Fats and Oils:

Fats and oils are chemical units commonly called “triglycerides” resulting from the combination of one unit of glycerol with three units of fatty acids. These triglycerides are found in both plants and animals, and composed one of the major food groups of our diet. They are insoluble in water but soluble in most of organic solvents such as petroleum ether, benzene, hexane, carbon tetra chloride, ethyl alcohol etc. Triglycerides that are solid or semi solid at room temp. Are classified as fats, and occur mainly in animals. Those triglycerides that are liquid are called oils and originate chiefly in plants, although triglycerides from fish are also largely oils. Fats and oils are important source of energy. They supply more than twice the energy as supplied by proteins and carbohydrates. They are excellent source of fat soluble vitamins.

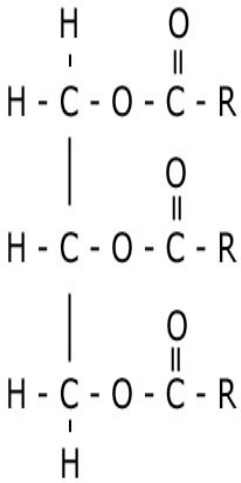
Oils: Esters of fatty acids and glycerol which normally are liquid at room temperature (21.1 – 23.9^{0}C) eg sunflower oil, mustard oil, groundnut oil, olive oil etc.

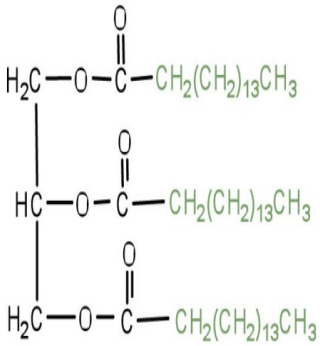
Fats: Esters of fatty acids and glycerol which normally are solid at room temperature (21.1 – 23.9^{0}C) eg lard, tallow, butter etc.

Esters: The chemical reaction product of an acid and an alcohol.

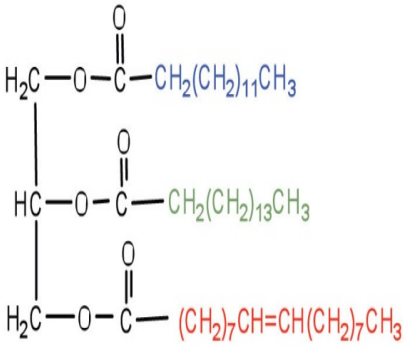
Acid: Is a molecule or ion capable of donating a hydron (proton or hydrogen ion $H^{+)}$

Triglycerides: is an ester resulting from the combination of glycerol and three fatty acids. When all of these three fatty acids in a triglyceride are identical, it is termed as a simple triglyceride and when 2 or 3 kinds of fatty acids are present it is termed as mixed triglyceride.





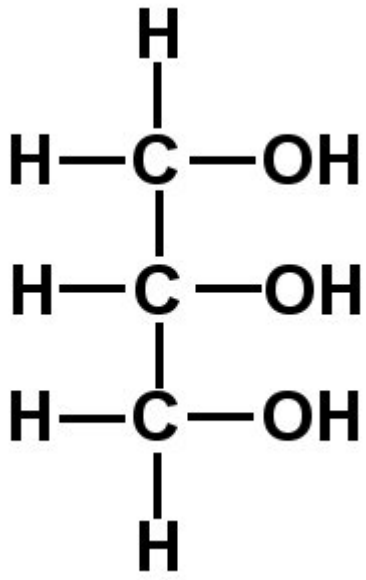
Tristearin
a simple triglyceride



a mixed triglyceride

When three fatty acids are combined to a glycerol molecule we have a triglyceride.

Glycerol:

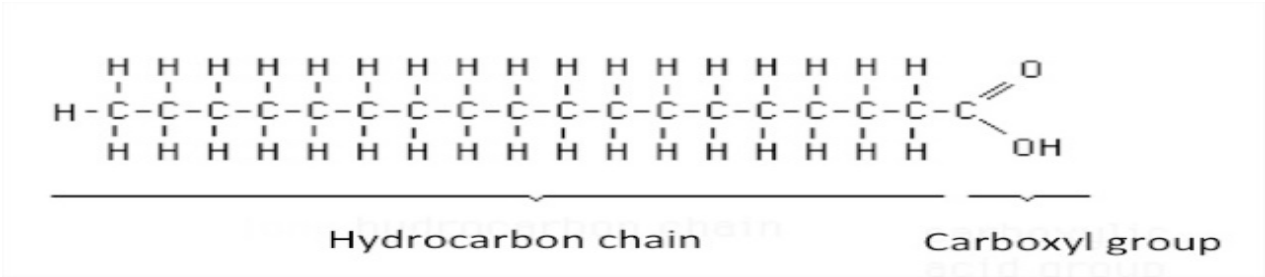


Contain 3 carbons, 5- hydrogen and 3 reactive OH group

Fatty acids: A chemical unit composed of a chain of carbon and hydrogen atoms ending with a reactive group consisting of carbon, hydrogen and oxygen (COOH) which is the fundamental unit within a triglyceri1de fat molecule.

Or

A long carbon chain having a COOH group at one end a methyl group at the other end

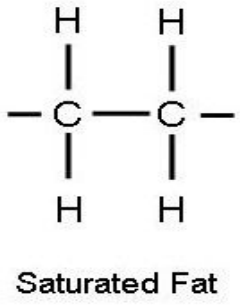


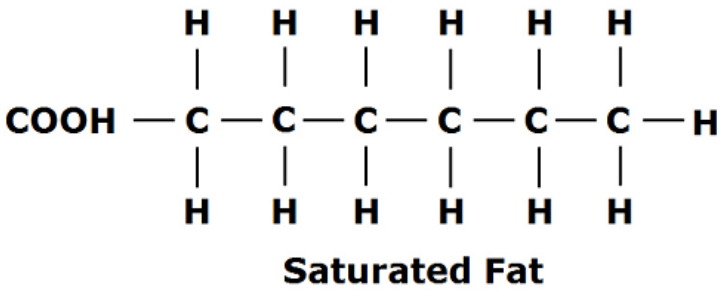
The general formula for fatty acid is “RCOOH” where “R” stands for hydrocarbon portion or alkyl group, which are different in different fatty acids. Most fatty acids have 4-22 carbon atoms, primarily in even number.

Types of fatty acids:

- Saturated Fatty Acids
- Unsaturated Fatty Acids

Saturated Fatty Acids: Those containing only single carbon-to-carbon bonds are termed as saturated fatty acids and are less reactive chemically.





Examples:

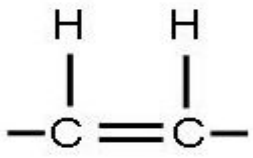
Acid	Formulae	No. Of carbon atom	Source
Butyric Acid	C_3H_7COOH	4	Butter

Lauric Acid	$C_{11}H_{23}COOH$	12	Coconut
Myristic Acid	$C_{13}H_{27}COOH$	14	Palm, Butter, Coconut
Palmitic Acid	$C_{15}H_{31}COOH$	16	Meat fat, Palm, Butter
Stearic Acid	$C_{17}H_{35}COOH$	18	Cocoa butter, Animal fat

Unsaturated Fatty acids: Fatty acids containing one or more carbon-to-carbon double bond are termed as unsaturated fatty acids.

Or

Fatty acid in which there is at least one double bond within the fatty acid chain. eg. Oleic, linoleic, linolenic, archidonic acid.



Unsaturated Fat

Unsaturated fatty acids further classified into two groups-

***MUFA (mono unsaturated fatty acid**): Fatty acid containing one carbon-to-carbon double bond in their structure.eg. Oleic acid

$CH_3\ (CH_2)_7CH{=}CH\ (CH_2)_7COOH$

$C_{17}H_{33}COOH$ (olive oil, peanut oil, animal fat, corn)

***PUFA (poly unsaturated fatty acid):** Fatty acids containing more than one carbon-to-carbon double bond in their structure. Eg. Linoleic acid

$CH_3\ (CH_2)_4CH{=}CH\ CH_2\ CH{=}CH\ (CH_2)_7COOH$

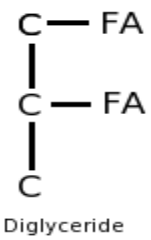
$C_{17}H_{31}COOH$ (sunflower oil, corn oil, cotton seed oil)

Linolenic acid

$CH_3\ CH_2CH{=}CH\ CH_2\ CH{=}CH{=}CH\ CH_2\ CH\ {=}CH\ (CH_2)_7COOH$

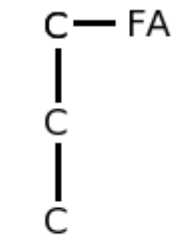
$C_{17}H_{29}COOH$ (soyabean oil, canola oil)

Diglyceride: The ester resulting from the combination of glycerol and 2 fatty acids.



Diglyceride

Monoglyceride: The ester resulting from the combination of glycerol and one fatty acid.



