# Appendix A

## Suggested Daily Intakes of Flax

### Suggested Flax Intakes

Suggested flax intakes are based on the scientific findings of clinical and epidemiologic studies published in peer-reviewed journals. Practical issues such as how much flax people can reasonably eat every day for a period of months or years were also considered. Data are missing for some populations, like pregnant women and children. The Adequate Intakes of alpha-linolenic acid (ALA) serve as the basis for the suggested flax intakes described below. (Refer to Table 10 on page 40 for a list of the Adequate Intakes of ALA.)

#### Suggested intakes for adults

**WHOLE FLAX SEEDS.** Whole flax seeds add a crunchy texture to baked goods, energy bars, cereals and salads. Whole seeds are likely to pass undigested through the gastrointestinal tract because their resilient seed coat resists the actions of digestive enzymes. Therefore, whole seeds must be chewed thoroughly to shred the seed coat and enhance digestion of the nutrients inside the seed. Whole flax seeds are best enjoyed as a topping or mixed into yeast breads and batters.

**MILLED FLAX.** One tbsp of milled flax provides 1.8 g of ALA. The Adequate Intake of ALA for women is 1.1 g daily and for men, 1.6 g daily (24). Therefore, an adult can achieve the Adequate Intake of ALA

by eating about 1 tbsp of milled flax daily. A daily intake of 1 tbsp of milled flax is practical and in keeping with the amounts used in some clinical studies (181,186,205,206,345,357). When eaten regularly, a daily intake of about 1-2 tbsp milled flax is likely to achieve the health benefits reported in clinical studies and also provide the Adequate Intake of ALA.

**FLAX OIL.** One tbsp of flax oil provides 8 g ALA. As little as 1/2 tsp of flax oil daily provides 1.3 g ALA, an amount that is more than sufficient to meet the Adequate Intake of ALA for adults (24). This intake level is consistent with that used in several clinical studies, where volunteers consumed 1-2 tsp of flax oil daily for 4-12 weeks (78,217,218,257).

## Suggested intakes for children and pregnant and lactating women

Children can consume about 1/4 tsp of flax oil daily, while pregnant and lactating women can consume about 1/2 tsp of flax oil daily to achieve the Adequate Intake of ALA. They can occasionally eat muffins, cookies and other foods containing milled flax but are advised to refrain from eating milled flax every day until more is known about the effects of lignans in these population groups. It is worth noting that many foods besides flax contain lignans–asparagus, chives, blackberries, cranberries, black and green tea, coffee, whole grain breads, and beans, to name only a few. The fact that lignans are fairly widespread in the food supply supports the old adage to pursue moderation and eat a variety of foods every day.

# Appendix B

## Storing and Cooking Flax

### Storing Flax

Flax has been described as a "remarkably stable product" (462). Freshness can be maintained by storing flax away from air and light. Placing whole flax seeds and milled flax in the freezer or refrigerator prolongs freshness.

- Whole flax seeds can be stored at room temperature for up to one year. Whole flax seed is remarkably resistant to oxidation, based on a study of samples stored in glass tubes for 280 days or ~9 months (463).
- Milled flax can be stored at room temperature for at least four months. In one study (464), there was no increase in peroxides (a measure of oxidation) in milled flax samples stored at 23°C (75°F) for 128 days (~4 months). Even after storage for 128 days under conditions similar to those found in commercial bakeries, trained panelists could not detect flavour differences between bread made with freshly milled flax and bread made with milled flax stored for 128 days (464). Two studies found good stability of milled flax when stored at room temperature for at least 280 days (~9 months) (463) and when stored under warehouse conditions at ambient temperature for up to 20 months (~1 1/2 years) (462). In the latter study, peroxide values were very low and did not differ from fresh samples.

- Flax oil should be stored in the refrigerator to maintain freshness. Flax oil is produced by cracking the seeds, flaking them between rollers, and pressing them in expellers fitted with water-cooled shafts. The oil is cold-pressed under conditions that limit the maximum temperature during processing to 35°C (95°F) (465). After filtering, the oil is shipped in opaque bottles that do not require refrigeration. Once the bottle has been opened, the oil must be refrigerated to maintain freshness (466). Most manufacturers recommend using flax oil within six weeks of opening the bottle.

