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## LEXICON OF LIPID NUTRITION

### (IUPAC Technical Report)

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## Lexicon of lipid nutrition (IUPAC Technical Report)

*Abstract:* The intertwining of lipid nutrition with many other disciplines makes contributions from different directions imperative. Chemistry, biochemistry, physiology, food science and technology, industrial processing, and consumer acceptance provide concepts and terms used in lipid nutrition. This document is the product of a working group comprising members of the Committee on the Biological Role of Fatty Acids in Human Nutrition of the International Union of Nutritional Sciences and of the Commission on Oils, Fats, and Derivatives of the International Union of Pure and Applied Chemistry. Shorthand formulas and systematic and trivial names of some biologically important fatty acids are given in Table 1 (saturated fatty acids), Table 2 (monoenoic fatty acids), and Table 3 (polyenoic fatty acids).

Fatty acid compositions of foods have been based on the data of the USDA reference that means official grade standards for agriculture of the U.S. Department of Agriculture. Because foods may show large variations in their composition the figures in the annexed tables serve as guidelines only, except those of the Codex alimentarius (Tables 4 and 5), where accepted ranges of the figures are reported. Further, as these standards are in constant revision the reader may contact directly the USDA Agriculture Marketing Service for the last editions of these standards.

It is evident that the explanation of the referred terms is a compromise between technological and scientific correctness and the readers' lack of interest in many of the details. But, sometimes a more exhaustive explanation is necessary. Further information then may be found in cross references, although they have been reduced to those of utmost necessity. Terms in the text where cross references are available are printed in boldfaced type.

As research and science are progressing and knowledge is increasing, consequently, views on certain nutritional aspects are constantly changing, e.g., the role of essential fatty acids in human nutrition. Therefore, such a work will never be complete, and readers are invited to send their comments and observations to the authors for incorporation into a next edition.

### - A -

**Absorption** - uptake of substances from the lumen of the intestine via or along intestinal epithelial cells. The different parts of the intestine (the lower part of the alimentary tract reaching from the end of the stomach to the **duodenum**, **jejunum**, **ileum**, coecum, **colon**, rectum) are specialized in the absorption of various food components. The percentage and rate of uptake differ widely for various substances due to differences in digestibility (see digestion), competition with other components, physiological conditions of the intestine, transit time, and other factors that facilitate the absorption of specific dietary substances.

**Acid value (AV)** - measure of the content of free fatty acids in fats and oils. The acid value is the number of mg of potassium hydroxide necessary to neutralize the free fatty acids present in 1 g of **fat**.

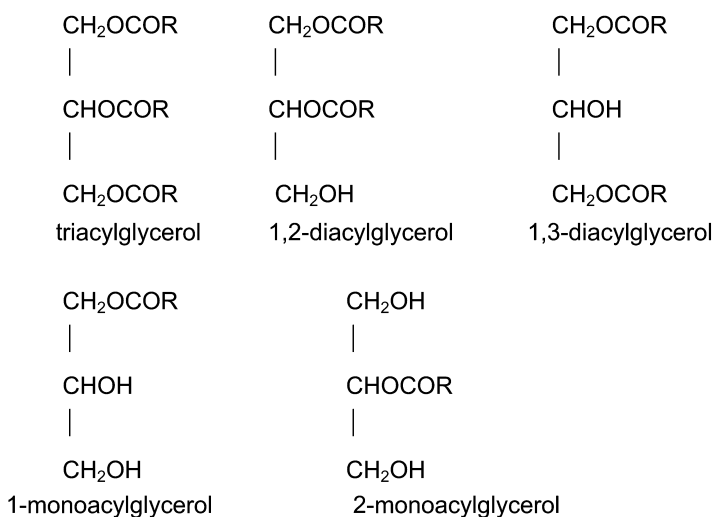
**Acidity** - acidity or **free fatty acid content** is a conventional expression of the percentage mass-fraction of total fat. According to the nature of the fat it is expressed as **lauric acid** (mol wt 200) for **coconut**, **palm kernel**, and similar oils, as **palmitic acid** (m.wt. 256) for **palm oil** and as oleic acid (mol wt 282) for all other oils.

**Acrolein** - trivial name for prop-2-enal, volatile acrid liquid,  $\text{CH}_2=\text{CHCHO}$ , from the decomposition of glycerides, boiling point of  $52^\circ\text{C}$ .

**Acylated glycerol** - glycerol containing one, two, or three acyl groups (mono-, di- and triacylglycerols). See glycerides.

Edible fats and oils are triacylglycerol mixtures made from a pool of at least five and frequently many more fatty acids. Since the number of possible structures is large, the natural mixtures are complex, and their full analysis is a challenge to the lipid analyst. Natural triacylglycerols usually have two or three different acyl groups; only unusually do they contain a single acid. Olive oil, for example, contains some triolein (trioleoylglycerol).

Diacylglycerols and monoacylglycerols, though important biosynthetic intermediates, are not significant components of lipids. Monoacylglycerols, made by glycerolysis, are important emulsifiers. These partial glycerides can exist in several isomeric forms, some of which are formulated below.



See triacylglycerol.

**Acylation** - process of introducing an acyl group into a molecule.

**Acylglyceride (acylglycerol)** - glycerol with at least one acyl group. See also acylated glycerol.

**Acyl group** - carboxylic acids may be represented by the general formula  $\text{RCOOH}$ .

The group  $\begin{array}{c} \diagup \\ \text{C}=\text{O} \\ \diagdown \\ \text{R} \end{array}$  is an acyl group, and this may replace hydrogen attached to oxygen or nitrogen, for example. See acylation.

**Additive** - substance added during refining of **vegetal** and **animal** oil or fat, or food in general, to improve specific properties. The most common groups of additives for fats and oils, in order of importance, are: **emulsifiers**, **antioxidants**, colorants, and flavoring compounds. Another additive is **lecithin**, phospholipids which are recovered from crude **edible** oils during refining.

**Adipocyte** - cell that stores **triacylglycerols** in connective tissue is specialized in this function. Adipocytes occur subcutaneously, intra-abdominally (abdominal fat tissue) and around several organs such as kidney, heart, etc. The distribution is to some extent sex-dependent. In the human female, adipocytes accumulate subcutaneously especially in the lower body, back side, thighs, and around the mammary glands; these adipocytes are metabolically not very active. In the human male, adipocytes

accumulate intra-abdominally, around the waist and shoulders; metabolically these adipocytes are quite active and under strong influence of insulin. The fatty acid composition of adipocytes is dependent on the fat composition of the average food intake; therefore, subcutaneous adipose cells can be used to obtain an accurate impression of average dietary fat intake of the last six months.

**Adipose tissue** - brown adipose tissue is a metabolically highly active tissue regulated by catecholamines and the adrenergic (sympathetic) nervous tissue (see adrenoreceptors and sympathetic nervous system). It is especially active in hibernating animals, but also in human babies, and probably in most human adults.

Exposure to cold or excess food energy intake (“cafeteria diet”) leads to activation of fatty acid catabolism (oxidation of fatty acids) resulting in this tissue producing heat instead of ATP and a consequent significant rise in body temperature.

Yellow adipose tissue is composed of adipocytes that are metabolically different from those of brown adipose tissue. Yellow adipose tissue stores triacylglycerols, storage being stimulated by insulin, while glucagon and especially catecholamines (adrenalin, noradrenaline) activate lipolysis, liberating free fatty acids from adipocytes into the blood for energy production in other tissues (mainly muscle tissue). The number and site of the adipocytes are dependent on genetically determined predisposition and on feeding habits. The number is difficult to determine as pre-adipocytes look like mesenchymal cells and show as adipocytes after accumulating sufficient triacylglycerol droplets.

**Adipositas** - adipositas or obesity is a condition of too much yellow adipose tissue. Cultural factors determine to great extent the definition of too much; however it is reasonably certain that a degree of obesity described by a Quetelet index (QI) of over 30 or a body mass index (BMI) of over 27 significantly increased risk of developing Type II diabetes mellitus (synonymous with maturity-onset diabetes mellitus, a pathological condition characterized by too much glucose in blood, glucose excretion via urine, and a normal-to-high insulin concentration in blood, but nevertheless a failing response to insulin in liver, muscles, and adipose tissue). Diabetes mellitus is a serious risk factor leading to atherosclerosis and associated cardio-, cerebro-, and peripheral vascular disease.

**Adrenergic nervous system** - see adrenoreceptors.

**Adrenoreceptors** - type of protein receptors responding to adrenalin and related hormones. There are 2 basic types of adrenoreceptors:  $\alpha$  and  $\beta$  (see receptor).  $\alpha$ -Receptors are located at the surface of smooth muscle cells of intestine, skin, and kidneys. Binding of adrenaline to these  $\alpha$ -receptors induces artery constriction which decreases blood stream in these organs.  $\beta$ -Adrenoreceptors are found on the surface of hepatic, adipose, and cardiac cells. Binding of adrenaline to cardiac  $\beta$ -receptors increases cardiac contraction speed, thus increasing blood supply to the other tissues.  $\beta$ -Receptor stimulation increases the level of circulating free fatty acids.

**Adsorption** - superficial penetration or fixation of liquid or a gas at a surface. Physical phenomena exploited in methods for separation of chemical compounds, as in chromatography with adsorbents. See chromatography.

**Alcohol** - organic compound characterized by a hydroxy group, -OH. Alcohols ( $\text{RCH}_2\text{OH}$ ) are related to aldehydes and carboxylic acids by oxidation and reduction. They are components of ester waxes. See wax.

**Aldehyde** - chemical compound with the general formula of  $\text{RCHO}$ . Higher unsaturated aldehydes lack aroma but some of them can contribute indirectly to aroma by acting as prooxidants. Aldehydes are closely related to **alcohols** and carboxylic acids:



They may be chromatographed as their dimethylacetals [RCH(OMe)<sub>2</sub>].

The oxidation of hydroperoxides, which are unstable and fragment, leads to the formation of aldehydes. Some aldehydes are responsible for the aroma and taste characteristic of oxidative changes in oils. They are formed by hydrolysis of alkenyl ethers. See glycerol ethers.

**Aldehyde value** - measure of the aldehydes formed by oxidative cleavage of unsaturated **acyl groups** in fats and oils.

**Alkyl groups** - alkyl groups (R or C<sub>n</sub>H<sub>2n+1</sub> if saturated) are part of alcohols (ROH), aldehydes (RCHO) and acids (RCOOH). See also acyl groups. Hydrogen atoms attached to oxygen and nitrogen (for example) can be replaced by alkyl groups. The alcohol (ROH) is thereby converted to ethers (ROR'). While most lipids are acyl derivatives of glycerol, alkyl (saturated) and alkenyl (unsaturated) derivatives also exist (see glycerol ethers).

**Almond** - nut-like kernel of the fruit of a small tree, *Prunus dulcis*, large commercial production in California, USA. USDA, dried, blanched, 53% fat. Fatty acids same as almond oil.

**Almond oil** - oil extracted from kernel of the fruit of *Prunus dulcis*. See fatty acid composition in Table 4.

**Almond paste** - made from ground blanched or unblanched almonds blended with sugar. USDA, 27% fat; fatty acids same as almond oil.

**$\alpha$ -linolenic acid** - *all-cis*-octadeca-9,12,15-trienoic acid. This is the first fatty acid of the n-3 series. See also linolenic acid.

**Ambadi seed oil** - oil of the seed of Ambadi, *Hibiscus cannabinos*, is used in some regions as an edible oil. It contains cyclopropenoid fatty acids such as **sterculic acid** (to an amount of 3% of the oil), which in experimental animals has induced reduced growth rates.

**Amyrin** - two isomeric triterpenoids. Present in vegetable oils up to 500 mg/kg each. The chemical structures are shown in Scheme C.

**Anabolism** - metabolic reactions for the biosynthesis of complex compounds from simple substances.

**Animal fat** - fat originating from animals including fish contrary to vegetable fat that originates from plants.

**Anisidine value (AnV)** - measure of aldehyde production during oxidation of fats. The value expresses the absorbance of fat reacted with *p*-anisidine, trivial name for *p*-methoxyaniline, under specified conditions. It is used to characterize the oxidative history of fat because aldehydes normally originate from oxidation of unsaturated fatty acids. See also peroxide value and TOTOX value.

**Annatto** - red coloring substances, from seeds of *Bixa orellana*, used for cheese or butter manufacture.

**Ante-iso acids** - see branched-chain acids.

**Antioxidant** - substance which curtails oxidation by trapping free radicals. Natural antioxidants include tocopherols (**vitamin E**) accompanying compounds in edible oils and fats. Synthetic antioxidants

include **gallates**, **BHA** (butylated hydroxyanisol), and **BHT** (butylated hydroxytoluene), the use of which is regulated legally.

**Apolipoprotein** - the protein moiety of lipoproteins.

**Arachidic acid** - trivial name for icosanoic acid, 20:0.

**Arachidonic acid** - trivial name for *all-cis*-icosa-5,8,11,14-tetraenoic acid, 20:4(n-6). It is derived metabolically from **linoleic acid**, an essential fatty acid; present in phospholipids in liver and brain.

**Arachidonic cascade** - arachidonic acid and the many oxygenated compounds, known as **icosanoids**, derived from arachidonic acid. See also icosanoids.

**Arachis oil** - see peanut oil.

**Argentation chromatography** - see thin-layer chromatography.

**Arteriosclerosis** - disease characterized by thickening and loss of elasticity of arterial walls. High amounts of saturated and hydrogenated fats in the diet are one of the risk factors for arteriosclerosis. See hydrogenation and fatty acids.

**Astaxanthin** - see xanthophyll.

**Atherosclerosis** - common form of arteriosclerosis in which deposits (atheromas) are formed within the intima and inner media of large and medium-sized arteries. It can be promoted by high amounts of saturated and hydrogenated fats in the diet. See hydrogenation and fatty acids.

**Autoxidation** - oxidation through a radical reaction. The primary oxidation products are hydroperoxides; the secondary oxidation products are aldehydes and ketones. Usually autoxidation is enhanced by heat, light, and metals.

**AV** - abbreviation for **acid value**.

**Avenasterol** - two isomeric sterols  $\Delta^5$ - and  $\Delta^7$ -avenasterol. Found in vegetable oils. The chemical structures are shown in Scheme A.

**Avocado** - also called avocado or alligator pear. The pulpy green or purple fruit of the tree, *Persea americana*, is originating in the West Indies. USDA, all commercial varieties (California and Florida), 15% fat. See fatty acid composition in Table 4.

## - B -

**Babassu fat** - fat from Brazilian palm species, *Orbignya martiana*, with nuts containing 63–70% fat. See fatty acid composition in Table 4.

**Babassu nut oil** - see babassu fat.

**Bacon** - pork, cured side of a pig after removal of spareribs. USDA, raw, 58% fat, cooked, 49% fat. See fatty acid composition in Table 5.

**Bacon, Canadian-style** - pork, cured loin of a pig, fully cooked as purchased. USDA, 7% fat. See fatty acid composition in Table 5.

**Baking fat** - fat for the baking industry. See shortening.

**Béarnaise sauce** - thick sauce for meat or fish made of egg yolks, butter, milk, wine or vinegar, and seasonings. USDA, 27% fat; fatty acids depend on ingredients.

**Beef** - flesh of a steer, cow, or other adult bovine animal when killed for food. USDA, composite of trimmed retail cuts, separable lean only, trimmed to "0" fat, all grades, cooked, 9% fat. See fatty acid composition in Table 5.

**Behenic acid** - trivial name for docosanoic acid, 22:0. Present in minor contents in peanut oil.

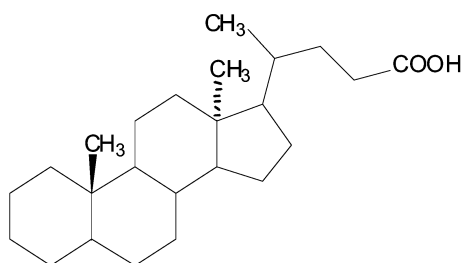
**$\beta$ -oxidation** - degradation of fatty acids in mitochondria beginning with activation by adenosine triphosphate (ATP) and **coenzyme A** (CoA) to form acyl CoA. The activated fatty acid (acyl CoA) undergoes a series of reactions ( $\beta$ -oxidation) involving dehydrogenation by flavin-adenine dinucleotide (FAD), uptake of water and dehydrogenation by nicotinamide adenine dinucleotide (NAD). The reduced coenzymes are oxidized again in the respiratory chain. The final product of one cycle of  $\beta$ -oxidation is a  $\beta$ -keto compound of the activated fatty acid. This reacts with one more CoA to form acetyl CoA and an activated fatty acid that is two carbon atoms shorter than the original fatty acid.

**BHA** - abbreviation for hydroxyanisol (2-*tert*-butyl-4-methoxyphenol), an **antioxidant**.

**BHT** - abbreviation for butylated hydroxytoluene (2,6-di-*tert*-butyl-4-methylphenol), an **antioxidant**.

**Bile** - secretion of the liver and collected in the gall bladder prior to use that contains bile acids, cholesterol, lecithin, fat, pigments, and mucin.

**Bile acids** - biologically important steroidal constituents of bile. They are derived from enzymatic transformation of cholesterol and differ chemically in the number and position of hydroxyl groups in 5 $\beta$ -cholanic acid (see formula). In **liver**, chenodeoxycholic acid (3 $\alpha$ ,7 $\alpha$ -dihydroxy-5 $\beta$ -cholanic acid) and cholic acid (3 $\alpha$ ,7 $\alpha$ ,12 $\alpha$ -trihydroxy-5 $\beta$ -cholanic acid) are formed and mostly conjugated with glycine or **taurine** (glyco- or taurochenodeoxycholic acids, glyco- or taurocholic acids). After their excretion in bile into the duodenum, these major bile acids can by intestinal bacteria be further converted into deoxycholic acid (3 $\alpha$ ,12 $\alpha$ -dihydroxy-5 $\beta$ -cholanic acid), ursodeoxycholic acid (3 $\alpha$ ,7 $\beta$ -dihydroxy-5 $\beta$ -cholanic acid) and lithocholic acid (3 $\alpha$ -hydroxy-5 $\beta$ -cholanic acid), and their corresponding glycine or taurine conjugates. The bile acids usually exist as sodium salts ("bile salts"). They can be reabsorbed from the gut and taken up again by the liver for new biliary secretion. The physiological significance of the bile acids is based upon their efficacy in activating the pancreatic lipase, in facilitating fat absorption in the small intestine by micellar solubilization of **fatty acids**, **monoacylglycerols**, **phospholipids**, **steroids**, **carotenoids**, and **fat-soluble vitamins**, and in stimulating bile secretion in the liver. See also steroid.



5 $\beta$ -cholanic acid

**Bioavailability** - fraction of a nutrient being digested, absorbed, and metabolically utilized by the organism through normal metabolic pathways. Numerous factors can affect the bioavailability of nutrients from the diet. Food processing is one of them.

**Biochemistry** - science of chemical compounds and processes in biological systems.

**Biomembrane** - highly organized structures surrounding eukaryotic cells (see plasma membrane) or intracellular organelles. Each biomembrane contains proteins (structural or functional), **phospholipids**, but also **glycolipids** and glycoproteins. **Lipids** (**phospholipids** and **sterols**) are organized in bilayers in

which proteins are more or less deeply embedded. Non-bilayer structures also occur. There are surface-bound proteins.

**Biosynthesis** - process through which a chemical compound is formed in living cells.

**Biotechnology** - generally defined as the application of biological organisms, systems, or processes to the manufacturing and service industries. Applications to health care, energy, drugs, agriculture food industry, waste treatment, and the environment are implicit in this definition.

**Blackcurrant seed oil** - oil obtained from the seed of *Ribes nigrum*; contains linoleic and both  $\alpha$ - and  $\gamma$ -linolenic acids.

**Bleaching** - process that removes colored pigments, impurities, oxidative materials, trace metals by adsorptive cleaning using montmorillonite clays or activated carbons. Prior to bleaching, the oil is normally pretreated with phosphoric acid to precipitate the “gums”. Bleaching of oil is usually carried out at 70–120 °C under vacuum.

**Bleaching earths** - natural clays of which the chief components are the minerals of montmorillonite and attapulgite (Fullers earth and Bentonite). In their natural state or after being heated by steam and then dried, or further chemically treated with sulfuric acid or hydrochloric acid (activation), these earths have the capacity to adsorb coloring pigments from oils. After steam treatment, the clays disclose their layered molecular lattice structure, giving rise to micropores for the adsorption of oil, phosphatides, color pigments, and metals.