Monoglyceride

Essential fatty acids: are those fatty acids which cannot be synthesised in the body and therefore need to be provided through dietary sources these are therefore called as essential fatty acids. Eg. Linolleic acid, Linolenic acid, archidonic acid. Of these Linoleic acid is most important as its presence is necessary for synthesizing archidonic acid in the body.

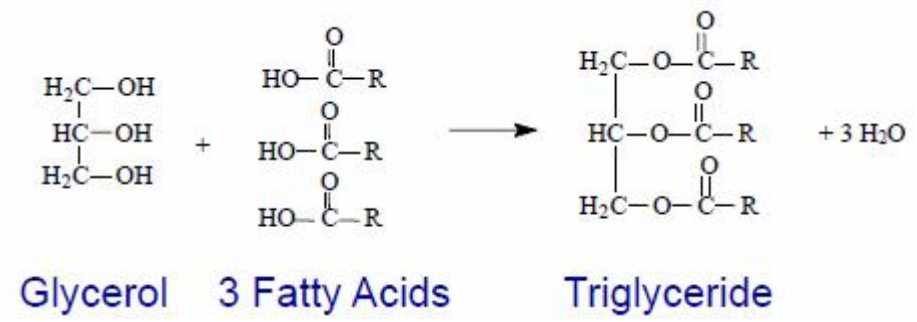
Importance of essential fatty acids:

i) Lowering cholesterol level
ii) Maintaining membrane structure
iii) Prevent impotency in men
iv) Prevent falling of hair and roughness of skin
v) Produce smooth and delicate complexion
vi) Used as a precursor for synthesis of prostaglandins (help in production of male sex harmone)

Free fatty acids: are those fatty acids in a fat which are not chemically bound to glycerol molecules. Unrefined oils contain high level of free fatty acids. Eg. crude soyabean oil contain 1-1.5% & crude palm oil contain 3-5% free fatty acids.

Simple structure of fat:

The simplest structure of fat contains one molecule of glycerol and 3 molecules of fatty acid and therefore termed as triglyceride.



Invisible fat: is defined as the fat present naturally in foods such fat is referred to as invisible fat eg. of foods containing invisible fat include meat, poultry, fish, dairy products, egg, nuts and seeds.

Visible fat: are made from meat, poultry, fish, dairy products, egg, nuts and seeds eg. Lard , cooking oil, salad oil, margarine, butter.

Shortenings: Shortenings are semisolid fats that impart a "short" or tender quality to baked goods, enhance the aeration of leavened products, and promote a desirable grain and flavour. They coat the gluten proteins of flour which prevents toughness. In contrast, toughness is desirable in yeast-raised products to give a chewy texture.

Omega fatty acids: "Omega" or "n misinus" classification is the another system of nomenclature used for unsaturated fatty acids.

Omega 3 Fatty Acids

Omega 3 fats are a kind of polyunsaturated fats. They have traditionally been classified as "essential fatty acids" because the body is unable to manufacture them on its own and because they play a fundamental role in several physiological functions.

"Omega" or "n misinus" refers to the position of double bond of the fatty acid closest to the methyl end of the molecule. Eg. Oleic acid

$CH_3 (CH_2)_7CH=CH (CH_2)_7COOH$

Omega-9 fatty acid

Omega-3 fatty acid is a type of polyunsaturated fat that is especially healthy. Omega-3 fatty acids help to reduce the risk of heart disease, lower blood pressure, guard against plaque buildup in the arteries, and aid in brain development. It is found in some plant oils and in the tissues of all sea creatures. Among the plant oils rich in omega-3 fatty acids are flaxseed, canola, and soybean oil. Fish that are particularly high in omega-3 are sardines, herring, tuna, and salmon.

Trans fats

Trans-fatty acid, also known as trans-fat, is formed when hydrogen is added to vegetable oil in order to change the liquid oil into a solid at room temperature. This process is known as hydrogenation, which also transforms the unsaturated fats of the liquid oils into saturated fat. In some cases, trans-fat may be worse in terms of health related issues than naturally occurring saturated fats. Like saturated fat, trans-fat may raise blood cholesterol levels and increase the risk of heart related diseases. Many shortenings, margarines, and commercially baked goods are high in trans-fatty acids.

Trans fats are rare in nature – they are only created in the stomach of cows and sheep. Because of this, trans fats are naturally found in small amounts in milk, cheese, beef and lamb. Trans fats are also created during the manufacture of some baked products such as pies, pastries, cakes, biscuits and buns. It is the trans fats that are produced during food manufacturing that you should be most concerned about, not the small amounts of trans fats naturally found in healthy foods like low-fat dairy products and lean meats.

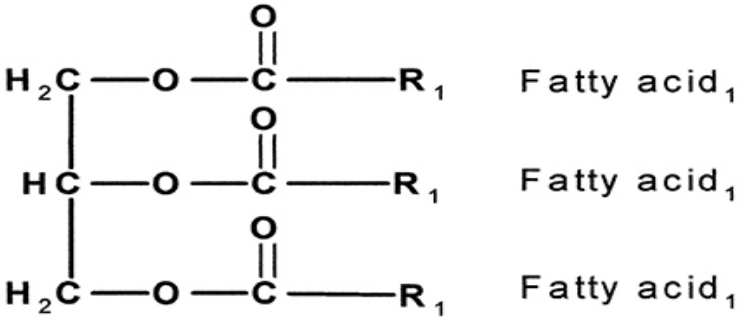
Composition of oils and fats

Triglycerides are the main component of most food fats and oils. The minor components include mono- and diglycerides, free fatty acids, phosphatides, sterols, fatty alcohols, fat-soluble vitamins, and other substances.

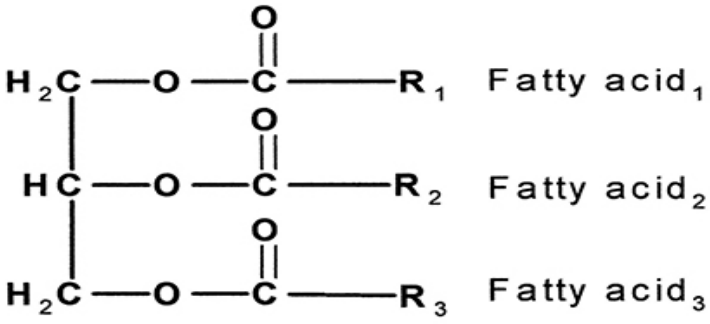
Major component:

Triglycerides:

A triglyceride is composed of glycerol and three fatty acids. When all of the fatty acids in a triglyceride are identical, it is termed a "simple" triglyceride. The more common forms, however, are the "mixed" triglycerides in which two or three kinds of fatty acids are present in the molecule.



Simple Triglyceride

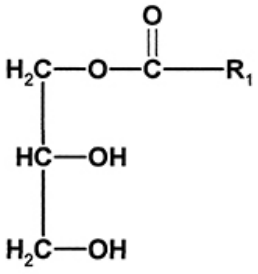


Mixed Triglyceride

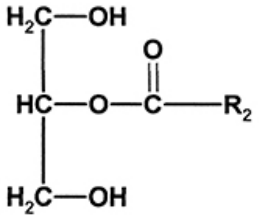
Minor components:

i) Mono- and diglycerides:

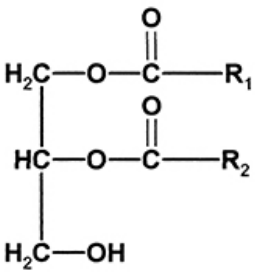
Mono- and diglycerides are mono- and diesters of fatty acids and glycerol. They are used frequently in foods as emulsifiers. They are prepared commercially by the reaction of glycerol and triglycerides or by the esterification of glycerol and fatty acids. Mono- and diglycerides are formed in the intestinal tract as a result of the normal digestion of triglycerides. They occur naturally in very minor amounts in both animal fats and vegetable oils.



