Fats and oils

In nutrition, biology, and chemistry, **fat** usually means any ester of fatty acids, or a mixture of such compounds, most commonly those that occur in living beings or in food.

The term often refers specifically to triglycerides (triple esters of glycerol), that are the main components of vegetable oils and of fatty tissue in animals or, even more narrowly, to triglycerides that are solid or semisolid at room temperature, thus excluding oils. The term may also be used more broadly as a synonym of lipid—any substance of biological relevance, composed of carbon, hydrogen, or oxygen, that is insoluble in water but soluble in non-polar solvents. Fats are one of the three main macronutrient groups in human diet, along with carbohydrates and proteins, and the main components of common food products like milk, butter, tallow, lard, salt pork, and cooking oils. They are a major and dense source of food energy for many animals and play important structural and metabolic functions, in most living beings, including energy storage, waterproofing, and thermal insulation. The human body can produce the fat it requires from other food ingredients, except for a few essential fatty acids that must be included in the diet. Dietary fats are also the carriers of some flavor and aroma ingredients and vitamins that are not water-soluble.

Natural fats

The group of oily substances of natural occurrence, as butter, lard, tallow, etc., as distinguished from certain fatlike substance of artificial production, as paraffin. Most natural fats are essentia lly mixtures of triglycerides of fatty acids.

Types of Fat

Unsaturated fats

Unsaturated fats, which are liquid at room temperature, are considered beneficial fats because they can improve blood cholesterol levels, ease inflammation, stabilize heart rhythms, and play a number of other beneficial roles. Unsaturated fats are predominantly found in foods from plants, such as vegetable oils, nuts, and seeds.

There are two types of “good” unsaturated fats:

1. Monounsaturated fats are found in high concentrations in:

- Olive, peanut, and canola oils

- Avocados
- Nuts such as almonds, hazelnuts, and pecans
- Seeds such as pumpkin and sesame seeds

2. Polyunsaturated fats are found in high concentrations in

- Sunflower, corn, soybean, and flaxseed oils
- Walnuts
- Flax seeds
- Fish
- Canola oil – though higher in monounsaturated fat, it’s also a good source of polyunsaturated fat.

Omega-3 fats are an important type of polyunsaturated fat. The body can’t make these, so they must come from food.

- An excellent way to get omega-3 fats is by eating fish 2-3 times a week.
- Good plant sources of omega-3 fats include flax seeds, walnuts, and canola or soybean oil.
- Higher blood omega-3 fats are associated with lower risk of premature death among older adults, according to a study by HSPH faculty.

Most people don’t eat enough healthful unsaturated fats. The American Heart Association suggests that 8-10 percent of daily calories should come from polyunsaturated fats, and there is evidence that eating more polyunsaturated fat—up to 15 percent of daily calories—in place of saturated fat can lower heart disease risk.

- Dutch researchers conducted an analysis of 60 trials that examined the effects of carbohydrates and various fats on blood lipid levels. In trials in which polyunsaturated and monounsaturated fats were eaten in place of carbohydrates, these good fats decreased levels of harmful LDL and increased protective HDL.
- More recently, a randomized trial known as the Optimal Macronutrient Intake Trial for Heart Health (OmniHeart) showed that replacing a carbohydrate-rich diet with one rich in unsaturated fat, predominantly monounsaturated fats, lowers blood pressure, improves lipid levels, and reduces the estimated cardiovascular risk.

Finding Foods with Healthy Fats is a handy visual guide to help you determine which fats are beneficial, and which are harmful.

Saturated Fats

All foods containing fat have a mix of specific types of fats. Even healthy foods like chicken and nuts have small amounts of saturated fat, though much less than the amounts found in beef, cheese, and ice cream. Saturated fat is mainly found in animal foods, but a few plant foods are also high in saturated fats, such as coconut, coconut oil, palm oil, and palm kernel oil.

- The Dietary Guidelines for Americans recommends getting less than 10 percent of calories each day from saturated fat.
- The American Heart Association goes even further, recommending limiting saturated fat to no more than 7 percent of calories.
- Cutting back on saturated fat will likely have no benefit, however, if people replace saturated fat with refined carbohydrates. Eating refined carbohydrates in place of saturated fat does lower “bad” LDL cholesterol, but it also lowers the “good” HDL cholesterol and increases triglycerides. The net effect is as bad for the heart as eating too much saturated fat.

