

Chapter 6

Lipids

6.1 Introduction

The term 'Lipids' is applied to a group of naturally occurring substances characterised by their insolubility in water, greasy feel and solubility in some organic solvents such as ether and chloroform.

6.2 Classification

Lipids are mainly classified into three. They are:

1. Simple lipids.
2. Complex lipids.
3. Derived lipids.

Simple lipids(Oils and fats)

Simple lipids are those which yield fatty acids and an alcohol upon hydrolysis. These are esters of fatty acids like palmitic acid($C_{15}H_{31}-COOH$), stearic acid($C_{17}H_{35}-COOH$), etc. and glycerol. They are known as triglycerides. Oils are liquids at $20^{\circ}C$, where as fats are solids at $20^{\circ}C$.

Complex lipids

Complex lipids are those which yield fatty acids, glycerol and other organic compounds on hydrolysis. They are of two types.

1. Phospholipids(phosphatides) :- These contain phosphoric acid and a nitrogenous base in addition to fatty acids and glycerol. e.g. Lecithin, cephalin, etc.
2. Glycolipids :- Complex lipids containing carbohydrates in combination with fatty acids and glycerol. e.g. cerebrosides.

Derived lipids.

These include sterols, fatty acids, Vitamins like, A, D, E, and K etc.

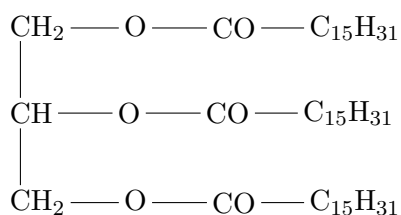
Waxes

These are esters of fatty acids and long chain aliphatic alcohols. E.g. bee's wax.

6.3 Chemistry of Lipids

6.3.1 Simple Lipids

Simple lipids consist of esters of fatty acids with glycerol. Fats and oils are triglycerides.



Fatty acids are divided into two main groups:

1. Saturated fatty acids :- Fatty acids containing only single bonds.
2. Unsaturated fatty acids :- Fatty acids containing one or more double bonds. e.g. oleic acid($C_{17}H_{33}-COOH$), linoleic acid($C_{17}H_{31}-COOH$), linolenic acid($C_{17}H_{29}-COOH$), etc. They contain one, two and three double bonds respectively.

6.3.2 Properties of Fats

Solubility

Fats are soluble in ethyl ether, petroleum ether, acetone, hot alcohol and benzene. The quantity of fat present in food materials is usually determined by extraction with ethyl ether or petroleum ether.

Iodine Value

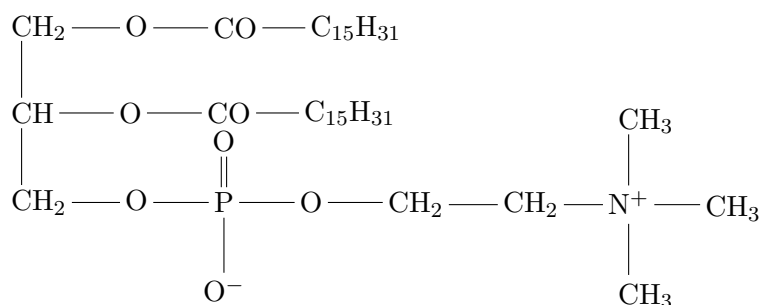
This is a measure of the extent of unsaturated fatty acids present in fats and in oils. It is defined as the number of grams of iodine absorbed by 100 g of fat. Two atoms of iodine are added to each unsaturated linkage.

6.3.3 Complex Lipids

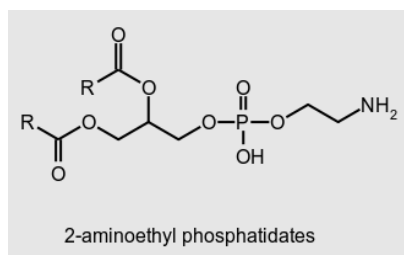
The important complex lipids present in animal and human tissue are given below.

Phospholipids

Lecithin: This contains glycerol, phosphoric acid, choline and fatty acid.

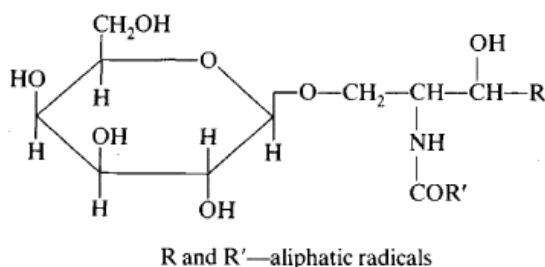


Cephalin: This contains glycerol, phosphoric acid, ethanolamine and fatty acids.