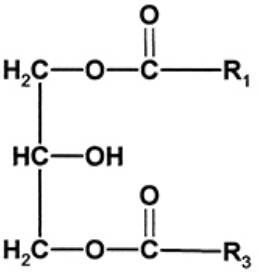
1 (α) - Monoglyceride



2 (β) - Monoglyceride



1, 2 (α, β) - Diglyceride



1, 3 (α, α') - Diglyceride

ii) Free fatty acids

Free fatty acids are the unattached fatty acids present in a fat. Some unrefined oils may contain as much as several percent free fatty acids. The levels of free fatty acids are reduced in the refining process. Fully refined fats and oils usually have a free fatty acid content of less than 0.1%.

iii) Phosphatides

Phosphatides, also known as phospholipids, consist of phosphoric acid and nitrogenous base in addition to fatty acid and glycerol. The majority of the phosphatides are removed from oil during the degumming and refining operations. Phosphatides are an important source of natural emulsifiers marketed as lecithin.

iv) Sterols

also known as steroid alcohols, are a class of chemicals that play multiple important role in body. They have parts that can dissolve in fat like molecules and parts that can dissolve in water. The most commonly known human sterol is cholesterol, which serve as a precursor to steroid hormones and fat soluble vitamins.

v) Fatty alcohols

Long chain alcohols are of little importance in most edible fats. A small amount esterified with fatty acids is present in waxes found in some vegetable oils. Larger quantities are found in some marine oils.

vi) Tocopherols

Tocopherols are important minor constituents of most vegetable fats. They serve as antioxidants to delay rancidity and as sources of the essential nutrient vitamin E. There are four types of tocopherols(alpha (α), beta (β), gamma (γ), and delta (δ)) varying in antioxidation and vitamin E activity. Among tocopherols, alpha-tocopherol has the highest vitamin E activity and the lowest antioxidant activity. Delta tocopherol has the highest antioxidant activity. Tocopherols which occur naturally in most vegetable oils are partially removed during processing.

vii) Pigments

Carotenoids are yellow to deep red color materials that occur naturally in fats and oils. They consist mainly of carotenes such as lycopene, and xanthophylls such as lutein. Palm oil contains the highest concentration of carotene. Chlorophyll is the green coloring matter of plants which plays an essential role in photosynthesis. Canola oil contains the highest levels of chlorophyll among common vegetable oils. At times, the naturally occurring level of chlorophyll in oils may cause the oils to have a green tinge. Gossypol is a pigment found only in cottonseed oil. The levels of most of these color bodies are reduced during the normal processing of oils to give them acceptable color, flavor, and stability.

Properties of oils and fats:

Fats and oils exhibit physical and chemical properties according to their fatty acid composition and their arrangement in the structure of the oil or fat.

Chemical properties:

1. Hydrolysis
2. Hydrogenation
3. Oxidation
4. Polymerization
5. Esterification
6. Interesterification /Rearrangement
7. Halogenation
8. Isomerisation
9. Rancidity

1. Hydrolysis:

Hydrolysis is the reaction of water with a fat. This results in the splitting of some the fatty acids from the fat or oil, yielding some free fatty acids and some glycerol. Some mono and diglycerides are produced, but in the frying operation this is not significant.

Triglyceride + water -------→ Glycerol + 3 free fatty acids

Hydrolysis is a reaction that takes place at the junction of the fatty acids and the glycerin portion of the molecule. Hydrolysis is accelerated by high temps and excessive amount of water.

2. Hydrogenation:

This is one of the more important chemical reactions of food fats. It is a typical example of a reaction that occurs at the point of unsaturation or double bonds.

$$\text{Fatty acid} + H_2 \xrightarrow[\text{Nickel catalyst}]{\text{Heat}} \text{Hydrogenated fatty acid}$$

In this process hydrogen gas is added directly at the point of unsaturation (means double bonds) in the fatty acids. This reaction is used to make fat products with greater flavour stability, minimizing the possibility of oxidation, especially if fatty acids such as linolenic (three points of unsaturation on the same fatty acid) and to change the physical form. In this process the oil is heated with a solid catalyst (nickel) and gaseous hydrogen is added at a high temperature and pressure.

3. Oxidation:

Like hydrogenation, this reaction occurs at the double bonds or point of unsaturation.

$$\text{Fatty acid} + \text{oxygen} \xrightarrow{\text{Light, Heat, Time}} \text{Peroxide}$$

This is the reaction of a fat or oil with oxygen in the air, and with food this is not good because the reaction will adversely affect the flavour of the fat and the food in which it is used.

Products containing a higher proportion of unsaturated fatty acids are more susceptible to oxidation than those containing lesser amounts.

The rate of oxidation increases with an increase in temp, exposure to oxygen in the air, the presence of light, and contact with materials that are classified as proxidants. An excellent example of a proxidant is the metal copper.

4. Polymerization:

This is the reaction of a fat with itself, where by relatively small molecules of fat or oil combine to form much larger molecules. Polymerization may occur either at points of unsaturation on fatty acids chains or at the junction of the fatty acid and glycerol molecules.

$$R + R \longrightarrow (R)_2$$

The polymerized molecule may be as much as hundreds and thousands of times the molecular weight of the original molecules.

Polymerization can occur in the deep frying of foods, where frying is done at temps ranging from 325-375^{0}F. Polymerization is evidenced by deposits of a gum like material around the sides of the frying kettle especially where fat, metal and air are in contact with each other. Polymerization also causes an increase in the viscosity of the frying oil. If polymerization is allowed to proceed to extremes, it can result in foaming of the frying fat.

5. Esterification:

This is reverse of hydrolysis and involves combining and recombining of fatty acids with glycerol to form triglycerides. Monoglycerides and diglycerides may also be produced by Esterification. Monoglycerides are important as emulsifying agents in many food products.

6. Interesterification/Rearrangement:

Means migration or interchange of fatty acid radicals from one fat molecule to another or from one point to another to develop specific properties in the resulting new fat molecule. When fat is heated in the presence of nitrogen and a suitable catalyst, fatty acid radicals migrate and recombine readily with glycerol to form new glyceride. (249^{0}C)

7. Halogenation:

The halogens include chlorine, bromine and iodine. They can readily add to the double bonds of unsaturated fatty acids. This process used in laboratories to determine the degree of unsaturation of a fat.

8. **Isomerization:** Is the process by which one molecule is transformed into another molecule which has exactly the same atoms but atoms are re-arranged.

   or

   It takes place when two or more fats are composed of same fatty acids although in different structural arrangement. Two important types of isomers have been identified, the cis and trans

If the hydrogen atoms are on the same side of the carbon chain, the arrangement is called cis, and if the hydrogen atoms are on opposite sides of the carbon chain, the arrangement is called trans

10. Rancidity: The development of off flavors in fat is known as rancidity. There are three types of rancidity:

    i) Hydrolytic rancidity: In this kind of rancidity the fats are hydrolyzed by enzyme such as lipases and broken down into glycerol and fatty acids. The enzyme may be present naturally in the fats or through microorganisms in foods cooked in the fats. The unpleasant taste and smell in the products is due to the formation of short chain fatty acids like butyric acid as found in rancid butter.

    ii) Oxidative rancidity: This refers to the reaction between unsaturated triglycerides and oxygen from the air, leading to the formation of aldehydes and ketones responsible for unpleasant rancid taste and odour.

iii) Ketonic rancidity: This type of rancidity occurs by the action of fungi such as *Aspergillus niger* and blue green mold. The tallowy odour developed by the action of enzyme present in fungi on oil.

Physical properties:

1. Color
2. Flavour
3. Feel
4. Satiety
5. Solubility
6. Aeration
7. Viscosity
8. Melting
9. Emulsification
10. Smoking
11. Flashing
12. Plasticity

1. **Color:** The colour of fats and oils ranges from light yellow through amber and various shades of brown.
2. **Flavour:** Fats usually act as vehicles for releasing and enhancing flavours of other ingredients with which they are combined in foods, since most flavouring compounds are fat soluble. Fats with lower viscosity and sharp melting points release flavours more readily than those with higher melting points. Butterfat, mustard and coconut oils are examples of fats which posses distinctive flavours and aroma.

3. **Feel**: Fats feel oily to the touch and exhibit lubricating properties. They form a greasy film around foods and prolong shelf life, prevent shrinkage in storage. This lubricating function is important in grilling foods as it helps in moisture and flavour retention. Fats act as lubricants and help in swallowing foods making them slippery and soft which may otherwise irritate the mucous membranes of the mouth and throat.
4. **Satiety:** Compared with other energy giving foods, fats provide greater satiety value. This is because they are digested slowly and therefore remain in the stomach longer, warding off the feeling of hunger. Besides, they also provide twice as much energy as carbohydrates or proteins and therefore help to relieve hunger for longer periods while at the same time increasing palatability of foods and meal satisfactions
5. **Solubility:** Fats and oils are in soluble in water, but in the presence of emulsifier can be made to mix and remain in dispersion. However they are soluble in organic solvents, a property used in their extraction from foods.
6. **Aeration:** Fats possess the property of aerating foods by forming a film around the fine grains of flour being used in batters and dough's, creating spaces for air or gas and thus helping to improve the volume of foods when heated, resulting in soft spongy textures.
7. **Viscosity**: Viscosity of oils decreases with increase in unsaturation of the fatty acids present. Fatty acids of relatively low molecular weight are less viscous then those of high weight, irrespective of the degree of the degree of unsaturation. Polymerization of fats also increases viscosity.
8. **Melting**: Most fats melt between 30-40^{0}C. The melting point of oils is usually the temp at which the viscosity or flow increases and the oil becomes more transparent and clear. The longer the carbon chain in the structure of the fat the higher is its melting point. For e.g. the melting point of cocoa butter ranges between 29-34^{0}C, palm oil is also less than 37^{0}C while vanaspati varies from 31-41^{0}C.
9. **Emulsification:** Fats exhibits the property of emulsification if beaten with water or any liquid and air. It is due to this property that it is possible to cream fat with sugar or other ingredients in food preparation.
10. **Smoking**: When a fat or oil is heated to high temps the triglycerides gradually breakdown to free fatty acids and glycerol. The glycerol then gets dehydrated and decomposes to form an unsaturated aldehyde called acrolein which results in a blue haze or smoke. The temp at which this appears is known as smoking point. Smoking points of different oils and fats vary between 185-230 ^{0}C, vegetables oils having higher points than animal fats.
11. **Flashing:** When fats are heated to a very high temp the vapours given off ignite into a flame. The temp at which this happens is called the flash or fire point which varies for different fats and oils usually occurring between 340-360^{0}C. This is important in commercial frying operations. The PFA Rules do not permit use of any fat or oil whose flash point is less than 250^{0}C.
12. **Plasticity:** Most fats that appear to be solid at room temp actually contain both solid fat crystals and liquid oil. The liquid part is held in a network of small crystals. Because of this unique combination of liquid and solid, the fat can be moulded or pressed into various shapes without breaking. This property of fat is called plasticity.