**Blood clot** - thrombus or clot of platelets formed within a blood vessel, for example, in an artery in the heart or brain or the lower extremities. Blood clots can give rise to severe thrombosis in the arterial system where they block the passage-way, causing death of cells in the area. Clots can form if an artery is injured or uneven. The most common blood clots occur in arteries or veins of the legs and abdomen where the formation of them is due to a slow blood flow, perhaps as the result of being bedridden. Sometimes the clot becomes a loose embolus which follows the circulatory system to the heart and clogs the small coronary vessels or lung capillaries. Linoleic acid in the diet can reduce the aggregation of blood platelets and hence the formation of blood clots. Some vegetable oils such as sunflower seed oil and soya bean oil are rich in linoleic acid (see Table 4).

**Blood platelet** - small blood cell involved in clotting. See blood clot.

**Blood pudding** - see blood sausage.

**Blood sausage** - boudin, sausage containing a large amount of blood so that it is very dark in color. USDA, total fat, 34%. See fatty acid composition in Table 5.

**Body mass index (BMI)** - body weight in kilograms divided by the height in meters squared. Also known as **Quetelet index**.

**Bologna** - bologna sausage, baloney, a large moist sausage usually made of beef, veal, and pork that is chopped fine, seasoned, enclosed in a casing, boiled, and smoked red. USDA, total fat, beef, 28%, beef and pork, 28%, pork, 20%, turkey, 15%. See fatty acid composition in Table 5.

**Borage oil** - oil from the seed of *Borago officinalis*; contains both  $\alpha$ - and  $\gamma$ -linolenic acids.

**Bran** - broken coat of the seeds of **wheat, rye, oat**, or other cereal grains separated from the kernel.

**Branched-chain acids** - fatty acids of which the chain of carbon atom of the alkyl rest is branched. Most of these branched-chain acids in **lipids** belong to two series: the iso series where methyl branching is on the penultimate carbon atom and the ante-iso series with methyl branching on the antepenultimate carbon atom.





Most important natural acids present in oils and fats are straight-chain compounds, but branched-chain compounds occur as minor components, especially in fats of animal origin.

**Brassica** - family name for mustard-type plants, including cabbage, rapeseed.

**Brassicidic acid** - trivial name for the *trans* isomer of erucic acid, docos-13-enoic acid.

**Bratwurst** - fresh pork sausage for frying. USDA, total fat, 26%, fatty acids same as pork.

**Brie** - soft French cheese made in flattish disc forms and dusted with white *Penicillium* molds; contains approximately 28% fat.

**Butter** - solid emulsion spread made from cow milk fat and used as a spread and in cooking. USDA, 81% fat. Same fatty acids as **cream**.

**Butter fat** - synonymous term for butter oil or cow **milk** fat.

**Butter oil** - clarified butter, 100% fat, same fatty acids as **cream**.

**Butyric acid** - trivial name for butanoic acid, 4:0. Characteristic fatty acid of **butter** fat which contains approx. 3% of butanoic acid.

## - C -

**Cacao butter** - see cocoa butter.

**Calciferol** - see vitamin D.

**Calorie** - unit defined as amount of heat required to warm 1 g water from 14.5 to 15.5 °C. It is 4.19 joules, a unit for the amount of heat and energy in the SI system. The calorie in nutrition is 1000 calories or 1 kcal.

**Calorimeter** - instrument for measuring the heat energy of a sample or generated by a chemical or physical reaction. It is comprised of a heat-insulated container in which the unknown amount of heat energy can rise the temperature in a known amount of water or other substance of known heat capacity. One reads the thermometer at the beginning and ending of the heating and thus can determine the amount of heat generated.

**Calorimetry** - measuring of amounts of heat energy in a given sample.

**Camembert cheese** - soft cheese made from whole milk; has surface mold which converts fats to aromatic substances; originated in Normandy, France; contains approximately 24% fat.

**Campesterol** - sterol, common to plants. Corn oil contains approx. 0.25% campesterol. The chemical structure is shown in Scheme A.

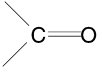
**Canadian-style bacon** - see bacon.

**Canola oil** - genus *Brassica*, species *napus* or *campestris*, from seed low in erucic acid and glucosinolates; grown in Western Canada, Ontario, North and Central United States. Estimated annual world production in 1988/89 was 7.55 million tonnes. See fatty acid composition in Table 4.

**Capric acid** - trivial name for decanoic acid (10:0); present in palm kernel and coconut fat in approx. 6%; also present in **milk fat**.

**Caproic acid** - trivial name for hexanoic acid (6:0); present in **milk fat** in approx. 2%.

**Caprylic acid** - trivial name for octanoic acid (8:0); present in approx. 7% in coconut and babassu fat; also present in **milk fat**.

**Carbonyl group** - functional group ; characteristic for aldehydes and ketones, but also characteristic for the functional group of carboxylic acids (**fatty acids**) and derivatives.

**Carboxylic acid** - see fatty acid and acyl group.

**Cardiolipin** - phosphatide first detected in the heart muscle. See diphosphatidylglycerol.

**Carnitine** - amino hydroxy carboxylic acid  $[(\text{CH}_3)_3\text{N}^+\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{COO}^-]$  which plays a role in the transport of acyl chains into **mitochondria** and thereby in  **$\beta$ -oxidation**.

**$\beta$ -Carotene** - see carotenes.

**Carotenes** - **isoprenoid** hydrocarbon members of the large class of carotenoids, having a series of conjugated double bonds and mainly of the general formula of  $\text{C}_{40}\text{H}_{56}$ . The most important and common member is  **$\beta$ -carotene** (see Scheme D) which occurs in green leafy vegetables and abundantly in carrots. It can be transformed in animals and humans into **vitamin A**.  $\alpha$ - and  $\gamma$ -carotene possess only half the provitamin A activity of  **$\beta$ -carotene**. Among the known carotenes and **xanthophylls**, approximately 50 carotenoids can serve as precursors of vitamin A. Lycopene, an acyclic carotene, is the pigment of red tomatoes. See also carotenoids, vitamin A.

**Carotenoids** - large class of over 600 fat-soluble, polyunsaturated compounds which in most cases consist of eight **isoprene units** with mostly **conjugated double bonds**. According to their light-absorbing properties, the carotenoids are pigments with a range of color from mostly yellow to deep red. They occur ubiquitously in green leaves and are also found in numerous flowers, seeds, fruits (e.g., tomatoes, rose hip, citrus fruits, maize), in some roots (e.g., carrots) and in species of animals such as crustaceans. Red palm oil is an important source of carotenoids in some parts of the world. Based on the chemical structure, the carotenoids are classified as **carotenes**, which are pure hydrocarbons and as **xanthophylls** which are oxygenated derivatives of the carotenes. Carotenoids found in animal and human tissues are obtained from the diet. See also carotenes and xanthophyll.

**Cashew nut** - fruit of *Anacardium occidentale*; a hard-shell nut used for food and oil. The proportion of oil in the kernel is 40–46%. Cashew kernels have a pleasant flavor, and they are used for confectionary purposes. See fatty acid composition in Table 4.

**Castor oil** - oil of the seed of *Ricinus communis*. Important industrial oil produced mainly in Brazil, India, and China. It is not used as a food because of its laxative effect, but is the source of several important oleochemicals. It is characterized by its high content of **ricinoleic acid**.

**Catabolism** - metabolic degradation of complex compounds into simple substances; frequently associated with the release of energy; opposite of **anabolism**.

**Catalase** - enzyme degrading hydrogen peroxide to water and oxygen. Common in both animal and plant cells. Hydrogen peroxide is formed during metabolism, but is toxic and must be destroyed by the cell.

**Catalyst** - agent that can accelerate a reaction (first-order catalyst) or participate in a reaction and is then reconstituted (second-order catalyst). Important first-order catalysts for biochemical reactions are **enzymes**. Synthetic or enzymatic catalysts are used in **fat modification techniques**. See biosynthesis.

**Caustic refining** - see chemical refining.

**Caviar** - processed, salted roe of the sturgeon and certain other large fish, prepared as an appetizer. USDA, black and red, granular, 18% fat.

**Cephalin** - old term for **phosphatidylethanolamine**.

**Ceramides** - see sphingolipids.

**Cerebrosides** - see sphingolipids.

**Cerotic acid** - trivial name for hexacosanoic acid (26:0).

**Cetoleic acid** - trivial name for *cis*-docos-11-enoic acid (20:1); found in many species of fish.

**Chain reaction** - reaction which once started keeps on going. See also autoxidation.

**Cheddar cheese** - hard cheese made by cutting the milk curd repeatedly; originated in England and extensively produced elsewhere; contains approximately 33% fat.

**Cheese** - dairy product prepared from the separated curd obtained by coagulating the casein of whole, skimmed, or cream-enriched milk. The coagulation is accomplished by means of rennet or other suitable enzymes, lactic fermentation or by a combination of the two. The curd may be modified by heat, pressure, ripening ferments, specific molds, or suitable seasoning. Cheeses are important sources of fats, proteins, and of some minerals (e.g., calcium) and **vitamins**. There exist hundreds of different species of cheese.

**Chelating agent** - organic compound that combines with metals to render them unavailable for oxidation, thereby acting as an antioxidant. Important chelating agents are citric acid and ethylenediaminetetraacetic acid (EDTA).

**Chemical refining** - removal of fatty acids by caustic moieties and deodorization at relatively low temperatures at 180–240 °C. Consists of a degumming, neutralization, **bleaching**, and deodorization step. Today more and more replaced by **physical refining** because of less effluent problems. See refining.

**Chenodeoxycholic acid** - see bile acids.

**Chicken** - domestic fowl *Gallus gallus*. USDA, flesh and skin, cooked, roasted, 15% fat; flesh only, cooked, roasted, 7% fat. See fatty acid composition in Table 5.

**Chips** - potato slices fried in oil. For market, they may be spiced with paprika, dill, or garlic. In some countries, they are known as **potato crisps**.

**Chlorophyll** - green pigment found in **chloroplasts** of plants, which absorbs light energy and is essential to photosynthesis.

**Chloroplast** - photosynthetic organelle of plant cells.

**Chocolate** - paste prepared from cocoa beans from the fruits of *Theobroma cacao*. See cocoa.

**Cholecalciferol** - vitamin D<sub>3</sub>. See vitamin D.

**Cholesterol** - principal sterol of the higher animals, and as such present in fats and oils. The chemical structure is shown in Scheme A.

Cholesterol can be synthesized in various tissues from activated acetic acid and is an important component of all cell membranes as well as the precursor for the biosynthesis of steroid hormones, bile acids, and vitamin D. Hepatic cholesterol biosynthesis is decreased by cholesterol from dietary sources. Both dietary intake and endogenous synthesis of cholesterol contribute to its plasma concentration. High cholesterol levels may be a risk factor for atherosclerotic vascular disease.

**Cholesterol ester** - cholesterol esterified to a fatty acid; occurs in lipoproteins and animal tissues.

**Cholic acid** - see bile acids.

**Chromatography** - procedure to separate the components in a mixture from each other. The components dissolved in a mobile phase (gas or liquid) pass through an immobile stationary phase (liquid or solid). The separation takes place because different substances have different tendencies to bind to the stationary phase. The different types of chromatography include **gas** (gas liquid), **gel permeation, liquid, thin-layer**, and **supercritical-fluid chromatography**.

**Chylomicron** - largest of the plasma lipoprotein particles that transport **triacylglycerols** from the intestine to peripheral tissues.

**Cis-fatty acid** - designation for an unsaturated fatty acid that is in the *cis* configuration. Most common fatty acids are of the *cis* form. See also isomers.

**Cis-trans isomerism** - conversion of a double bond from one configuration to another, either *cis* or *trans*; the isomeric form is dependent on the arrangement of the groups (atoms) attached to each of the unsaturated carbon atoms.



*Cis* and *trans* isomers show similar but not identical chemical properties but may have markedly different physical, chemical, and **biochemical** properties.

**Citrostadienol** (also known as  $\alpha_1$ -sitosterol) - **sterol** belonging to the 4-monomethylsterol group. The sterol is present in vegetable oils up to 500 mg/kg. The chemical structure is shown in Scheme B.

**Clupanodonic acid** - trivial name for *all-cis*-docosa-7,10,13,16,19-pentaenoic acid, (22:5 n-3); formerly used for all C22 fatty acids in fish oil.

**CoA** - abbreviation for **coenzyme A**.

**Cocoa** - obtained from the fruits of a small rain forest tree, *Theobroma cacao*, which produces the cocoa bean. The tree originated in tropical America, but two-thirds of the current production is in West Africa. The tree belongs to the tropical family Sterculiaceae which is closely related to the linden tree. It has a wide crown and large leather-like leaves. The small rose-colored flowers develop in large numbers directly from trunks and older branches, but only some of them give rise to fruits. These are 10 to 20 cm long, brown or reddish yellow cucumber-like berries with a rose-colored, sweet-sour fruit mass, and rows of thin seeds called cocoa beans producing cocoa. Cocoa beans are fermented, peeled, and ground, and contain about 50% fat, the so-called cocoa butter, 10–15% albuminous substance, 15–20% carbohydrates, and small amounts of the alkaloid, theobromine, which is related to caffeine and has a stimulating effect. In the production of cocoa powder, two-thirds of the cocoa butter is pressed out, but in the production of chocolate, extra cocoa butter is added.

**Cocoa (cacao) butter** - fat of the beans of the fruit of *Theobroma cacao*, 100% fat. It is very stable and is used in the chocolate industry and in the production of medical and cosmetic preparations. See vegetable tallow. See fatty acid composition in Table 4.

**Cocoa butter equivalent (CBE)** - vegetable fat composed of symmetrical 2-oleo-disaturated triacylglycerols of C16 and C18 fatty acids. They should be compatible with cocoa butter in the proportions normally used in chocolate.

**Cocoa butter improver (CBI)** - harder version of CBE due to the content of triacylglycerol containing stearic-oleic-stearic acids. It is used in chocolate formulations having a high content of milk fat or those meant for tropical climates.

**Cocoa butter replacer (CBR)** - nontempering fat differing in composition from cocoa butter and the tempering CBE and CBI; produced by fractionation and hydrogenation of oils rich in C16 and C18 fatty acids.

**Cocoa butter substitute (CBS)** - fat based on palm kernel and coconut oil, fractionated and hydrogenated. Because of poor miscibility with cocoa butter, CBS is normally used with only low-fat cocoa powder (10–12% fat).

**Coconut** - fruit of the **coconut palm**, *Cocos nucifera*, consists of an outer fibrous husk and a large nut containing edible meat. USDA, raw 34% fat; the dried nut meat is called copra. USDA, 65% fat. See also copra.

**Coconut oil** - obtained from copra and also called coconut fat. It melts at 25 °C. It has a high content of saturated fatty acids and is used, among other applications, for margarine and chocolate. See fatty acid composition in Table 4.

**Coco-oil** - other name for **coconut oil** or fat.

**Cocopalms** - coconut palm, *Cocos nucifera*, found in the entire tropical belt, especially along the ocean shoreline; probably originates from Asia.

**Cod liver oil** - oil extracted from cod liver; rich source of fat-soluble vitamins and C20 and C22(n-3) fatty acids.

**Codex Alimentarius Commission** - international organization founded in 1962 by FAO and WHO after a conference on food standards. Its purpose is to carry out programs for the Joint FAO/WHO Food Standards Programs to protect the consumer. It prepares worldwide standards on labeling, hygiene, food additives, pesticides, and food commodities.

**Coenzyme** - low molecular compound which is a dissociable moiety of an enzyme and may act as an acceptor or donor of atoms or electrons.

**Coenzyme A** - constituent of all living cells that is necessary for the transfer of acyl groups, especially acetyl groups, to specific receptor molecules and for the degradation of fatty acids. Pantothenic acid, a water-soluble vitamin, is an essential component of coenzyme A. See  $\beta$ -oxidation.

**Colon** - large intestine, beginning at the caecum and terminating at the sigmoid flexure.

**Columbinic acid** - trivial name for *trans,cis,cis*-octadeca-5,9,12-trienoic acid (18:3).

**Confectionery fat** - fat such as cocoa butter, cocoa butter equivalent or substitute, coating or filling fat, used by the confectionery industry.

**Conjugated double bonds** - double bonds separated in a molecule by only one single bond. Two electrons from each double bond form a so-called conjugated system in which the electrons combine as a unit and give the molecule specific characteristics.

**Consistency** - characteristic in a material which resists change in form. In food fats, consistency depends strongly on pretreatment and temperature and can be determined by **sensory analysis**.

**Copra** - dried coconut meat (endosperm layer) used as a flavoring; it provides a stable form of coconut oil and meat to allow for storage; usually 63–68% fat. See coconut.

**Corn (maize) oil** - vegetable oil from the germ after separation from the grain (seeds) of *Zea mays* which contain 1.2% fat in the raw, undried state. See fatty acid composition in Table 4.

**Cottage cheese** - drained curd of soured milk, seasoned and sometimes pressed.

**Cottonseed oil** - oil from the seed of *Gossypium* spp. See fatty acid composition in Table 4.

**Cream** - portion of cow milk that is high in milk fat and will rise to the top of undisturbed milk, fluid. USDA, EEC. Half and half, 12% fat; coffee or table cream, 19% fat; medium, 25% fat; light whipping, 31% fat; heavy whipping, 37% fat. See fatty acid composition in Table 5.

**Crude oil** - oil or fat obtained from oil-bearing seeds and fruits by mechanical pressure or extraction by using solvents; fatty material not subjected to refining.

**Crystallization** - change from liquid to solid state. Also, change from dissolved to solid state in solutions. Fats crystallize slowly and thus are easily undercooled. Crystallization is used to separate components based on differences in melting points. See fractionation.

**Cryptoxanthin** - see xanthophyll.

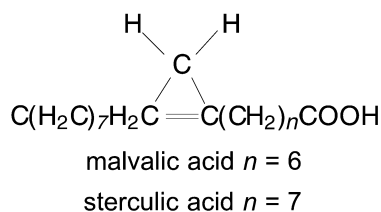
**Cucurbita seed oil** - oil of the seeds of *cucurbitae* species, used in several areas as edible oil, similar in composition to **watermelon seed oil**.

**Cyclic fatty acids** - unsaturated acids, especially those with more than one double bond; can cyclize under vigorous reaction conditions. The product may be monomeric or have a higher molecular weight. Such compounds may be present at low level in processed oils that have been exposed to high temperatures.

**Cycloartenol** - phytosterol belonging to the 4,4-dimethylsterol group. The sterol is present in vegetable oils up to 500 mg/kg. The chemical structure is shown in Scheme C.

**Cycloeucaleanol** - phytosterol belonging to the 4-monomethylsterol group. The sterol is present in vegetable oils up to 500 mg/kg. The chemical structure is shown in Scheme B.

**Cyclopropene acid** - generic name for an acid that contains an unusual unsaturated C<sub>3</sub> ring in its structure. **Sterculic acid**, frequently accompanied by malvalic acid, is present in some rare seed oils of the *Malvaceae* but, also, at lower levels in **cottonseed oil** (1%) and kapok seed oil (13%). Sterculic acid is probably removed from cottonseed oil during processing. It is remarkable for its ability to inhibit the metabolic desaturation of stearic to oleic acid.



**Cyclooxygenase** - enzyme responsible for the initiation of the biosynthesis of **prostaglandins** and **thromboxanes**, principally from **arachidonic acid**

## - D -

**Dairy fat** - see milk fat, cream, cheese.

**Decanoic acid** - saturated fatty acid of 10 carbons (10:0).

**Deep-frying** - thermal process to cook foods (potato chips, french fries, fish, etc.) immersed in fat. Depending on fatty acid composition, heating temperature and duration, the deep-frying can cause

appreciable changes in the fat. Undesirable changes may include the loss of essential fatty acids and vitamins, and to a lesser degree the formation of new compounds such as geometrical and positional isomers of polyunsaturated fatty acids, cyclic isomers, polymers, polar compounds, and oxysterols.

**Deficiency** - deficit; shortage; dietary lack.

**Degumming** - removal of substances including phospholipids, sugars, trace metals, and pigments by the addition of water or phosphoric acid during refining of an oil.

**Dehydrogenation** - transfer of hydrogen from chemical compounds to an oxidizing substance, a critical reaction in many metabolic steps.

**Dehydroretinol** - see vitamin A.

**Density** - kg/m<sup>3</sup>, kilogram per cubic meter.

**Deodorization** - process which removes odors, the last step in refining of oils. Steam is passed through the oil under vacuum 3–10 mm Hg (400–1333 Pa) and at a temperature which usually lies between 200 and 250 °C. Temperatures higher than 240 or 250 °C may cause the formation of *trans* fatty acids. Unpleasant tasting and odorous compounds and a large amount of **free fatty acids** are removed with the steam.

**Deoxycholic acid** - see bile acids.

**Desaturase** - enzyme that removes hydrogen atoms to produce an unsaturated double bond.

**DGDG** - abbreviation for digalactosyldiacylglycerol. See glycolipid.

**DHA** - abbreviation for **docosahexaenoic acid**.

**Dhupa fat** - fat from the seeds of Dhupa, *Valeria indica*; rich in stearic and oleic acid mainly as distearo-oleic glycerol; used as **cocoa butter substitute**; also called Malabar tallow. See vegetable tallow.

