Omega-6 fatty acid

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Omega-6 fatty acids (also referred to as **ω-6 fatty acids** or ***n*-6 fatty acids**) are a family of pro-inflammatory and anti-inflammatory polyunsaturated fatty acids [1] that have in common a final carbon-carbon double bond in the *n*-6 position, that is, the sixth bond, counting from the methyl end.[2]

The chemical structure of linoleic acid, a common omega-6 fatty acid found in many nuts, seeds and vegetable oils.

The biological effects of the omega-6 fatty acids are largely produced during and after physical activity for the purpose of promoting growth and during the inflammatory cascade to halt cell damage and promote cell repair by their conversion to omega-6 eicosanoids that bind to diverse receptors found in every tissue of the body.

Contents

Biochemistry

Linoleic acid (18:2, *n*−6), the shortest-chained omega-6 fatty acid, is one of many essential fatty acids and is categorized as an essential fatty acid because the human body cannot synthesize it. Mammalian cells lack the enzyme omega-3 desaturase and therefore cannot convert omega-6 fatty acids to omega-3 fatty acids. Closely related omega-3 and omega-6 fatty acids act as competing substrates for the same enzymes.[3] This outlines the importance of the proportion of omega-3 to omega-6 fatty acids in a diet.[3]

Omega-6 fatty acids are precursors to endocannabinoids, lipoxins, and specific eicosanoids.

Medical research on humans found a correlation (correlation does not imply causation) between the high intake of omega-6 fatty acids from vegetable oils and disease in humans. However, biochemistry research has concluded that air pollution, heavy metals, smoking, second-hand smoke, Lipopolysaccharides, lipid peroxidation products (found mainly in vegetable oils, roasted nuts and roasted oily seeds) and other exogenous toxins initiate the inflammatory response in the cells which leads to the expression of the COX-2 enzyme and subsequently to the temporary production of inflammatory *promoting* prostaglandins from arachidonic acid for the purpose of alerting the immune system of the cell damage and eventually to the production of anti-inflammatory molecules (e.g. lipoxins & prostacyclin) during the resolution phase of inflammation, after the cell damage has been repaired.[4][5][6][7][8][9][10][11][12][13][14][15]

Pharmacology

The conversion of cell membrane arachidonic acid (20:4n-6) to omega-6 prostaglandin and omega-6 leukotriene eicosanoids during the inflammatory cascade provides many targets for pharmaceutical drugs to impede the inflammatory process in atherosclerosis,[16] asthma, arthritis, vascular disease, thrombosis, immune-inflammatory processes, and tumor proliferation. Competitive interactions with the omega-3 fatty acids affect the relative storage, mobilization, conversion and action of the omega-3 and omega-6 eicosanoid precursors (see Essential fatty acid interactions).

Suggested negative health effects

Some medical research suggests that excessive levels of omega-6 fatty acids from seed oils relative to certain omega-3 fatty acids may increase the probability of a number of diseases.[17][18][19]

Modern Western diets typically have ratios of omega-6 to omega-3 in excess of 10 to 1, some as high as 30 to 1; the average ratio of omega-6 to omega-3 in the Western diet is 15:1–16.7:1.[16] Humans are thought to have evolved with a diet of a 1-to-1 ratio of omega-6 to omega-3 and the optimal ratio is thought to be 4 to 1 or lower,[16][20] although some sources suggest ratios as low as 1:1.[21] A ratio of 2–3:1 omega 6 to omega 3 helped reduce inflammation in patients with rheumatoid arthritis.[16] A ratio of 5:1 had a beneficial effect on patients with asthma but a 10:1 ratio had a negative effect.[16] A ratio of 2.5:1 reduced rectal cell proliferation in patients with colorectal cancer, whereas a ratio of 4:1 had no effect.[16]

Excess omega-6 fatty acids from vegetable oils interfere with the health benefits of omega-3 fats, in part because they compete for the same rate-limiting enzymes. A high proportion of omega-6 to omega-3 fat in the diet shifts the physiological state in the tissues toward the pathogenesis of many diseases: prothrombotic, proinflammatory and proconstrictive.[22]

Chronic excessive production of omega-6 eicosanoids is correlated with arthritis, inflammation, and cancer. Many of the medications used to treat and manage these conditions work by blocking the effects of the COX-2 enzyme.[23] Many steps in formation and action of omega-6 prostaglandins from omega-6 arachidonic acid proceed more vigorously than the corresponding competitive steps in formation and

action of omega-3 hormones from omega-3 eicosapentaenoic acid.[24] The COX-1 and COX-2 inhibitor medications, used to treat inflammation and pain, work by preventing the COX enzymes from turning arachidonic acid into inflammatory compounds.[25] (See Cyclooxygenase for more information.) The LOX inhibitor medications often used to treat asthma work by preventing the LOX enzyme from converting arachidonic acid into the leukotrienes.[26][27] Many of the anti-mania medications used to treat bipolar disorder work by targeting the arachidonic acid cascade in the brain.[28]

A high consumption of oxidized polyunsaturated fatty acids (PUFAs), which are found in most types of vegetable oil, may increase the likelihood that postmenopausal women will develop breast cancer.[29] Similar effect was observed on prostate cancer, but the study was performed on mice.[30] Another "analysis suggested an inverse association between total polyunsaturated fatty acids and breast cancer risk, but individual polyunsaturated fatty acids behaved differently [from each other]. [...] a 20:2 derivative of linoleic acid [...] was inversely associated with the risk of breast cancer".[31]