Nutritional Importance of Oils and Fats:

1. They are concentrated source of our energy, yielding more than twice the energy supplied by carbohydrate and protein per unit weight. They supply 2.25 times more energy than proteins and carbohydrates.
2. They are for excellent source of fat- soluble vitamins A, D, E, and K.
3. They are excellent source of essential fatty acid, linolenic acid, which is needed for human health. Essential fatty acids from fats are component of membranes of living cells.
4. They improve the palatability of foods and give satiety value (feeling of fullness in the stomach).
5. Fats are essential for the utilization of galactose present in lactose.
6. They play an important role in the biosynthesis of several long chain alcohols.
7. They help to reduce the bulk of diet as starchy foods absorb lot of water during cooking.
8. They also play a role in immunity.
9. They are also used by the body to make prostaglandins involved in a large variety of vital physiological functions.
10. Fats are deposited in the adipose tissue and this deposit serves as a reserve source of energy during starvation.
11. Phosphatides and other complex lipids are essential constituents of nervous tissue.

Function of oils and fats in foods:

In addition to their nutritional functions, oils and fats have other uses because of their distinct physical properties. They contribute to tenderness, flavour, colour and texture of food products. They are also used as ingredient in preparing foods that form emulsions.

1. **Tenderness**: The one of the most important function of oils and fats is to tenderize baked products like bread, cakes, biscuits & cookies etc. Their function is particularly important in pastry and bread, which have little or no sugar to contribute to tenderness. In the absence of oils and fats gluten strands will be held firmly together as solid mass. Fats are insoluble in water therefore they interfere with gluten development during mixing. Fats act as shortening in the preparation of baked products. Different shortening agents are used in the baking of different products for e.g.

   In yeast bread------- butter or margarine is used

   In biscuits---------- a hard fat is used for desired flakiness

   In cakes----------plastic fats are used because they are readily mix with ingredients

   In cookies----------butter and commercial shortening are used

   Fats also contribute to incorporation and retention of air in the form of small bubbles in the batter.

   During baking carbon dioxide and steam are diffused into these air cells.

2. **Flavour:** Fats influence the flavour of food because they are act as a vehicle for releasing and enhancing flavours of other ingredients with which they are combined in foods, since most of the

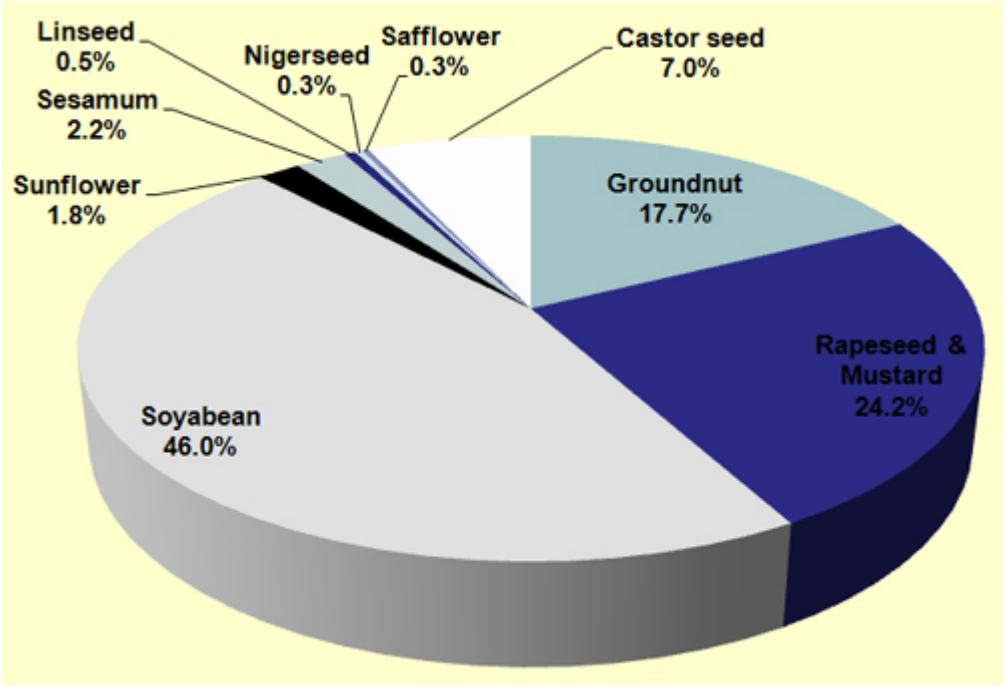
flavouring compounds are fat soluble for e.g. the flavour of onions, pepper & and other flavoured foods is extracted by fats when they are cooked. Fats are used as seasonings mainly for table use and salad dressing because of its pleasing flavour. Butter margarine and olive oil are commonly used for salad dressing. Cottonseed oil, corn oil, groundnut oil and soyabean oils are lacking in flavour and they are used in salad dressing when bland flavour is required.

3. **Texture:** Fats have textural effects in foods. They form a greasy film around the foods and increase shelf life. They act as lubricants and helps in swallowing of foods. They affect the smoothness of crystalline candies and frozen desserts through the retardation of crystallization and gelatinization of starch. They contribute to the juiciness of meats and the foam structure of whipped cream.
4. **Emulsion**: Fats are important constituents of food emulsion. Milk cream and egg yolks are natural food emulsions. In most of food emulsions the oil is the dispersed phase and water is dispersion medium. For stabilization of emulsion some emulsifiers are used. The examples of some common emulsifiers are egg yolk, whole egg, gelatin, vegetable gum, casein etc. Some common emulsions used in salad dressings are Mayonnaise, French dressing and cooked salad dressing.
    a) Mayonnaise: These are semi solid emulsion of vegetable oil, egg yolk or whole egg, vinegar and seasonings. (Contains about 75% oils)
    b) French dressing: is an emulsion of vinegar, vegetable oils, salts & spices. The emulsion is not as stable as mayonnaise.(35%oils)
    c) Cooked salad dressing: are made from fat, egg, vinegar, starch and seasonings. Fruit juice or milk may be used in place of vinegar.(contains about 30% oils)

India holds a significant share in world oil seed production. It is second largest producer of groundnut after China and third largest producer of Rapeseed after China and Canada.

- In 1970s, India produced around 9 million tonnes of oil seeds. This figure has grown up to 25 million tonnes in nineties.

This statistic shows the global oilseed production in 2015/1016 by type. In crop year 2015/2016, some 320.15 million metric tons of soybeans were produced worldwide.



80% of total oil and fat production is used for food --- frying oils, baking fats, cooking fats, shortenings, spreads, salad oils, mayonnaise, confectionery fats, & ice cream

Sunflower oil

Sunflower, this name comes from its property of turning its head during the day to follow the sun to get enough energy for its growing. Each big and bright yellow flower head has about 1,000 seeds surrounded the petals. Sunflowers can grow up to 10 feet high, and their roots may grow 6 feet into the ground.

It is native to America. It is thought to have been domesticated around 1000 B.C. by Native Americans. In India, It is relatively a new oilseed crop but it was grown in India as an ornamental crop, since ancient time. Sunflower was introduced in India as an oilseed crop for the first time in 1969. Commercial extraction of sunflower oil for food use appears to have begun in Russia about 1830. Today it forms a well known crop in Russia, Ukraine, Portugal, Spain, France, Germany, Italy, Egypt, India, Manchuria and Japan etc. Globally Ukraine and Russia is the largest producer of sunflower oil. Sunflower accounts for about 14% of the world production of seed oil and 7% of oil seed cake.

Sunflower oil is obtained from the seeds of the sunflower plant- Helianthus Annuus. The oil content of seed ranges from 22-36%, the kernel contains 45-55% oil. The crude oil contains some phosphatides and mucilaginous matter. Sunflower oil has a characteristic flavour and odour which is removed by deodorization.

Sunflower seeds come in 2 types: the non-oil seed that are eaten as confectionery products after roasted with the shell or without the shell as kernels, and the oil seed that are processed into oil and meal which is a by-product of sunflower seed oil extraction primarily used as an ingredient in livestock feed rations.