In the United States, the biggest sources of saturated fats in the diet are

- Pizza and cheese
- Whole and reduced fat milk, butter and dairy desserts
- Meat products (sausage, bacon, beef, hamburgers)
- Cookies and other grain-based desserts
- A variety of mixed fast food dishes

Though decades of dietary advice suggested saturated fat was harmful, in recent years that idea has begun to evolve. Several studies suggest that eating diets high in saturated fat do not raise the risk of heart disease, with one report analyzing the findings of 21 studies that followed 350,000 people for up to 23 years.

Trans Fats

Trans fatty acids, more commonly called trans fats, are made by heating liquid vegetable oils in the presence of hydrogen gas and a catalyst, a process called hydrogenation.

- Partially hydrogenating vegetable oils makes them more stable and less likely to become rancid. This process also converts the oil into a solid, which makes them function as margarine or shortening.
- Partially hydrogenated oils can withstand repeated heating without breaking down, making them ideal for frying fast foods.
- For these reasons, partially hydrogenated oils became a mainstay in restaurants and the food industry – for frying, baked goods, and processed snack foods and margarine.

Partially hydrogenated oil is not the only source of trans fats in our diets. Trans fats are also naturally found in beef fat and dairy fat in small amounts.

Trans fats are the worst type of fat for the heart, blood vessels, and rest of the body because they:

- Raise bad LDL and lower good HDL
- Create inflammation,a reaction related to immunity – which has been implicated in heart disease, stroke, diabetes, and other chronic conditions
- Contribute to insulin resistance
- Can have harmful health effects even in small amounts – for each additional 2 percent of calories from trans fat consumed daily, the risk of coronary heart disease increases by 23 percent.

Edible Oil and Non-Edible Oil

All over the world, people have started diversifying oilseed cultivation to better match modern day's health, nutritional and taste requirements. Although oil is popularly derived from oilseeds like groundnut, soybean, sunflower, rapeseed mustered, castor, cotton seed, etc., various tree fruits (like coconut, palm, olive, etc.) are also reliable sources for oils; in fact, fruit sources provide higher yielding. Oil, derived from such vegetable sources, is called vegetable oil. However, every vegetable oil may not necessarily be suitable for human consumption and thus they are used industrially. Moreover, commercial value of certain edible oils is better for industrial usage, for example castor oil.

Apart from vegetable oil, there are many petroleum based oils which are non-edible. Such petroleum oils are extensively used for various industrial applications like fuels. Rapid depletion of petroleum oil reserve along with the steep increase in energy demand throughout the world paved the way for finding out alternative sources for wide industrial requirements. As a result of extensive researches, now-a-days it is possible to utilize certain vegetable oils as bio-diesel and others. However, large scale commercialization is still pending owing to its high cost and low rate of supply. Therefore, all vegetable and petroleum oils can be broadly classified into another two groups—edible oil and non-edible oil.

As the name suggests, **edible oils** are beneficial for human consumption and are popularly used for such purpose. They have high nutritional value and less industrial demand. Such oils also require less processing to make it safe and hygienic for health. Majority of vegetable oils come under edible oil; however not all. There are few vegetable oils and all petroleum oils which are not suitable for eating and have industrial demand. Such oils are grouped under the umbrella of **non-edible oils**. Even animal fats also come under this group. Various differences between edible oil and non-edible oil are given below in table format.

Table: Differences between edible oil and non-edible oil

Edible Oil	Non-Edible Oil
These are based on vegetable sources (oilseed grains and plant fruits).	These can be vegetable oils, petroleum oils or animal fat.
Edible oils are mainly used for direct human consumption as food intake.	Non-edible oils have industrial usages such as fuel and biofuel, or in producing soap, detergent, paint, etc.
Edible oils contain various nutritional elements and thus are healthy and hygienic.	Non-edible oils may not necessarily be healthy and hygienic.
Extraction of edible oil usually does not require any chemical processing.	Different chemical processing are desired to make this oil suitable for a particular application.
These are more expansive due to tight requirement cleanliness and also limited supply.	They have comparatively lower price and are economic for industrial large scale applications.