**Diacylglycerols** - see acylated glycerol.

**Diet** - food and drinks regularly consumed.

**Dietary allowance** - recommendation of the level of daily or weekly intake of essential nutrients considered to be adequate to meet the known nutritional needs of practically all healthy persons.

**Dietetics** - science or study of the application of nutrition to the feeding of individuals or groups, or those living under special circumstances (for example, illness).

**Differential scanning calorimetry (DSC)** - measurement of the heat flow associated with transitions in materials as a function of time and temperature. In lipid analysis, the technique, also called differential thermal analysis or DTA, gives information about melting characteristics.

**Differential thermal analysis (DTA)** - see differential scanning calorimetry (DSC).

**Digalactosyldiacylglycerol** - see glycolipid.

**Digestible energy** - energy available from food after digestion in the gastrointestinal tract.

**Digestion** - process of converting food in the gastrointestinal tract into substances for absorption.

Digestion involves mechanical and chemical breaking up of the food to substances that can be absorbed from the intestinal tract.

There by many operations and enzymes involved acylglycerols are split into fatty acids and glycerol, proteins into amino acids, and carbohydrates into monomeric sugars (e.g., glucose). These food substances are absorbed in the small intestine. The blood takes up glucose and amino acids and carries them

to the liver which supplies nutrients to the cells. The fatty acids are taken up to a large extent by the lymphatic system.

**Diglyceride** - see diacylglycerol and acylated glycerol.

**Dihomo- $\gamma$ -linolenic acid (DHLA)** - trivial name for *all-cis*-icosa-8,11,14-trienoic acid (20:3 n-6).

**Dilatometry** - measurement of volume changes associated with temperature changes. Detects phase transformations.

**Dimer** - compound formed by the chemical combination of two identical molecules.

**Dimer acids and glycerides** - dimers of unsaturated fatty acids and glycerides. Unsaturated acids dimerize on heating, and processed oils may contain dimeric compounds of uncertain structure at low concentration. Oxygen-linked dimers may be produced during oxidation (for example, during frying).

**Dimethyl acetal** - see aldehyde.

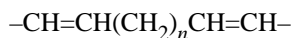
**Diphosphatidylglycerol** - phospholipid containing three moles of glycerol, 2 moles of phosphoric acid, and 4 moles of fatty acids. See cardiolipin.

**Docosahexaenoic acid** - *all-cis*-docosa-4,7,10,13,16,19-hexaenoic acid (DHA), (22:6 n-3) - important member of the n-3 fatty acid family. The fatty acid is present in many marine oils and is a major fatty acid in sperm and brain phospholipids, especially retinal lipids.

**Docosanoic acid** - saturated fatty acid of 22 carbons (22:0), trivial name **behenic acid**.

**Docosapentaenoic acid (22:5)** - exists in many isomeric forms such as an n-3 fatty acid in fish oils and as an n-6 fatty acid at low concentration in animal fats.

**Double bond** - unsaturated carbon-carbon bond. When carbon atoms are not fully saturated with hydrogen (or other atoms) they are said to be unsaturated, and two adjacent carbon atoms may then be linked with a double bond; sometimes called an olefinic link. Natural carboxylic acids containing one or more double bonds are known as monoene (monounsaturated) or polyene (polyunsaturated) acids. The relative position of two or more double bonds is described by the following terms: **conjugated** ( $n = 0$ ), **methylene-interrupted** ( $n = 1$ ), and non-methylene-interrupted ( $n > 1$ ).



**Dressing** - salad sauce containing oil with vinegar or lemon juice, seasonings, and thickeners or emulsifiers.

**Dripping** - unbleached and untreated fat from the fatty tissues or bones of animal carcasses obtained by heating.

**Drying** - removal of traces of water in oil or fat, especially before bleaching or to improve stability of crude oils.

**DSC** - see differential scanning calorimetry.

**Duck** - domesticated waterfowl, *Anas platyrhynchos*. USDA, flesh and skin, cooked, roasted, 28% fat; flesh only, cooked, roasted, 11% fat. See fatty acid composition in Table 5.

**Duck liver paste** - see paté.

**Duodenum** - first or proximal part of the small intestine, extending from the pylorus to the jejunum. See digestion.



**- E -**

**Edam cheese** - hard Dutch cheese, made from partly skimmed pasteurized cow's milk; contains 30 to 40% fat.

**EDTA** - abbreviation for ethylenediaminetetraacetic acid, a **chelating agent** of metals.

**Edible oil** - fatty oil in edible form; differentiated from mineral oil and essential oil.

**Edible tallow** - rendered fat of cattle and sheep that is white and almost tasteless. See fatty acid composition in Table 5.

**EFA** - essential fatty acid(s). These are of the linoleic (n-6) or linolenic (n-3) type.

**Egg** - hard-shelled reproductive body produced by a bird, especially of domesticated poultry, the content used for food. USDA, chicken, yolk, 33% fat, whole, 11%; duck, whole, 14% fat; goose, whole, 13% fat; turkey, whole, 12% fat. See fatty acid composition in Table 5.

**Egg yolk** - yellow spherical mass in the egg of a bird or reptile, rich in cholesterol, phospholipids, and essential nutrients.

**Eico** - Greek syllable for twenty. Should be replaced by Ico in biological related chemical compounds.

**Eicosanoid cascade** - see icosanoids.

**Eicosanoids** - see icosanoids.

**Eicosapentaenoic acid (EPA)** - *all-cis-icosa-5,8,11,14,17-pentaenoic acid*, (20:5 n-3). Present in fish oils. It may be derived from  $\alpha$ -linolenic acid by desaturation and elongation steps.

**Eicosenoic acid** - *icosenoic acid* (20:1), *cis-icos-9-enoic acid* (**gadoleic acid**), and *cis-icos-11-enoic acid* (**gondoic acid**) are present in fish and plant seed oils. See Table 2.

**Elaidic acid** - trivial name for *trans*-octadec-9-enoic acid, *t*-18:1(n-9). Occurs in minor amounts in many ruminant fats, e.g., beef fat; found in partially hydrogenated vegetable oils.

**Electrocardiogram** - tracing of weak electric currents that occur in the heart. Registration is done with an electrocardiograph which contains a galvanometer.

**Electron spin resonance (ESR)** - spectroscopic technique similar to nuclear magnetic resonance (NMR) where microwave radiation is used instead of radio frequencies in NMR. The technique is used among physical phenomena related to mobility of electrons to study radicals that are important for lipid oxidation.

**Elongase** - enzyme involved in the elongation of a fatty acid by the addition of a 2-carbon unit.

**Embolus** - see blood clot.

**Emmentaler cheese** - hard Swiss cheese containing olive-shaped holes; made in wheels up to 100 kg in weight; contains approximately 28% fat.

**Emulsifier** - surface-active agent that aids the dispersion of one liquid phase into another, usually oil in water or vice versa.

**Emulsion** - dispersion of small globules of one liquid throughout the body of another liquid.

**Endoplasmic reticulum** - complex **biomembrane** on which are located a large number of enzymes and enzyme systems. Can be either smooth (without ribosomes) or rough (with ribosomes). Among the functions associated with this organelle are the metabolism of **xenobiotics**; synthesis and transport of proteins; synthesis of **lipids** (cholesterol, phospholipids, and triacylglycerols); and participation in glycogen breakdown.

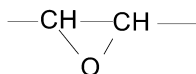
**Endosperm** - nutritive material within the embryo sac of a plant seed.

**Endothelium** - lining of blood and lymph vessels or closed cavity in the body.

**Enzyme** - biocatalyzator; protein that accelerates a specific chemical reaction.

**EPA** - abbreviation for icosapentaenoic acid.

**Epoxide** - oxidation product of an unsaturated fatty acid.



**Ergocalciferol** - vitamin D<sub>2</sub>. See vitamin D.

**Erucic acid** - trivial name for *cis*-docos-13-enoic acid, 22:1(n-9). Present in 20-40% in oils from mustard seeds and up to 50% in original high erucic rapeseed oil.

**Essential fatty acids (EFA)** - polyunsaturated acids that cannot be made by man or animals, endogenously, but must be derived from dietary sources, exogenously. **Linoleic acid** and **α-linolenic acid** are parent compounds of the **n-6** and **n-3** families (PUFA) of essential fatty acids.

**Ester value (EV)** - number of milligrams of potassium hydroxide required to saponify the esters contained in 1 gram of fat. Determined as the difference between the **acid value** and the **saponification value**.

**Ester waxes** - esters of long-chain acids and long-chain alcohols. **Jobba oil**, for example, contains C18, C20, and C22 components of these two series of chemical compounds producing ester molecules of approximately 40 carbon atoms. Many of the materials called waxes also contain free acids, alcohols, aldehydes, and hydrocarbons.

**Equivalent chain length (ECL)** - chromatographic characteristic of a methyl ester of a fatty acid related to the retention time of a saturated fatty acid.

**Evening primrose oil** - oil from the seed of *Oenothera biennis* or *O. lamarkiana*; contains **linoleic acid** and approximately 9% **γ-linolenic acid**.

**Extender** - substance that reduces the amount of fat required in a formulation. An example is lecithin in chocolate.

**Extraction** - recovery of oils and fats from oil-bearing material. In the narrower sense, extraction is the process of using solvents to extract fat. Industrially, hydraulic presses are used to extract cocoa butter, but screw presses (expellers) are preferred to extract oil from oilseeds.

## - F -

**Faecal (fecal) fat** - fat excreted from the intestinal tract of the body.

**FAO** - abbreviation for Food and Agriculture Organization of the United Nations.

**Fat** - mixture of **triacylglycerols** (glycerides). Fat is insoluble in water, but readily soluble in organic solvents. If it contains many saturated fatty acids it is solid at ambient temperature, e.g., animal fat, especially from mammals. Oil contains many unsaturated fatty acids and is liquid at ambient temperature. Fat carries fat-soluble vitamins and other solutes (**sterols**, **carotenoids**, **squalene**). It supplies 9.3 Kcal/g, acts as a storage form of energy (depot fat), and serves as an insulator. See triacylglycerol.

**Fat modification techniques** - modification techniques applied to adapt physical properties of oils and fats to specific requirements for food application. Main modification techniques are:

Fractionation: Changes of composition of triacylglycerols.

Hydrogenation: Saturation of the fatty acid chains.

Interesterification: Rearrangement of fatty acids along the glycerol; formation of new triacylglycerols.

**Fat-soluble vitamins** - see vitamin A, vitamin D, vitamin E, and vitamin K.

**Fat substitute** - substance having physical and palatability characteristics similar to fat, but yielding fewer calories.

**Fatty acid** - hydrocarbon chain with a terminal carboxyl group, R-COOH. If every carbon atom has its full quota of hydrogen atoms, the fatty acid is saturated. A double bond forms to compensate for a shortage of hydrogen atoms. Fatty acids may be saturated, monounsaturated (**monoenoic fatty acids**), or polyunsaturated (**polyenoic fatty acids**). See Table 1 (saturated fatty acids), Table 2 (monoenoic fatty acids), and Table 3 (polyenoic fatty acids).

**Fermentation** - enzymatic process; important for the production of **cocoa**, yogurt, and many other products.

**Feta** - soft-ripened cheese made from goat's or cow's milk; depends on lactic acid fermentation for its character; contains approximately 22% fat.

**FFA** - see free fatty acids, also abbreviation for **free fatty acid content**.

**Filberts** - see hazelnut.

**Fish oil** - oil extracted from the body muscle, liver, or other tissues of fish. The oil usually has a high concentration of n-3 polyunsaturated fatty acids, particularly **icosapentaenoic** acid and **docosa-hexaenoic** acid.

**Fishery products** - edible flesh and processed products of cold-blooded aquatic water-breathing crani-ate vertebrates.

**Flash point** - temperature at which the vapor of an oil or fat ignites spontaneously. The flash point is between 300–360 °C.

**Flavor (off-)** - reappearance of the flavor and odor of crude oil in fully refined oil after storage.

**Flaxseed oil** - see linseed oil.

**Food additive** - see additive.

**Fractionation** - separation of an oil or fat into at least two fractions, usually by partial crystallization at a given temperature. Separation of the solid from the liquid part. The solid part is called stearin, and the liquid one olein. Different fractionation techniques are known. See olein and stearin.

**Frankfurter** - sausage of beef, pork, chicken, turkey, or a mixture, that is cured and cooked, and stuffed in a casing or skinless. USDA, beef, 29% fat; beef and pork, 29% fat; chicken, 19% fat; turkey, 18% fat. See fatty acid composition in Table 5.

**Free fatty acids (FFA)** - unesterified fatty acids. In blood, FFAs are derived from **adipocytes** or **chylomicrons** and **VLDL** (see lipoprotein) depending on nutritional status of the organism and concomitant conditions. FFAs are bound to albumin (molar ratio 0.5 to 0.8) or lipoproteins and are characterized by a rapid turnover.

**Free fatty acid content** - see acidity.

**Free radical** – former term used for radical, not recommended by IUPAC. See radical.

**French fries** - French fried potatoes, strips of potato deep fried in fat until brown. See chips.

**Frying** - method of preparing food, usually with hot fat or oil. Frying in a pan is usually done with fat at temperatures between 150–200 °C.

**Frying fat or oil** - fat or oil with characteristics allowing heating to 150–200 °C without smoking.

## - G -

**Gadoleic acid** - trivial name for *cis*-icos-9-enoic acid, (20:1 n-11). Present in **marine oils** (from fish or sea mammals).

**Galactolipids** - lipids containing galactose.

**Game** - flesh of a wild animal considered as food.

**$\gamma$ -Linolenic acid (GLA)** - trivial name for *all-cis*-octadeca-6,9,12-trienoic acid, (18:3 n-6). See also linolenic acid.

**Ganglioside** - see sphingolipids.

**Gas chromatography (GC)** - chromatographic technique (see chromatography) where the mobile phase is a gas (usually hydrogen, helium, or nitrogen), and the stationary phase is normally a high-boiling liquid absorbed on a porous material such as silica, frequently fused silica in a capillary column. These conditions are often more specifically called gas-liquid chromatography (GLC) or high-precision GLC when capillary columns of 60 m and more are used. In lipid analysis the technique is used to separate fatty acid methyl esters or to separate lipid classes such as mono-, di-, and triacylglycerols.

**Gas-liquid chromatography (GLC)** - see chromatography.

**Gel permeation chromatography (GPC)** - liquid chromatographic technique that separates molecules according to molecular size. The mobile phase is a liquid and the stationary phase is a porous material with a pore size corresponding to that of the molecules to be separated. In lipid analysis GPC is used to determine di- and polymeric fatty materials. See liquid chromatography.

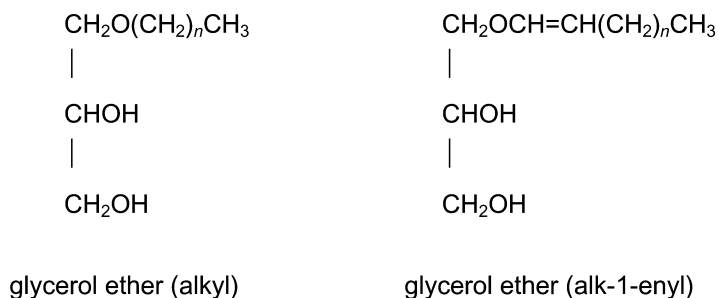
**Ghee** - clarified buffalo milk fat.

**GLA** - abbreviation for  $\gamma$ -linolenic acid.

**Glyceride** - organic ester of glycerol; see fat.

**Glycerol** - glycerine; propane-1,2,3-triol, a clear, colorless syrupy liquid, C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>; the alcohol component of fat.

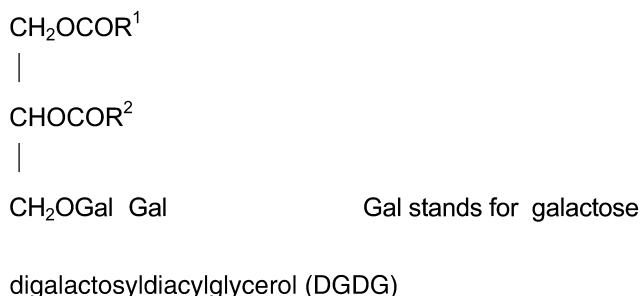
**Glycerol ethers** - glycerol alkylated (mainly at the *sn*-1 position) to give glycerol ethers instead of the more usual acylated derivatives. The alkyl group may be saturated or unsaturated. The alk-1-enyl glycerol unit is present in **plasmalogens**. Such components are vinyl ethers and produce **aldehydes** on hydrolysis. The remaining hydroxyl groups can be acylated or linked to phosphate and another alcohol such as choline.



**Glycochenodeoxycholic acid** - see bile acids.

**Glycocholic acid** - see bile acids.

**Glycolipid** - compound showing typical lipid solubility and also containing a sugar unit in its molecule. There are many types including compounds based on sphingosine (see sphingolipids) and compounds based on glycerol. A typical example of the latter (glycosyldiacylglycerols) is formulated:



**Glycosyldiacylglycerols** - see glycolipid.

**Goat milk** - see milk.

**Gondoic acid** - trivial name for *cis*-icos-11-enoic acid, (20:1 n-9). Present in **jojoba wax**.

**Goose** - domesticated fowl; *Anser anser*. USDA, cooked, roasted, flesh and skin, 22% fat; flesh only, 13% fat. See fatty acid composition in Table 5.

**Goose liver paste** - see pâté.

**Gorgonzola cheese** - Italian blue cheese with a greater concentration of molds towards the center; the oldest named cheese in the world.

**Gossypol** - phenolic substance in crude cottonseed oil; trivial name for 1,1',6,6',7,7'-hexahydroxy-3,3'-dimethyl-5,5'-diisopropyl-2,2'-binaphthalene-8,8'-dicarbaldehyde.

**Gouda cheese** - hard Dutch cheese; high in butter fat; recognized by its yellow wax coating.

**Gramisterol** - member of the 4-monomethylsterol group, present in up to 500 mg/kg in vegetable oils. The chemical structure is shown in Scheme B.

**Grapeseed oil** - oil obtained from the seed of grapes (*Vitis vinifera*). The seed contains 6–20% oil; the oil is a golden yellow liquid. See fatty acid composition in Table 4.

**Groundnut** - see peanut.

**Groundnut oil** - see peanut oil.

**Gruyere cheese** - hard Swiss cheese with a firm, but friable interior.

## - H -

**Halva** - sweetmeat composed of sugar (or other sweeteners) and crushed sesame seeds; contains 25–30% fat.

**Halvarine** - table spread containing 40% fat (introduced in Holland in 1960). See minarine.

**Ham** - thigh of an animal prepared for food, usually hog, either fresh or cured by salting and smoking.

**Hamburger** - ground beef; a cooked patty of ground beef; a sandwich made of ground beef in a split round bun.

**Hardening** - synonym for **hydrogenation**. Because of saturation of double bonds the melting point of soft fats arise and they become harder. Liquid oils become semi-solid or solid fats.

**Hare** - swift, long-eared mammal of the genus *Lepus*; called rabbit in some parts of the world but lacking the burrowing habits of a rabbit.

**Hazelnut** - nut of a shrub or small tree, *Corylus avellana*, also called **filbert**; the kernels of the nuts contain 50–60% oil.

**Hazelnut oil** - oil of the hazelnut, *Corylus avellana*. See fatty acid composition in Table 4.

**HDL** - abbreviation for high-density lipoprotein; see lipoprotein.

**Heart** - muscular organ that maintains the circulation of the blood; called a variety meat when used as food. See fatty acid composition in Table 5.

**Heat stability** - ability to resist the influence of heat. The heat stability of a dietary fat indicates its ability to maintain structure, composition, and appearance at room temperature.

**Herring oil** - oil obtained by cooking or pressing of herring or herring liver. Herrings, which exist on plankton, are found in shoals in the North Atlantic and North Pacific Oceans. The fat content varies between 6.5 and 23%.

**Hidden fat** - structural fat in plants and animals that cannot be removed by trimming; fats and oils that cannot be separately observed in bakery and other prepared foods.

**High-performance liquid chromatography (HPLC)** - see liquid chromatography.

**Hog fat** - see lard.

**Hollandaise sauce** - sauce used on vegetables and meats, made from egg yolks, butter or vegetable oil, milk or water, and seasonings. USDA, 8–27% fat, fatty acids depend on ingredients.

**Hot dog** - long narrow sandwich made with a frankfurter.

**Human milk** - see milk.

**Hydrogenation** - addition of hydrogen to unsaturated bonds; for oils and fats addition of hydrogen to a carbon–carbon double bond with the help of a **catalyst** a process that rises the melting point of liquid oils for the production of hardened fats. A re-refining is necessary to remove traces of catalyst. See refining of oil.