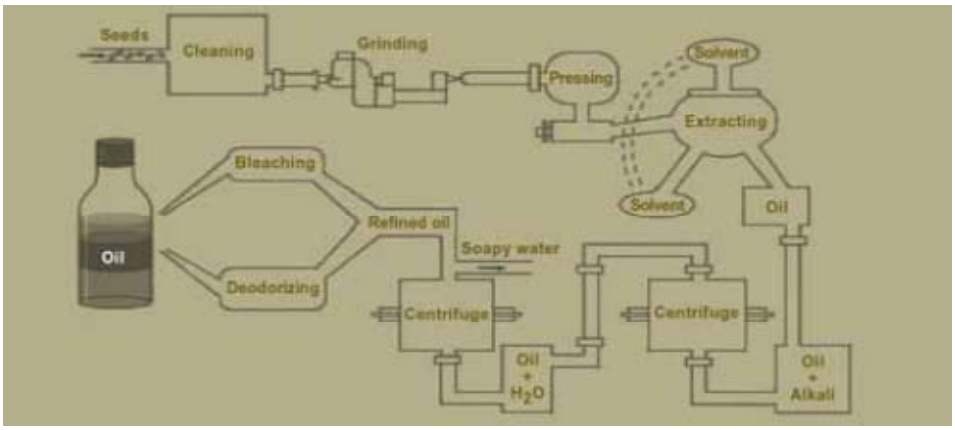
Nutritive value:

Sunflower oil contains higher amount of unsaturated fatty acids such as linoleic acid 59% and oleic acid 30% and lower amount of saturated fatty acids such as stearic acid 6% and palmitic acid 5%. It also contains protein and vitamin A, D & E. It helps in curing the heart diseases because it does not raise the cholesterol level in blood.

Physico- chemical properties of sunflower oil: the sunflower oil is light yellow in colour and have good odour therefore it can be used for a variety of cooking purposes like any other edible oil. The typical characteristics of sunflower oil are:

Specific gravity at 25^0C	0.915-0.919
Refractive index	1.472-1.474
Iodine value	125-136
Saponification value	188-194
Unsaponifiable matter	0.3-1.3
Acid value	.5-5.0
Wax(%)	0.02-0.35
Melting point	-18 to -16 ^{0}C
Cloud point	9.5^0C

Methods of extraction:



Drying: Sunflower seeds after harvesting are rapidly dried to under10% moisture content by a drying machine or by sun drying.

Cleaning

The dried seeds are (delivered onto wire screens) then cleaned using magnets to remove metal and screening to remove impurities (dirt, dust, unwanted debris) that can interfere with the process. Then the outer covering (hulls) of the seeds are removed to obtain pure seeds.

Grinding & conditioning

The de-hulled seeds are then ground into coarse meal by Mechanized grooved rollers or hammer mills to provide more surface area to be pressed. The material is then conditioned. During conditioning material is heated to 90^0C with steam, which cause the oil cells to expand.

Pressing

The conditioned material is fed into the crusher where approximately 50% of the oil is crushed out. The oil cake that is created in this way contains approximately half of the oil that it initially contained.

Extracting additional oil with solvents

During this process oil cake is mixed with an organic solvent to dissolve out remaining oil. The most commonly used solvent is hexane. Then the mixture of hexane and oil is separated from the fibre, after which the hexane is vapourized to be recycled for reuse later. The oil recovered by distilling the solvent out is known as crude oil.

Refining the oil

The oil is next refined to remove colour, odour, and bitterness. Refining consists of heating the oil to between 40 and 85 °C and mixing an alkaline substance such as sodium hydroxide or sodium carbonate with it. Oils are also degummed at this time by treating them with water heated to between 85 and 95 °C steam, or water with acid. The gums, most of which are phosphatides, precipitate out, and the dregs are removed by centrifuge.

Oil that will be heated (for use in cooking) is then bleached by filtering it through fuller's earth, activated carbon, or activated clays that absorb certain pigmented material from the oil.

By contrast, oil that will undergo refrigeration (because it is intended for salad dressing, for example) is winterized – rapidly chilled and filtered to remove waxes. This procedure ensures that the oil will not partially solidify in the refrigerator.

Finally, the oil is deodorized. In this process, steam is passed over hot oil in a vacuum at between 225 and 250 °C, thus allowing the volatile taste and odour components to distil from the oil. Typically, citric acid at 1% is also added to oil after deodorization to inactivate trace metals that might promote oxidation within the oil and hence shorten its shelf-life.

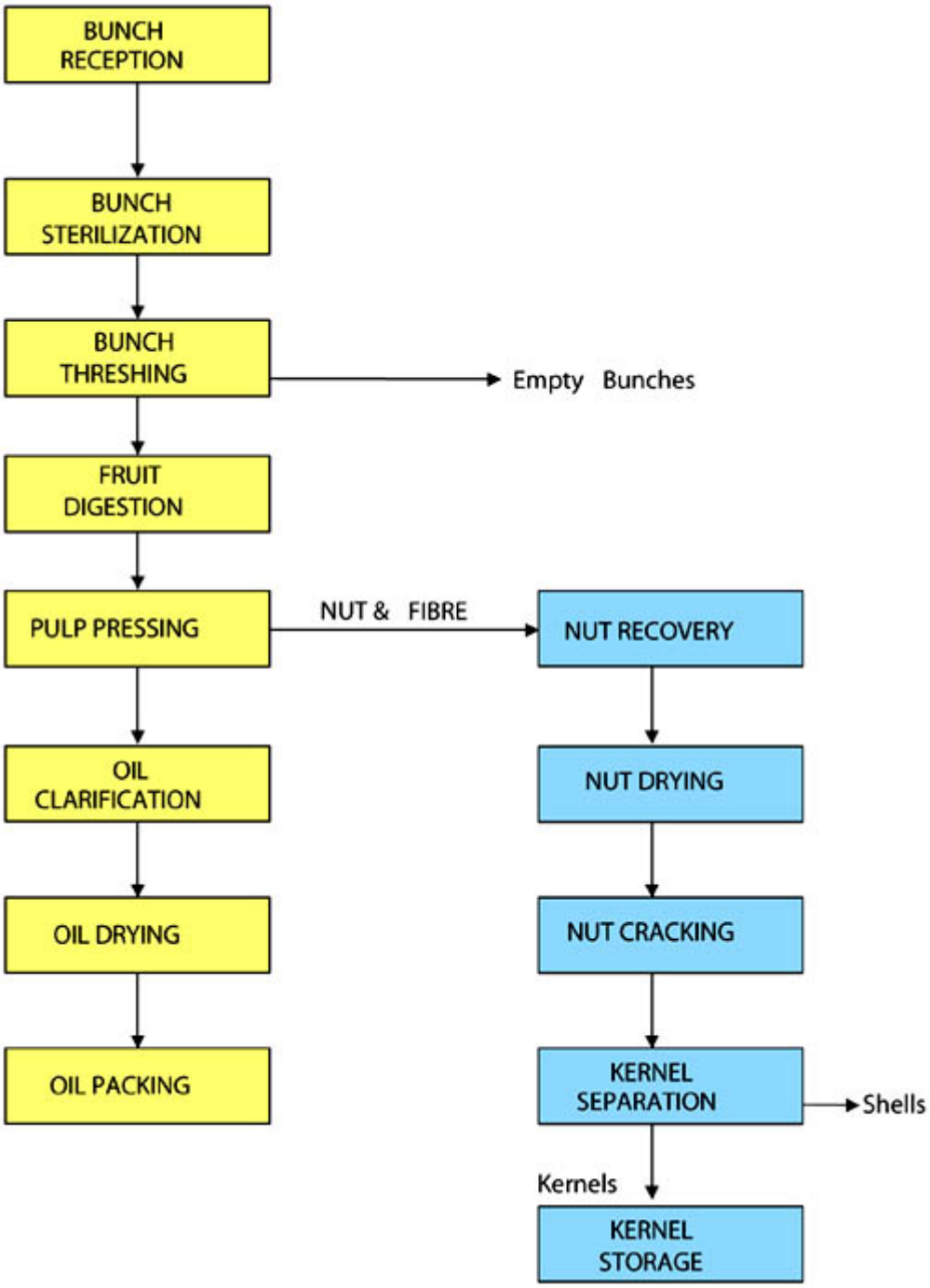
Uses of Sunflower oil:

1. It is used as a cooking medium.
2. It is very good salad oil.
3. It is used in manufacturing of margarine.
4. The Sunflower seeds are a good poultry feed.
5. The cake is used as a stock feed.
6. Sunflower yields honey and wax.
7. The semi dried oil is used in the manufacturing of paints, varnish, soap and cosmetics.

