coat—the more pigment, the darker the seed. Seed colour is easily modified through simple plant breeding techniques.

Brown-seeded flax, which is rich in alpha-linolenic acid (ALA), an omega-3 fatty acid, is the most common flax grown in Canada. Yellow-seeded flax is one of two types. One type, a U.S.-developed variety named Omega, is as rich in ALA as brown flax. The second type is an entirely different flax called solin, which is low in ALA. Solin was

developed for use in foods and is being used in premium margarines, especially in Europe. (Solin is the generic name for low-ALA flax; the trademarked name for the only commercial source of this flax is Linola™.) Brown and Omega flax are sold in health food stores, some supermarkets and over the Internet. Solin varieties are not sold directly to consumers, although whole seed solin is available to consumers as an ingredient in some commercial whole grain breads sold in Australia and the United Kingdom (9). In Canada, solin is required to have a yellow seed coat to make it easier for growers and handlers to keep it apart from brown flax seeds at all stages of handling. A new type of flax called NuLin™ contains more ALA than traditional flax and may be available commercially as early as 2008 (9).

The terms “flaxseed” and “linseed” are often used interchangeably, although North Americans use “flaxseed” to describe flax when it is eaten by humans and “linseed” to describe flax when it is used for industrial purposes, such as linoleum flooring. In Europe, the term “flaxseed” describes the varieties grown for making linen.

Flax varieties grown for human consumption are different from flax varieties grown to produce fibre for making linen (10). All flax varieties grown for human consumption or other purposes were developed using traditional plant breeding methods and do not contain genetically-modified organisms (GMOs).

Composition

Flax is rich in fat, protein and dietary fibre. An analysis of brown Canadian flax averaged 41% fat, 20% protein, 28% total dietary fibre, 7.7% moisture and 3.4% ash, which is the mineral-rich residue left after samples are burned (11). The composition of flax can vary with genetics, growing environment, seed processing and method of analysis (7). The protein content of the seed decreases as the oil content increases (12). The oil content of flax can be altered through traditional plant breeding methods, and it is affected by geography – the cool nights of northern Canada improve oil content and quality. The composition of flax is provided in **Table 1**.

TABLE 1

Proximate composition of flax based on common measures^a

Form of flax	Weight g	Common measure	Energy kcal	Total fat g	ALA ^b g	Protein g	Total CHO ^d g	Total dietary fibre g
Proximate analysis	100	–	450	41.0	23.0	20.0	29.0	28.0
Whole seed	180	1 cup	810	74.0	41.0	36.0	52.0	50.0
	11	1 tbsp	50	4.5	2.5	2.2	3.0	3.0
	4	1 tsp	18	1.6	0.9	0.8	1.2	1.1
Milled seed	130	1 cup	585	53.0	30.0	26.0	38.0	36.0
	8	1 tbsp	36	3.3	1.8	1.6	2.3	2.2
	2.7	1 tsp	12	1.1	0.6	0.5	0.8	0.8
Flax oil	100	–	884	100.0	57.0	–	–	–
	14	1 tbsp	124	14.0	8.0	–	–	–
	5	1 tsp	44	5.0	2.8	–	–	–

^aBased on a proximate analysis conducted by the Canadian Grain Commission (11). The fat content was determined using the American Oil Chemists' Society (AOCS) Official Method Am 2-93. The moisture content was 7.7%.

^bALA = Alpha-linolenic acid, the essential omega-3 fatty acid.

^cCHO = Carbohydrate.

^dTotal Carbohydrate includes carbohydrates like sugars and starches (1 g) and total dietary fibre (28 g) per 100 g flax seeds.

Fatty acids

Flax has been valued historically for its abundance of fat, which provides a unique mix of fatty acids. Fatty acids are organic compounds found in virtually all foods. Refer to **Table 2** for a description of common fatty acids.