Sources: Edible oils are directly extracted from oilseed grains, nuts and tree fruits. Thus their sources are predominantly organic; for example seeds of groundnut, soybean, sunflower, rapeseed, linseed, safflower, peanut, etc. Oil extracted from tree fruits or seeds like palm oil, coconut oil, olive oil, etc. are also edible. All vegetable oils are not edible; some vegetable oils have low demand as food source. There are more than 50 crops whose oil is primarily used for industrial purposes, some popular examples are rubber, neem, tobacco, castor, drumstick, almond, avocado, tomato, bean, date, rice, milkweed, sal, salmon, kusum, jojoba, etc. Apart from these non-edible vegetable oils, petroleum based oils and animal fat are predominantly used for non-edible purposes. So non-edible oils consist of non-edible vegetable oils, petroleum oils, and animal fats and therefore, it can be organic or inorganic. However, there exist no clear boundary between culinary use and industrial use, so certain oils can be used for both purposes based on market demand and production.

Applications: Edible oils are consumed, directly or indirectly, as food ingredients. They are mainly used for cooking including sautéing, frying and baking. They can also be consumed directly (like flavouring) without any culinary processing; however, in limited amount. Non-edible oils are not used as food intake, rather they are utilized in various forms for several industrial applications. Few major consumers of such oils are transport industries, candle, soap, synthetic detergent, resin, ink, wax, dye, paint and varnish factories. Non-edible vegetable oils, which are also known as second generation feedstock, can be used for sustainable production of biodiesel and thus have emerged as promising substitute for rapidly depleting petroleum oil reserves. Apart from fuel, they can also be used for the production of lubricant, coolant, engine oil, grease, etc. Some of them also have pesticidal, medicinal and cosmetic usages.

Nutritional value: Edible oils must be rich in nutrition; ideally such oils should be digestible, rich in caloric value and free from unsaturated fat. Most edible oils are actually healthy fat and don't contain any toxic component like lectin that can pose a risk on human health. Oils help absorbing fat soluble vitamins (A, D, E, and K) and also provide other benefits. Non-edible oils are either not safe for human consumption as food or not rich in nutrition.

Processing requirement: Usually edible oils do not require any chemical processing for its extraction from oilseeds, nuts or fruits. Cold or hot pressing are considered as sufficient for extraction. First pressed oil are of high quality in terms of nutrition and purity and the same has extra value towards culinary usage. However, animal fat must be processed in various physical and chemical methods before its consumption. Non-edible organic or inorganic oil usually requires several chemical treatments to make it suitable for specific purpose.

Oil cost: Edible oil extraction process must be hygienic with highest level of purity. Any deviation may cause altercation with toxic elements or bacterial infection that can make the oil unsafe for human consumption. Tight quality control requirement along with higher demands and limited production made edible oil costlier. Non-edible vegetable oil plants can be grown in marginal lands having low fertility. They can be grown in arid zones (regions with low rainfall) with minimum requirement of irrigation facility. Apart from oil, such plants also generate by-products that have sufficient commercial value. So non-edible vegetable oils are cheaper as compared to edible one. Other forms of non-edible oils are also cheaper but their resources are limited and are influenced by geo-political factors.

Fatty acid

In chemistry, particularly in biochemistry, a **fatty acid** is a carboxylic acid with an aliphatic chain, which is either saturated or unsaturated. Most naturally occurring fatty acids have an unbranched chain of an even number of carbon atoms, from 4 to 28.[1] Fatty acids are a major component of the lipids (up to 70 wt%) in some species such as microalgae[2] but in some other organisms are not found in their standalone form, but instead exist as three main classes of esters: triglycerides, phospholipids, and cholesteryl esters. In any of these forms, fatty acids are both important dietary sources of fuel for animals and important structural components for cells.

Saturated fatty acid

Saturated fatty acids have no C=C double bonds. They have the same formula $CH_3(CH_2)_nCOOH$, with variations in "n". An important saturated fatty acid is stearic acid (n = 18), which when neutralized with lye is the most common form of soap.

Arachidic acid, a saturated fatty acid.

Examples of saturated fatty acids

Common name	Chemical structure	
Caprylic acid	$CH_3(CH_2)_6COOH$	8:0
Capric acid	$CH_3(CH_2)_8COOH$	10:0
Lauric acid	$CH_3(CH_2)_{10}COOH$	12:0
Myristic acid	$CH_3(CH_2)_{12}COOH$	14:0
Palmitic acid	$CH_3(CH_2)_{14}COOH$	16:0
Stearic acid	$CH_3(CH_2)_{16}COOH$	18:0
Arachidic acid	$CH_3(CH_2)_{18}COOH$	20:0

Behenic acid	$CH_3(CH_2)_{20}COOH$	22:0
Lignoceric acid	$CH_3(CH_2)_{22}COOH$	24:0
Cerotic acid	$CH_3(CH_2)_{24}COOH$	26:0

C:D“ is the numerical symbol: total amount of (C)arbon atoms of the fatty acid, and the number of (D)ouble (*unsaturated*) bonds in it; if D > 1 it is assumed that the double bonds are separated by one or more methylene bridge(s).