### Don't Believe Everything You Hear!

Some reports would have you believe that flax becomes rancid if not eaten within 15 or 20 minutes of grinding. This is not true. Milled flax is stable when stored at room temperature and remains fresh for several months, most likely because it is rich in lignans. Lignans are powerful antioxidants that may protect the polyunsaturated fats in flax from oxidation. In fact, the antioxidant action of secoisolariciresinol and enterodiol is greater than that of vitamin E.
(Read more on this topic in Chapter 4.)

## Cooking Flax

Flax is widely consumed because of its nutritional components, especially alpha-linolenic acid (ALA) and lignans. Both hold up well to cooking, baking and roasting.

ALA can withstand the temperatures of baking. One study found that heating both whole and milled flax at either 100°C or 350°C (212°F or 660°F) for 1 hour had little effect on fatty acid composition or oxidation. Moreover, there was no evidence of the formation of new *trans* forms of ALA or other undesirable fatty acid byproducts after this severe heat treatment (456). In two other studies in which milled flax was added to muffin mixes, the ALA was not degraded after baking, in one case after two hours of baking at 178°C (350°F) (204,463). ALA was also stable during the processing and cooking of flax-enriched spaghetti boiled for 12 minutes (467).

The flax lignan, secoisolariciresinol diglucoside (SDG), is stable to baking (468). In a study of SDG stability, there were no differences in the SDG content of the crust and crumb of baked bread, indicating that SDG survives the higher temperature the crust is exposed to during baking (469). SDG isolated from flax is stable during the bread-making process and during subsequent storage at room temperature or in the deep-freezer (470). SDG is also stable to high-temperature pasteurization of milk and during the normal manufacturing of yogurt and ripened cheese (471).

Roasting whole flax seed at 110°C (230°F) for 1 hour and then grinding the seeds to produce milled flax had no effect on oxygen consumption. Oxygen consumption was the same in roasted milled flax and in milled raw flax (463).

### Need more information about flax storage and stability?

Go on-line to www.flaxcouncil.ca and click on the Nutrition tab on the home page. Under Technical Nutrition Information, click on the fact sheet titled *Flaxseed–Storage and Baking Stability*. This referenced fact sheet is available in PDF format for easy downloading.

# Appendix C

## Regulatory Status of Flax as a Human Food Ingredient in Canada and the United States

Flax is consumed worldwide, and individual countries have their own regulations governing the use of flax in their food supplies. The Canadian and U.S. governments regulate flax as a food ingredient based on its use in their respective food supplies over a period of several decades (472).

### Canada

In Canada, flax is regulated as a food and not as a food additive. There is presently no regulation that limits the level of flax in foods, although the Health Protection Branch of Health Canada has specified a guideline for use of flax in foods, indicating it has no objection to the use of flax at the level of 8% or lower on a dry-weight basis in baking (or 4% in dry cereal). The Branch recognizes that flax has become increasingly popular as a source of omega-3 fatty acids and has been used in more foods at higher levels. The Branch is aware that some foods contain flax in the range of 12% and has no reports of adverse reactions. In one study (204), men consumed two muffins containing flax at much higher levels (50 g/day) for 4 weeks without apparent ill effects. Whether consumption of flax at higher levels than previously recommended would be a safety concern is not known due to a lack of conclusive scientific studies in this area (473).

## United States

In the United States, a substance can be legally added to foods if it is a food additive and hence approved for use, or if it is deemed to be generally recognized as safe (GRAS). A substance can be confirmed as GRAS through a formal rulemaking process or be designated GRAS status informally through its long history of safe use outside the United States. Under current regulations, no food additive petition has been submitted to the Food and Drug Administration (FDA) for flax, nor has a formal review of the GRAS status of whole or milled flax been conducted. Basically the GRAS status of flax has been declared by food manufacturers (474). FDA has indicated that it has no objection to its use in foods up to 12% flax (475). FDA has indicated that refined solin oil is GRAS under the conditions of use proposed by United Grain Growers, now operating as Saskatchewan Wheat Pool (476).