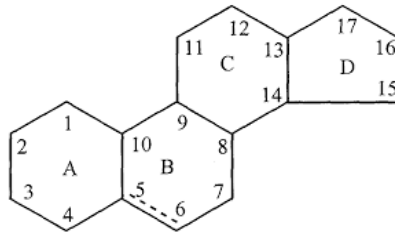
6.3.4 Glyco Lipids

Cerebrosides : They contain hexoses(galactose and glucose), fatty acids and amino alcohol; but no phosphoric acid or glycerol.



6.3.5 Sterols

The sterols comprise one of the important groups of lipids. They possess a cyclic structure, i.e. cyclopentenophenanthrene ring with one secondary alcoholic group.

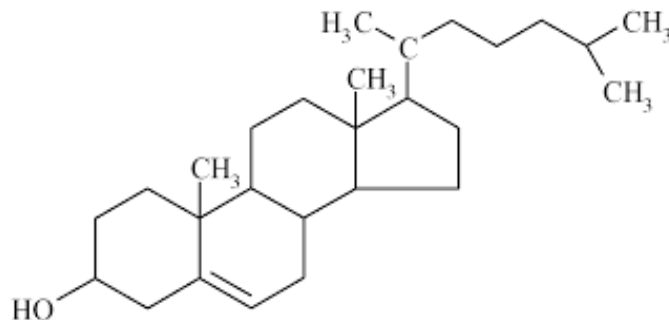


In nature they occur in the free state and as esters with fatty acids. Sterols are classified as follows:

- i. Animal sterols e.g. Cholesterol.
- ii. Plant sterols e.g. phytosterol.
- iii. Mycosterols e.g. ergosterol.

Cholesterol

The white matter of brain contains about 4.5%, and grey matter, 1% of cholesterol on the fresh weight basis. Large amounts of cholesterol are also present in sebum secreted by sebaceous glands. The blood of normal human beings contains 150 - 250 mg/100 ml.



6.4 Refined and Hydrogenated Oils

The process of refining and hydrogenation is given below.

Refined Oil

The process of preparation of refined oil consists of the following step:

1. Alkali refining for removing free fatty acids.
2. Bleaching with the fullers earth or activated carbon to remove colouring matter and
3. Deodorisation with super heated steam.

The refined oils thus obtained are free from odour and colour.

Hydrogenated Oils

The refined oil obtained as described above is hydrogenated under optimal temperature and pressure in the presence of nickel catalyst. During the process of hydrogenation, hydrogen is added to unsaturated linkages. The liquid fat becomes a solid fat and the unsaturated fatty acid contents decrease as a result of hydrogenation. Vanaspathi, sold in India consists mostly of hydrogenated refined ground nut oil to which sesame oil(5%) is added. Since it is used to substitute for ghee, Vanaspathi has been fortified with vitamin A.

6.4.1 Rancidity in Oils

The development of off-flavours in fact is known as rancidity. There are two main types of rancidity.

- (a). Hydrolytic and
- (b). Oxidative

Hydrolytic Rancidity

When fat is hydrolysed by lipase, free fatty acids are formed. The odours of low molecular weight fatty acids contribute to rancidity.

Oxidative Rancidity

The oxidation takes place at the unsaturated linkage (double bond). The addition of oxygen to the unsaturated linkage results in the formation of peroxide which, on decomposition yields aldehydes and ketones having pronounced off-odour.

6.5 Functions Fats in the Diet

Fat has several important functions:

1. It is concentrated source of energy yielding more than twice the energy supplied by carbohydrates per unit weight.
2. Fats are essential for the absorption of vitamins A, D, E, K and especially carotenes (pro vitamin A) present in foods of vegetable origin.
3. Some animal fats e.g. fish liver oils, butter and ghee contains vitamin A and many vegetable fats contain vitamin E and red palm oil is good source of carotene (pro vitamin A)
4. Fats contain essential fatty acids. viz. Linoleic, linolenic and arachidonic acids which are essential for maintaining tissues in normal health.
5. Fats helps to reduce the bulk of the diet as starchy foods absorbs a lot of water during cooking.
6. Fats improve palatability of the diet and give satiety value i.e. a feeling of fullness in the stomach.
7. Fats are essential for the utilisation of galactose present in the lactose.
8. Phosphatides and other complex lipids are essential constituents of nerve tissue and
9. Fats are deposited in the adipose tissue and this deposits serves as a reserve source of energy during starvation. Further, adipose tissue functions like an insulation material against cold and physical injury.