TABLE 2
Types of fatty acids found in foods

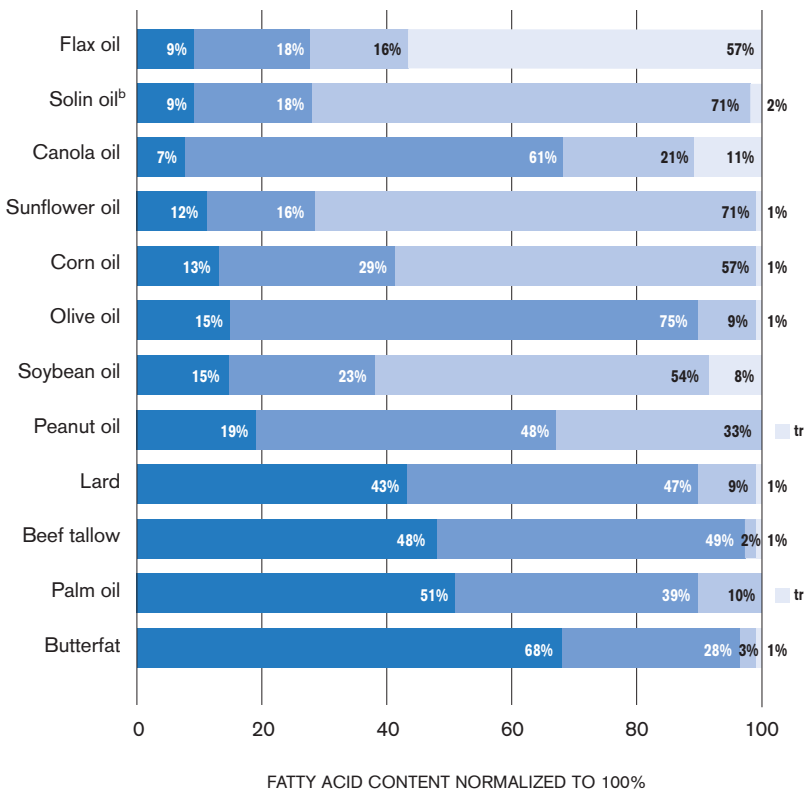
Fatty acid	Number of double bonds	Saturation	Family name ^a	Formula ^b	Common food sources
stearic acid	0	saturated	–	18:0	most animal fats, chocolate
oleic acid	1	monounsaturated	Omega-9 (ω-9)	18:1n-9 or 18:1ω-9	olive oil, canola oil
palmitoleic acid	1	monounsaturated	Omega-7 (ω-7)	16:1n-7 or 16:1ω-7	beef tallow, lard
linoleic acid	2	polyunsaturated	Omega-6 (ω-6)	18:2n-6 or 18:2ω-6	vegetable oils like sunflower, corn, and safflower oils; meat from grain-fed livestock
alpha-linolenic acid	3	polyunsaturated	Omega-3 (ω-3)	18:3n-3 or 18:3ω-3	flax, flax oil, canola oil, soybean oil, walnuts, small amounts are found in meats like beef and pork and in eggs

^aThe family name shows the position of the first double bond in the carbon chain or backbone of the fatty acid, marked from the methyl end with either an omega symbol (“ω”) or with an “n”. Thus, the double bond in oleic acid occurs at the ninth carbon from the methyl end of the fatty acid.

^bThe fatty acid formula is read as follows: The number to the left of the colon shows the number of carbon atoms in the fatty acid chain. The first number to the right of the colon shows the number of double bonds in the carbon chain. The last three digits on the right show the family name. The formula for alpha-linolenic acid is 18:3n-3 or 18:3ω-3, meaning that it contains 18 carbons, has three double bonds and belongs to the omega-3 family.

Flax contains a mixture of fatty acids (see **Figure 1**). It is rich in polyunsaturated fatty acids, particularly ALA (or LNA, as it is sometimes abbreviated), the essential omega-3 fatty acid, and linoleic acid (LA), the essential omega-6 fatty acid. These two polyunsaturated fatty acids are essential for humans—that is, the body needs them. They must be obtained from the fats and oils in foods because our bodies cannot make them.

FIGURE 1
Comparison of saturated and unsaturated fatty acids in dietary fats and oils^a

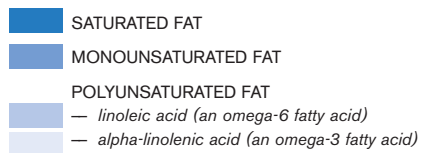


^aAdapted from McDonald (13).

