As for saturated and monounsaturated fatty acids, the omega-6 and omega-3 polyunsaturated fatty acids (PUFA) are chemically linked to fat structures known as triglycerides in the various foods and oils that are consumed. The natural triglyceride or fat structure consists of a 3-carbon glycerol backbone onto which 3 long-chain fatty acids of varying types and structures are linked or 'esterified'. These are hydrolyzed by enzymes and digested in the small intestine thereby providing for their absorption, transport in the blood, and assimilation into cells and body tissues. Table 1 lists some common food sources of both the omega-6 and omega-3 fatty acids as found in a typical North American diet.

**Table 1**: Dietary Sources of Omega-3 and Omega-3 Fatty Acids

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(i) Omega-6 Types</strong></td>
<td></td>
</tr>
<tr>
<td>LA, linoleic acid (18:2 n-6)</td>
<td>Vegetable oils (corn, safflower, sunflower, soybean), animal meats</td>
</tr>
</tbody>
</table>

| AA, arachidonic acid (20:4 n-6) | |
Animal sources only (meat, eggs)

(ii) Omega-3 Types

**ALA**, (LNA) **alpha-linolenic acid**
(18:3 n-3)

- Flaxseed, canola oil, English walnuts, specialty eggs

**EPA**, **eicosapentaenoic acid**
(20:5 n-3)

- Fish, fish oils, marine sources

**DHA**, **docosahexaenoic acid**
(22:6 n-3)

- Fish, fish oils, specialty egg/dairy products

In view of the high intake of vegetable oils containing n-6 PUFA directly and via various processed food products including meats, a typical diet contains 8-15 g/day of LA (omega-6) but
much lower intakes of the omega-3 types. ALA consumption ranges from approximately 1.3-2.0 g/day or approximately 0.6% of total energy intake. In contrast to the considerable intake of ALA from plant sources, the intake of fish/fish oil-derived DHA/EPA (combined) represents approximately 0.13-0.15 g/day (130-150 mg/day) which is 0.05% of total energy intake or about 1/10 of the intake of ALA. The vast majority of the DHA plus EPA as consumed in the North American diet is from fish/fish oils with much smaller amounts from selected animal sources (e.g., eggs, some meat sources) and none from plant food/oils regardless of their ALA levels. The overall ratio of omega-6:omega-3 fatty acids in the current North American diet ranges from 6:1 to approximately 10:1.

Selected food sources of a-linolenic acid (ALA) are given in Table 2. Some of the common plant oils have significant levels of ALA - e.g., 7% by weight in soybean oil, 10% in canola oil, and approximately 20% in hemp oil. Much higher amounts are found in the oils from flax, perilla (Japan and elsewhere), and chia (Argentina and elsewhere) with approximately 50-60% of the fatty acids being in the form of ALA.

Table 2: Alpha-Linolenic Acid Content of Various Foods and Oils

<table>
<thead>
<tr>
<th>Source</th>
<th>ALA (g)</th>
<th>(100 g raw edible portion)</th>
</tr>
</thead>
</table>

Nuts and Seeds
Legumes

Almonds

0.4

Beans, common (dry)

0.6

Beechnuts (dried)

1.7

Chickpeas (dry)

0.1
Butternuts (dried)

8.7

Cowpeas (dry)

0.3

Chia seeds (dried)

3.9

Lentils (dry)

0.1

Flaxseed

22.8

Lima beans (dry)
Dietary Sources of Omega-3 Fatty Acids

Hickory nuts (dried) 0.2

Peas, garden (dry) 1.0

Mixed nuts 0.2

Soybeans (dry) 1.6

Peanuts 0.003
### Dietary Sources of Omega-3 Fatty Acids

<table>
<thead>
<tr>
<th>Food</th>
<th>Omega-3 Fatty Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pecans</td>
<td>0.7</td>
</tr>
<tr>
<td>Soybean kernels</td>
<td>1.5</td>
</tr>
<tr>
<td>Barley, bran</td>
<td>0.3</td>
</tr>
<tr>
<td>Walnuts, black</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Dietary Sources of Omega-3 Fatty Acids

Corn, germ

0.3

Walnuts, English and Persian

6.8

Oats, germ

1.4

Rice, bran

0.2

Vegetables
Dietary Sources of Omega-3 Fatty Acids

Wheat, bran

0.2

Beans, navy, sprouted (cooked)

0.3

Wheat, germ

0.7

Beans, pinto, sprouted (cooked)