**Hydrolase** - enzyme which catalyzes the hydrolytic cleavage of a compound, e.g., esters.

**Hydrolysis** – 1) chemical: splitting of an ester by water in the presence of an acid or a base catalyst, to yield an alcohol and an acid. 2) enzymatic: e.g., stepwise splitting by lipase of triacylglycerol into partial glycerides and free fatty acids and ultimately into glycerol and free fatty acids.

**Hydroperoxide** - compound containing the group  $\begin{array}{c} | \\ -\text{C}-\text{O}-\text{O}-\text{H} \\ | \end{array}$  which is unstable.

**Hydroxyfatty acid** - fatty acid containing a hydroxyl (–OH) group.

**Hydroxyl value** - number of milligrams of potassium hydroxide required to neutralize the acetic acid capable of combining by acetylation with 1 g of oil or fat. The value is a measure of the number of free hydroxyl groups in fats and oils.

**Hypercholesterolemia** - excess of cholesterol in the blood.

**Hyperlipidaemia (hyperlipidemia)** - excess of lipid in the blood.

**Hyperlipoproteinemia** - excess of lipoprotein in the blood.

**Hypertriglyceridemia** - excess of triacylglycerol in the blood.

**Hypocholesterolemia** - below normal level of cholesterol in blood.

- | -

**Ice cream** - frozen dessert made primarily from cream (or vegetable-based products) and sugar, vanilla-flavored, or containing other flavors, fruits, nuts, etc. USDA, regular, ~10% fat; rich ~16% fat.

**Ice milk** - frozen dessert containing milk and sugar and flavorings. USDA, vanilla, soft serve, 2.6% fat.

**Ico** - IUPAC syllable for eico

**Icosanoid cascade** - group of intermediate compounds that are related by biologic pathways. See icosanoids.

**Icosanoids** - the IUBMB/IUPAC name for the biological oxidation products of arachidonic acid and of some other C20 polyene acids which give rise to a wide variety of products of remarkable physiological activity. These are known in general as (e)icosanoids or as products of the eicosanoid cascade. They include the **prostaglandins, thromboxanes, leukotrienes, and lipoxins**.

**IHD** - abbreviation for ischemic heart disease.

**Ileum** - lower part of the small intestine extending from the jejunum to the large intestine.

**Illipe fat** - yellow to green, hard and brittle fat, resembling cocoa butter. It is obtained from the seeds of various members of the family Dipterocarpaceae. In the strict sense Illipe is the seed fat from *Shorea stenoptera* also called Borneo tallow. See vegetable tallow and fatty acid composition in Table 4.

**Infrared spectrometry (IR)** - characterization of a material by measuring the absorbance in the infrared region (2 to 15  $\mu\text{m}$ ). Infrared absorption bands identify molecular components and structures. The most widespread single application of IR measurements on lipids is the quantitative determination of *trans*-unsaturated fatty acids based on the absorption at 10.3  $\mu\text{m}$  (or 971  $\text{cm}^{-1}$ ).

**Inositides** - see phosphatidylinositides.

**Interesterification** - process for a random redistribution of acyl groups within triacylglycerols.

**Invisible fat (hidden fat)** - fat that is not apparent to the eye.

**Iodine value (IV)** - measure of the amount of unsaturation in fats and oils and expressed as the number of grams of iodine absorbed by 100 g of fat.

**Ischemia** - sudden stop or strongly reduced circulation of blood in an organ or a tissue due to clogging of blood vessels. See blood clot.

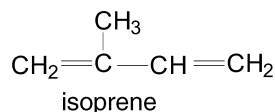
**Iso acids** - see branched-chain acids.

**Isomers** - chemical compounds having the same molecular formulae but with a different arrangement of their constituent atoms. These differences may result from different carbon skeletons (for example, unbranched and branched chain acids); different positions of double bonds (for example, oleic acid which is 9*c*-18:1 and petroselinic acid which is 6*c*-18:1); different arrangements of the atoms in space (for example, *cis-trans* isomerism).

**Isomerization** - the conversion of a compound to one or more of its isomers. Isomerization of fatty acids during partial hydrogenation frequently involves the conversion from a *cis* to a *trans* conformation of a double bond as well as a change in position of the double bond.

**Isomerism** - see isomers.

**Isoprene unit** - often considered as repeating C<sub>5</sub>H<sub>8</sub> unit (residue) of a variety of compounds called **terpenoids**, also known as isoprenoid compounds or isoprenoids, such as **terpenes**, **squalene**, **steroids** (including bile acids), **carotenoids**, and the **vitamins A and D**. The **vitamins E and K** contain varying isoprenoid side chains attached to aromatic ring systems. Terpenes, steroids, carotenoids and other related substances. Isopentenyl diphosphate is the universal building block for the biosynthesis of isoprenoids.



**Isoprenoids** - see isoprene unit.

**Isovaleric acid** - 3-methylbutanoic acid, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>COOH; present in blubber of seals.

**IUBMB** - abbreviation for International Union of Biochemistry and Molecular Biology.

**IUNS** - abbreviation for International Union of Nutritional Sciences.

**IUPAC** - abbreviation for International Union of Pure and Applied Chemistry.

## - J -

**Jejunum** - second portion of the small intestine extending from the duodenum to the ileum. See digestion.

**Jojoba oil** - oil of the seed of *Simmondsia chinensis*; contains a high concentration of wax esters. See ester waxes.

**Joule** - SI (System International) unit of energy, work, or quantity of heat. 1 joule (J) is 0.239 kcal. See calorie.

## - K -

**Kapok seed oil** - oil of seed of kapoc, *Ceiba pentandra*, tropical tree in Asia, contains about 13% of sterculic acid and similar fatty acids; lethal to rats when fed at high levels.

**Karanja seed oil** - oil of karanja seed, *Pongamia glabra*; unpleasant smell even after refining; extremely toxic.

**Kcal** - abbreviation for kilocalorie or Cal. Old unit for heat energy should be replaced by **Joule**. See calorie.

**Kidney** - one of two glandular bodies in the lumbar region that secrete the urine; called variety meat when used as food; USDA, pork, cooked, 4.7% fat; beef, cooked, 3.4% fat; lamb, cooked 3.6% fat; veal, cooked, 6% fat. See fatty acid composition in Table 5.

**Kokum seed fat** - fat extracted from the seed of kokum, *Garcinia indica*; is basically stearo-oleostearate and does not contain unusual fatty acids nor toxic nonglyceride components; can be considered for cocoa butter substitute.

## - L -

**Lamb** - flesh of an immature ovine animal when killed for food. USDA, composite of trimmed retail cuts, separable lean only, cooked, total fat 10%. See fatty acid composition in Table 5.

**Lard** - rendered pork fat. See fatty acid composition in Table 5.



**Lauric acid** - trivial name for dodecanoic acid, 12:0. Palm kernel oil and coconut oil contain approx. 50% lauric acid.

**Laurics** - abbreviation and generic name for lauric acid containing fats (lauric fats). See palm kernel fat and coconut oil.

**LCAT** - abbreviation for lecithin-cholesterol acyltransferase; enzyme catalyzing the formation of cholesterol esters.

**LDL** - abbreviation for low-density lipoprotein.

**Lecithin** - phosphatidylcholine; in commerce **phospholipids** recovered from **soya bean oil**; sometimes lecithin refers to the group of phosphatides that exists in all plants and animal cells, e.g., rapeseed lecithins. See phospholipid.

**Leukotriene** - formed from arachidonic acid by intermediary oxidative steps; together with **prostaglandins** and **thromboxanes**, leukotrienes are active biological substances known as eicosanoids.

**Light** - part of the electromagnetic spectrum that can be seen by the naked eye; wavelengths from 390 to 770 nm. Invisible ultraviolet and infrared light embrace the nearby wavelengths on either side. Oxidation of lipids is enhanced by light.

**Lignoceric acid** - trivial name for tetracosanoic acid (24:0).

**Linola** - low-linolenic flax developed in Australia by using induced mutation techniques. See fatty acid composition in Table 4.

**Linoleic acid** - trivial name for *cis,cis*-octadeca-9,12-dienoic acid (18:2); the first member of the (n-6) series of fatty acids; primary fatty acid in seed oils such as **safflower**, **sunflower**, and **cottonseed** oils.

**Linolenic acid** - 1)  $\alpha$ -linolenic acid (n-3), trivial name for *all-cis*-octadeca-9,12,15-trienoic acid; the first member of the (n-3) series of fatty acids; present at high levels in linseed oil and at lower levels in many other seed oils. 2)  $\gamma$ -linolenic acid (n-6), trivial name for *all-cis*-octadeca-6,9,12-trienoic acid; a desaturation product of linoleic acid; present in the seeds of **borage**, **blackcurrant**, and **evening primrose**.

**Linolenic acid group** - comprised of linseed, rapeseed, canola, and soya bean oil which, in addition to linoleic acid, also contains linolenic acid. Oils of this group show tendencies to flavor reversion and reduced shelf-life.

**Linseed oil** - oil of flaxseed, *Linaceae* family; a yellow-greenish oil obtained by pressing or solvent extraction; used mostly as a non-food oil. Linseed oil becomes rancid quickly because of its high content of linolenic acid. A low-linolenic linseed also exists for human use. See fatty acid composition in Table 4.

**Lipase** - enzyme that catalyzes the hydrolysis of fats to glycerol and free fatty acids. Lipases exist in all animals, but also in certain plant seeds. In humans, they exist mainly in the cells of the pancreas.

**Lipemic** - hyperlipidemic.

**Lipids** - substances that are insoluble in water but soluble in nonpolar solvents such as chloroform, hydrocarbons; exist in plants and animals and are chemically heterogeneous. Lipids can be divided into simple lipids, compound lipids, and isoprenoid lipids. The most important dietary simple lipids are triacylglycerols. Important lipid compounds are **phospholipids**, such as **lecithin**, which have special properties as structural elements in the membrane system of the cell. Lipid compounds also serve to insulate the nervous system where the white substance consists of cerebrosides and other lipids. **Lipoproteins** of the blood are also lipid compounds. Isoprenoid lipids in nature are often found dis-

solved in neutral fats. Important representatives are sterols such as **cholesterol**, **carotenoids**, and the fat-soluble **vitamins A, D, E, and K**.

**Lipofuscin** - dark-staining pigment in cells, sometimes called the wear-and-tear pigment.

**Lipogenesis** - biosynthesis of fat.

**Lipolysis** - hydrolysis of triacylglycerols to glycerol and free fatty acids with the aid of lipase. Hydrolysis takes place gradually with preference for fatty acids that are bound to the outer positions of the glycerol molecule. The intermediate products of the hydrolysis are free fatty acids, 1,2-diacylglycerols, and 2-monoacylglycerols.

**Lipoprotein** - exists in cell plasma and blood and consists of protein associated with triacylglycerols, phospholipids, and cholesterol. A part of the lipoprotein is water-soluble and acts as a transporter of the water-insoluble components. Lipoproteins are spherical particles with a core consisting of cholesterol esters and triacylglycerols. Each type of lipoprotein has its characteristic density. The lipoproteins in blood plasma occur in the density area of 0.92–1.21 g/ml. Four major lipoprotein classes exist: the high-density lipoproteins (HDLs), the low-density lipoproteins (LDLs), the very-low-density lipoproteins (VLDLs), and **chylomicrons**.

**Lipoprotein lipase** - enzyme that hydrolyzes the triacylglycerols of lipoprotein.

**Lipoxins** - see icosanoids.

**Lipoxygenase** - enzyme that promotes the oxidation of polyunsaturated fatty acids to form hydroperoxides.

**Liquid chromatography (LC)** - chromatographic technique where the mobile phase is a liquid and the stationary phase is a solid material (e.g., silica particles). For analytical purposes, the liquid is normally pumped through the stationary phase by high pressure to speed up and improve separation. This is called high-performance liquid chromatography (HPLC). See chromatography.

**Lithocholic acid** - see bile acids.

**Liver** - large gland situated in the upper part of the abdomen on the right side; called variety meat or by-product; USDA, pork, cooked, total fat 4.4%; beef, cooked, 4.9% fat; chicken, 5.5% fat. See fatty acid composition in Table 5.

**Liver paté** - seasoned minced liver, baked and chilled for slicing.

**Low-density lipoprotein (LDL)** - serum lipoprotein synthesized in the liver, originally called  $\beta$ -lipoprotein; density: 1.00 to 1.063 g/ml; contains 79% lipid and 21% protein; serum level elevated by dietary saturated fatty acids.

**Lutein** - see xanthophyll.

**Lycopene** - see carotenes.

**Lymph** - liquid that circulates in the lymphatic system. The cells of the body are surrounded by interstitial fluid which is formed by filtration from the arterial part of the blood circulatory system and brings about the exchange of substances between the cells and the blood. One part of the interstitial tissue liquid is taken up by the venous part of the capillary net and the rest re-enters the blood via lymphatic vessels.

**Lyso compounds** - term applied as a prefix to the various phospholipids to indicate the removal of one of the two acyl groups. For example, lysophosphatidylcholines are phosphatidylcholines with a single acyl group in either the 1- or 2-position.

**Lysophospholipids** - mono-acyl derivatives of phospholipids; formed during the synthesis or hydrolysis of phospholipids; are usually minor components of tissue phospholipids (1–5%). Abnormal accu-

mulation of lysophospholipids can occur under certain pathological conditions (such as **ischemia**) and are deleterious to biomembrane structure.

## - M -

**Macadamia nut** - hard-shelled nut of the tree, *Macadamia integrifolia*, *M. tetraphylla*, native to Australia, growing in tropical and hot subtropical zones as in Hawaii and California (USA). USDA, oil roasted, 77% fat. See fatty acid composition in Table 4.

**Maize oil** - synonym for **corn oil**.

**Malnutrition** - inadequate nourishment.

**Malonyl-CoA** - malonic acid bound to coenzyme A; involved in the biosynthesis of fatty acids.

**Malvalic acid** - see cyclopropene acid.

**Mango kernel oil** - oil derived from the kernel of the mango (*Mangifera judica*) which contains about 10% fat. No unusual or toxic constituents have been reported. See also vegetable tallow.

**Margaric acid** - trivial name for heptadecanoic acid (17:0); present in minor amounts in tallow (1%).

**Margarine** - emulsion containing at least 80% fat; other ingredients are water, skim milk, salt, and vitamins.

**Marine oil** - oil extracted from fish or sea mammals.

**Mass spectrometry** - analytical technique that gives information on molecular structure by fragmentation of the molecules. The substance to be analyzed is heated and placed in vacuum. Molecules in vapor phase are exposed to an electron beam which converts the molecules to charged fragments that are accelerated in an electric field and separated by a magnetic field. By this operation, it is possible to identify the fragments that are characteristic for a certain molecule.

**Mayonnaise** - cold sauce of egg yolk, vinegar, and oil, whipped together with French mustard and used for salads and cold dishes of fish and meat. The fat content is usually 80%.

**Mead acid** - trivial name for *all-cis*-icosa-5, 8,11-trienoic acid (20:3 n-9).

**Meat** - animal tissue used as food.

**Medium chain triglycerides (MCT)** - triacylglycerols that consist of fatty acids with an average length of eight to ten carbons.

**Melting point** - temperature at which the solid and liquid phases are in equilibrium. As fats melt over a temperature range, it is not possible to characterize the melting properties of a fat as consistently as most pure chemical substances. Therefore, empirical methods are applied to characterize the melting behavior of fats, e.g., the drop point as the temperature at which the first small drop of oils falls from an open hollow cylinder. Often used, the slip point or open capillary melting point is that temperature at which the fat in an open capillary placed in a water-bath starts to move upwards.

**Membrane** - bilayers of lipid and protein acting as biological barriers.

**Menaquinones** - see vitamin K.

**Menhaden oil** - the oil extracted from the body of menhaden fish.

**24-Methylenecycloartenol** - sterol belonging to the 4,4-dimethylsterol group; present in vegetable oils up to 500 mg/kg. The chemical structure is shown in Scheme C.

**Methyl esters** - ester formed from a carboxylic acid and methanol; e.g., methyl oleate.

**Methylene-interrupted double bonds** - arrangement of double bonds in essential fatty acids. See double bond.

**Micelle** - small, colloidal aggregate formed in water by such compounds as fatty acid salts (**soap**), **lysophospholipids**, **mono-acylglycerols**, and bile salts.

**Microsomes** - crude membrane fraction containing smooth and rough endoplasmic reticulum; contain most of the Golgi's complex and **ribosomes**.

**Milk (cow)** - white or yellowish fluid secreted by the mammary glands of mammals for the nourishment of their young, holding in suspension fat, protein, and containing sugar and inorganic salts in varying proportions; total fat varies with breed and other factors. USDA, full milk total fat, cow 3.3% fat; goat, 4.1% fat; human, 4.4% fat; Indian buffalo, 7% fat; sheep, 7% fat. Milk fat contains *trans*-unsaturated fatty acids that arise from microbial action in the rumen. See fatty acid composition in Table 5.

**Milk chocolate** - chocolate containing at least 12% (cow) milk solids.

**Milk fat** - fat in the secret of mammalian glands. Because we are using almost exclusively cow milk (fat), milk fat is synonymous with cow milk fat. See also milk (cow).

**Minarine** - spread containing 34–41% fat; same ingredients are used as for margarine (vegetable fat, salt, emulsifier, flavorings, and natural colors) .

**Mitochondria** - intracellular organelles in all eukaryotic cells; made of two membranes, an external and an internal one, and of an inner space called matrix. Mitochondria carry out the synthesis of ATP coupled to the catabolism of many substrates: terminal oxidation of pyruvate derived from carbohydrate and amino-acid catabolism;  **$\beta$ -oxidation of fatty acids**; oxidation of acetate (acetyl CoA); and minor amounts of fatty acid elongation, etc.

**Monoacylglycerols** - see acylated glycerols.

**Monoenoic acids** - monounsaturated fatty acids; carboxylic acids having one double bond. The natural acids usually have *cis*-configuration. The best known example is oleic acid (9-*cis*-18:1). See Table 2.

**Monoglycerides (monoacyl glycerols)** - see acylated glycerols.

**Monounsaturated acids** - see monoenoic acids.

**Mustard seed oil (mustard oil)** - oil of seeds of various species of *Brassicaceae*; isothiocyanates (R–N=C=S) in mustard seed oil contribute to the plants' characteristic, often pungent, smell.

**Mutton** - flesh of a mature ovine animal when killed for food.

**Myristic acid** - trivial name for tetradecanoic acid (14:0).

**Myristoleic acid** - trivial name for *cis*-tetradec-9-enoic acid (14:1).

## - N -

**n-3 PUFA** - group of polyunsaturated fatty acids derived biosynthetically from  $\alpha$ -linolenic acid and including such important acids as icosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In all these acids, the pattern of *cis* double bonds is methylene-interrupted and starts at the third carbon atom from the methyl end. These acids are represented by the general structure  $\text{CH}_3\text{CH}_2(\text{CH}=\text{CHCH}_2)_n(\text{CH}_2)_m\text{COOH}$  and are sometimes described as  $\omega$  3 acids.

**n-6 PUFA** - group of polyunsaturated fatty acids derived biosynthetically from linoleic acid and including such important acids as  $\gamma$ -linolenic and arachidonic acids. The pattern of *cis* double bonds is methylene-interrupted and starts at the sixth carbon atom from the methyl end. These acids are represented

by the general structure  $\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CHCH}_2)_n(\text{CH}_2)_m\text{COOH}$  and are sometimes described as  $\omega$  6 acids.

**Neem seed oil** - oil extracted from the seed of *Azadirachta indica*; contains nonglyceride compounds, mainly triterpenoids; refining with alkaline ethanol removes the bitter components.

**Nervonic acid** - trivial name for *cis*-tetracos-15-enoic acid (24:1 n-9).

**Neutralization** - removal of free fatty acids from crude oil by reacting them with alkali and removal of the soap that is formed by centrifugation and washing.

**Nonmethylene-interrupted double bonds** - see double bond.

**Nonsaponifiable** - see unsaponifiable material (matter).

**Nouvelle huile de colza** - new French, low erucic acid, rapeseed oil with less than 5% of erucic acid; comparable to the Canadian **canola oil**.

**Nuclear magnetic resonance (NMR)** - radio-frequency spectroscopic technique based on interactions of the magnetic moment of atomic nuclei in a strong magnetic field with radiated radiofrequency. Various techniques are known, e.g., as the low-resolution wide-line or pulsed NMR. With sophisticated high-resolution NMR equipment it is possible to obtain exact structural information on a molecule by proton or  $^{13}\text{C}$  NMR. Low-resolution NMR is applied to measure the **solid fat content** or solid content of a lipid sample.