^bThe solin oil values are those for Linola™.

Data sources:

POS Pilot Plant Corporation (14); for flax, Daun and DeClercq (12); for solin oil, Dean (9).



In **Figure 1**, the fatty acid composition of flax oil is compared with other fats and oils (9,12-14). ALA constitutes 57% of the total fatty acids in flax, making flax the richest source of ALA in the North American diet. Linoleic acid constitutes 16% of total fatty acids. Flax oil and canola oil have the lowest levels of the nutritionally undesirable saturated fatty acids. The level of the desirable monounsaturates in flax oil is modest.

Solin oil is low in the essential omega-3 fatty acid, ALA. Solin oil was developed by plant breeders in Australia and Canada, who modified traditional flax oil to reduce the ALA content from 50-60% to less than 5% (9). Solin oil has a fatty acid profile that is similar to sunflower seed oil, making it a good choice for certain food applications like margarine (15). Other vegetable oils rich in ALA have been modified to lower the ALA content, as shown in **Table 3** (14,16-18).

TABLE 3

ALA content of traditional and modified vegetable oils

ALPHA-LINOLENIC ACID (ALA) AS % OF TOTAL FATTY ACIDS

<i>Traditional oil^a</i>		<i>Modified oil</i>	
Flax oil	57.0	Solin oil	1.9 ^b
Canola oil	11.0	Low-linolenic canola oil	2.5 ^c
Soybean oil	8.0	Low-linolenic soybean oil	3.7 ^d

^aPOS (14).

^bKibiuk (17).

^cVaisey-Genser et al. (16).

^dWarner and Mounts (18).

Protein

Amino acids are the building blocks of protein. The amino acid pattern of flax protein is similar to that of soybean protein, which is viewed as one of the most nutritious of the plant proteins. There appears to be little difference in the amino acid content of the proteins from two flax varieties shown in **Table 4**, even though they differ in seed coat colour (19-21). The essential amino acids are identified with an asterisk in **Table 4**. These are the ones that must be included in the diet because the human body cannot make them.

Gluten

Flax is gluten-free (22). Gluten is a protein found in wheat, oats, barley and rye. The specific agent in gluten that causes the condition known as celiac disease is gliadin, which is rich in the amino acids proline and glutamine. The cereals that are toxic for patients with celiac disease are wheat, rye and barley; oats are tolerated by some patients. Although celiac disease is now recognized as a chronic inflammatory disorder, the mechanism by which dietary gluten irritates the mucosal

TABLE 4

Amino acid composition of flax

Amino acid	Flax Cultivar ^a		Soy flour ^b
	Brown flax (NorLin)	Yellow flax (Omega)	
	g/100 g protein		
Alanine	4.4	4.5	4.1
Arginine	9.2	9.4	7.3
Aspartic acid	9.3	9.7	11.7
Cystine	1.1	1.1	1.1
Glutamic acid	19.6	19.7	18.6
Glycine	5.8	5.8	4.0
Histidine*	2.2	2.3	2.5
Isoleucine*	4.0	4.0	4.7
Leucine*	5.8	5.9	7.7
Lysine*	4.0	3.9	5.8
Methionine*	1.5	1.4	1.2
Phenylalanine*	4.6	4.7	5.1
Proline	3.5	3.5	5.2
Serine	4.5	4.6	4.9
Threonine*	3.6	3.7	3.6
Tryptophan ^c	1.8	NR ^d	NR
Tyrosine	2.3	2.3	3.4
Valine*	4.6	4.7	5.2

^aOomah and Mazza (20).

^bFriedman and Levin (21).

^cBhatty and Cherdkiatgumchai (mixture of NorLin, NorMan and McGregor cultivars) (19).

^dNR = Not reported.

*Essential amino acids for humans.

lining of the gastrointestinal tract in susceptible people is not well understood (23). Fortunately, people who are sensitive to gluten can enjoy flax in their diets.

Carbohydrates

Flax is low in carbohydrates (sugars and starches), providing only 1 gram (g) per 100 g (11). For this reason, flax contributes little to total carbohydrate intake.

