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Heinz Infant Nutrition Institute

CELEBRATING TWENTY THREE YEARS OF INFANT NUTRITION EDUCATION

Demystifying fatty acids and their roles: Questions and answers with Dr. Ma

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1. What are the differences among Omega-3, Omega-6, and Omega-9 fatty acids?

Fats and oils consumed in the diet are typically in the form of triglycerides, which are composed of three fatty acids joined by a glycerol backbone (Figure 1).

The carbon hydrogen units of fatty acids are linked together through “saturated” bonds (Figure 2). However, fatty acids may also contain unsaturated double bonds (Figure 2). Most double bonds in fatty acids are in the *cis* configuration, however, naturally occurring *trans* fats are also found in dairy and beef fat.

Based on the number of double bonds, this forms the basis for the classification of several families of fatty acids, which include saturated, monounsaturated and polyunsaturated fatty acids. The presence of double bonds alters the chemical and physical properties of fats. For example, saturated fats which contain no double bonds are solid at room temperature, such as butter and lard. In contrast, monounsaturated and polyunsaturated fatty acids are liquids at room temperature. The term mono, meaning “one,” indicates that monounsaturated fatty acids contain one double bond. Similarly, the term poly, meaning “multiple,” indicates that polyunsaturated fatty acids have two or more double bonds. Most double bonds in fats are present in the “*cis*” configuration; however, through the process of partial hydrogenation of polyunsaturated fatty acids, “*trans*” monounsaturated fatty acids are produced (Figure 2).

The usual nomenclature of fatty acids is stated as follows: for example, Δ9-18:1ω9 (Figure 3)

- Δ refers to the position of double bond relative to the carboxyl (as shown in Figure 3, this is the left side of the molecule). Carbon units are always numbered relative to the carboxyl.
- The first number preceding the colon refers to the number of carbon units.
- The number following the colon refers to the number of double bonds.
- The ω refers to the position of the last double bond relative to the methyl terminal end (as shown in Figure 3, this is the right side of the molecule). The current accepted IUPAC nomenclature is “n”, but ω is still widely used.

Shown in Figure 3 are representative saturated, ω9, ω6, and ω3 fatty acids. A common saturated fatty acid is stearic acid, which is an 18 carbon fatty acid with no double bonds, indicated by the nomenclature 18:0. The most common ω9 fatty acid is oleic acid, which is an 18 carbon fatty acid with one double bond. As indicated in the figure, the double bond is found 9 carbons relative to the methyl carbon. The most

Figure 1.

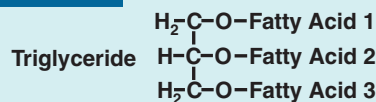
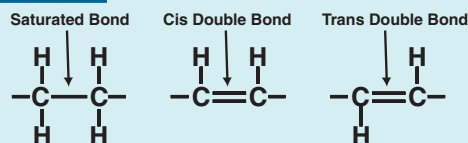


Figure 2.



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Demystifying fatty acids and their roles: Questions and answers with Dr. Ma 1

CLIENT HANDOUT:
Frequently Asked Questions About Omega-3 Fatty Acids for Pregnant/Lactating Women and Infants

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common ω 6 fatty acid is linoleic acid which contains two double bonds. Alpha-linolenic acid (ALA), which is found in flaxseed is an ω 3 fatty acid with 18 carbons and three double bonds. Two other major forms of ω 3 fatty acids found in fish oil are eicosapentaenoic acid (20:5 ω 3, EPA) and docosahexaenoic acid (22:6 ω 3, DHA) (Figure 4).

Figure 3.

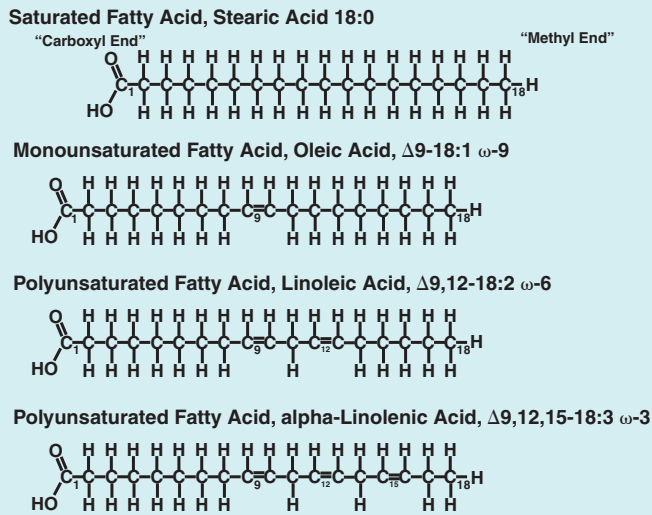
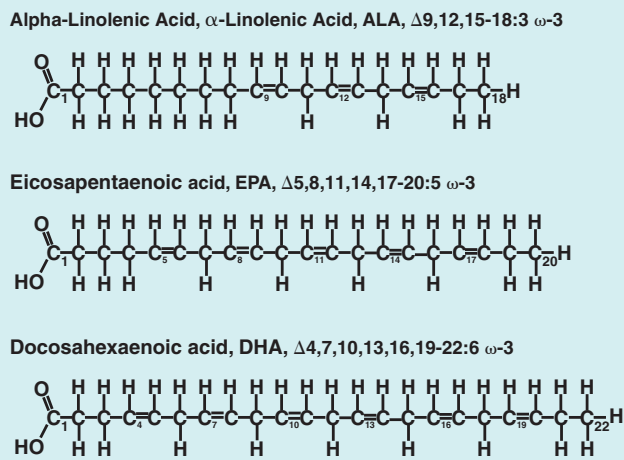