## Labeling of Omega-3 Fatty Acids

The labeling of foods and food products is regulated in Canada by Health Canada and the Canadian Food Inspection Agency and in the United States by the Food Safety and Inspection Service and FDA. Food labels provide information about the composition of foods and, in some cases, the health or nutrient benefits of a food or nutrient (466). In both countries, nutrition labeling is mandatory on virtually all foods, except fresh fruits and vegetables and self-serve bulk foods sold in retail stores. Thus, flax sold in bulk directly to consumers does not require a nutrient content label, while flax and flax oil added to a food product must be listed in the ingredient statement and the nutrient content declared on the food product label (474,477,478).

In Canada, food manufacturers may declare the omega-3 fatty acid content of their food products on the Nutrition Facts label. For example, the label of a food containing flax can state the amount of ALA (e.g., 0.5 g of ALA) per serving (479). The updated Nutrition Facts label became mandatory in December 2005. Small businesses have until December 12, 2007 to change over to the new food labels. This grace period allows food manufacturers to use up their old labels before switching to the new ones (480).

In the United States, FDA has allowed a nutrient content claim for omega-3 fatty acids, including ALA, on food product labels (2,3). A food product containing added flax qualifies for a “high”-type claim if the product contains 260 mg or more of ALA. A “high”-type and “good

source" label claim is accompanied by a statement regarding the Daily Value. For example, the label would read: Contains ____% of the Daily Value for ALA per serving. The Daily Value for ALA is 1.3 g (2).

Flax oil and whole or milled flax can be labeled "organic" in keeping with regulations issued by the National Standard for Organic Agriculture in Canada (481) or by the U.S. Department of Agriculture in the United States (482). Health claims regarding omega-3 fatty acids are not permitted on food products in either country (478,483), although a qualified claim for omega-3 fatty acids [specifically, for eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), but not ALA] in dietary supplements is allowed in the United States (484).

# Appendix D

## Descriptions and Actions of Inflammatory Agents

| INFLAMMATORY AGENT | DESCRIPTION | ACTION |
|---|---|---|
| Acute-phase plasma proteins | Proteins released by the liver in response to infection, trauma or inflammation.<br><br>Examples:<br>C-reactive protein (CRP)<br>Serum amyloid A (SAA) | Can increase 1000-fold in response to infection or injury (485). CRP is an independent risk factor for cardiovascular disease (261). Increased blood levels of SAA also predict the risk of cardiovascular disease in humans (485). |
| Cell adhesion molecules | Proteins found on the surface of many cell membranes and in the bloodstream.<br><br>Examples:<br>E-selectin<br>Vascular cell adhesion molecule type 1 (VCAM-1)<br>Intercellular adhesion molecule type 1 (ICAM-1) | Respond to signals received from cytokines; they promote the sticking of white blood cells (leukocytes) to the inner lining of the blood vessels (the endothelium). Their blood levels may help predict risk of heart attack and stroke (247). ICAM-1 is considered a marker of a more general inflammatory process, whereas VCAM-1 seems to be an indicator of plaque activity in patients with atherosclerosis (486). |

| INFLAMMATORY AGENT | DESCRIPTION | ACTION |
|---|---|---|
| Cytokines | Proteins released by immune cells.<br><br>Examples:<br>Interleukin 6 (IL-6)<br>Interleukin 1β (IL-1β)<br>Tumor necrosis factor α (TNF-α) | Start and amplify inflammatory reactions (94). They stimulate the liver to produce and release acute-phase proteins (see description above) (261). |
| Eicosanoids | Powerful compounds derived from fatty acids like arachidonic acid and eicosapentaenoic acid.<br><br>Examples:<br>Prostaglandin $E_2$ ($PGE_2$)<br>Prostaglandin $I_2$ ($PGI_2$)<br>Thromboxane $A_2$ ($TXA_2$)<br>NOTE: Eicosanoids derived from arachidonic acid tend to be pro-inflammatory, whereas those derived from eicosapentaenoic acid tend to be less biologically active. | Are involved in the onset of pain and fever, the regulation of vascular tone, platelet aggregation and thrombosis. Some eicosanoids like $PGI_2$ (also called prostacyclin) promote the dilation of blood vessels, inhibit platelet aggregation and reduce inflammatory symptoms such as pain and fever. $TXA_2$ promotes the constriction of blood vessels, platelet aggregation and the adhesion of leukocytes to the endothelium. $PGE_2$ is unique in that it both enhances platelet aggregation and also promotes vasodilation (85). |