Unsaturated fatty acids have one or more C=C double bonds. The C=C double bonds can give either *cis* or *trans* isomers.

cis

A *cis* configuration means that the two hydrogen atoms adjacent to the double bond stick out on the same side of the chain. The rigidity of the double bond freezes its conformation and, in the case of the *cis* isomer, causes the chain to bend and restricts the conformational freedom of the fatty acid. The more double bonds the chain has in the *cis* configuration, the less flexibility it has. When a chain has many *cis* bonds, it becomes quite curved in its most accessible conformations. For example, oleic acid, with one double bond, has a "kink" in it, whereas linoleic acid, with two double bonds, has a more pronounced bend. α-Linolenic acid, with three double bonds, favors a hooked shape. The effect of this is that, in restricted environments, such as when fatty acids are part of a phospholipid in a lipid bilayer or triglycerides in lipid droplets, cis bonds limit the ability of fatty acids to be closely packed, and therefore can affect the melting temperature of the membrane or of the fat. Cis unsaturated fatty acids, however, increase cellular membrane fluidity, whereas trans unsaturated fatty acids do not.

trans

A *trans* configuration, by contrast, means that the adjacent two hydrogen atoms lie on *opposite* sides of the chain. As a result, they do not cause the chain to bend much, and their shape is similar to straight saturated fatty acids.

In most naturally occurring unsaturated fatty acids, each double bond has three (n-3), six (n-6), or nine (n-9) carbon atoms after it, and all double bonds have a cis configuration. Most fatty acids in the *trans* configuration (trans fats) are not found in nature and are the result of human processing (e.g., hydrogenation). Some trans fatty acids also occur naturally in the milk and meat of ruminants (such as cattle and sheep). They are produced, by fermentation, in the rumen of these animals. They are also found in dairy products from milk of ruminants, and may be also found in breast milk of women who obtained them from their diet.

The geometric differences between the various types of unsaturated fatty acids, as well as between saturated and unsaturated fatty acids, play an important role in biological processes, and in the construction of biological structures (such as cell membranes).

Common name	**Chemical structure**	**Δx**[11]	***C*:*D***[10]
Myristoleic acid	$CH_3(CH_2)_3$**CH=CH**$(CH_2)_7COOH$	*cis*-Δ^9	14:1
Palmitoleic acid	$CH_3(CH_2)_5$**CH=CH**$(CH_2)_7COOH$	*cis*-Δ^9	16:1
Sapienic acid	$CH_3(CH_2)_8$**CH=CH**$(CH_2)_4COOH$	*cis*-Δ^6	16:1
Oleic acid	$CH_3(CH_2)_7$**CH=CH**$(CH_2)_7COOH$	*cis*-Δ^9	18:1
Elaidic acid	$CH_3(CH_2)_7$**CH=CH**$(CH_2)_7COOH$	*trans*-Δ^9	18:1
Vaccenic acid	$CH_3(CH_2)_5$**CH=CH**$(CH_2)_9COOH$	*trans*-Δ^{11}	18:1
Linoleic acid	$CH_3(CH_2)_4$**CH=CH**CH_2**CH=CH**$(CH_2)_7COOH$	*cis*,*cis*-Δ^9,Δ^{12}	18:2
Linoelaidic acid	$CH_3(CH_2)_4$**CH=CH**CH_2**CH=CH**$(CH_2)_7COOH$	*trans*,*trans*-Δ^9,Δ^{12}	18:2
α-Linolenic acid	CH_3CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**$(CH_2)_7COOH$	*cis*,*cis*,*cis*-Δ^9,Δ^{12},Δ^{15}	18:3
Arachidonic acid	$CH_3(CH_2)_4$**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**$(CH_2)_3COOH$[NIST]	*cis*,*cis*,*cis*,*cis*-$\Delta^5\Delta^8$,Δ^{11},Δ^{14}	20:4
Eicosapentaenoic acid	CH_3CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**$(CH_2)_3COOH$	*cis*,*cis*,*cis*,*cis*,*cis*-	20:5