**Nut** - dried fruit that consists of an edible kernel enclosed in a shell. Some foods known as nuts are actually seeds (Brazil nuts) or legumes (peanuts). Common nuts are almonds, cashews, pecans, and walnuts.

**Nutrient** - substance in food that provides nourishment.

**Nutrition** - science of the utilization of food in growth, maintenance, and repair of the body.

## - O -

**Oat bran** - *broken coat* of the seed of the cereal grass *Avena sativa*; grown in temperate regions as food for human beings and animals. USDA, raw, 7% fat. See fatty acid composition in Table 4.

**Oat oil** - oil extracted from oat bran; same fatty acids as oat bran.

**Obesity** - excessive storage of fat in the body. See also adipositas.

**Obtusifoliol** - phytosterol belonging to the 4-monomethylsterol group; present in vegetable oils up to 500 mg/kg. The chemical structure is shown in Scheme B.

**Octadecadienoic acid** - fatty acid having 18 carbon atoms and 2 double bonds, e.g., **linoleic acid**.

**Octadecanoic acid** - saturated fatty acid having 18 carbon atoms. See stearic acid.

**Octadecenoic acid** - monounsaturated fatty acid having 18 carbon atoms, e.g., **oleic acid**.

**Octanoic acid** - a saturated fatty acid having 8 carbon atoms. See caprylic acid.

**Oil** - a mixture of triacylglycerols, liquid at ambient temperature. See fat.

**Oleic acid** - trivial name for *cis*-octadec-9-enoic acid (18:1 n-9); occurring in almost all animal fats and vegetable oils. Olive oil contains about 75% oleic acid.

**Olein** - liquid fraction after **fractionation**; more unsaturated than the starting oil or fat.

**Oleomargarine** - old term; derived from oleo oil which was used in the past for production of margarine. See margarine.

**Oleo oil** - edible white or yellowish fat of soft consistency with a faint smell of tallow and an agreeable flavor; finely crystalline, but may become granular on rolling or smoothing. It is composed mainly of the glyceride of oleic acid (triolein); chiefly used for the manufacture of edible products, such as margarine or imitation lard, and as a lubricant.

**Olive kernel oil, olive residue oil, olive  $\beta$ -oil** - oil obtained by treating olive cake with solvents. The refined and winterized (dewaxed) oil is very similar in composition to refined olive oil.

**Olive oil** - obtained from the fruit of the olive tree, *Olea europaea*.

(A) Virgin olive oils are obtained solely by mechanical or physical means (pressing), particularly under thermal conditions, that do not lead to deterioration of the oil. They must have undergone no treatment other than washing, decantation, centrifugation, or filtration. Virgin olive oils include (1) virgin olive oil suitable for consumption in the natural state. It has a clear, light yellow to green color and a specific odor and taste; and (2) lampante olive oil, which has either an off-flavor taste or odor, or a free fatty acid content (expressed in terms of oleic acid) exceeding 3.3 g per 100 g, or both of these characteristics. After refining, lampante olive oil may be used for human consumption.

(B) Refined olive oil is obtained from virgin olive oils by refining methods that do not lead to alterations in the initial glyceridic structure, or to any other modification of the structure of the constituent fatty acids. Refined olive oil is a clear, limpid oil containing no sediment and with a free fatty acid content (expressed in terms of oleic acid) not exceeding 0.3 g per 100 g. It has a yellow color and no specific odor or taste and is suitable for human consumption either by itself or as a blend with virgin olive oil (EEC). See fatty acid composition in Table 4.

**Omega-x fatty acids** - indicated by n-x before the name. Alternative nomenclature to the IUPAC nomenclature, where the counting of alkyl carbon atoms starts with the C-atom bearing the carboxyl group. The number replacing x signifies the number of carbons from the terminal methyl end where a double bond exists.  $\omega$  often used for n. See also n-3 PUFA and n-6 PUFA.

**Omega-oxidation** - oxidation of the carbon atom at the end ( $\omega$ ) of the alkyl rest in the molecule.

**Organoleptic** - making an impression on the senses.

**Oxidase** - enzymes promoting an oxidation of molecules.

**Oxidation** - traditionally the reaction of a substance with oxygen, for example the combustion of carbon,  $C + O_2 \rightarrow CO_2$ , or rust attack on iron,  $4 Fe + 3 O_2 \rightarrow 2 Fe_2O_3$ . The opposite is reduction. In a wider sense, oxidation means the removal of a pair of electrons from an atom or molecule, whereas reduction is the addition of a pair of electrons. Also, deterioration reaction of lipids by oxygen at low temperature leading to off flavors due to formation of olfactive decomposition products.

**Oxygenase** - an enzyme that transfers oxygen to a substrate.

**Ozonolysis** - oxidation of an organic compound by means of ozone. Ozone reacts with double bonds to form an ozonide which cleaves the carbon chain into short-chain compounds, the identity of which indicates the position of the double bond. In lipid analysis, ozonolysis is used to determine the double-bond position in an unsaturated fatty acid.

## - P -

**PA** - abbreviation for **phosphatidic acid**.

**PAF** - abbreviation for **platelet activating factor**.

**Palm kernel fat** - fat from the kernels of *Elaeis guineensis*; growing in regions covering 10° north and south of the equator in Malaysia, Indonesia, Papua New Guinea, Africa, and South America; resembles

coconut in chemical, physical properties. Palm kernel fat is often fractionated to give a sharper melting (solid) fraction (**stearin**) and a liquid (softer) fraction (**olein**). The edible uses of palm kernel fat are cocoa butter substitutes, confectionery fats, ice cream, margarine formulations, filled milk products, and coffee whiteners. See fractionation and fatty acid composition in Table 4.

**Palm oil** - oil from the mesocarp of the fruit of *Elaeis guineensis* growing in regions covering 10° north and south of the equator in Malaysia, Indonesia, Papua New Guinea, West Africa, South America, Thailand, and Solomon Islands. The edible uses of palm oil and palm oil fractions are frying fats, cooking oils, shortenings, margarines, vanaspati, confectionery fats, and filled milks. Palm oil is rich in tocopherols and tocotrienols, and red palm oil is also rich in carotenoids. Ranges of contents of these compounds are:

Tocopherols/Tocotrienols	600–1000 mg/kg (ppm)
Carotenoids	500–800 mg/kg (ppm)

See fatty acid composition in Table 4.

**Palm olein** - liquid fraction derived from the **fractionation** of palm oil. Physical and chemical properties depend on fractionation conditions. See fatty acid composition in Table 4.

**Palm stearin** - high-melting fraction derived from the **fractionation** of palm oil. Physical and chemical properties depend on fractionation conditions. See fatty acid composition in Table 4.

**Palmitic acid** - trivial name for hexadecanoic acid (16:0); occurs in nearly all fats and oils. Palmitic acid comprises approximately 40% of the fatty acids of palm oil, and is also prominent in animal fats such as lard and tallow.

**Palmitoleic acid** - trivial name for *cis*-hexadec-9-enoic acid (16:1 n-7). Principal sources are marine oils such as menhaden and sardine oils that contain 10–20%. It is also a significant component of the oil from macadamia nuts.

**Partial glycerides** - see acylated glycerols.

**Pâté (French)** - fatty preparation of liver or meat, for example, pâté de foie gras. A spread of finely mashed seasoned and spiced meat (as chicken or goose liver). USDA, total fat, chicken liver, 13%; goose liver, 44%.

**PC** - abbreviation for **phosphatidylcholine**.

**PE** - abbreviation for **phosphatidylethanolamine**.

**Peanut** - synonym to **groundnut**, low-branching annual herb, *Arachis hypogaea* with hypanthium which bends into the soil; the ovary ripens into a pod containing one to three edible seeds; probably native to Brazil, but cultivated in most tropical and many mild temperate regions for its oily seeds. USDA, dry-roasted, all types, 50% fat; fatty acids same as peanut oil.

**Peanut butter** - a paste made by grinding roasted, skinned, and degermed peanuts and used as a spread or condiment. USDA, 50% fat.

**Peanut oil** - groundnut oil; arachis oil; obtained from the seeds of *Arachis hypogaea*; colorless to yellow oil used as a salad or frying oil and in margarine. See fatty acid composition in Table 4.

**Pecan nut** - thin-shelled, oblong nut of the hickory tree, *Carya illinoensis*, of the south central United States; USDA, dried, 68% fat. See fatty acid composition in Table 4.

**Peroxide** - chemical compound that contains the atom grouping –O–O–. Compounds of this type are as a rule unstable.

**Peroxisomes** - small cellular membrane vesicles containing numerous enzymes involved in oxidation pathways (amino or fatty acids); produce hydrogen peroxide ( $H_2O_2$ ). Some drugs or chemicals (such as fibrates or erucic acid) can induce their proliferation in the liver.

**Peroxide value (PV)** - measure of the extent of oxidation of a fat or oil. The value indicates the quantity of oxidized substances, normally hydroperoxides, that liberate iodine from potassium iodide under specified conditions. PV is expressed in milliequivalents of active oxygen per kg fat. See anisidine value and TOTOX value.

**Petroselinic acid** - trivial name for *cis*-octadec-6-enoic acid (18:1 n-12); principal source is parsley seed oil of which petroselinic acid represents approx. 75% of the total fatty acids.

**Phosphatide** - see phospholipid.

**Phosphatidic acid (PA)** - acidic phospholipid occurring in low concentrations as an intermediate in the biosynthesis of other phospholipids.

**Phosphatidylcholine (PC)** - phospholipid based on choline; an important phospholipid component of membranes. There are many subspecies depending on the acyl groups present. On complete chemical hydrolysis they furnish glycerol, carboxylic acids, phosphoric acid, and choline. The various ester linkages can be split specifically by phospholipases. See phospholipid.

**Phosphatidylethanolamine (PE)** - phospholipid based on ethanolamine [ $HO(CH_2)_2NH_2$ ]; an important component of membrane lipids. There are many subspecies depending on the acyl groups present. On complete chemical hydrolysis they furnish glycerol, carboxylic acids, phosphoric acid, and ethanolamine. The various ester linkages can be split specifically by phospholipases. See phospholipid.

**Phosphatidylglycerol (PG)** - phospholipid containing a second molecule of glycerol; a major phospholipid in photosynthetic tissues and in many bacteria.

**Phosphatidylinositol (PI)** - phospholipid based on inositol [ $C_6H_6(OH)_6$ ]; an important component of membrane lipids. There are many subspecies depending on the acyl groups present. On complete chemical hydrolysis they furnish glycerol, carboxylic acids, phosphoric acid, and inositol. The various ester linkages can be split specifically by phospholipases. These compounds occur mainly as mono- or diphosphates and are commonly called phosphoinositides.

**Phosphatidylserine (PS)** - phospholipid based on serine ( $HOCH_2CHNH_2COOH$ ); an important component of membrane lipids. There are many subspecies depending on the acyl groups present. On complete chemical hydrolysis they furnish glycerol, carboxylic acids, phosphoric acid, and serine. The various ester linkages can be split specifically by phospholipases.

**Phospholipase** - enzyme that promotes the hydrolysis of ester bonds in phospholipids.

**Phospholipase A1** - enzyme that promotes the liberation of the fatty acid on the 1-position of a glycerolphospholipid.

**Phospholipase A2** - enzyme that promotes the liberation of the fatty acid on the 2-position of a glycerolphospholipid.

**Phospholipase B** - enzyme that promotes the liberation of both fatty acids from a glycerolphospholipid.

**Phospholipase C** - enzyme that promotes the hydrolysis of phospholipids such as phosphatidylcholine to give 1,2-diacylglycerol and phosphorylcholine.

**Phospholipase D** - enzyme that promotes the hydrolysis of a phospholipid such as phosphatidylcholine to give phosphatidic acid and choline.



**Phospholipid (phosphatide)** - lipid containing phosphorus; the most important ones are derivatives of glycerol, phosphoric acid, fatty acids, and an hydroxy compound such as choline, ethanolamine, serine, or inositol. These compounds are described as phosphatidylcholines (PC), phosphatidylethanolamines (PE), phosphatidylserines (PS), and phosphatidylinositols (PI). The plural is used because, if these are of natural origin rather than synthetic, they are mixtures of similar molecules differing in the acyl groups present. The phosphate unit and its attached alcohol are present in the *sn*-3 position of glycerol. See also phosphatidic acid, cardiolipin, lyso compounds, PAF, and sphingolipids. The term **lecithin** is applied to mixed phospholipids in which PC usually predominate and **cephalin** was used to describe mixtures rich in PE.

**Phylloquinone** - see vitamin K.

**Physical refining** - short two-step method consisting of a bleaching earth treatment followed by removal of oxidation products, free fatty acids, and other compounds under reduced pressure with steam. This refining technique is called physical refining because of removal of fatty acids by physical means. See refining.

**Phytanic acid** - trivial name for 3,7,11,15-tetramethylhexadecanoic acid; arises from phytol in chlorophyll; cannot be degraded by  $\beta$ -oxidation because of the presence of a 3-methyl group;  $\alpha$ -oxidation must precede  $\beta$ -oxidation.

**Phytosphingosine** - see sphingolipids.

**Phytosterol** - sterol present mainly in plants.

**PI** - abbreviation for **phosphatidyl inositol**.

**Pig** - see pork.

**Pilu-khakhhan seed fat** - fat derived from the seed of *Talvadora oleoides*; rich in **lauric** (12:0) and **myristic** (14:0) acid with little **oleic acid** (18:1); not regarded as an **edible fat**.

**Pistachio nut** - edible green fruit of the pistachio tree (*Pistacia vera*) of southern Europe and Asia Minor. USDA, dried, 48% fat. See fatty acid composition in Table 4.

**Plasma** - in blood the fluid in which the corpuscles are suspended.

**Plasma membrane** - biomembrane that separates the internal environment of the cell from the external environment; involved in a wide variety of fundamental cellular functions such as exchange of molecules or ions (water, electrolytes, amino acids, etc.) between the cell exterior and the interior and vice versa; transfer of hormonal signals, etc.

**Plasmalogens** - glycerophospholipids that contain a vinyl-ether linkage of the *sn*-1 glycerol moiety and an acyl-chain linkage at the *sn*-2 moiety. There are two subclasses of plasmalogens: ethanolamine-containing and choline-containing ones. They are common components of membrane phospholipids, and are abundant in some tissues (cardiac, nervous). Few specific functions have been ascribed to the ether glycerolipids so far, apart from the potent biological effects of platelet activating factor in processes such as inflammation, hypertension, and anaphylaxis. Plasmalogens are believed to modulate the physical properties of membranes and to play a role in the protection of the cells against oxidation and reactive oxygen species. They may serve as a reservoir for polyunsaturated fatty acids, the precursors of **icosanoids**.

**Plasticity** - ability or tendency to deformation of a solid body. The plasticity of the fats depends upon the number of solid glycerides and the nature of the crystallization of the fats.

**Platelet** - circular or oval disc found in the blood of mammals and involved in coagulation and clot formation.

**Platelet activating factor (PAF)** - alkyl-ether phospholipid (1-*O*-alkyl)-1-2-*sn*-glycero-3-phosphocholine; first described as a “fluid phase mediator” of the interaction between leukocytes and platelets; activates, at nanomolar concentrations, pathways involved in coagulation and inflammation. At high concentrations, PAF is cytotoxic and causes neuronal death.

**Polyenoic acid** - polyunsaturated fatty acid; carboxylic acid having more than one double bond. The common acids of this type have *cis*-configuration, are methylene-interrupted, and belong to biosynthetically related groups. See n-3 and n-6 PUFA. See also Table 3.

**Polymer** - multiple units of simpler molecules.

**Polymerization** - process of combining low-molecular-weight compounds into high-molecular-weight compounds. When unsaturated fats are heated in air at a high temperature (250–275 °C), fat molecules polymerize to dimers, trimers, or possibly higher polymers. The molecules can be formed with either oxygen or carbon bridges.

**Polyunsaturated acids** - see polyenoic acid, n-3 PUFA, n-6 PUFA.

**Poppyseed** - seed of the poppy, *Papaver somniferum*; used as food such as bakery products and as the source of poppy-seed oil.

**Poppyseed oil** - pale to reddish oil obtained from the seed of poppy, *Papaver somniferum*. See fatty acid composition in Table 4.

**Pork** - fresh or salted flesh of swine when used for food.

**Pork fat** - see lard.

**Potato chip** - thin slice of white potato deep fried in fat. In some country synonym to potato *crisp* and further to **French fries**, especially in those countries where chips are called crisps.

**Potato crisp** - potato cut into long square section used in some countries for potato chips.

**Premier jus** - best grade of edible tallow; also called oleo stock, obtained by rendering at low heat adipose tissues of bovine animals, *Bos taurus*. Solid, white or yellowish odorless if recently prepared but develops a characteristic rancid odor after exposure to air.

**Press cake** - seed residue after removal of oil by pressing. It may contain, according to the efficiency of pressing, between 8 and 12% fat or oil.

**Pressing** - treatment by hydraulic or mechanical means of oil-bearing material to recover oil. Screw-type presses are usually used for oil seeds.

**Pristanic acid** - trivial name for 2,6,10,14-tetramethylpentadecanoic acid; present at low concentration in animal fats.

**Pro-oxidant** - material that promotes oxidation of unsaturated fatty acids and other compounds.

**Propanoic acid** - three-carbon acid that serves as a precursor of branched-chain fatty acids.

**Propyl gallate** - propyl ester of 3,4,5-trihydroxybenzoic acid; an **antioxidant**.

**Prostacyclin (PGI<sub>2</sub>)** - icosanoid derived from arachidonic acid; inhibits the aggregation of blood platelets.

**Prostaglandins** - group of biologically potent substances, derived from cyclic, unsaturated fatty acids with 20 carbon atoms; exist in almost all tissues and are of importance, among other things, for the activity in smooth muscles as well as for gland secretion, transferring of impulses in nerves, and induction of parturition. The greatest number of prostaglandins and the largest concentrations are found in semen. See also icosanoids.

**Prostanoid** - see prostaglandins.

**PS** - abbreviation for **phosphatidyl serine**.

**PUFA** - abbreviation for polyunsaturated fatty acid. See also fatty acid and polyenoic acid.

**Punicic acid** - trivial name for *cis,trans,cis*-octadeca-9,11,13-trienoic acid (18:3).

## - Q -

**Quality assurance** - investigations undertaken to assure the desired quality of a product. It includes the selection of raw material, supervision, and continuous control of the different processing steps.

**Quetelet index** - see body mass index.

**Quetelet's rule** - the body weight of an adult ought to be as many kilograms as the body length in centimeters exceeds 100.

## - R -

**Rabbit** - small greyish-brown mammal, *Oryctolagus cuniculus*, of the hare family (*Leporidae*). Unlike ordinary hares, its young are born naked. Many wild and domesticated forms exist. USDA, wild, cooked, 3.5% fat. See fatty acid composition in Table 5.

**Radical** - any species of independent existence that contains one or more unpaired electrons. An unpaired electron is one that occupies an atomic or molecular orbital by itself. The unpaired electron(s) generally convey considerable reactivity to the radical. Radicals derived from oxygen can be generated within the cells and damage a wide range of biological materials including nucleic acids, proteins, and lipids (cholesterol and polyunsaturated fatty acids). Radicals are implicated in aging and in the aetiology of many chronic diseases.

**Radical scavengers** - enzymatic systems or molecules that scavenge radicals, thus protecting living organisms from potentially injurious effects. Superoxide dismutase and vitamin E are potent scavengers of cellular radicals.

**Rancidity** - development of off-flavors from the oxidation and/or hydrolysis of lipids in foods.

**Rapeseed oil** - oil extracted from rapeseed, *Brassica* spp.; major food oil in middle and northern Europe. Up to the beginning of the 1970s, rapeseed oil had a relatively high content of **erucic acid** (40–50%) but through the genetic selection of plants this was almost eliminated at the same time as the oleic acid was increased. See fatty acid composition in Table 4.

**Receptor (membrane)** - protein located on the exterior surface of the cell plasma membrane that specifically interacts with a drug or a hormone to produce an effect on the cell.

**Refining of oil** - treatments applied to a crude oil to make it acceptable for human consumption. It may consist of a simple alkaline washing followed by drying and filtration, or it may involve many stages of treatment. In the United States, “refining” applies to neutralization and bleaching, whereas in Europe it also includes deodorization.

Types of refining are: (1) **physical refining**, which involves pretreatment of the oil with phosphoric acid and activated clay followed by steam deodorization; (2) **chemical refining**, which involves caustic neutralization of the phosphoric acid-treated oil followed by activated clay treatment and steam deodorization.

**Refractive index** - ratio of the speed of light at a defined wavelength (normally the D-line of sodium, 589.6 nm) in vacuum to its speed in the medium of which the refractive index is to be measured. Among

other parameters, the refractive index increases with the chain length of the fatty acid and the number of double bonds and is therefore used to characterize fats and oils.