Figure 4.



2. What are the sources of each (Omega-3, 6, and 9)?

Omega-9 fatty acids in the form of oleic acid are found abundantly in plant oils such as canola and olive oil which contain 61 and 75% of total fatty acids, respectively. (<http://www.canolainfo.org/health/dietfat.html>)

Omega-6 fatty acids are found abundantly in plant oils and to a lesser extent in animal fat. For example, safflower, sunflower and corn oil contain upwards of 76, 71 and 57% of total fatty acids. (<http://www.canolainfo.org/health/dietfat.html>)

Omega-3 fatty acids are found abundantly in flaxseed containing ALA, upwards of 57% of total fatty acids. (<http://www.flaxcouncil.ca/english/index.php?p=g4&mp=nutrition>). Other major sources of omega-3 fatty acids are found in sea foods, which contain EPA and DHA¹. Another unique source of omega-3 fatty acids are walnuts which are rich in alpha-linolenic acid².

3. What fatty acids does breast feeding provide?

Breast milk contains a range of saturated, monounsaturated and polyunsaturated fatty acids³. Importantly, breast milk contains the omega-3 fatty acids, ALA and DHA, which are important fatty acids involved in cognitive and visual development in infants. In particular, DHA is the most important form of omega-3 fatty acids for infants given that it is readily incorporated into cells of the brain and eyes. ALA can be used by the liver as a precursor for the synthesis of DHA; therefore, ALA can be a potential source of DHA in the body. This conversion, however, is very low. In a recent tracer study, modelling demonstrated that only 7% of ALA is converted to EPA, and 0.08% is converted to DHA⁴. Given the limited conversion that occurs in infants, preformed DHA in the breast milk or fortified infant formula is optimal for infants^{5,6}.

4. What does Infant Formula with Omega-3 provide? How much? What are the guidelines/standards?

Infant formulas in Canada contain either the precursor ALA or preformed DHA.

Current guidelines for the consumption of omega-3 fatty acids are provided in the Dietary Reference Intakes (DRI) which replaced the previous Recommended Nutrient Intake (RNI) values^{7,8}. The acceptable macronutrient distribution range (AMDR) for omega-3 fatty acids is 0.6-1.2% of energy intake from ALA. Up to 10% of the AMDR can be consumed in the form of EPA or DHA. This recommendation includes pregnant and lactating women. There is currently no established recommended dietary allowance (RDA) level, which is the level required by 97-98% of the population sufficient to meet nutrient requirements. In the absence of an RDA, the adequate intake (AI) is a suitable goal, which is 0.5 g/day, 1.6 g/day and 1.1 g/day of ALA, for infants (0-12 months), adult men and women, respectively. During pregnancy and lactation women are recommended to consume 1.4 and 1.3 g/day of omega-3 fatty acids, respectively. (http://www.hc-sc.gc.ca/fn-an/nutrition/reference/table/ref_macronutr_tbl_e.html#34)

Prior to the release of the DRI report, the International Society for the Study of Fats and Lipids (ISSFAL), released a report recommending that adults should consume 1.3% of their energy from omega-3 fatty acids, with 1% from ALA and 0.3% from EPA+DHA^{9,10}. In addition, pregnant and lactating women are recommended to consume at least 300 mg/day^{9,10}. In Canadian women, it is reported that pregnant women consume on average 82 mg/day of DHA, less than the levels recommended by the DRI guidelines and ISSFAL.