Dietary fibre

Fibre occurs as structural material in the cell walls of plants and has important health benefits for humans. There are two main types of fibre:

- *Dietary fibre* consists of nondigestible plant carbohydrates and other materials that are found intact in plants. Whole flax seeds and milled flax are sources of dietary fibre.
- *Functional fibre* consists of nondigestible carbohydrates that have been extracted from plants, purified and added to foods and other products (24). Mucilage gums extracted from flax seeds and added to laxatives and cough syrups (10) are a functional fibre.

Total fibre is the sum of dietary fibre and functional fibre. Dietary fibre and functional fibre are not digested and absorbed by the human small intestine and, therefore, pass relatively intact into the large intestine (24). The North American definition of dietary fibre and the use of fibre terms on food labels are under review (25).

Total fibre accounts for about 28% of the weight of full-fat flax seeds. The major fibre fractions in flax consist of the following:

- Cellulose – the main structural material of plant cell walls.
- Mucilage gums – a type of polysaccharide that becomes viscous when mixed with water or other fluids. Flax mucilage consists of three distinct types of arabinoxylans which form large aggregates in solution and contribute to its gel qualities (26).
- Lignin – a highly-branched fibre found within the cell walls of woody plants. Lignins are related to a similar-sounding compound – lignans. Both are part of plant cell walls and are associated with cell wall carbohydrates. *Lignins* contribute to the strength and rigidity of the cell walls. *Lignans* are phytochemicals (“phyto” means “plant”) whose role in human nutrition, particularly cancer prevention, is being studied actively (27).

Soluble and Insoluble Fibre in Flax

Flax contains both soluble and insoluble dietary fibre. Dietary fibre acts as a bulking agent in the gut. It increases stool weight and the viscosity of digested material, while also decreasing the transit time of material through the gut. In this manner, dietary fibre helps control appetite and blood glucose, promotes laxation and reduces blood lipids. Diets rich in dietary fibre may help reduce the risk of heart disease, diabetes, colorectal cancer, obesity and inflammation (28-31). The soluble and insoluble dietary fibre content of flax varies, as shown below, depending on the method of fibre extraction and chemical analysis (7).

	Soluble Fibre	Insoluble Fibre
Whole flax seed (1 tbsp)	0.6 – 1.2 g	1.8 – 2.4 g
Milled flax (1 tbsp)	0.4 – 0.9 g	1.3 – 1.8 g

Phenolics

Phenolics are plant compounds that have many different functions, including adding colour to the plant and attracting bees and other insects for pollination (32). Many phenolics appear to have anticancer and antioxidant effects in humans (33-35). Flax contains at least three types of phenolics: phenolic acids, flavonoids, and lignans. The phenolic content of flax is shown below.

PHENOLIC ACIDS. Flax contains about 8 to 10 g of total phenolic acids per kilogram of flax (36) or about 64-80 milligrams (mg) of total phenolic acids/tbsp of milled flax.

FLAVONOIDS. Flax contains about 35-70 mg of flavonoids/100 g (37), which is equivalent to about 2.8-5.6 mg of flavonoids/tbsp of milled flax.

LIGNANS. Flax is a very rich source of a lignan called secoisolariciresinol diglucoside (SDG), which is found in amounts ranging from 1 mg/g of seed to nearly 26 mg/g of seed. The wide range in SDG content reflects differences in flax cultivars, growing region and method of analysis (38).

TABLE 5

Vitamin content of flax^a

Water soluble	mg/100 g	mg/tbsp milled flax
Ascorbic acid/vitamin C	0.50	0.04
Thiamin/vitamin B ₁	0.53	0.04
Riboflavin/vitamin B ₂	0.23	0.02
Niacin/nicotinic acid	3.21	0.26
Pyridoxine/vitamin B ₆	0.61	0.05
Pantothenic acid	0.57	0.05
	mcg/100g	mcg/100g
Folic acid	112	9.0
Biotin	6	0.5
Fat soluble	mg/kg in oil	mg/tbsp in oil
Carotenes	not detected	not detected
Vitamin E ^b		
Alpha-tocopherol	7	0.10
Delta-tocopherol	10	0.14
Gamma-tocopherol	552	7.73
		mcg/tbsp milled flax
Vitamin K ^c		0.3

^aComposite sample of whole flax (39).