**Refsum's disease** - disease characterized by an accumulation of **phytanic acid** arising from a block in  $\alpha$ -oxidation.

**Reindeer** - deer of the genus *Rangifer* that inhabit the northern parts of Europe, Asia, and America; having large hooves and antlers in both sexes; often domesticated, especially in Lapland, and used for food.

**Rendering** - recovery of animal fats from adipose tissue. In dry rendering, steam is used only to heat the adipose tissue; in wet rendering, the tissues are placed in steam-heated water.

**Re-refining** - refining of previously refined oils and fats that have become oxidized during storage. These oils are washed with dilute caustic soda followed by a light treatment with bleaching earth and then deodorized. Resulting conjugated fatty acids formed from hydroperoxides during oxidation, however, reduce the stability of re-refined oils. Re-refining is also applied to remove catalysts used in fat modification techniques as after hydrogenation to remove traces of metal catalyst or after interesterification to remove the catalytic alkaline moieties.

**Retinal** - see vitamin A.

**Retinoic acid** - see vitamin A.

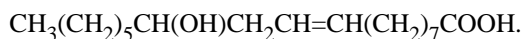
**Retinol** - see vitamin A.

**Retinyl ester** - see vitamin A.

**Ribosome** - cytoplasmic organelle in living cells synthesising proteins.

**Rice bran oil** - obtained by extraction of rice bran of the seeds of *Oryza sativa*. See fatty acid composition in Table 4.

**Ricinoleic acid** - trivial name for (*R*)-(*Z*)-12-hydroxyoctadec-9-enoic acid (12-hydroxyoleic acid); the major component of castor oil and the most readily available long-chain hydroxy acid.



**Roe** - eggs of fish especially when still enclosed in the ovarian membrane; consumed as food; used to make caviar.

## - S -

**Safflower oil** - oil obtained from the seeds of the safflower, *Carthamus tinctorius*; an old world herb resembling a thistle. Original varieties contained high concentrations of linoleic acid; other varieties have been developed that have lower linoleic and high oleic acid content. See fatty acid composition in Table 4.

**Salad dressing** - sauce for salads, usually made from vegetable oil, vinegar or lemon juice, and seasonings; may include eggs, cream, or cheeses.

**Salad oil** - refined vegetable oil stable to refrigeration.

**Salami** - highly seasoned sausage made of pork and beef in various proportions either air-dried, hard, and of good keeping qualities or fresh, soft, and requiring refrigeration until consumed. USDA, total fat, beef, cooked, 20%; cooked, beef and pork, 20%; dry or hard, pork, 34%; dry or hard, pork and beef, 34%. See fatty acid composition in Table 5.

**Saliva** - excretion of the salivary glands. Makes swallowing easier. Contains the enzyme amylase, which initiates the decomposition of starch (for example, in bread and potatoes) to simpler carbohydrates.

**Saponification value (SV)** - number of mg of potassium hydroxide necessary to saponify 1 g fat; indicates the number of ester groups in the fat measured.

**Saponification equivalent (Sap. Equiv.)** - number of grams of fat that 56.1 mg of potassium hydroxide can saponify. For fats and oils the mean molecular weight of triacylglycerols can be found by multiplying the Sap. Equiv. by three.

**Saturated acids** - fatty acids with no double bonds; usually straight-chain compounds of general formula  $\text{CH}_3(\text{CH}_2)_n\text{COOH}$  where COOH represents the carboxylic acid group. The natural compounds typically have an even number of carbon atoms in each molecule, and the  $\text{C}_2$  to  $\text{C}_{24}$  members of this series are listed under their separate names. See also Table 1.

**Sausage** - highly seasoned finely divided meat that is usually a mixture of beef and pork; is often extended with cereal or milk solids; is stuffed in casings of prepared animal intestine or synthetic material which are tied shut at both ends to form a single cylindrical unit or at intervals to form links; used either fresh or cured.

**Seed cake or seed meal** - seed residue after hexane extraction containing up to 1.5% fat.

**Seed crushing** - manipulations applied to recover oils and fats from seed. They consist of seed milling, flaking, cooking, pressing, reflaking, second pressing and flaking in preparation for solvent extraction. The defatted **press cake** is also called seed meal.

**Sensory analysis** - assessment of food products by human sensory organs. For fat, color, consistency, taste, and smell are judged; often carried out by trained panels consisting of 5–10 testing persons.

**Serum (in plural, sera)** - blood serum, clear, yellowish liquid that remains when the blood is freed from blood corpuscles and fibrin (an albuminous substance deposited as a threadlike mass when blood is coagulated).

**Sesame oil** - pale yellow oil obtained from seed of *Sesamin indicum*; contains sesamol and sesamin, which have strong antioxidative activity. Upon treatment, these substances give a characteristic red coloring (Baudouin reaction). Sesame oil is used as salad oil and for margarine; the oil is also called gingelly oil or teel oil. See fatty acid composition in Table 4.

**Shea butter (shea nut oil)** - vegetable butter obtained from the seeds of the fruit of *Butyrospermum parkii* or *Butyrospermum paradoxum*; used for various food purposes and for the preparation of cocoa butter substitutes; it has a high unsaponifiable matter content (2–11%, typical specimen 6.9%, AOCs). See fatty acid composition in Table 4.

**Sheep meat** - see lamb, mutton.

**Shortening** - plastic baking fats. Prevents cohesion of gluten strands in the dough during mixing and makes it "shorter" and the product becomes tender. Generic name for industrial fats, e.g., liquid frying shortening.

**$\alpha_1$ -Sitosterol** - see citrostadienol.

**$\beta_1$ -Sitosterol** - predominant sterol in vegetable oils. In corn oil  $\beta_1$ -sitosterol is present at approx. 1000 mg/kg but levels from 20–500 mg/kg are normal for vegetable oils. The chemical structure is shown in Scheme A.

**Skim milk** - milk from which the cream has been removed.

**Slip Point** - see melting point.

**Smoke point** - temperature at which smoking is first detected under conditions protected from draught and with special illumination. The temperature at which fats and oils smoke freely is normally somewhat higher.

**sn** - abbreviation for stereospecifically numbered glycerol with different acyl groups attached to the two primary hydroxyl groups becomes chiral and exists in two enantiomeric forms. When written as a Fischer projection with the 2-acyl group projecting to the left, the glycerol carbon atoms are numbered 1, 2, and 3 from the top.

**Soap** - trivial name for fatty acid salts. In toilet preparations mainly sodium salts are used.

**Soapstock** - concentrated aqueous solution of fatty acid salts obtained during chemical refining of oils.

**Solid fat content (SC)** - percentage mass fraction of solid (crystalline) fat in a fat sample. SC is measured by wide-line NMR techniques, which can measure levels up to 95%. See nuclear magnetic resonance. The previously used abbreviation SFC is the same for supercritical fluid chromatography. IUPAC defines percent solids: S %.

**Solid fat index (SFI)** - index of solid fat in a lipid sample; measured by dilatometry; applicable to solid levels below 50%.

**Solvent** - medium in which substances such as fats and oils can be dissolved. Typical solvents for fats and oils are: technical hexane, light petroleum hydrocarbons, isopropanol, trichloroethylene, acetone. See also solvent extraction and fractionation.

**Solvent extraction** - process using a solvent (technical hexane) to extract oil from oil-bearing materials. In seed crushing press cakes are solvent extracted to reduce the oil content of press cakes from 8–12% to press performance at disposal down to 1%.

**Soya milk** - a mixture of cooking liquor and purée of soybean before fermentation.

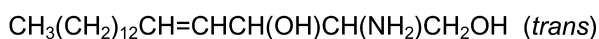
**Soya bean oil (soybean oil)** - oil extracted from the soybean, the fruits of *Soja maxima*. See fatty acid composition in Table 4.

**Soybean** - erect, bushy, hairy annual legume of *Soja maxima* native to Asia and extensively cultivated in the western hemisphere; also called soja, soya. USDA, raw, 20% fat; roasted, 25% fat.

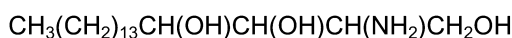
**Soya paste** - paste used in preparing soups and other foods; made by grinding a mixture of steamed rice, cooked soybeans, and salt and fermenting it in brine. Also known under meso (miso), netto (natto), and tempeh. USDA, miso, 6% fat; natto, 11% fat; tempeh 8% fat.

**Spareribs** - cut of pork ribs and breastbone separated from the bacon strip.

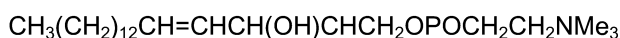
**Sphingolipids** - **compounds** containing a long-chain base such as sphingosine or phytosphingosine, fatty acids bound to the NH<sub>2</sub> group as an amide, and either sugars or phosphoric acid and alcohols like choline bound to the primary hydroxy group.



sphingosine



phytosphingosine



|  
HNCOR

sphingomyelin

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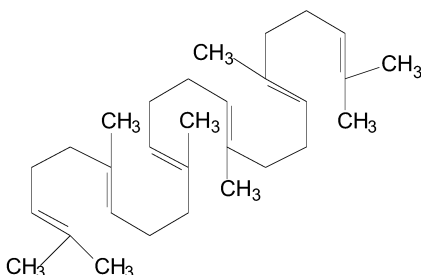
The *N*-acyl derivatives of these bases are called ceramides, while their sugar derivatives are cerebro-sides and gangliosides.

**Sphingomyelin** - see sphingolipids.

**Sphingosine** - see sphingolipids.

**Sprue** - chronic disease characterized by voluminous fatty stools due to the presence of voluminous fatty acids. See steatorrhea.

**Squalene** - unsaturated aliphatic hydrocarbon consisting of six isoprene units. Biosynthetic precursor of cholesterol from which the bile acids, steroid hormones, and vitamin D are generated (See Scheme A). Squalene occurs in larger quantities in shark liver oil and in smaller amounts in fish oils, vegetable oils (e.g., olive, wheat germ, peanut oils), and in yeast.



squalene

**Stability of fat** - resistance of a fat to oxidative deterioration. Chemical stability may be determined by **peroxide value**, **anisidine value**, **free fatty acids**, induction period, etc.; organoleptic stability by resistance to flavor and taste deterioration (off-flavors); hydrolytic stability by resistance against hydrolysis.

**Stearic acid** - trivial name for octadecanoic acid,  $\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$ ; one of the most common fatty acids, exists as a glycerol ester in most animal and plant fats.

**Stearin** - mixtures of stearic acid and palmitic acids; the higher melting portion in fractionated fat. The word stearin is also used to indicate the glycerol esters of stearic acid.

**Steatorrhea** - excessive loss of fat in faeces.

**Steatosis** - fatty degeneration of tissue.

**Sterculia foetida oil** - plant oil of jangli badam (from Java olive bush) containing up to 35% of sterculic acid and similar cyclopropenoid fatty acids; lethal if fed to animals at levels of 1.8% of sterculic acid in the diet.

**Sterculic acid** - trivial name for 8-(2-octylcyclopropenyl)octanoic acid, a cyclopropene acid of 19 carbon atoms with the ring structure starting at position 9.

**Steroid** - compound containing the perhydrocyclopenta[*a*]phenanthrene nucleus; synthesized by animals and plants. More than 100 000 natural and synthetic steroids are known. The natural ones include adrenocortical hormones, progesterone, **bile acids**, **cholesterol**, **phytosterols**, **vitamin D**, etc.

**Sterol** - steroid containing a hydroxyl group (–OH) in the 3-position and a branched aliphatic chain at position 17. The main part of unsaponifiable material in fats and oils is a mixture of sterols. Cholesterol (see Scheme A) is the most abundant sterol in animal tissue, but is present in plant tissue in only minor

amounts. Phytosterols appear in different types and quantities in vegetable oils. The sterols are divided into three main groups according to the number of methyl groups substituted at the C-4 carbon atom. The majority of the sterols have no methyl group in the 4-position (desmethylsterols). The other two groups have one or two methyl groups in the 4-position and are called 4-monomethylsterols and 4,4-dimethylsterols, respectively (see Schemes B and C). The content of these two sterol groups can be up to 40% of the total sterol content. See also cholesterol.

**7-Stigmastenol** - minor sterol in vegetable oils; present in safflower-seed and sunflower-seed oils at approx. 300 mg/kg.

**Stigmasterol** - minor sterol in vegetable oils. Soya bean and corn oil contain approx. 500 mg/kg. The chemical structure is shown in Scheme A.

**Sulfolipids** - lipids containing sulfonic acid or other sulfur-containing groups.

**Sunflower oil** - pale yellow oil extracted from the seeds of the common sunflower, *Helianthus annuus*; one variety contains <60% linoleic acid and another >60% linoleic acid. See fatty acid composition in Table 4.

**Supercritical fluid chromatography (SFC)** - chromatographic technique where the mobile phase is a supercritical fluid (normally carbon dioxide at high pressure and elevated temperature), and the stationary phase is a solid material or a liquid absorbed on a solid material. See chromatography.

## - T -

**Tallow** - edible fat from beef, mutton or goat; contains small amounts of odd-chain, branched-chain, and *trans*-unsaturated fatty acids.

**Taste** - sensation obtained via buds on the tongue; there are special receptors for each of the four basic tastes: sweet, salty, acidic, and bitter. They are distributed so that sweetness is most strongly felt at the tip of the tongue, salt and acidity at the sides of the tongue, and bitterness at the base of the tongue. A perception of taste is often a combination of several basic sensations. In addition, the appearance of food, its temperature, consistency, and particularly its smell contribute to the total taste experience.

**Taurine** - trivial name for 2-aminoethanesulfonic acid, see bile acids.

**Taurochenodeoxycholic acid** - see bile acids.

**Taurocholic acid** - see bile acids.

**TBA** - abbreviation for **thiobarbituric acid value**.

**TBHQ** - abbreviation for 2-*tert*-butylbenzene-1,4-diol, an **antioxidant** allowed in some countries.

**Tetracosanoic acid** - saturated fatty acid with 24 carbon atoms (24:0); lignoceric acid.

**Tetracosenoic acid** - monounsaturated fatty acid with 24 carbon atoms, (24:1). When the *cis* double bond is at position 15, it is called nervonic acid.

**Tetradecanoic acid** - saturated fatty acid with 14 carbon atoms (14:0); myristic acid.

**Tetradecenoic acid** - monounsaturated fatty acid with 14 carbon atoms and a double bond at position 9 (14:1); myristoleic acid.

**Thin-layer chromatography (TLC)** - chromatographic technique, where the mobile phase is a liquid and the stationary phase is a solid material fixed to a surface such as a glass plate or aluminium foil. The mixture to be separated is applied along one edge, and this edge is then dipped into a solvent (mobile phase). The solvent carries the constituents of the mixture up the thin-layer plate in a selective separation. A special TLC-technique used in lipid analysis is argentation chromatography (silver nitrate



chromatography) where the stationary phase consists of silver nitrate-treated silica. This technique is used to separate *cis* and *trans* fatty acid esters, and esters differing in the number of unsaturated bonds. See chromatography.

**Thiobarbituric acid value (TBA)** - measure of the malondialdehyde content of fats and oils. As malondialdehyde is a by-product formed by oxidation of unsaturated fats, the value is a measure of the oxidation level of a fat. The TBA value is most useful during the initial stages of oxidation.

**Thrombocyte** - blood platelet; important in the clotting of blood. See blood clot.

**Thrombosis** - formation or presence of a thrombus, a plug, or a clot in a blood vessel. See blood clot.

**Thromboxane** - see icosanoids (*eicosanoids*); thromboxane abbreviations: TxA<sub>2</sub>, TxB<sub>2</sub>, TxA<sub>3</sub>. The subscript number indicates the number of double bonds in the molecule.

**Thyinnic acid** - trivial name for hexacosahexaenoic acid (26:6); found in fish oils.

**Timnodonic acid (EPA)** - trivial name for *all-cis*-icosa-5,8,11,14,17-pentaenoic acid (20:5 n-3); present in fish oils.

**Titre** - highest temperature reached by an oil or fat when the liberated water-insoluble fatty acids are crystallizing under arbitrarily controlled conditions. The titre is generally taken to represent the solidifying point of the fatty acids, although they actually solidify over a range of temperatures.

**Tocopherol** - see vitamin E.

**Tocotrienols** - see vitamin E.

**Tomato seed oil** - red or yellow oil extracted from the seed of the large rounded or oblate pulpy berry of the tomato plant *Lycopersicon esculentum*; a native South American perennial herb. See fatty acid composition in Table 4.

**Tongue** - the flesh of the tongue of an animal (as cattle, sheep, or pigs) used as food. USDA, total fat, beef, cooked, 21% fat; pork, cooked, 19% fat; lamb, cooked, 20% fat; veal, cooked, 10% fat. See fatty acid composition in Table 5.

**TOTOX value** - abbreviation for total oxidation value; number used to describe the total oxidative load to which a fat has been exposed. The value is calculated as the sum of the **anisidine value** and twice the **peroxide value**.

**Toxicology** - science of the nature and effects of substances that are toxic to the body.

**trans** - see *cis-trans* isomerism.

**Trans fatty acid** - fatty acid in which at least one double bond is in the *trans* configuration. *Trans* fatty acids occur in partly hydrogenated fats and in butter fat, and tend to behave **biochemically** more like saturated fatty acids than unsaturated ones. See also *cis-trans* isomerism.

**Transesterification** - redistribution of fatty acids in acylglycerols glycerol among the esterification sites of the glycerol part. Also called randomization as fatty acids of oil and fat blends are randomly distributed. Synonym to interesterification. When fatty acids of a given oil with a specific triacylglycerols structure are redistributed, then it is often called intraesterification.

**Triacylglycerol** - glycerol esterified with three fatty acids; the basic unit of fats and oils that determines their characteristics. The number of possible triacylglycerols increases quickly with the number of fatty acids. To form triacylglycerols from two fatty acids, such as oleic acid (O) and palmitic acid (P), six different triacylglycerols may occur: OOO, OOP, POP, OPO, PPO, and PPP. With six different fatty acids, the number of possible triacylglycerols is over 200, with 8 fatty acids over 500. The fat in fatty tissue and in food is comprised of triacylglycerols. The exogenous (dietary) triacylglycerols are broken down in the intestine, absorbed, and transported via the lymphatic system. Fatty acids of shorter chain

length (12 carbon atoms or less) are soluble in water and are transported directly to the liver via the portal vein. About 100 g of exogenous fat are ingested daily in the form of triacylglycerols. The endogenous triacylglycerols are produced in the liver, where biosynthesis is dependent upon various metabolic factors. The glycerol moiety comes from glucose metabolism, while the fatty acids come from free fatty acids in plasma or through new synthesis in the liver from glucose or amino acids.

**Triglyceride** - trivial name for **triacylglycerol**. See acylated glycerol.

**Triolein** - **triacylglycerol** of oleic acid, colorless high-boiling liquid, insoluble in water.

**Tripalmitin** - **triacylglycerol** of palmitic acid, white solid, insoluble in water.

**Tristearin** - **triacylglycerol** of stearic acid, white solid, insoluble in water.

**Turkey** - flesh of a large American bird, *Meleagris gallopavo*; wild or domesticated and raised for food. USDA, total fat, flesh and skin, cooked, roasted, 10%; flesh only, cooked, roasted, 5.0%. See fatty acid composition in Table 5.

## - U -

**Ultraviolet spectroscopy (UV)** - measurement of absorption of a material in the UV-region (from 200–400 nm); technique used to determine conjugated double bonds in fatty acids.

**Unsaponifiable material** - material obtained after saponification of a lipid sample that excludes soaps (salts of fatty acids), glycerol, and other water-soluble compounds and is nonvolatile at 100 °C; usually amounts to 1–2% and includes hydrocarbons (e.g., squalene, carotenes), alcohols including sterols, and other compounds (e.g., fat-soluble vitamins, **xanthophylls**).

**Unsaturated fatty acids** - see monoenoic and polyenoic fatty acids.

**Ursodeoxycholic acid** - see bile acids.

**USDA** - abbreviation for United States Department of Agriculture.

## - V -

**Vaccenic acid** - trivial name for *trans*-octadec-11-enoic acid (18:1 n-7). Occurs in butter and other ruminant fats.

**Vanaspati** - hydrogenated shortening used in India and Pakistan as a substitute for ghee; also popular in Mediterranean countries. When allowed to set slowly, vanaspati crystallizes in a granular texture, an indication of purity and quality to the consumer.

**Veal** - flesh of a calf, *Bos taurus*, a few days to 12–14 weeks old. USDA, composite of lean retail cuts, lean only, cooked, 7% fat. See fatty acid composition in Table 5.

**Vegetable oil** - oil of plant origin.

**Vegetable tallow** - fat of plant origin, having often a specific structure that shows a pronounced polymorphism. The best known vegetable tallow is **cocoa butter**. Others are, for example, **illipe fat** (borneo tallow) and **dhupa fat** (malabar tallow).