5. What are their different functions and benefits of DHA, ALA, and EPA?

Like all fatty acids, ALA, EPA and DHA can be broken down for the synthesis of energy and can serve a functional role as part of cell membranes. The many biological functions of omega-3 fatty acids are attributed to the unique chemical structure of omega-3 fatty acids which are highly polyunsaturated fatty acids. Many biological effects have been linked to the consumption of omega-3 fatty acids. These include:

- improved cognitive and visual function in infants
- cardioprotective against heart disease
- anti-cancer effects on cancer growth (breast, colon, prostate)

- improvements in blood sugar and lipid levels in obesity and diabetes
- neuroprotective effect, providing protection against neurological diseases and dementia such as Alzheimer's disease
- enhanced bone development in children and delayed development of osteoporosis
- prevention of macular degeneration

Many mechanisms have been proposed such as:

- anti-inflammatory actions
- pro-inflammatory actions
- modulation of essential fatty acid metabolism
- signal transduction
- gene expression

Most studies have focused on DHA and suggest that it is the most biologically active of the omega-3 fatty acids. Studies suggest that ALA and EPA may have direct biological effects or their effects may be due to their conversion to DHA. The effects of individual omega-3 fatty acids are likely tissue specific. For example, the brain is highly enriched in DHA and only trace amounts of ALA and EPA are found in this organ. Therefore, DHA is the biologically relevant omega-3 fatty acid, and ALA and EPA may contribute via their conversion to DHA. Although the metabolic conversion is low, the net cumulative effect over time may be beneficial for health in adults. Like financial investments, small incremental changes may potentially have significant long term gains. In infants, however, the benefits are most likely due to intake of preformed DHA.

6. What is the recommended daily intake of Omega-3 fatty acids for an infant aged 0 to 6 months, 7 to 12 months, 12 months to 36 months?

0-6 months – 0.5 g/day alpha-linolenic acid (ALA)¹¹

7-12 months – 0.5 g/day alpha-linolenic acid (ALA)¹¹

1-3 yrs – 0.7g/day or 0.6-1.2% of energy alpha-linolenic acid (where 10% can be either EPA or DHA)¹¹

7. What are the benefits of Omega-3 for an infant 6-12 months vs. 24-36 months?

The benefits of consuming omega-3 fatty acids are strongest for pre-term infants, suggesting that DHA is important for cognitive and visual development during this early period of life¹². In term infants, the benefits for IQ and visual acuity have either showed no effect or small gain. This is likely due to confounding social factors or the sensitivity of test measures. Most studies have focused on the effect of maternal or perinatal supplementation of omega-3 fatty acids; however, supplementation later in life may have potential benefits. In young children omega-3 fatty acids may be beneficial for the treatment of Attention-Deficit/Hyperactivity Disorder¹³, but not all studies have reported an effect^{14,15}. There is also a growing body of literature suggesting that early exposure to omega-3 fatty acids may be beneficial for reducing the risk of adult diseases such as breast cancer and osteoporosis¹⁶⁻¹⁸. Further research is needed to substantiate the effects of omega-3 fatty acids in growing children.

8. What is the maximum allowable daily intake for an adult vs. an infant? What are the side effects of

exceeding this limit? If there are no guidelines, is there a recommended amount for an infant?

Current recommendations for the consumption of omega-3 fatty acids are based on Adequate Intake (AI) values. “*Adequate Intake (AI): the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate—used when an RDA cannot be determined*”¹⁹. Essentially, the AI reflects usual intake in a healthy population for adults, infants and children, therefore this level is assumed to be adequate. There is currently insufficient evidence to establish upper limits for the consumption of omega-3 fatty acids for adults or infants. However, this does not mean that chronic consumption of high levels is necessarily safe or tolerable. Additional research is needed to establish upper tolerable limits.

There is evidence that higher levels of intake may have additional health benefits. In particular, a wide range of doses has been used in experimental clinical studies, particularly investigations of the cardioprotective effects of omega-3 fatty acids in adults. Dosages in these studies ranged between ~1-7 g/day²⁰. In children, ~0.5-3.6 g/day have been used to investigate the effect of omega-3 fatty acids on Attention-Deficit/Hyperactivity Disorder (see 7 above). However, potential side effects include gastrointestinal disturbances, flatulence, fishy odor and the potential for increased bleeding times²⁰.

9. What are the differences in delivery and absorption of Omega-3 fatty acids between flax seed and fish oils? Are there any side effects to either for an infant?

Because omega-3 fatty acids in flaxseed as a whole food and extracted fish oil in capsule form are both found in triglycerides, the absorption is likely similar. There may be some concern that the extracted fish oil is susceptible to oxidation and can become rancid if not properly stored. As with all foods, the introduction of solid foods to infants should be carefully monitored for intolerance and potential allergies. Cod liver oil, which contains omega-3 fatty acids has a long history as a supplement given to children. Some may recall being given a teaspoon of cod liver oil as children.

