FATS & OILS

Fats are a more concentrated form of storage of energy than carbohydrates. They are found in the adipose (fatty) tissue of animals. Oils and fats are composed of the elements carbon, hydrogen and oxygen.

Chemical Composition

Fat is a complex molecule constituting a mixture of fatty acids and an alcohol, generally glycerol. Like carbohydrates, it contains carbon, hydrogen and oxygen, but it differs from carbohydrate in that it contains more carbon and hydrogen and less oxygen. When oxidized, it gives 9.1 kcalories per gram fat which are approximately 2 ¼ times more than those supplied by 1 gram of carbohydrate.

A) Classification of Fats (Lipids)

Fats can be classified into 3 main categories:

Group-I

1. Simple Lipids
2. Compound Lipids
3. Derived Lipids
4. Unsaponifiable Lipids

Group-II

1. Saturated Fatty Acids
2. Unsaturated Fatty Acids

Group-III

1. Essential Fatty Acids
2. Non-Essential Fatty Acids

Group-I

1. **Simple Lipids:** The simple lipids are the neutral fats. These are chemically made up of triglycerides. Triglycerides contain a glycerol base with three fatty acids. These 'neutral fats' make up 98-99 percent of food and body fats.
2. **Compound Lipids:** These are chemically made up of simple lipids containing phosphorous, carbohydrates and protein. Such similar ones are known as phospholipids, glycolipids and lipoproteins. Lipoproteins are the most important as they are the carries of lipids in the blood and form cell membranes. Phospholipids are associated commonly with the nervous system (nerve tissue).
3. **Derived Lipids:** They are fat like substances produced from fats and fatty compounds. The important members of this group are glycerol and fatty acids.

   Glycerol: It makes up about 10 percent of the fat. It is the water soluble base of triglycerides or neutral fat.

   Fatty acids: They are the key, refined fuel forms of fat that the cell burns for energy. They are part of the basic structural units of a fat and they may be saturated or unsaturated. Example: oleic acid, linoleic acid, linolenic acid, arachidonic acid, palmitic acid, myristic and stearic acid.

4. **Unsapoifiable Lipids:** These includes steroids, terpenoids etc.

Steroids: They are fat related substances containing sterols. The important member of this group is cholesterol.

Group-II

1. **Saturated Fatty Acids:** Fatty acids having single bond between the carbon atoms in their molecules. The predominance of saturated fatty acids in a fat makes it solid at room temperature. Example: Palmitic and stearic are found in animal products such as whole milk, cream, butter, whole milk, ice cream, cheese made from whole milk, egg yolk, meat, fish, pork, margarine, vanaspati, coconut oil etc.

2. **Unsaturated Fatty Acids:** Fatty acids which have double or triple bond between the carbon atoms in their molecules are known as unsaturated fatty acids. A fat containing more unsaturated fatty acids is liquid at room temperature.

Most animal fats are saturated while most vegetable fats are unsaturated.

Unsaturated fatty acids are of **two** types:

a) **Monounsaturated fatty acids (MUFA):** Oleic acid has only one double bond hence it is a mono- unsaturated fatty acid. While linoleic & linolenic acids with their 2 or 3 double bonds respectively make them PUFA's. It is found in vegetable oils including safflower, cottonseed, soyabean, corn, sunflower, groundnut, til, fish, salad dressing, etc. olive oil, corn oil etc.

b) **Polyunsaturated fatty acid (PUFA):** They include linoleic acid (2 double bond) linolenic acid (3 double bond). They help in lowering

blood cholesterol levels and prevent coronary heart disease. PUFA are found in vegetable oil including sunflower, ground nut, soyabean, corn oil.

Group-III

A nutritional classification of fatty acid is:

1. **Essential Fatty Acids:** EFA's are those which cannot be synthesised by the body and need to be supplied through diet. Linoleic acid, Linolenic acid and arachidonic acid are the three EFA's. The primary source of linoleic acid in a diet is vegetable oils.