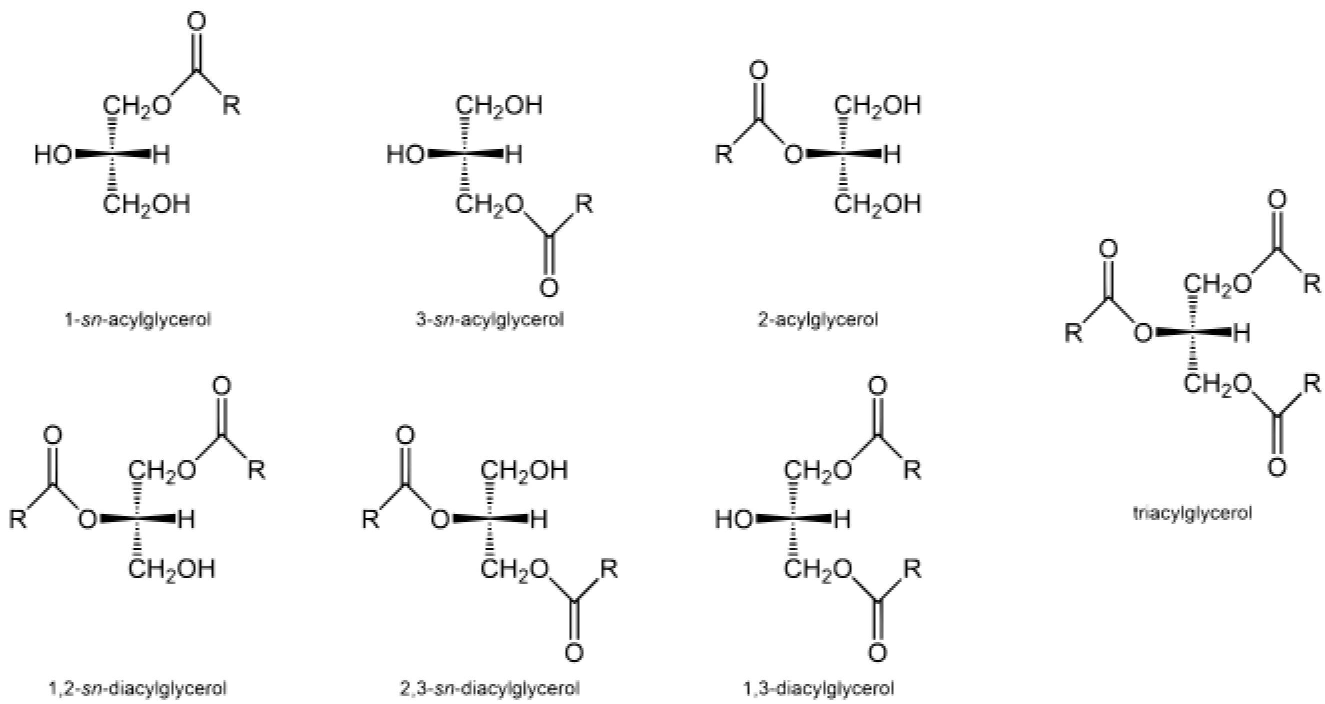
		Δ^5,Δ^8,Δ^{11},Δ^{14},Δ^{17}	
Erucic acid	$CH_3(CH_2)_7$**CH=CH**$(CH_2)_{11}COOH$	*cis*-Δ^{13}	22:1
Docosahexaenoic acid	CH_3CH_3**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**CH_2**CH=CH**$(CH_2)_2COOH$	*cis*,*cis*,*cis*,*cis*,*cis*,*cis*-Δ^4,Δ^7,Δ^{10},Δ^{13},Δ^{16},Δ^{19}	22:6

Each double bond in the fatty acid is indicated by Δx, where the double bond is located on the xth carbon–carbon bond, counting from the carboxylic acid end.

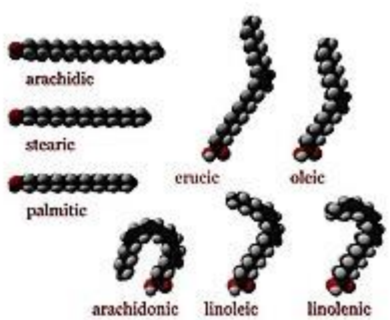
Glyceride

Glycerides, more correctly known as **acylglycerols**, are esters formed from glycerol and fatty acids, and are generally very hydrophobic.