PALM OIL

Palm oil is an edible vegetable oil derived/extracted from the mesocarp (reddish pulp) of the fruit of the oil palm. Palm oil is naturally reddish in colour because of high beta-carotene content. It is semi-solid at room temp. because it contains equal amount of saturated fatty acid and unsaturated fatty acid (44% palmitic & 5% stearic ; 39% oleic & 10% linoleic). Palm oil can also be separated into a solid part called stearin which is used in shortening and margarine and a liquid part called the olein which is used as frying oil.

PALM OIL PROCESSING UNIT OPERATIONS



Harvesting:

In the early stages of fruit formation, the oil content of the fruit is very low. As the fruit approaches maturity the formation of oil increases rapidly to about 50 percent of mesocarp weigh. In a fresh ripe, un-bruised fruit the free fatty acid (FFA) content of the oil is below 0.3 percent. However, in the ripe fruit the exocarp becomes soft and is more easily attacked by lipolytic enzymes, especially at the base when the fruit becomes detached from the bunch. The enzymatic attack results in an increase in the FFA of the oil through hydrolysis. Harvesting involves the cutting of the bunch from the tree and allowing it to fall to the ground by gravity.

Bunch reception

Fresh fruit arrives from the field as bunches (Average wt. 25 Kg; 1500-2000 fruits per bunch) or loose fruit. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked.

Sterilization of bunches

Sterilization means the use of high-temperature wet-heat treatment (40 psi for 60-90 min) of loose fruit. Sterilization inactivates the lipases in the fruits, and prevents build-up of free fatty acids. It also softens the fruits mesocarp for digestion and release of oil and conditioning of nuts to minimize kernel breakage.

Threshing (removal of fruit from the bunches)

Threshing or Stripping involves separating the sterilized fruits from the bunch stalks. Sterilized FFBs are fed into a drum stripper and the drum is rotated, causing the fruits to be detached from the bunch. The bunch stalks are removed as they do not contain any oil. It is important to ensure that oil loss in the bunch stalk is kept to a minimum.

Digestion of the fruit

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. The fruits are rotated about, causing the loosening of the pericarps from the nuts.

Pressing (Extracting the palm oil)

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the 'dry' method. The other called the 'wet' method uses hot water to leach out the oil.

In the 'dry' method the objective of the extraction stage is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. Material is placed in a heavy metal 'cage' and a metal plunger is used to press the material. The plunger can be moved manually or by a motor. The motorised method is faster but more expensive.

The 'wet' method uses a vertical digester with a perforated bottom plate to pound a batch of fruit and then flush out the oil and other non-oil solids from the mashed pulp with hot water. The advantage of the wet system is that it is simple and completely leaches all oil.

Clarification and drying of oil

The main objective of clarification is to remove the impurities from the oil. The fluid coming out of the press is a mixture of palm oil, water, cell debris, fibrous material and 'non-oily solids'. Because of the non-oily solids the mixture is very thick (viscous). Hot water is therefore added to reduce its viscosity. Water is added in a ratio of 3:1. The diluted mixture is passed through a screen to remove coarse fiber. The screened mixture is heated to 85-90^{0}C for one or two hours and then allowed to settle by gravity. A settling time of 1-3 hrs is acceptable. Oil from the top is skimmed off and purified in the centrifuge prior to drying in vacuum dryer.

Oil storage

The purified and dried oil is transferred to a tank for storage prior to dispatch from the mill. Since the rate of oxidation of the oil increases with the temperature of storage the oil is normally maintained around 50°C, using hot water or low-pressure steam-heating coils, to prevent solidification and fractionation.

Groundnut oil:

Groundnut is an important oilseed crop and food crop of India. This plant is native to South America and has never been found uncultivated. The botanical name for groundnut, Arachis hypogaea L, is derived from two Greek words, arachis meaning legume and hypogaea meaning below ground, referring to the formation of pods in the soil. Groundnut is grown on a large scale in almost all the tropical and subtropical countries of the world. The most important groundnut growing countries are India, China, Nigeria, Sudan and USA and is cultivated in more than 60 countries of the world.

Groundnut was introduced by Portuguese from Brazil to West Aferica and then to south western India in 16th century. At present, India is the 2nd largest producer of groundnuts after China. Groundnut is the largest oilseed in India in terms of production. It accounted for 35.99% of oilseeds production of the country during 2007-2008. Gujrat is the largest producer contributing 25% of total production followed by TN, Andhra Pradesh, Karnataka, and it contribute about 70% of the total oilseed crops of the India.

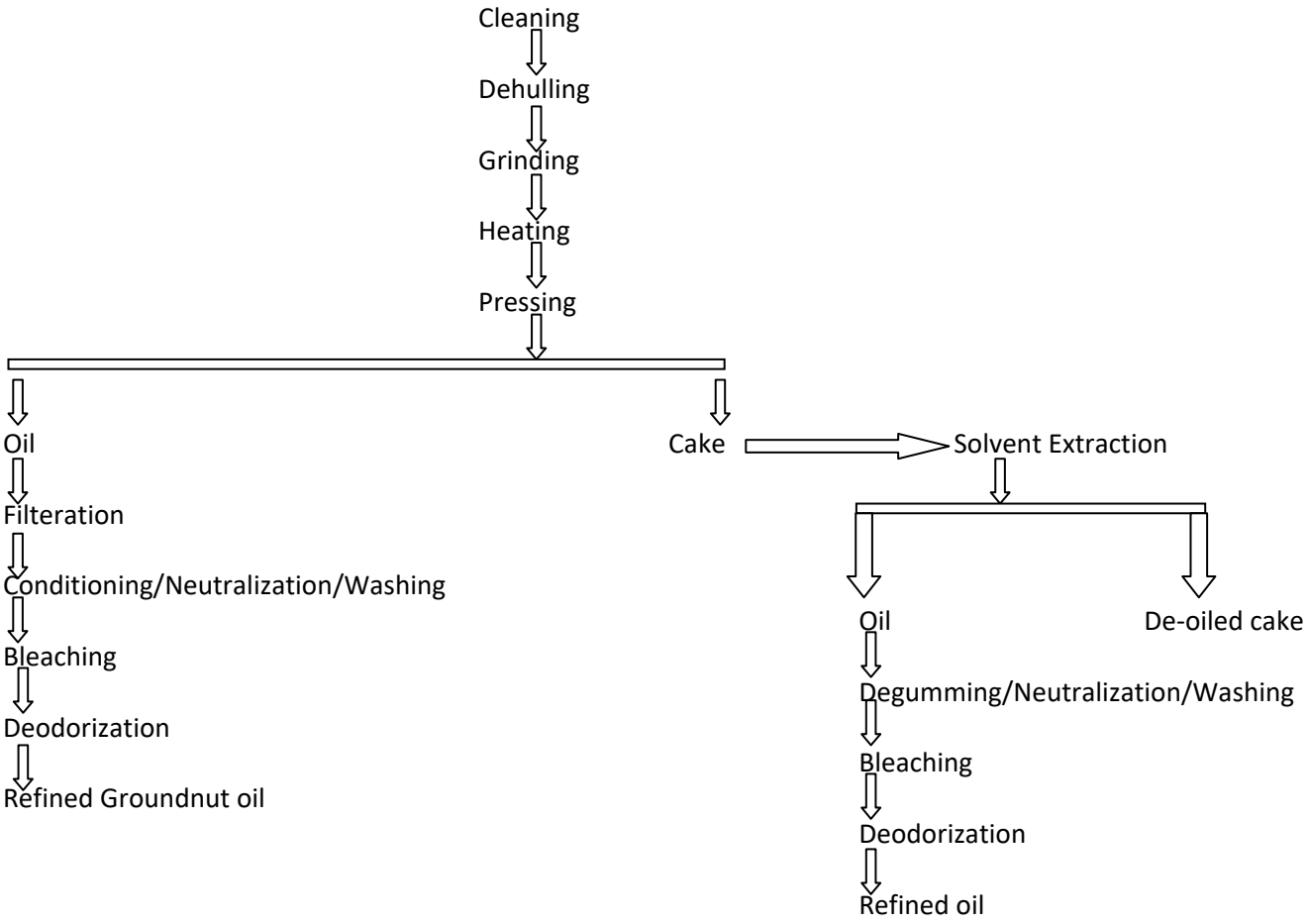
Groundnut is called the KING of oilseeds. It is one of the important food and cash crop of our country. While being a valuable source of all nutrients it is a low priced commodity. It is also called as wonder nut and poor man's cashew nut.

In India, about 80% of peanut crop is crushed for oil; 12% is used as a seed, 5.3% as feed and about 2% export.

Composition of Groundnut Oil: Groundnut contains on an average 40.1% of fat and 25.3% of protein and a rich source of Ca, Iron, and vitamin B-complex. The oil has a pale yellow colour contributed by B-carotene and Lutein and has a high smoke point (425^0C) and flash point. (650^0C).

Groundnut oil contains higher amount of unsaturated fatty acids such as oleic acid 51%, Lenoleic acid 30.9% and lower amount of saturated fatty acids such as arachidic acid 0.7%, lignoceric acid 0.8%, behenic acid 2.3% and stearic acid 2.3% therefore it has 84-100 iodine value ,188-195 saponification value and -2^0C melting point.