2. **Non-Essential Fatty Acids:** NEFA's are those which can be synthesized in the body and need not be supplied through diet. Palmitic acid, oleic acid, butyric acid are examples of NFA's.

B) Auto Oxidation

The spontaneous uptake of oxygen by the unsaturated oils exposed to air is known as oxidative rancidity. It is the most common and important type of rancidity which results in the production of rancid or tallowy flavours. It is caused by the reaction of unsaturated oils with oxygen. Moisture and impurities do not have any effect on oxidative rancidity. Pure and refined oils can turn rancid on exposure to oxygen. Oxidative rancidity is a complex process in the form of a chain reaction. Once the reaction begins it is a continuous process.

C) Reversion

Many fats and oils undergo a change in flavor before becoming rancid. This change in flavor which is very different from the rancid flavor is called reversion.

In rancidity the change in flavor is the same for all fats. But in reversion the flavor may be buttery, beany, grassy, painty and fishy. Reversion is seen in fish oils, linseed and soya been oil. Very small amounts of oxygen are required as compared to oxidative rancidity.

Factors Leading To Rancidity And Reversion

1. **Temperature:** High storage temperatures accelerate the development of off-odours and flavours in fats and oils.

2. **Moisture:** Low moisture content in cereals especially breakfast cereals to keep them crisp, accelerates their deterioration due to rancidity (Presence of moisture leads rancidity). Presence of moisture in butter and oils brings about hydrolytic rancidity. In butter, the enzyme lipase hydrolyses butter fat to butyric acid, which gives stale butter a rancid smell. When butter is heated to prepare clarified butter or pure ghee, the enzyme lipase is inactivated and moisture from butter is removed by heat. Clarified butter can be stored at room temperature and doesn't turn rancid.

3. **Air:** The amount of air in contact with the fat or oil is an important factor in determining its shelf life. Auto oxidation or oxidative rancidity occurs when fats are exposed to oxygen. Reversion occurs with very minor amounts of oxygen. Potato chips and salted nuts because of their large surface area turn rancid at a faster rate.

4. **Light:** Light accelerates the development of both rancidity and reversion.

5. **Metals:** The presence of metals in traces accelerates the development of both rancidity and reversion as they are active pro-oxidants. Metal contamination can occur from equipment used for extraction and refining of oils. Rust from steel equipment, traces of copper, lead, zinc and tin can accelerate the onset of rancidity.
6. **Degree of Unsaturation:** This is an important criteria of oxidative rancidity and reversion. Oils containing high proportions of unsaturated fatty acids and shortenings made from such oils show flavour reversion. Oils with high proportions of linolenic acid and linoleic acid revert. Oils with unsaturated fatty acids turn rancid.
7. **Absence of Antioxidants:** The natural presence or addition of antioxidants to oils prevents rancidity. Vitamin E or tocopherol is naturally present in vegetable oils and acts as an antioxidant preventing auto oxidation of oil. The antioxidant takes up oxygen and gets oxidized thereby preventing rancidity.

Prevention of Rancidity

Disagreeable odours and flavour in fat can be prevented by the following ways:

1. Store fat at low temperatures in a cool, dark place.
2. Use airtight containers. Keep minimum headspace.
3. Do not keep strong smelling foods in the vicinity of fats and oils as they absorb foreign odours and get tainted.
4. Copper containers and rusted iron accelerate rancidity. Only steel or aluminium should be used.
5. Avoid undue exposure to light and air. Expose minimum surface area.
6. If antioxidants are added to fats rich in unsaturated fatty acids, oxidative rancidity can be significantly delayed. Tocopherol (V-E) and lecithin are antioxidants naturally present in some oils. Synthetic antioxidants such as

butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA), TBHQ added to oils in which snacks are fried, ethylenediamine tetraacetic acid (EDTA), citric acid, or ascorbic acid may be added to fats to prevent rancidity. These substances act as scavengers and bind copper and other metals present which cause oxidative rancidity. Tocopherols and ascorbic acid are excellent antioxidants.