**Vegetarian** - person who eats only food from the vegetable kingdom, sometimes with the addition of certain animal foodstuffs such as milk, butter, cheese, and eggs (lactovegetarian).

**Venison** - edible flesh of a wild ruminant mammal, usually deer Cervidae. USDA, deer, cooked, 3.2% fat. See fatty acid composition in Table 5.

**Very-low-density lipoproteins (VLDL)** - serum lipoprotein fraction having a density of 0.94 to 1.00 g/ml and containing about 90% lipid (triacylglycerol, phospholipid, and cholesterol) and the rest protein. Degradation products from VLDL are converted to LDL.

**Vitamin** - organic substance needed by animals and humans in amounts ranging from micrograms to milligrams per day; essential for normal growth, development, and maintenance of the organism; can either not be synthesized in the body or produced only in inadequate amounts. In either case, dietary sources are necessary. There are four fat-soluble vitamins and nine water-soluble vitamins.

**Vitamin A** - group of monocyclic, unsaturated C<sub>20</sub> compounds consisting of four isoprene units with conjugated double bonds in the side chain. Vitamin A includes retinol (see Scheme D), retinal (also called retinaldehyde), and retinyl esters (fatty acid esters of retinol). Retinoic acid, a metabolite of retinol, can only partially perform the biological activities of retinol. Dehydroretinol (vitamin A<sub>2</sub>) exists in fresh water fish. It has an additional double bond in the cyclic part of the molecule and is less than half as biologically active as retinol. Retinal is necessary for vision in dim light, the other forms of Vitamin A are necessary for growth, reproduction, the functioning of epithelial cells, and the integrity of membrane structures. It occurs in foods of plant origin solely as provitamin A, i.e., in the form of  $\beta$ -carotene or some other carotenes and xanthophylls. Typical sources are green leafy vegetables, red palm oil, carrots, and yellow fruits.  $\beta$ -carotene, which is quantitatively the most important precursor of vitamin A, and other carotenoids with provitamin A activity are converted in intestinal mucosal cells into vitamin A. Preformed vitamin A exists only in foods of animal origin and is mainly present as retinyl ester. The ester is hydrolyzed during digestion and, after absorption, the retinol is reesterified. Retinyl ester is the storage form of vitamin A in the liver, which is accordingly a particularly rich source of the vitamin. Major sources are also milk, milk fat, and eggs.

**Vitamin D** - group of compounds with antirachitic activity which are derived biosynthetically from the ring system of steroids containing a hydroxy group in position 3 of the A ring and a side chain of varying structure in position 17 of the D ring (compare Scheme A). Characteristic and common for the D vitamins, however, is the fission of the B ring resulting in a conjugated triene system with a varying number of double bonds. The most important members of the vitamin D group are vitamin D<sub>2</sub> (ergocalciferol, ercalcio; formerly known as calciferol) and vitamin D<sub>3</sub> (cholecalciferol, calcio) (see Scheme D). Ergocalciferol arises from ergosterol, a steroid found in some microorganism (yeast), by the action of UV light. Cholecalciferol is, in a strict sense, not a vitamin because it can be formed in the skin of mammals and humans from 7-dehydrocholesterol by the influence of sunlight (UV light). This metabolite of cholesterol exists in all tissues but the skin contains a relatively high concentration of 7-dehydrocholesterol. Nevertheless, cholecalciferol synthesis in the skin may not be sufficient to meet the daily vitamin D requirement of the organism. Vitamin D is essential for the intestinal absorption of calcium and for the mineralization of bone. Before this can occur, the vitamins D<sub>2</sub> and D<sub>3</sub> have to be converted in the body into their active forms: 1,25-dihydroxyergocalciferol (ercalcitriol) and 1,25-dihydroxycholecalciferol (calcitriol). Principal dietary sources of vitamin D are fatty fish and fish-liver oils, eggs, liver, and butter.

**Vitamin E** - group of eight chroman-6-ol derivatives with an isoprenoid side chain of 16 carbon atoms originating biosynthetically in a chain of four isoprene units. There are four tocopherols, the  $\alpha$ -,  $\beta$ -,  $\delta$ - and  $\gamma$ -tocopherols, which differ structurally in the number and position of methyl groups in the aromatic part of the ring component. All have a saturated side chain. The tocotrienols with a corresponding methylation of the ring system, the  $\alpha$ -,  $\beta$ -,  $\delta$ - and  $\gamma$ -tocotrienols, differ from the tocopherols in having unsaturated side chains with three double bonds. All eight compounds possess vitamin E activity, but the degree of biological potency varies widely. The most active form of vitamin E is  $\alpha$ -tocopherol (see Scheme D), whereas the biopotency of the remaining vitamin E substances is about 1 to 50% of the activity of  $\alpha$ -tocopherol. Vitamin E functions in animal tissues as a lipid-soluble antioxidant by preventing the propagation of nonenzymatic oxidation of polyunsaturated fatty acids by trapping peroxy

radicals. Accordingly, vitamin E in tissues is found in cellular membranes that are rich in polyunsaturated fatty acids that occur in phospholipids. All members of the vitamin E group are widely distributed in plant material. The richest sources of vitamin E are vegetable oils, but individual tocopherols can vary considerably. Tocotrienols occur mainly in wheat germ and palm oils. Nuts, seeds, and green leafy vegetables also contain appreciable amounts of the vitamin. Fruits, animal fats, meat, and fish are comparatively poor sources of vitamin E.

**Vitamin K** - group of compounds with antihemorrhagic activity which are derivatives of 2-methyl-1,4-naphthoquinone having an isoprenoid side chain of varying length and degree of saturation. The compound with a phytyl side chain (consisting of four isoprene units, of which three are saturated) is called phylloquinone or vitamin K<sub>1</sub> (see Scheme D). It is present in green leaves and other plant tissues. The series of menaquinones or vitamin K<sub>2</sub> occurs in bacteria and comprises compounds with a side chain of 4 to 13 isoprene units. Phylloquinone and menaquinones occur in animal and human tissues and are essential for normal blood clotting in that prothrombin and three other protein factors of the blood coagulation system are dependent on vitamin K for their synthesis and activation. The biological activity of vitamin K<sub>2</sub> is approximately 75% of that of vitamin K<sub>1</sub>. Excellent sources of vitamin K are green leafy vegetables. Small, but still significant, amounts of the vitamin exist in dairy products, eggs, and liver.

**VLDL** - abbreviation for very-low-density lipoprotein; see lipoprotein.

## - W -

**Walnut** - edible nut from the tree, *Juglans regia*. "English" walnuts are originated in Persia. Black walnuts, *Juglans nigra*, are native to North America. USDA, English, dried, 62% fat; black, dried, 57% fat. See fatty acid composition in Table 4.

**Walnut oil** - oil extracted from cold-pressed walnut kernels that contain about 60% fat. See fatty acid composition in Table 4.

**Watermelon seed oil** - edible oil from the seed of *Citrullus vulgaris*; with 60% linoleic acid, 20% oleic acid, and 20% palmitic and stearic acids.

**Wax** - water-resistant material composed principally of esters of long-chain alcohols and fatty acids. See also ester waxes.

**Whale** - mammal of the genus *Cetacea* which lives all its life in water. The front extremities are formed as fins, and the rear extremities are lacking. Under the skin, whales have a layer of blubber (fat) up to 35 cm, which acts as an insulator and gives a low specific gravity.

**Whale oil** - oil from different types of whales. The now protected blue whale can provide up to 30 tonnes of oil, and a herring whale can give up to 15 tonnes. The composition of whale oil varies with the locale. Whale harvesting is mostly prohibited by international agreements.

**Wheat germ oil** - oil from the embryo or germ of wheat, *Triticum aestivum*. See fatty acid composition in Table 4.

**Whey** - the liquid part of milk separated from the curd.

**WHO** - abbreviation for World Health Organization of the United Nations.

**Winterization** - process of separating solid phases from oils by crystallization, often used as synonym for fractionation. Originally the removal of waxes from cooking and salad oils by cooling to refrigerator temperatures.

**- X -**

**X-ray diffraction (XRD)** - bending of a beam of X-rays consisting of electromagnetic vibrations with a wavelength of about 0.1 nm. Crystals give certain specific diffraction lines when exposed to X-ray light. The technique is used to obtain information on crystal structures. The information is used to distinguish between the different modifications (polymorphic forms) in which a fat crystallizes.

**Xanthomatosis** - accumulation of excess lipids in the body marked by the formation of lipid deposits.

**Xanthophyll** – oxygen-containing derivatives of carotenes. Among the carotenoids the xanthophylls are generally more widely distributed in nature and show much more diversity in color and chemical structure than the carotenes. Some very widely occurring xanthophylls in plants are zeaxanthin ( $\beta,\beta$ -carotene-3,3'-diol, the major pigment in yellow maize) and lutein ( $\beta,\epsilon$ -carotene-3,3'-diol, originally designated as 'xanthophyll'). Astaxanthin (3,3'-dihydroxy- $\beta,\beta$ -carotene-4,4'-dione) is the major red pigment in many aquatic animals such as crustaceans. They are able to form astaxanthin from lutein, zeaxanthin, and  $\beta$ -carotene. Cryptoxanthin ( $\beta,\epsilon$ -caroten-3-ol) existing in plants, yellow maize, many berries and fruits (e.g., peaches), can be converted in animals and humans into vitamin A. See also carotenes, carotenoids, and vitamin A.

**Xenobiotics** - chemical compounds foreign to the body; from the Greek "xenos" and "bios" meaning stranger to life, such as food additives, pesticides, drugs, industrial products, by-products, pollutants, and some natural food products. Xenobiotics, after entry into the body, undergo metabolic changes whereby lipid-soluble compounds are converted into polar, water-soluble products and excreted from the body.

**- Y -**

**Yellow fat** - other name for butter and margarine.

**Yogurt** - cultured milk product of East European origin. The acidifying bacterial cultures that are used are a mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Yogurt occurs with different fat contents. USDA, plain, total fat, 0.2 to 3.3%; fatty acids derived from milk fat.

**- Z -**

**Zeaxanthin** - see xanthophyll.

**ACKNOWLEDGMENTS**

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**Table 1** Saturated fatty acids.

Shorthand formula	Systematic name	Trivial name	Melting point °C
4:0	butanoic	Butyric	-7.9
6:0	hexanoic	Caproic	-3.4
8:0	octanoic	Caprylic	16.7
10:0	decanoic	Capric	31.6
12:0	dodecanoic	Lauric	44.2
14:0	tetradecanoic	Myristic	54.4
16:0	hexadecanoic	Palmitic	62.9
17:0	heptadecanoic	Margaric	61.3
18:0	octadecanoic	Stearic	69.9
20:0	icosanoic	Arachidic	75.4
22:0	docosanoic	Behenic	80.0
24:0	tetracosanoic	Lignoceric	84.2

**Table 2** Monoenoic fatty acids.

Shorthand formula	Systematic name	Trivial name
16:1(n-7)	<i>cis</i> -hexadec-9-enoic	Palmitoleic
t-16:1(n-7)	<i>trans</i> -hexadec-9-enoic	
18:1(n-12)	<i>cis</i> -octadec-6-enoic	Petroselinic
18:1(n-9)	<i>cis</i> -octadec-9-enoic	Oleic
t-18:1(n-9)	<i>trans</i> -octadec-9-enoic	Elaidic
18:1(n-7)	<i>cis</i> -octadec-11-enoic	<i>Cis</i> -vaccenic
t-18:1(n-7)	<i>trans</i> -octadec-11-enoic	<i>Trans</i> -vaccenic
20:1(n-11)	<i>cis</i> -icos-9-enoic	Gadoleic
20:1(n-9)	<i>cis</i> -icos-11-enoic	Gondoic
22:1(n-9)	<i>cis</i> -docos-13-enoic	Erucic
24:1(n-9)	<i>cis</i> -tetracos-15-enoic	Nervonic

**Table 3** Polyunsaturated fatty acids.

Shorthand formula	Systematic name	Trivial name	Abbreviation
18:2(n-6)	<i>cis,cis</i> -octadeca-9,12-dienoic	Linoleic	
18:3(n-6)	<i>all-cis</i> -octadeca-6,9,12-trienoic	$\gamma$ -Linolenic	GLA
18:3(n-3)	<i>all-cis</i> -octadeca-9,12,15-trienoic	$\alpha$ -Linolenic	
18:4(n-3)	<i>all-cis</i> -octadeca-6,9,12,15-tetraenoic	Stearidonic	
20:3(n-9)	<i>all-cis</i> -icosa-5,8,11-trienoic		
20:3(n-6)	<i>all-cis</i> -icosa-8,11,14-trienoic	Dihomo- $\gamma$ -linolenic	DHLA
20:4(n-6)	<i>all-cis</i> -icosa-5,8,11,14-tetraenoic	Arachidonic	
20:5(n-3)	<i>all-cis</i> -icosa-5,8,11,14,17-pentaenoic	Timnodonic	EPA
22:5(n-3)	<i>all-cis</i> -docosa-7,10,13,16,19-pentaenoic		DPA
22:6(n-3)	<i>all-cis</i> -docosa-4,7,10,13,16,19-hexaenoic	Clupanodonic*	DHA

\*Clupanodonic acid was previously a mixture of docosapentaenoic and docosahexaenoic acids.

## COMMENTS ON THE TABLES

For Tables 4 and 5, the authors have consulted the following references for the listed figures:

**USDA:** Official Standards of the U.S. Department of Agriculture

**Codex:** Codex Alimentarius: Alinorm 95/17

Reference [1]: A. Karleskind and J. P. Wolff (Eds.). *Manuel des Corps Gras, TEC-Lavoisier, Paris (1992)*.

**Table 4** Fatty acid composition of oils and fats of vegetable sources (expressed as percentage mass-fraction of total fatty acids).

	Almond oil	Avocado oil	Babassu fat	Canola oil	Cashew nut oil	Cocoa butter	Coconut oil	Corn (maize) oil	Cottonseed oil
C10:0			1.2–7.6				6.0		
C12:0			40.0–55.0				44.6	0.0–0.3	<0.2
C14:0			11.0–27.0			0.1	16.8	0.0–0.3	0.6–1.0
C16:1 n-7	0.6	4.6				0.2*		0.0–0.4*	<1.2
C17:0									
C17:1						0.1			
C18:3 n-3		0.8		10.0				0.5–1.5*	<0.4
C20:0								0.3–0.7	0.2–0.5
C20:1 n-9								0.2–0.4*	<0.1*
C20:2 n-6									
C20:4 n-6									
C22:0									
C22:1 n-9								<0.5	<0.6
C22:2 n-6								<0.1*	<0.3*
C24:0								<0.4	<0.1*
C24:1 n-9									
C6:0							0.6		
C8:0			2.6–7.3				7.5		
C16:0	6.5	17.2	5.2–11.0	4.0	4–6	25.4	8.2	8.6–16.5	21.4–26.4
C18:0	1.7	0.2	1.8–7.4	2.0	6–12	33.2	2.8	<3.3	2.1–3.3
C18:1 n-9	69.6	64.0	9.0–20.0*	56.0	68–75	32.6	5.8	20.0–42.2*	14.7–21.7
C18:2 n-6	17.4	13.1	1.4–6.6*	26.0	7–22	2.8	1.8	39.4–65.6*	46.7–58.2
Source	USDA	USDA	Codex	Codex	Codex		Codex	Codex	Codex

\*Exact position of double bond not available.

(continued on next page)

**Table 4** (*cont'd.*) Fatty acid composition of oils and fats of vegetable sources (expressed as percentage mass-fraction of total fatty acids).

	Grapeseed oil	Hazelnut oil	Illipe fat	Linola	Linseed oil	Macadamia nut	Oat bran	Olive oil	Palm kernel fat
C6:0									<0.8
C8:0									2.4–6.2
C10:0									2.6–5.0
C12:0	<0.5						0.4		45.0–55.0
C14:0	<0.3	0.1				0.7	0.2	0.0–0.1	14.0–18.0
C16:0	5.5–11	5.2	18–22	6	4–7	8.9	17.4	7.5–20.0	6.5–10.0
C16:1 n-7	<1.2	0.2				22.6	0.2	0.3–3.5	
C17:0								<0.5	
C17:1								<0.6*	
C18:0	3.0–6.0	2.0	40–45	4	3–6	2.9	1.1	0.5–5.0	1.3–3.0
C18:1 n-9	12–28	77.8	37–42*	16	13–29*	58.4	36.5	56.0–83.0	12.0–19.0*
C18:2 n-6	58–78	10.1	0.3*	72	17–30*	1.8	40.9	3.5–20.0	1.0–3.5*
C18:3 n-3	<1.0			2	47–55*		1.9	0.0–1.5	
C20:0	<1.0							<0.8	
C20:1 n-9						1.5			
C20:2 n-6									
C20:4 n-6									
C22:0	<0.3							<0.2	
C22:1 n-9									
C22:2 n-6									
C24:0	<0.1							<1.0	
C24:1 n-9									
Source	Codex 97	USDA		CSIRO		USDA	USDA	IOOC 84	Codex 97

\*Exact position of double bond not available.



**Table 4 (cont'd.)** Fatty acid composition of oils and fats of vegetable sources (expressed as percentage mass-fraction of total fatty acids).

	Palm oil	Palm olein	Palm stearin	Peanut oil	Pecan nut oil	Pistachio nut oil	Poppyseed oil	Rapeseed oil	Rapeseed oil (low erucic acid)
C6:0									
C8:0									
C10:0									
C12:0	<0.4	0.1–0.5	0.1–0.4	0.0–0.1					<0.2
C14:0	0.5–2.0	0.9–1.4	1.1–1.8	0.0–0.1	6.4	0.3	10.6	0.2	3.3–6.0
C16:0	40.1–47.5	38.2–42.9	48.4–73.8	8.3–14.0	0.5	11.6		1.5–6.0	0.1–0.6*
C16:1 n-7	<0.6*	0.1–0.3*	>0.2*	<0.2*		0.6		<3.0*	<0.3
C17:0									<0.3
C17:1									1.1–2.5
C18:0	3.5–6.0	3.7–4.8	3.9–5.6	1.9–4.4	1.6	1.4	2.9	0.5–3.1	52.0–66.9*
C18:1 n-9	36.0–44.0*	39.8–43.9*	15.6–36.0*	36.4–67.1*	64	69.3	19.7	8–60*	16.1–24.8*
C18:2 n-6	6.5–12.0*	10.4–13.4*	3.2–9.8*	14.0–43.0*	24.8	15.2	62.4	11–23*	6.4–14.1*
C18:3 n-3	<0.5*	0.1–0.6*	0.1–0.6*	<0.1*	1.1	0.5		5–13*	0.2–0.8
C20:0	<1.0	0.2–0.6	0.3–0.6	1.1–1.7	0.7	0.5		3–15	0.1–3.4
C20:1 n-9				0.7–1.7				<1.0	<0.1
C20:2 n-6									
C20:4 n-6									
C22:0				2.1–4.4				<2.0	<0.5
C22:1 n-9				<0.3*				2–60*	<2.0*
C22:2 n-6								<2.0*	<2.0*
C24:0				1.1–2.2				<2.0	<2.0
C24:1 n-9				<0.3*				<3.0*	<0.4*
Source	Codex	Codex	Codex	Codex	USDA	USDA	USDA	Codex	Codex

\*Exact position of double bond not available.

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**Table 4 (cont'd.)** Fatty acid composition of oils and fats of vegetable sources (expressed as percentage mass-fraction of total fatty acids).

	Rice bran oil	Safflower oil (high-linoleic)	Safflower oil (high-oleic)	Rice bran oil	Sesame oil	Shea butter <i>Butyrospermum parkii</i>	Shea butter <i>Butyrospermum paradoxum</i>	Soya bean oil	Sunflower oil (<60% linoleic acid)
C6:0									
C8:0							0.2		
C10:0							0.2		
C12:0						<1	1.3	<0.1	
C14:0	0.7	0.1		0.7	<0.1	<0.7	0.1	<0.2	
C16:0	16.9	6.2	4.8	16.9	7.9–10.2	3–5	4.4	8.0–13.3	5.4
C16:1 n-7	0.2	0.4		0.2	0.1–0.2*		0.1	<0.2*	0.2
C17:0					<0.2				
C17:1					<0.1				
C18:0	1.6	2.2	1.3	1.6	4.8–6.1	28–45	38.8	2.4–5.4	3.5
C18:1 n-9	39.1	11.7	75.3	39.1	35.9–42.3*	42–59	43.5	17.7–26.1*	45.3
C18:2 n-6	33.4	74.1	14.2	33.4	41.5–47.9*	3–9	4.9	49.8–57.1*	39.8
C18:3 n-3	1.6	0.4		1.6	0.3–0.4*	<1	0.3	5.5–9.5*	0.2
C20:0					0.3–0.6			0.1–0.6	
C20:1 n-9					<0.3*			<0.3*	
C20:2 n-6								<0.1*	
C20:4 n-6									
C22:0					<0.3	<1.5		0.3–0.7	
C22:1 n-9								<0.3*	
C22:2 n-6									
C24:0					<0.3			<0.4	
C24:1 n-9									
Source		USDA	USDA	USDA	Codex	Ref. 1, p. 206	USDA	Codex 7	USDA

\*Exact position of double bond not available.