0.3

Wheat, hard red Winter

0.1

Broccoli (raw)
Dietary Sources of Omega-3 Fatty Acids

Cauliflower (raw)

Fruit

Kale (raw)

Avocados, California (raw)

Leeks (freeze-dried)
Dietary Sources of Omega-3 Fatty Acids

0.7

Raspberries (raw)

0.1

Lettuce, butterhead

0.1

Strawberries (raw)

0.1

Lettuce, red leaf

0.1

Mustard

0.1
Dietary Sources of Omega-3 Fatty Acids

- Purslane
  - 0.4

- Radish seeds, sprouted (raw)
  - 0.7

- Seaweed, Spirulina (dried)
  - 0.8

- Soybeans, green (raw)
  - 3.2

- Soybeans, mature seeds, sprouted (cooked)
  - 2.1
Dietary Sources of Omega-3 Fatty Acids

Spinach (raw)

0.1

Data from Kris-Etherton et al. (2000)

Recently, strains of flaxseed oils have become available which contain approximately 70% by weight of the oil as ALA which is significantly higher than the 50-55% found in conventional flax oil varieties. **Table 3** gives the levels of EPA plus DHA in a few selected fish and seafood.

**Table 3**: Fish and Seafood Sources of DHA plus EPA

<table>
<thead>
<tr>
<th>Source</th>
<th>(100 g portion)</th>
<th>DHA + EPA</th>
<th>(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchovy, European, raw</td>
<td>1.449</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fish
Dietary Sources of Omega-3 Fatty Acids

Carp, cooked, dry heat

0.451

Catfish, channel, farmed, cooked, dry heat

0.177

Cod, Atlantic, cooked, dry heat

0.158

Eel, mixed species, cooked, dry heat

0.189

Flatfish (flounder and sole), cooked, dry heat

0.501

Haddock, cooked, dry heat
Dietary Sources of Omega-3 Fatty Acids

0.238

Halibut, Atlantic and Pacific, cooked, dry heat

0.465

Herring, Atlantic, cooked, dry heat

2.014

Mackerel, Pacific and jack, mixed species, cooked, dry heat

1.848

Mullet, striped, cooked, dry heat

0.328

Perch, mixed species, cooked, dry heat
Dietary Sources of Omega-3 Fatty Acids

0.324

Pike, northern, cooked, dry heat

0.137

Pollock, Atlantic, cooked, dry heat

0.542

Salmon, Atlantic, farmed, cooked, dry heat

2.147

Sardine, Atlantic, canned in oil, drained solids with bone

0.982

Sea bass, mixed species, cooked, dry heat

0.762
Dietary Sources of Omega-3 Fatty Acids

Shark, mixed species, raw

0.843

Snapper, mixed species, cooked, dry heat

0.321

Swordfish, cooked, dry heat

0.819

Trout, mixed species, cooked, dry heat

0.936

Tuna, skipjack, fresh, cooked, dry heat

0.328
Dietary Sources of Omega-3 Fatty Acids

Whiting, mixed species, cooked, dry heat

0.518

Crustaceans

Crab, Alaska king, cooked, moist heat

0.413

Shrimp, mixed species, cooked, moist heat

0.315

Spiny lobster, mixed species, cooked, moist heat
Dietary Sources of Omega-3 Fatty Acids

0.480

**Mollusks**

Clam, mixed species, cooked, moist heat

0.284

Conch, baked or broiled

0.120

Mussel, blue, cooked, moist heat

0.782
Octopus, common, cooked, moist heat

0.314

Oyster, eastern, farmed, cooked, dry heat

0.440

Scallop, mixed species, cooked, breaded and fried

0.180

It should be noted that algal oils have recently become available as a source of DHA (free of EPA) for infant formulas and other functional food fortification. There has been a marked increase in the use of high quality liquid fish oils containing DHA plus EPA as ingredients in a wide variety of functional foods (e.g., liquid eggs). Furthermore, stable and microencapsulated forms of DHA plus EPA (with varying amounts and ratios of DHA:EPA) have been utilized in a whole plethora of processed food formulations (breads, yogurts, snack foods, etc). In view of the resistance of the North American and other populations to increase fish consumption as a source of DHA plus EPA for health despite recommendations by health care agencies and professionals, it is apparent that functional foods will became an ever-increasing source of these important nutrients in the omega-3 family.

Denomme, J., et al., Directly Quantitated Dietary (n-3) Fatty Acid Intakes of Pregnant Canadian Women are Lower than Current Dietary Recommendations. Human Nutrition and Metabolism. 135(2): 206-211, 2005.