Production of Groundnut oil:



1. Cleaning: The first step in preparing oilseeds for oil extraction is to clean them. Cleaning is done so that the oil is not contaminated with foreign materials and the extraction process can proceed as efficiently as possible. During the process inspection of seeds is carefully done to remove stones, sand, dirt and spoilt seeds. Dry screening technique is often used to remove all material that is over or undersized.

2. Dehulling: During this process, the outer seed coat is removed. A power operated dehuller is generally used for the operation. The removal of the outer seed coat is necessary as it does not contain oil and inclusion of it in the unit operations makes the oil extraction process less efficient.

3. Grinding and rolling: Seed is not usually pressed whole since oil extraction is more efficient if seed is in smaller particles.

Grinding is the process for reducing the particle size. Small motor powered hammer mills are used for the unit operation. Another alternate process used for reduction of particle size is rolling the seeds to produce flakes for oil extraction.

4. Heating: It is the final step for preparing the row material for oil extraction. Heating leads to increase oil yield. Heating helps in killing those enzymes present in the plant tissue which have a deteriorative effect on the oil quality. More ever, if oilseed cake is to be used for feed, heating is useful as it increases protein availability. Some time oil bearing material is pressed without being heated. Oil extracted in this way is called cold press oil extraction.

5. Extraction of oil:

Pressing: During this operation the oil bearing material is pressed using lever press, hydraulic press or a mechanical expeller to remove the oil.

Solvent extraction: Mainly three organic solvents are used to extract oil from groundnut seeds i.e. Hexane, 95% ethanol, Absolute ethanol. In this operation the oil fractions are dissolved with organic solvent which is then separated by distillation method.

6. Refining: In this process the fresh crude oil from hydraulic or expeller units is passed through a screen to remove groundnut particles and then passed through a filter press to clarify it. The clarified oil is then treated with NaOH to neutralize free fatty acids and deodorizing by heating under vacuum and blowing super heated steam through it.

The alkali produces a precipitate, which is then removed by high speed centrifuge in filter press.

Oil from solvent extraction method is refined to remove fatty acids, foreign flavor and colour. The residue from hydraulic or expeller pressing is ground into meal and used as a valuable protein supplement in animal feed.

The residue from solvent extraction may be ground into flour for human consumption.

Uses of groundnut oil:

- It is an excellent fat for pan frying or deep fat frying.
- It may be clarified and reused many times for foods of different flavor.
- It is used in manufacturing of pastries, oleomargarine, mayonnaise, salad dressing and other food products.
- It is used in soaps and detergents manufacturing.
- It is also used in base formation of many face cream, hair lotions and other cosmetics because it is believed that it energized the skin.
- It is used as a lubricant.
- It is extensively used for massaging of polio patients.
- It is also used in furniture cream manufacturing.
- It is also used in pickle and chutney manufacturing.
- It is also used for different types of medical treatments.

Olive oil:

Olive oil is a liquid fat obtained from olives, a traditional tree crop of the Mediterranean Basin. The oil is produced by pressing whole olives. It is commonly used in cooking, whether for frying or as a salad dressing.

Fatty Acid Composition:

Saturated Fatty Acids:	Unsaturated Fatty Acids:
Palmitic 13%	Oleic 70%
Stearic 1.5%	Palmitoleic .3 to 3.5%
	Linolenic 15%
	α-Linolenic 0.5%

Olive oil extraction:

Olives must be harvested as soon as they reach maturity and brought directly to extraction plant after collection. Being a fruit, it can't be stored as if it were a seed nor it can be dried to preserve it. Olive oil has to be extracted as soon as possible before the acidity increases and impair quality. Oil extraction can be divided into following steps:

1. Cleaning the olive:

The first step in the olive oil extraction process is cleaning the olives and removing the stems, leaves , twigs , and other debris left with the olives. The olives should be washed with water to remove pesticides, dirt etc. It is amazing and some time entertaining, to see what can be found in the bins with the olives. We have heard millers talk not only about rocks and branches, but broken glass, rings, bracelets, pieces of

metal, knives, and even razor blades. Light contaminants are removed a heavy air flow(blower) and heavy objects sink in the water bath.

2. Grinding:

The second step is crushing the olives into paste. The purpose of crushing is to tear the oil- bearing cells and helps smaller droplets of oil merge into larger drops. This step can be done with mills, metal tooth grinders, or various kind of hammer mills. If frozen or very dry olives are processed, a small quantity of water is added.

3. Malaxing / Mixing/ Beating of the olive pulp:

Mixing the paste for 20 to 45 minutes allows small oil droplets to combine into bigger ones. The paste can be heated or water added during this process to increase the yield, although this generally results in lowering the quality of the oil. Longer mixing times increase oil yield but allows a longer oxidation period that decreases shelf life.

4. Separating the oil from paste:

The next step consists in separating the oil from the rest of the olive components. Three general procedures are utilized for oil extraction from the paste: Hydraulic presses, Continuous centrifuges, or adhesion filtering.

In small oil mills the olive oil is extracted by using traditional press method, but is now done by centrifugation. Some centrifuges are called three –phase because they separate the oil, the water, and the solids separately. The two phase centrifuge separate the oil from a wet paste. The adhesion filtering equipment has a series of steel blades that are dipped into the olive paste and then withdrawn, after which the oil is allowed to drip off the blades. Generally 3 fractions are separated from the olive paste: 1. Oil 2. Waste water 3. Husk or residue. The husks are dried and the remaining oil extracted with solvent; therefore two oil types are obtained from olives:

a) Olive oil: Which is pressed without further processing and contains less than 3.5% FFA

b) Pomance oil: this is obtained by solvent extraction of the husks and does not qualify as olive oil.

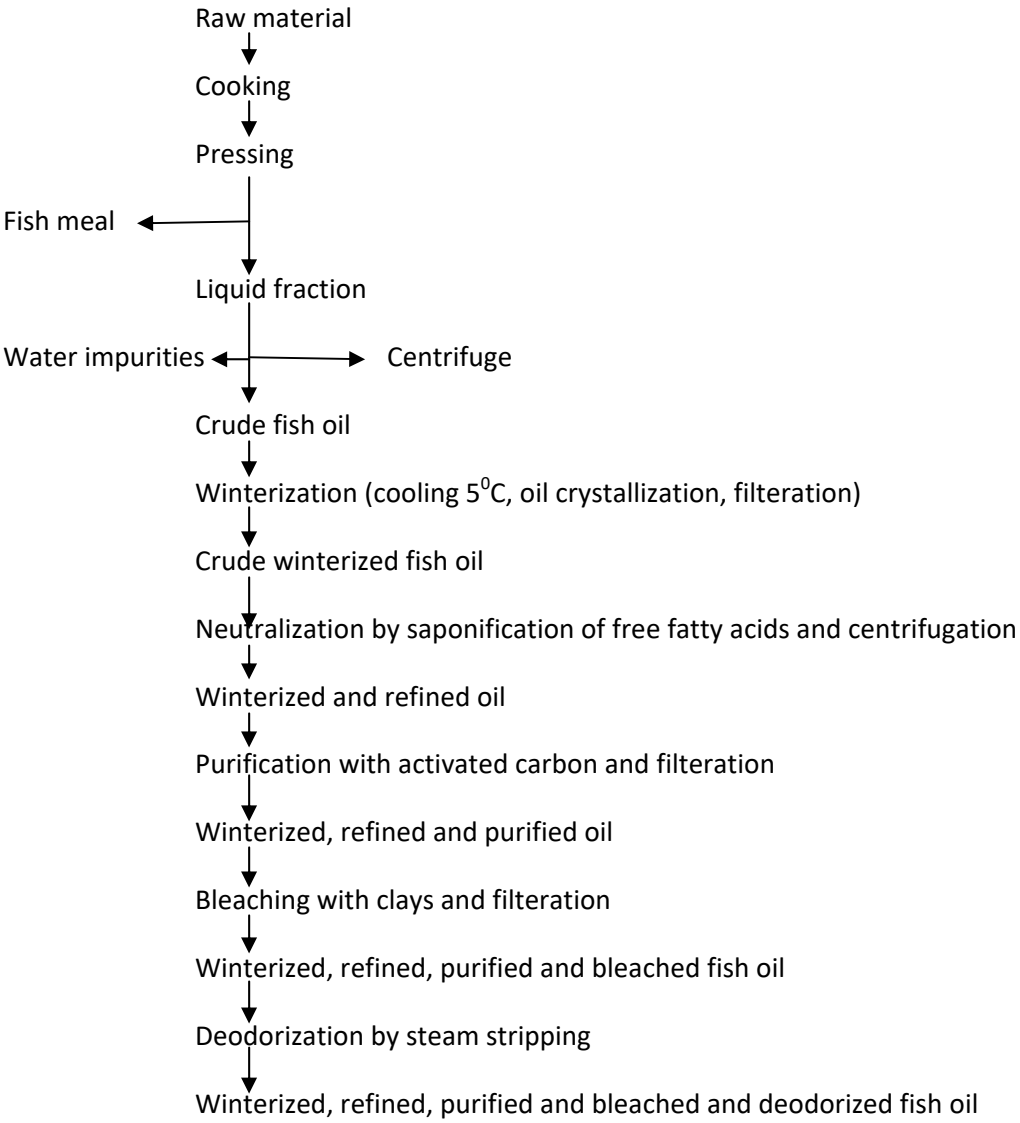
Optional steps:

Finally, possible additional processing steps include refining the oil to reduce its acidity and improve flavor by alkali or steam processing; bleaching the oil to reduce chlorophyll, carotenoids, residual fatty acids and pesticides using diatomaceous earth, activated carbon, or synthetic silica treatment, and deodorization to reduce odours with the use of activated carbon. Needless to say, these steps are only used for low Quality oil.