Glycerol has three hydroxyl functional groups, which can be esterified with one, two, or three fatty acids to form mono-, di-, and triglycerides. These structures vary in their fatty acid alkyl groups as they can contain different carbon numbers, different degrees of unsaturation, and different configurations and positions of olefins.[1]



General structures of mono-, di-, and tri-acylglycerides with names according to the stereospecific numbering



Vegetable oils and animal fats contain mostly triglycerides, but are broken down by natural enzymes (lipases) into mono and diglycerides and free fatty acids and glycerol.

Soaps are formed from the reaction of glycerides with sodium hydroxide. The product of the reaction is glycerol and salts of fatty acids. Fatty acids in the soap emulsify the oils in dirt, enabling the removal of oily dirt with water.

Partial glycerides are esters of glycerol with fatty acids, where not all the hydroxyl groups are esterified. Since some of their hydroxyl groups are free their molecules are polar. Partial glycerides may be monoglycerides (two hydroxyl groups free) or diglycerides (one hydroxyl group free). Short chain partial glycerides are more strongly polar than long chain partial glycerides, and have excellent solvent properties for many hard-to-solubilize drugs, making them valuable as excipients in improving the formulation of certain pharmaceuticals. The most common forms of acylglycerol are triglycerides, having high caloric value and usually yielding twice as much energy per gram as carbohydrate. [2]

What is hydrogenated oil?

Food companies began using hydrogenated oil to help increase shelf life and save costs. Hydrogenation is a process in which a liquid unsaturated fat is turned into a solid fat by adding hydrogen. During this manufactured partially hydrogenated processing, a type of fat called trans fat is made.

While small amounts of trans fats are found naturally in some foods, most trans fats in the diet come from these processed hydrogenated fats.

Partially hydrogenated oils can affect heart health because they increase "bad" (low-density lipoprotein, or LDL) cholesterol and lower "good" (high-density lipoprotein, or HDL) cholesterol. On the other hand, a fully hydrogenated oil contains very little trans fat, mostly saturated fat, and doesn't carry the same health risks as trans fat.

Still, food manufacturers continue to use partially hydrogenated oils to:

- save money
- extend shelf life
- add texture
- increase stability

Partially hydrogenated oil isn't always easy to spot, but there are ways to spot it and avoid it.

Vanaspati

Vanaspati is a fully or partially hydrogenated vegetable cooking oil often used as a cheaper substitute for ghee. Vanaspati is a desi vegetable ghee that has been hydrogenated and hardened. It is much cheaper than desi ghee. All brands of Vanaspati are made from palm or palm olein oil. **Hydrogenation is brought about by using nickel as a catalyst in reactors at low to medium pressure. Vanaspati contains trans fats. It is used for cooking purposes in different domestic and commercial places. They are rich in the taste and flavor.**

Ghee is primarily used for cooking and frying and as dressing or toppings for various foods. It is also used in the manufacture of snacks and sweets often mixed with vegetables, cereals, fruits, and nuts. In some parts of the world, ghee is considered as a sacred product and is used in religious rites. It could also be mentioned that ghee is used in Ayurveda, which is a system of traditional medicine developed in India several thousand years ago and now also practiced in other parts of the world as alternative medicine.

There are various different forms of edible oil found in the market. One of the old and most highly used form is the vanaspati ghee; this is a cheaper version of the pure ghee which is the most used and ancient form of fatty oil used by Indians made from cow milk.

Margarine

Margarine is a spread used for flavoring, baking and cooking. It is most often used as a substitute for butter. Although originally made from animal fats, most margarine consumed today is made from vegetable oil. The foodstuff was originally named *oleomargarine* from Latin for *oleum* (olive oil) and Greek *margarite* (pearl indicating luster). The name was later shortened to *margarine*.[2]

Margarine consists of a water-in-fat emulsion, with tiny droplets of water dispersed uniformly throughout a fat phase in a stable solid form. While butter is made from the butterfat of milk, modern margarine is made through a more intensive processing of refined vegetable oil and water. In some US jurisdictions, margarine must have a minimum fat content of 80 percent (with a maximum of 16% water) to be labeled as such

The basic method of making margarine today consists of emulsifying a blend of oils and fats from vegetable and animal sources, which can be modified using fractionation, interesterification or hydrogenation, with skimmed milk which may be fermented or soured, salt, citric or lactic acid, chilling the mixture to solidify it, and working it to improve the texture. Margarines and vegetable fat spreads found in the market can range from 10% to 90% fat, depending on dietary marketing and purpose (spreading, cooking or baking). The softer tub margarines are made with less hydrogenated and more liquid oils than block margarines.