6.6 Essential Fatty Acids

Linoleic, linolenic and arachidonic acids are found to be highly effective in promoting the growth of rats fed diets. Hence they are called essential fatty acids.

6.6.1 EFA content of oils:

Sunflower seed, soya bean, safflower seed, sesame, niger seed, and ground nut oils and egg yolk fat are good sources of EFA. Butter, Vanaspathi, and coconut oil are poor sources.

6.6.2 Effect of Deficiency

Rats

Deficiency of Essential fatty acids leads to cessation of growth and development of scaliness of the skin and haemorrhages on the tail. Scales also develop on the dorsal and plantar surface of the feet and around the ears. Hair is lost from the face and the back and blood may appear in the urine. Addition of essential fatty acids to the diets cures the above symptom.

Infants

Hansen and co workers have reported that infants fed on a EFA deficient diet develop perianal irritation and skin changes such as dryness etc. within a few weeks. Supplementation of the diet with linoleic acid cured the condition.

Adults and Children

Recent studies by Gopalan and associates in India have shown that frynoderma in adults and children is cured rapidly by the administration of linseed or safflower seed oil which in essential fatty acids along with Vitamins of B₂ complex and not by Vitamin A.

6.7 Digestion and Absorption of Fats

Fat is not digested in the stomach. The presence of fat in the diet delays the emptying of the food from the stomach. Fats are hydrolysed by the pancreatic and intestinal lipases in the intestines into a mixture of diglycerides, monoglycerides and fatty acids. Bile is essential for the digestion and absorption as it helps to emulsify fats before digestion. The products of digestion pass into the cells of the intestinal wall, where synthesis of new glycerides characteristic of the animal species takes place. The resynthesised lipids pass through the lacteals of the small intestines to the thoracic duct and then to the blood stream in the form of fine particles known as chylomicrons. A greater part of the cholesterol present in the diet is absorbed while phytosterols present in vegetable fats and oils are not absorbed.

6.7.1 Lipids in Blood

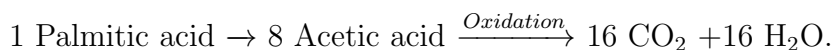
Normal human plasma in the post absorptive state contains about 500 mg of total lipids(per 100 ml) of which about 120 mg are triglycerides, 160 mg of Phospholipids, 180 mg of cholesterol and about 10 -15 mg free fatty acids. Plasma contains two lipo proteins which are involved in the transport of fat.

6.7.2 Storage of Fat

Fat is stored in the adipose tissues. In normal human subjects, adipose tissue constitutes about 10 to 15 percent of the body weight. It increases up to 30 percent in obese persons.

6.7.3 Fat Metabolism

Fatty acids are oxidised by certain enzymes in the tissues to carbon dioxide and water.



The oxidation takes place through the tricarboxylic acid cycle. Fat is also synthesised in the body from carbohydrates by complex mechanism.

6.8 Hypercholesterolemia And Coronary Heart Disorders

The following factors influence the serum cholesterol level.

1. Calorie intake.
2. Cholesterol intake.
3. Fat intake.
4. Essential fatty acid content of the fat.

Low calorie intake tend to reduce, while calorie excess tends to increase serum cholesterol levels. The dietary intake of cholesterol may vary from 500 to 1200 mg depending upon the quantity of milk, butter, eggs, meat and fish in the diet. The adult human body synthesises daily about 2000 mg of cholesterol. Saturated fats like animal body fats, butter, coconut oil and hydrogenated fats tend to increase markedly the serum cholesterol level, while fats rich in essential fatty acids viz. sunflower seed, safflower seed, sesame, soya bean, niger seed, and cotton seed oils and fish oils tend to reduce the serum cholesterol level. When the blood cholesterol level is over 250 mg / 100 ml, the incidence of atherosclerosis and coronary heart disease is high. Consumption of fats rich in essential fatty acids has been reported to reduce blood cholesterol levels in the above subjects.

6.9 Fat Requirements

The dietary fats should be a good source of essential fatty acids. At least 50% fat should consist of vegetable oils rich in essential fatty acids. The approximate fat requirements of different age groups are as follows.

Subjects	% of total calories from fat
Normal adult, expectant, and nursing mothers	10 - 20
Children and adolescents (2-18 years)	15 - 20
Infants (Birth to 1 year)	25 - 30