Fish oil: Fish oil is the oil derived from the tissues of oily fish. Fish oil contain omega-3-fatty acids EPA(eicosapentaenoic acid) and DHA(docosahexaenoic acid); precursors of certain eicosanoids that are known to reduce inflammation throughout the body and have other health benefits.

The oil from fish can be obtained from fish liver or fish body. Cod, Helibet, Tuna, Shark, and Menhaden are good source of fish liver oil. Body oil is obtained from fishes such as sardine, herring and salmon.

Method of production:



Fish oil is also called as" brain food" because it provides the essential omega-3-fatty acids DHA and EPA, which are crucial for brain development. Studies have also shown that EPA & DHA are beneficial for heart health, eye health and brain function. Omega-3-fatty acids are essential because our bodies cannot make them.

Uses and benefits:

1. Lower blood pressure
2. Reduce blood triglyceride level
3. Cardiovascular disease prevention
4. It also lowers the level of bad cholesterol(LDL) and increases the level of good cholesterol (HDL)
5. Fish oil also aids in losing weight
6. It is also believed that regular consumption of fish oil aids in increasing your immunity thereby enabling you to resist incidence of common diseases such as cold, cough and flu.
7. Due to the presence of omega-3-fatty acids fish oil is good for relieving depression, sadness, anxiety, restlessness, mental fatigue, stress, decreased sexual desire, suicidal tendencies and other nervous disorders.

Lard: is the fat separated from the fatty tissues of the hog / pig. It is one of the oldest of household fats and is used as a cooking fat or shortening or as a spread similar to butter. Its quality depends upon the part of the body from which the fat is obtained, feed used for fattening the animal, and the rendering process.

Composition:

Saturated fats: 38-43% (Palmitic acid 25-28%; stearic acid 12-14%; myristic acid 1%)

Unsaturated fats: 56-62% (MUFA: 47-50 % (Oleic acid 44-47%))

Method of making lard:

1) Wet rendering
2) Dry rendering

Wet rendering: In this method the fatty tissues of hogs are chopped into small pieces and boiled in water to remove fat from the cells. The fat, which is insoluble in water, is skimmed off from the surface of mixture.

Dry rendering: In this method also the fatty tissues are subdivided into small pieces and then exposed to high heat in a pan or oven without the presence of water.

The two processes yield somewhat differing products. Wet rendered lard has a more neutral flavour, a lighter colour, and a high smoke point. Dry-rendered lard is somewhat more browned in colour and flavour has lower smoke point. Rendered lard produces an unpleasant smell when mixed with oxygen. To improve stability at room temperature, lard is often hydrogenated and treated with bleaching and deodorizing agents, emulsifiers and antioxidants. These treatments make lard more consistent and prevent spoilage.

Types of lard:

1.) Neutral lard
2.) Leaf lard
3.) Prime steam lard
    1.) Neutral lard:- It Is a special product made by wet rendering of selected fatty tissues, adipose tissues at a temperature between 40-500C. This lard is generally used in the manufacturing of margarine and biscuits.
    2.) Leaf lard: This is the highest grade of lard and is made by dry rendering of leaf (abdominal cavity) in an open kettle. This lard is harder than other lard. It has little pork flavour and is used in baked goods.
    3.) Prime steam lard or Refined lard:- This lard is produced by wet rendering in close tanks by steam pressure. This lard is also called refined lard because it is clarified, dried and resolidified.

Soya bean oil:

Soyabean oil is obtained from soyabeans, *Glycina maxima* which are grown in the several countries of the world. Soyabeans are native to Eastern Asia, where ancient Chinese literature indicates that soyabeans have been an important part of their diet. According to early authors, soyabean production was localized in China until after the Chinese- Japanese war of 1894-95, when the Japanese began to impart soyabean oil cake for use as fertilizer. Shipments of soyabean were made to Europe about 1908, and soyabean attracted world wide attention.

It contributes over a half of the oilseeds produced world wide. The US ranks first in soyabean production (84.2 million tonnes), followed by Brazil, Argentina, China and EU-15.

Soyabean oil is widely used oil and is commonly called “vegetable oil”. It is very popular because it is cheap, healthful and has a high smoke point. It does not contain much saturated fat. Soyabean oil contains natural antioxidants which remain in the oil even after extraction. These antioxidants help to prevent the oxidative rancidity. Soyabean oil has normally a shelf life of one year but its better to store the soyabean oil only a few months at room temperature.

Composition of fatty acids:

16% saturated fatty acids(stearic 4%, palmitic 10%)

23% MUFA (oleic acid)

58% PUFA(linoleic and linolenic acid)

Soyabean oil production:

Preparation: The soyabeans are first cleaned, dried and dehulled prior to oil extraction. The soyabean hulls needs to be removed because they absorb oil and give a lower yield. This Dehulling is done by cracking the soyabeans and a mechanical separation of the hulls and cracked soyabeans. Magnets are used to separate any iron from the soyabeans. The soyabeans are also heated to about 75^0C to coagulate the soyaproteins to make the oil extraction easier.

Extraction and refining of soyabean oil:

Oil extraction: There are three main methods for extracting oil from soyabeans. These are

- Hydraulic pressing
- Expeller pressing
- Solvent Extraction

1. Hydraulic pressing: is one of the oldest pressing method. At present it is rarely used for soyabean.

2. Expeller pressing: has replaced the hydraulic pressing procedure for extraction of oils. Operation is same as in case of other vegetable oils.

3. Solvent Extraction: This method is most commonly used for extraction of oil from soyabean. In this method the soyabeans are cut into flakes and extraction can be performed by equipment of either percolation type or immersion type. Normally Hexane is used because it gives the highest yield. The extraction flakes contain only about 1% of soyabean oil and is used as livestock meal or to produce food products such as soyaprotein.

Degumming: is a process of removing gums from crude soyabean oil, to improve its physical stability and to facilitate further refining. In this process gums in oils are removed by hydration with the help of phosphoric acid.

Neutralization: is also described as deacidification or caustic refining. It is achieved by treating the soyabean oil with aqueous alkaline solution (NaOH) to neutralize the free fatty acid. The soap formed

in the reaction also absorbs natural pigments, hydrated gums and mucilaginous substances contained in the oil. Setting or centrifugation is used to remove the soap.

Bleaching: is a process designed not only to remove the pigment chlorophyll but, more importantly, to breakdown peroxides(primary oxidation products) into lower molecular weight carbonyl compounds that can be subsequently removed by deodorization. In soyabean oil refining colour reduction occurs at each step of degumming, neutralization, bleaching, hydrogenation and deodorization. Acid activated bleaching clay is most effective in adsorbing chlorophyll and decomposing peroxides.

Deodorization: Usually the last step in oil refining, is a steam- stripping process in which good quality steam, generated from de-aerated and properly treated feed water, is injected into soyabean oil under high temperature(252-266^{0}C) and high vacuum. Under these conditions peroxides are decomposed and the free fatty acids and odours compounds are vaporized.

Uses of soyabean oil:

1. It is used in manufacturing of margarine.
2. It is used as a cooking medium.
3. It is used in baked products.
4. It used in mayonnaise manufacturing and salad dressing.

Palm Oil Extraction

In contrast to other oils, palm oil is expressed by cooking and pressing. First, it is sterilized with steam at 266 to 293°F (130 to 145°C) for about 1 hour to inactivate hydrolytic enzymes, loosen the individual fruits, and prepare it for subsequent processing steps. The sterilized fruits are stripped from the bunch stalks by vigorous shaking and beating using drum-type strippers. Then, the fruits are reheated to 95 to 100°C (203 to 212°F) for 20 to 30 minutes in a digester to loosen the pericarp from the nuts and to break the oil cells. The liquid and semisolid phases are then separated with a screw press similar to those used for oilseed extraction. The liquid phase is centrifuged and vacuum dried to remove moisture. The quality of the palm oil is dependent upon the fruit bunches delivered to the oil mill. Overripe fruit bruises easily, accelerating FFA rise through enzymatic hydrolysis and adversely affecting bleachability of the extracted oil.9