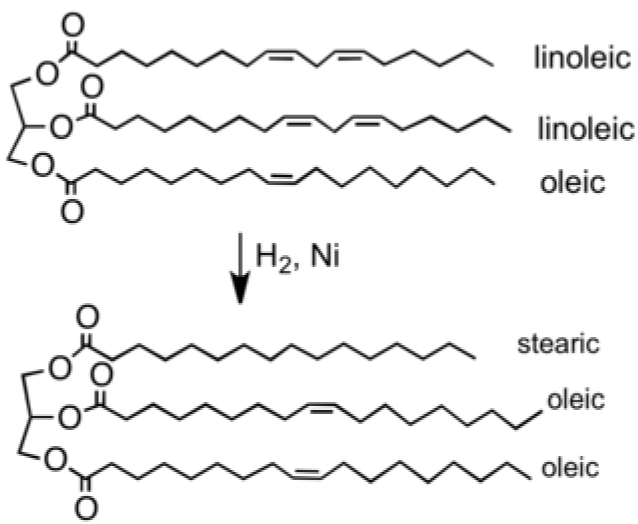
Three types of margarine are common:

- Bottled liquid margarine to cook or top dishes.
- Soft vegetable fat spreads, high in mono- or polyunsaturated fats, which are made from safflower, sunflower, soybean, cottonseed, rapeseed, or olive oil.
- Hard margarine (sometimes uncolored) for cooking or baking.

Technically, margarine is a form of shortening, but the commercial products sold as “shortening” are generally uncolored and do not taste like butter.

To produce margarine, first oils and fats are extracted, e.g. by pressing from seeds, and then refined. Oils may undergo a full or partial hydrogenation process to solidify them. The milk/water mixture is kept separate from the oil mixture until the emulsion step. The fats are warmed so that they are liquid during the mixing process. The water-soluble additives are added to the water or milk mixture, and emulsifiers such as lecithin are added to help disperse the water phase evenly throughout the oil. Other water-soluble additives include powdered skim milk, salt, citric acid, lactic acid, and preservatives such as potassium sorbate. The fat soluble additives are mixed into the oil. These include carotenoids for coloring and antioxidants. Then the two mixtures are emulsified by slowly adding the oil into the milk/water mixture with constant stirring. Next, the mixture is cooled. Rapid chilling avoids the production of large crystals and results in a smooth texture. The product is then rolled or kneaded. Finally, the product may be aerated with nitrogen to facilitate spreading it.

Hydrogenation



Partial hydrogenation of a typical plant oil to a typical component of margarine. Most of the C=C double bonds are removed in this process, which elevates the melting point of the product.

Vegetable and animal fats are similar compounds with different melting points. Fats that are liquid at room temperature are generally known as oils. The melting points are related to the presence of carbon-carbon double bonds in the fatty acids components. A higher number of double bonds gives a lower melting point. Oils can be converted into solid substances at room temperature through hydrogenation.

Commonly, natural oils are hydrogenated by passing hydrogen gas through the oil in the presence of a nickel catalyst, under controlled conditions.[c The addition of hydrogen to the unsaturated bonds (alkenic double C=C bonds) results in saturated C-C bonds, effectively increasing the melting point of the oil and thus "hardening" it. This is due to the increase in van der Waals' forces between the saturated molecules compared with the unsaturated molecules. However, as there are possible health benefits in limiting the amount of saturated fats in the human diet, the process is controlled so that only enough of the bonds are hydrogenated to give the required texture. Margarines made in this way are said to contain hydrogenated fat.[29] This method is used today for some margarines although the process has been developed and sometimes other metal catalysts are used such as palladium.] If hydrogenation is incomplete (partial hardening), the relatively high temperatures used in the hydrogenation process tend to flip some of the carbon-carbon double bonds into the "trans" form. If these particular bonds are not hydrogenated during the process, they remain present in the final margarine in molecules of trans fats, the consumption of which has been shown to be a risk factor for cardiovascular disease. For this reason, partially hardened fats are used less and less in the margarine industry. Some tropical oils, such as palm oil and coconut oil, are naturally semi-solid and do not require hydrogenation.