10. What source provides the best delivery and absorption for an infant?

Breast milk is the gold standard for infant nutrition in terms of delivery and nutrient composition. Therefore, breast milk is the best source of omega-3 fatty acids for infants. Breast milk contains fat primarily in the form of triglycerides (98%) and a small amount as phospholipids (0.8%)²¹. Absorption of fats is facilitated by the specific position of saturated and polyunsaturated fatty acids within the molecular structure of triglycerides (see Figure 1). The saturated fatty acid, palmitic acid, is found primarily in the sn2 position (denoted as fatty acid 2 in Figure 1) to facilitate absorption²². Similarly 50-60% of DHA is also found in the sn2 position²².

In a recent study, it was shown that DHA when consumed as a triglyceride or phospholipid does not differentially affect blood lipid profiles²¹. These findings suggest that diet composition, rather than the vehicle of delivery, is a stronger determinant of blood lipid profile. Further research is required to verify these observations.

11. Are there any side effects or watch outs for consumers to consider when using flax or fish oil as the delivery mechanism for Omega-3?

Only one report to date has shown that consuming omega-3 fatty acids in flax, has the potential to induce an allergic response due to a flaxseed specific protein²³. More research is needed to determine the prevalence of such an allergy in the population, which is probably low.

There are health concerns that fish are contaminated with mercury, dioxins, and polychlorinated biphenyls (PCBs). In particular, mercury may be damaging to the nervous system, especially during fetal development. Additional concerns have been raised regarding the potential extraction of industrial contaminants along with the fish oil²⁴. In a recent review published in *JAMA*, the benefits of consuming omega-3 fatty acids in fish were considered by the authors to outweigh the potential risk due to methylmercury and industrial contaminants²⁵.

Alternatively, purified DHA is available from algae sources which are free of contaminants, which can be used in the manufacture of novel foods (functional foods).

12. Are there other sources of Omega-3 fatty acids that will be appropriate for use in a baby food?

Martek (<http://www.lifesdha.com/>) produces pure DHA from algae sources. This is free of contaminants and widely used in many infant formulas.

Parents who want to ensure that their infants and children obtain adequate omega-3 fatty acids should look for infant formulas that contain DHA in combination with arachidonic acid (AA or ARA). Consuming foods such as fish would be a good source of omega-3 fatty acids. If fish is not a child's favourite food, there are now a number of novel food products that parents can buy for their children. In many grocery stores in Canada, omega-3 enriched breads, milk and eggs are available. It should be noted that these novel foods may contain either of the omega-3 fatty acids, α -linolenic acid or DHA. Usually, the ingredient label will indicate which form of omega-3 fatty acid is present. Both are good sources of omega-3 fatty acids, however, α -linolenic acid is the precursor of DHA, but only a limited amount is converted to DHA (see 3 above).

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Frequently Asked Questions about Omega-3 Fatty Acids for Pregnant/Lactating Women and Infants

What are omega-3 fatty acids?

Omega-3 fatty acids are polyunsaturated fatty acids important for heart health as well as brain and visual development.

Do pregnant women consume enough omega-3 fatty acids?

A small study* of 20 pregnant Canadian women found that only 35% of them met the current recommendation for omega-3 fatty acid intake.

*Reference: Denomme J, Stark KD, Holub BJ. *J Nutr* 135;206-211, 2005.

What are the benefits of omega-3 fatty acids?

Studies in adults have shown benefits for the heart and blood vessels. In pre-term infants, the omega-3 fatty acids are important for brain maturation and visual development. Research continues to explore benefits for term infants. Exciting areas of investigation include the role of omega-3 fatty acids in regulating blood sugar levels, bone development, cancer prevention, and protection against dementia.

What food sources of omega-3 fatty acids are appropriate for pregnant and lactating women?



Canola oil
Flaxseed oil
Mackerel
Omega-3 enriched bread, milk, and eggs

Salmon
Sardines
Tuna*
Walnuts



*Advice from Health Canada: To avoid exposure to excess mercury, children, pregnant women and women of childbearing age are advised to limit the consumption of shark, swordfish and fresh or frozen tuna (not canned) to a maximum of no more than one meal per month. These fish exceed the 0.5 ppm guideline for mercury set by the Food Directorate of Health Canada.

What food sources of omega-3 fatty acids are appropriate for infants?



0 to 6 months

- Breast Milk
- Formula with DHA

After 6 months of age

- Breast milk
- Formula with DHA
- Appropriate finfish (see above list), finely chopped with no bones
- Omega-3 enriched products such as bread and cooked egg yolks, mashed

After 9 months of age

- Breast milk
- Formula with DHA
- Appropriate finfish (see above list)