7. If fats and oils have to be stored for some time, they should be hydrogenated and stored.

Hydrogenation increases the shelf life of fats and prevents rancidity.

D) <u>Refining</u>

The oil extracted by rendering, pressing or solvent extraction is called crude oil. It may contain undesirable constituents such as gums, free fatty acids, pigments, cellular materials and odourous compounds such as aldehydes, ketones and essential oils.

Crude oil needs several types of treatment to extend it shelf life and make it suitable and pure for use.

Steps in refining oil:

1. **<u>Settling:</u>** The cell debris is allowed to settle down and is removed by filtration.
2. **<u>Degumming and Neutralization:</u>** The gum and free fatty acids present are removed by steam distillation. Steam is passed through hot oil under pressure. Water soluble low molecular weight fatty acids which are volatile are removed. Hot oil is treated with sodium hydroxide or sodium carbonate. The free fatty acids saponify and soap is separated out. This step is called **Alkali refining.**

3. **Bleaching:** This step removes undesirable colouring and flavouring contaminants. Pigments are removed by filtering the oil through activated charcoal till it is light in color.
4. **Steam Deodourization:** Steam is injected into the hot fat under pressure. Low molecular weight aldehydes, ketones, peroxides and free fatty acids are removed. The oil is cooled rapidly.

Hydrogenation: Liquid oils can be converted to solid fats by a process known as hydrogenation. Plant oils contain a large percentage of unsaturated fatty acids and hence have a tendency to become rancid.

These unsaturated glycerides in the oil can be converted to more saturated glycerides by addition of hydrogen. This process is known as hydrogenation.

Hydrogenated fat is manufactured from vegetable oils by the addition of molecules hydrogen to the double bonds in the unsaturated fatty acids in the presence of a catalyst (finely divided nickel). The product formed is a solid fat with higher melting point than that of the oil used as a starting material. Hydrogenation is of great economic importance, because it allows oils to be converted into fats, which has better keeping quality. The various brands of vanaspati we find in the market are prepared by this process.

Winterization: After steam deodourization, the oils are chilled rapidly without stirring so that large filterable crystals are formed. These crystals are composed of high molecular weight triglycerides which have a high melting point. They are separated out by filtration and the cold viscous oil is obtained is said to be winterized.

Winterized oil does not turn cloudy or solidify in the refrigerator. It is suitable to be used in foods which require refrigeration example: salad dressings and

mayonnaise which can be poured even when chilled. It is an important step in refining oil. Olive oil is not winterized or deodourized as desirable flavor is lost in these processes.

E) Effect of Heating on Fats and Oils with respect to smoke point:

During cooking or prolonged heating of fats and oils, certain changes are seen:

1. There is an increase in the free fatty acid content.
2. Smoke point is lowered.
3. Iodine number decreases.
4. Melting point falls.
5. Fat turns darker in color.
6. Fat gets polymerized.
7. Refractive index increases.

All these changes influence the overall quality of food. These changes are faster when the cooking temperature is increased.

F)Commercial Uses of Fats and Oils

Fats and oils are used in the food industry because of their ability to:

1. Increase tenderness and make the product short.
2. Form emulsions
3. Spread and be plastic
4. Fry or cook food
5. Get creamed and form foams
6. Impart flavour, aroma, and color to food

Fats available in the market are specially manufactured for a variety of applications. Separate hydrogenated fats are available for each of the following:

1. Crispness of biscuits
2. Puff pastry for excellent layer separation, i.e. highly plastic variety available as vanaspati or as margarine.
3. Soft and tender cakes with high volume.
4. Softer bread with easy dough handling.
5. Cream filling for cakes and biscuits
6. Crunchy cookies and biscuits
7. Easy release of baked products from the baking pan

Shortening Power

Superglycerinated or high ratio shortenings are specially manufactured to achieve a desired consistency by hydrogenation of oil. Mono and diglycerides are added to improve the emulsification ability of the shortening in batters and doughs.