**Table 4 (cont'd.)** Fatty acid composition of oils and fats of vegetable sources (expressed as percentage mass-fraction of total fatty acids).

	Sunflower oil (>60% linoleic acid)	Tomato seed oil	Walnut oil (English)	Walnut oil (Black)	Walnut oil oil	Wheat germ
C6:0						
C8:0						
C10:0						
C12:0						
C14:0		0.2	0.3			0.1
C16:0	5.9	12.0–15.5	7.2	3.9	7.0	16.6
C16:1 n-7		<0.3	0.3	0.1	0.1	0.5
C17:0		<0.3				
C17:1		<0.6				
C18:0	4.5	4.0–6.5	1.8	2.6	2.0	0.5
C18:1 n-9	19.6	16.0–25.0	39.6	22.0	22.2	14.6
C18:2 n-6	65.7	50.0–60.0	53.9	62.1	52.9	54.8
C18:3 n-3		1.5–2.5	11.6	6.1	10.4	6.9
C20:0		<0.6				
C20:1 n-9			0.9	1.0	0.4	
C20:2 n-6						
C20:4 n-6						
C22:0		<0.2				
C22:1 n-9		<0.2*				
C22:2 n-6						
C24:0						
C24:1 n-9						
Source	USDA	Ref. 1	USDA	USDA	USDA	USDA

\*Exact position of double bond not available.

**Table 5** Fatty acid composition of oils and fats in foods of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Bacon fat (raw)	Bacon fat (cooked)	Bacon fat (Canadian style cooked)	Beef fat	Blood sausage	Bologna sausage (beef)	Bologna sausage (beef & pork)	Bologna sausage (pork)	Chicken (flesh & skin)
C4:0									
C6:0									
C8:0									
C10:0	0.4	0.2	0.3	0.1		0.3	0.2	0.1	
C12:0	0.4	0.2	0.3	0.1	0.1	0.2	0.2		0.2
C14:0	1.6	1.3	1.7	3.4	1.9	3.2	2.3	1.3	0.9
C16:0	24.4	23.4	23.3	30.5	25.4	25.2	23.7	23.1	23.0
C16:1 n-7	3.3	3.7	5.0*	4.3	2.7	6.0	5.2	3.8	6.0
C17:0									
C17:1									
C18:0	12.3	12.1	11.3	14.7	13.5	16.1	14.0	12.1	6.4
C18:1 n-9	45.1	46.8	47.5*	45.8	45.8	45.1	45.3	48.3	36.7
C18:2 n-6	11.0	10.4	9.0*	3.2	9.8	3.1	7.5	9.8	21.2
C18:3 n-3			1.5*	0.4	0.8	0.9	1.6	1.5	0.9
C20:1 n-9									1.1
C20:4 n-6				0.5					0.9
C20:5 n-3									0.1
C22:0									
C22:1 n-9									
C22:2 n-6									
C22:6 n-3									
Source	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA

\*Exact position of double bond not available.

**Table 5 (cont'd.)** Fatty acid composition of oils and fats of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Chicken (flesh only)	Cream	Duck (flesh & skin)	Duck (flesh only)	Eddible tallow (beef)	Eddible tallow (mutton)	Egg (chicken)	Egg (duck)	Egg (goose)
C4:0		3.5							
C6:0		2.1							
C8:0		1.2							
C10:0		2.8							
C12:0	0.3	3.1	0.2	0.4	0.9				
C14:0	0.9	11.1	0.7	0.5	3.7	3.8	0.3	0.4	0.5
C16:0	22.1	28.8	25.9	26.2	24.9	21.5	26.6	26.3	25.9
C16:1 n-7	5.5	2.5*	4.3	4.6	4.2	2.3	4.0	3.9	3.5
C17:0									
C17:1									
C18:0	7.7	13.3	9.2	13.7	18.9	19.5	9.3	5.5	6.4
C18:1 n-9	34.7	27.6*	43.9	34.8	36.0	37.6	44.1	53.2	48.6
C18:2 n-6	26.5	2.5	12.8	13.9	3.1	5.5	13.4	4.9	6.2
C18:3 n-3	1.1	1.6	1.1	1.5	0.6	2.3			
C20:1 n-9	0.6				0.3		1.0	2.8	2.5
C20:4 n-6	1.7								
C20:5 n-3	0.2								
C22:0									
C22:1 n-9									
C22:1 n-6									
C22:6 n-3	0.6								
Source	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA

\*Exact position of double bond not available.

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**Table 5 (cont'd.)** Fatty acid composition of oils and fats in foods of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Egg (turkey)	Frankfurter (beef)	Frankfurter (beef & pork)	Frankfurter (chicken)	Goose (flesh & skin)	Goose (flesh only)	Heart (beef)	Heart (pork)	Kidney (lamb)
C4:0									
C6:0									
C8:0									
C10:0		0.1	0.3	0.3	0.2	0.4		0.3	0.4
C12:0		0.1	0.2	1.0	0.6	0.5	3.0	2.6	1.5
C14:0	0.4	3.2	2.0	22.8	23.1	25.0	16.3	18.0	19.1
C16:0	27.6	25.2	23.8	6.6	3.5	4.2	2.3	2.9	1.9
C16:1 n-7	6.8	6.5	4.8						
C17:0									
C17:1									
C18:0	8.9	14.9	13.4	6.1	9.2	13.4	17.9	13.6	23.6
C18:1 n-9	39.6	45.7	45.5	39.5	48.5	37.2	24.4	27.5	25.5
C18:2 n-6	11.9	3.1	8.6	20.7	10.2	10.8	20.9	23.3	9.7
C18:3 n-3	0.8	1.1	1.4	0.8	0.9	1.4	0.5	2.6	3.4
C20:1 n-9								0.5	
C20:4 n-6	1.3						10.5	8.1	6.4
C20:5 n-6									2.3
C22:0									0.4
C22:1 n-9									
C22:2 n-6									
C22:5 n-3									1.9
C22:6 n-3									1.5
Source	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA

\*Exact position of double bond not available.

**Table 5 (cont'd.)** Fatty acid composition of oils and fats of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Kidney (veal)	Lamb	Lard	Liver (pork)	Liver (beef)	Liver (chicken)	Milk (cow)	Milk (goat)	Milk (human)
C4:0							3.5	3.3	
C6:0							1.9	3.3	
C8:0							1.3	2.6	
C10:0		0.2					2.5	6.6	1.4
C12:0	0.2	0.4					2.9	3.1	6.2
C14:0	2.7	3.7	0.5–2.5	0.7	1.7	0.5	10.8	8.2	7.7
C16:0	22.9	22.3	20–32	17.2	16.6	25.3	27.9	23.2	22.1
C16:1 n-7	2.4	3.4	1.7–5.0*	1.0	1.4	3.7	2.5	2.0	3.1
C17:0			<0.5						
C17:1			<0.5						
C18:0	15.3	14.3	5.0–24	27.2	33.4	19.4	12.7	11.2	7.0
C18:1 n-7									
C18:1 n-9	26.0	47.1	35–62*	19.1	16.6	28.7	26.6	25.0	3.6
C18:2 n-6	13.4	6.2	3.0–16.6*	13.6	12.4	14.0	2.6	2.8	8.9
C18:3 n-3	1.7	0.7	<1.5*	1.3		0.3	1.6	1.0	1.2
C18:3 n-9									
C20:1 n-9			<1.0*						1.0*
C20:4 n-6	7.8	0.7	<1.0*	17.2	8.0	4.2			0.7
C20:5 n-6	2.2					0.5			
C22:0									
C22:1 n-9	0.7*								
C22:2 n-6									
C22:5 n-3	1.7			1.3		0.3			
C22:6 n-3	0.7			1.0	6.9	2.0			
Source	USDA	USDA	Codex	USDA	USDA	USDA	USDA	USDA	USDA

\*Exact position of double bond not available.

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**Table 5 (cont'd.)** Fatty acid composition of oils and fats foods of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Milk (buffalo)	Milk (sheep)	Rabbit	Salami (beef, cooked)	Salami (pork, dry)	Salami (pork & beef, dry)	Tongue (beef)	Tongue (lamb)	Tongue (pork)
C4:0	4.3	3.0							
C6:0	2.3	2.1							
C8:0	1.1	2.1							
C10:0	2.1	6.0		0.3		0.2			01.
C12:0	2.6	3.6		0.3		0.1		0.2	0.5
C14:0	10.7	10.0	3.4	3.1	1.6	1.6	4.4	3.0	2.0
C16:0	30.6	24.4	29.5	25.3	24.2	23.4	30.8	20.4	24.1
C16:1 n-7	2.1	2.0	4.5	6.5	3.9	5.2	3.3	2.7	4.1
C17:0									
C17:1									
C18:0	0.4	15.1	6.0	16.3	11.3	12.3	11.4	15.6	10.9
C18:1 n-7									
C18:1 n-9	24.0	23.5	30.2	43.5	46.4	47.4	46.1	48.4	46.0
C18:2 n-6	1.1	2.7	20.2	3.6	10.3	8.8	3.0	3.0	10.7
C18:3 n-3	1.2	2.0	5.2	1.1	0.9	1.0		3.2	0.5
C20:1 n-9									
C20:4 n-6					0.5		1.0	0.4	
C20:5 n-6									
C22:0								1.2*	
C22:1 n-9									
C22:2 n-6									
C22:5 n-3									
C22:6 n-3									
Source	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA

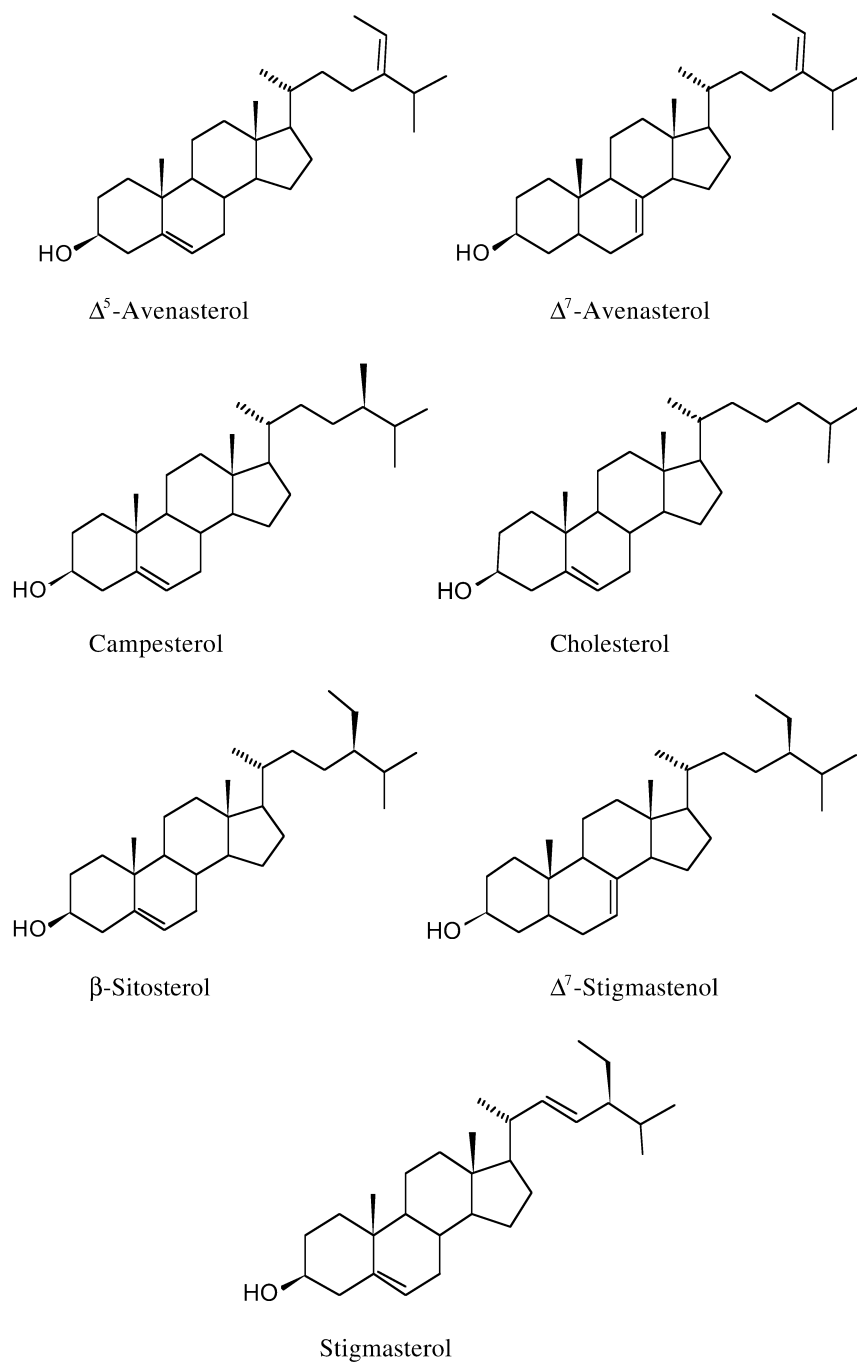
\*Exact position of double bond not available.



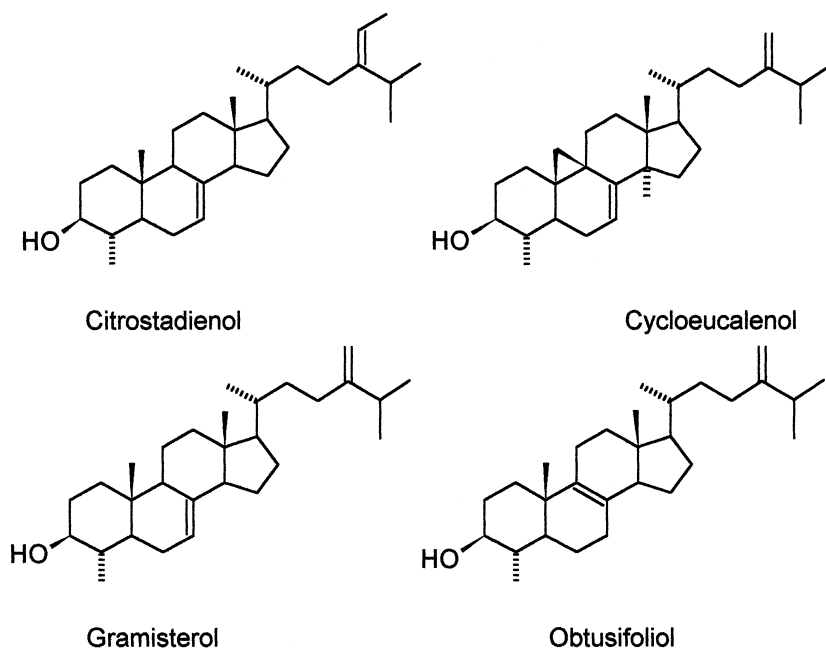
**Table 5** (*cont'd.*) Fatty acid composition of oils and fats of animal origin (expressed as percentage mass-fraction of total fatty acids). The reported figures serve as guidelines only as foods may show relative large variations in the fatty acid composition.

	Turkey (flesh & skin)	Turkey (flesh only)	Veal	Venison
C4:0				
C6:0				
C8:0				
C10:0				
C12:0	0.1	0.5	0.2	
C14:0	0.9	0.7	2.5	1.1
C16:0	20.3	20.0	22.4	19.6
C16:1 n-7	6.1	6.7	4.4	1.5
C17:0				
C17:1				
C18:0	8.2	13.0	13.2	24.4
C18:1 n-7				
C18:1 n-9	30.4	20.7	44.1	30.2
C18:2 n-6	24.2	26.3	9.4	14.6
C18:3 n-3	1.3	1.0	0.6	3.3
C18:3 n-9				
C20:1 n-9	0.2*	0.5*		
C20:4 n-6	2.3	5.1	2.3	4.7
C20:5 n-6				
C22:0				
C22:1 n-9	0.1	0.5		
C22:2 n-6				
C22:5 n-3	0.4	0.7		
C22:6 n-3	0.5	1.0		
Source	USDA	USDA	USDA	USDA

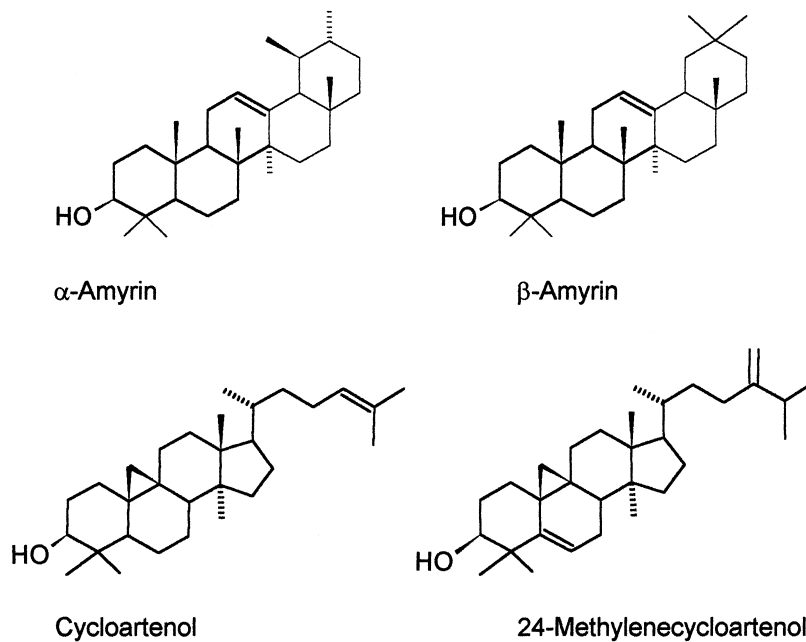
\*Exact position of double bond not available.



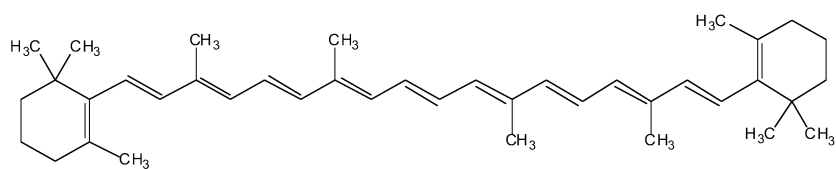
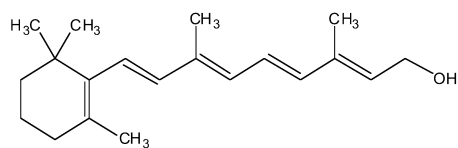
**Scheme A** Structural formulae of 4-desmethylsterols.



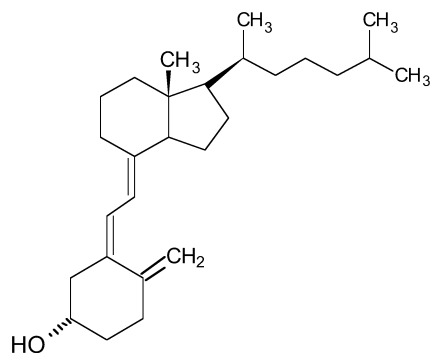
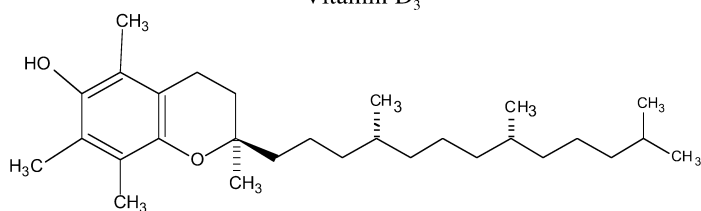
**Scheme B** Structural formulae of 4-monomethylsterols.



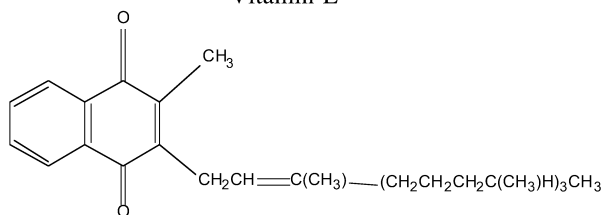
**Scheme C** Structural formulae of 4,4-dimethylsterols.

 $\beta$ -Carotene

Vitamin A (retinol)

Vitamin D<sub>3</sub>

Vitamin E

Vitamin K<sub>1</sub>**Scheme D** Structural formulae of fat-soluble vitamins.