Omega-6 Consumption

Industry-sponsored studies have suggested that omega-6 fatty acids should be consumed in a 1:1 ratio to omega-3,[32] though it has been observed that the diet of many individuals today is at a ratio of about 16:1, mainly from vegetable oils.[32] Omega-6 and omega-3 are essential fatty acids that are metabolized by some of the same enzymes, and therefore an imbalanced ratio can affect how the other is metabolized.[33] In a study performed by Ponnampalam,[34] it was noticed that feeding systems had a great effect on nutrient content on the meat sold to consumers. Cynthia Doyle conducted an experiment to observe the fatty acid content of beef raised through grass feeding versus grain feeding; she concluded that grass fed animals contain an overall omega-6:omega-3 ratio that is preferred by nutritionists.[33] In today's modern agriculture, the main focus is on production quantity, which has decreased the omega-3 content, and increased the omega-6 content, due to simple changes such as grain-feeding cattle.[35] Grain-feeding cattle is a way to increase their weight, to prepare them for slaughter much quicker compared to grass-feeding. This modern way of feeding animals may be one of many indications as to why the omega-6:omega-3 ratio has increased.

List of omega-6 fatty acids

Common name	Lipid name	Chemical name
Linoleic acid (LA)	18:2 (*n*−6)	*all-cis*-9,12-octadecadienoic acid
Gamma-linolenic acid (GLA)	18:3 (*n*−6)	*all-cis*-6,9,12-octadecatrienoic acid
Calendic acid	18:3 (*n*−6)	8E,10E,12Z-octadecatrienoic acid
Eicosadienoic acid	20:2 (*n*−6)	*all-cis*-11,14-eicosadienoic acid
Dihomo-gamma-linolenic acid (DGLA)	20:3 (*n*−6)	*all-cis*-8,11,14-eicosatrienoic acid
Arachidonic acid (AA)	20:4 (*n*−6)	*all-cis*-5,8,11,14-eicosatetraenoic acid
Docosadienoic acid	22:2 (*n*−6)	*all-cis*-13,16-docosadienoic acid
Adrenic acid	22:4 (*n*−6)	*all-cis*-7,10,13,16-docosatetraenoic acid
Docosapentaenoic acid	22:5 (*n*−6)	*all-cis*-4,7,10,13,16-docosapentaenoic acid
Tetracosatetraenoic acid	24:4 (*n*−6)	*all-cis*-9,12,15,18-tetracosatetraenoic acid
Tetracosapentaenoic acid	24:5 (*n*−6)	*all-cis*-6,9,12,15,18-tetracosapentaenoic acid

It is interesting to note that melting point of the fatty acids increase as the number of carbons in the chain increases.

Dietary linoleic acid requirement

Adding more controversy to the omega-6 fat issue is that the dietary requirement for linoleic acid has been questioned, because of a significant methodology error proposed by University of Toronto scientist Stephen Cunnane.[36] Cunnane proposed that the seminal research used to determine the dietary requirement for linoleic acid was based on feeding animals linoleic acid-deficient diets, which were simultaneously deficient in omega-3 fats. The omega-3 deficiency was not taken into account. The omega-6 oils added back systematically to correct the deficiency also contained trace amounts of omega-3 fats. Therefore, the researchers were inadvertently correcting the omega-3 deficiency as well. Ultimately, it took more oil to correct both deficiencies. According to Cunnane, this error overestimates linoleic acid requirements by 5 to 15 times.

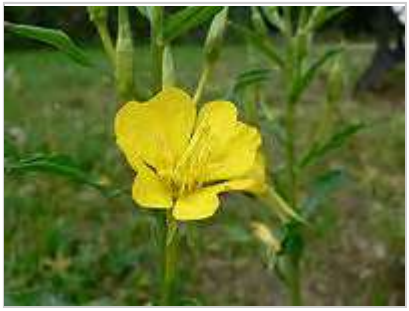
Dietary sources

Four major food oils (palm, soybean, rapeseed, and sunflower) provide more than 100 million metric tons annually, providing more than 32 million metric tons of omega-6 linoleic acid and 4 million metric tons of omega-3 alpha-linolenic acid.[37]

Dietary sources of omega-6 fatty acids include:[38]

- poultry
- eggs
- nuts

- cereals
- durum wheat
- whole-grain breads
- most vegetable oils
- grape seed oil
- evening primrose oil
- borage oil
- blackcurrant seed oil
- flax/linseed oil
- rapeseed or canola oil
- hemp oil
- soybean oil
- cottonseed oil
- sunflower seed oil
- corn oil
- safflower oil
- pumpkin seeds
- acai berry
- cashews
- pecans
- pine nuts
- walnuts[39]
- spirulina



The evening primrose flower (*O. biennis*) produces an oil containing a high content of γ-linolenic acid, a type of omega-6 fatty acid.

See also

- Essential fatty acid interactions
- Essential nutrients
- Linolenic acid
- Omega-3 fatty acid
- Omega-7 fatty acid
- Omega-9 fatty acid
- Wheat germ oil
- Lipid peroxidation
- Inflammation
- Cattle feeding
- Olive oil regulation and adulteration
- Ratio of fatty acids in different foods

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