^bTocopherol values represent the average of four varieties (40). The following forms of vitamin E were not detected: beta-tocopherol and alpha-, delta- and gamma-tocotrienol.

^cAs phylloquinone (44).

Vitamins and minerals

Flax contains minor amounts of water- and fat-soluble vitamins, as shown in Table 5 (39). Vitamin E, a fat-soluble vitamin, is present in flax primarily as gamma-tocopherol (40). Gamma-tocopherol is an antioxidant that protects cell proteins and fats from oxidation; promotes sodium excretion in the urine, which may help lower blood pressure; and helps lower the risk of heart disease, some types of cancer and Alzheimer disease (41,42). The tocopherol content of flax is affected by the variety, maturity of the seed, growing region, growing conditions and method of extraction. The gamma-tocopherol content can range from 8.5 to 39.5 mg/100 g of seed or about 0.7-3.2 mg/tbsp of milled flax (7).

Flax also contains a small amount – 0.3 micrograms (mcg) – of vitamin K in the form of phyloquinone, which is the plant form of the vitamin. Vitamin K plays an essential role in the formation of certain proteins involved in blood clotting and in building bone (43). The amount of vitamin K in 1 tbsp of milled flax is similar to that found in 1 ear of sweet corn, 1 wedge of watermelon or 1 cup of cooked beets (44).

Table 6 shows the mineral content of flax (39). One tablespoon of milled flax contains 34 mg of magnesium, about the same amount of magnesium found in a 250 mL (8-oz) container of low-fat yogurt with fruit, 30 g (1 oz) of pecan halves, or half a fried chicken breast (140 g). The potassium content of milled flax is about 66 mg per tablespoon or about the same amount of potassium found in one slice of toasted typical pumpernickel bread, a 175 mL (6-oz) mug of brewed tea or a hard-boiled egg (44). Flax is low in sodium.

TABLE 6
Mineral content of flax^a

	mg/100 g	mg/tbsp milled flax
Calcium	236	19.0
Copper	1	0.1
Iron	5	0.4
Magnesium	431	34.0
Manganese	3	0.2
Phosphorus	622	50.0
Potassium	831	66.0
Sodium	27	2.0
Zinc	4	0.3

^aComposite sample of whole flax (39).

Comparison of Brown and Yellow Flax

Brown and yellow (Omega) varieties of flax are virtually identical in their nutrient content (11), as shown in Table 7. The nutritional differences between them are small and likely result from differences in growing conditions. As mentioned previously, seed coat colour is determined by the amount of pigment present, a feature that can be changed through normal plant breeding practices. Consumers can buy brown or yellow flax based on price and appearance of the flax-containing food product, since the nutritional value of brown and yellow flax is similar.

TABLE 7

Comparison of brown flax and yellow flax^a

Constituent	Brown flax	g/100 g	
			Yellow flax
Protein (% nitrogen x 6.25)	22.3		29.2
Oil/fat	44.4		43.6
	% of total fatty acids		
Specific fatty acids			
Saturated fatty acids	8.7		9.0
Monounsaturated fatty acids	18.0		23.5
Polyunsaturated fatty acids			
Alpha-linolenic acid	58.2		50.9
Linoleic acid	14.6		15.8

^aBased on an analysis of a small number of samples conducted by the Canadian Grain Commission (11). Moisture content: brown flax, 7.7%; yellow flax, 7.0%.

U.S. Department of Agriculture’s Nutrient Database

The U.S. Department of Agriculture (USDA) publishes the nutrient content of flax seeds and flaxseed oil in its nutrient database online (44). The USDA figures for the weight of whole seeds, milled flax and flax oil and also for nutrient content differ from those used by the Flax Council of Canada. The reason for these discrepancies is that the two organizations use nutrient and analytic data from different researchers, university and commercial laboratories and other sources.

Looking for more information about flax?

- **Appendix A** summarizes the suggested daily flax intakes for adults and children.
- **Appendix B** provides information about the storage and stability of flax.
- **Appendix C** describes the regulatory status of flax in Canada and the United States.