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LIPIDS

Subject name: Animal Nutrition

Subject year: 2nd

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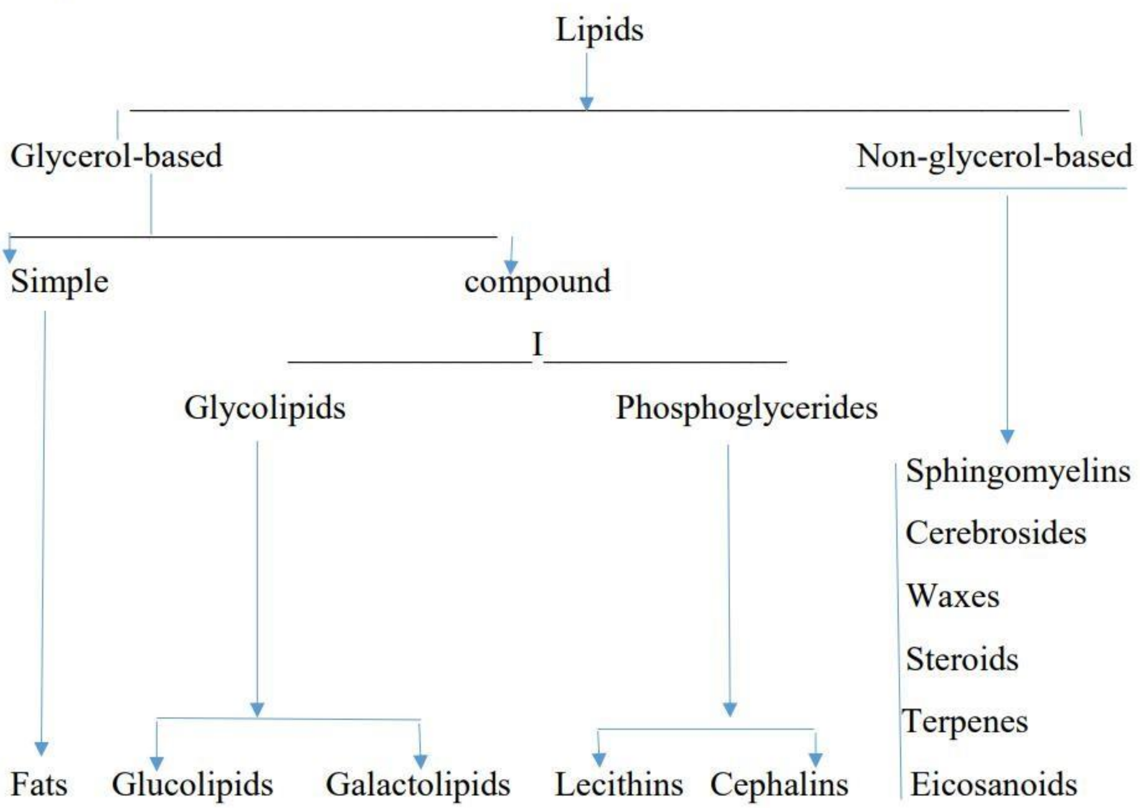
LIPIDS

CLASSIFICATION OF LIPIDS

The lipids are a group of substances found in plant and animal tissues. They are insoluble in water but soluble in common organic solvents such as benzene, ether and chloroform. They act as electron carriers, as substrate carriers in enzymic reactions , as components of biological membranes, and as sources and stores of energy. In the proximate analysis of foods they are included in the ether extract fraction. They may be classified as shown in Fig :



Types of Lipids:

Triglycerides: Function as a long-term energy source in animals (fats) and Phospholipids: Structural component of cell membranes.

Steroids: Act as hormones in plants and animals, and is a structural component of animal cell membranes (cholesterol).

Waxes: Act as a protective layer against water loss in plant leaves and animal skin

Carotenoids: Light-absorbing accessory pigment in plants (involved in photosynthesis)

Glycolipids: Complexes of carbohydrate and lipid that function as cell receptor and cell recognition molecules.

Plant lipids are of two main types: structural and storage. The structural lipids are present as constituents of various membranes and protective surface layers and make up about 7 per cent of the leaves of higher plants.The surface lipids are mainly ,waxes, with relatively minor contributions from long-chain hydrocarbons, fatty acids and cutin. The membrane lipids, present in mitochondria, the endoplasmic reticulum and the plasma membranes, are mainly glycolipids (40– 50 per cent) and phosphoglycerides. Plant storage lipids occur in fruits and seeds and are, predominantly, triacylglycerols. Over 300 different fatty acids have been isolated from plant tissues, but only about seven are of common occurrence. The most abundant is -linolenic acid; the most common saturated acid is palmitic acid and the most common monounsaturated acid is oleic acid.

In animals, lipids are the major form of energy storage, mainly as fat, which may constitute up to 97 per cent of the adipose tissue of obese animals.The yield of energy from the complete oxidation of fat is about 39 MJ/kg DM compared with about 17 MJ/kg DM from glycogen, the major carbohydrate form of stored energy. In addition, stored fat is almost anhydrous, whereas stored glycogen is highly hydrated . Weight for weight, fat is, therefore, about six times as effective as glycogen as a stored energy source.

Structure of fats:

Fats are esters of fatty acids with the trihydric alcohol glycerol; they are also referred to as glycerides or acylglycerols.When all three alcohol groups are esterified by fatty acids, the compound is a triacylglycerol (triglyceride).

CH2OH			CH2.O.CO.R	
CH OH	+ 3R.COOH	------------	CH.O.CO.R	+ 3H2O
CH2OH			CH2.O.CO.R	
Glycerol	Fatty acid		Triacylglycerol	

It is important to appreciate that, in stereochemical terms, the positions occupied by the acid chains are not identical. Under the stereospecific numbering system the positions are designated sn-1, sn-2 and sn-3, as shown.They are readily distinguished by enzymes and this may lead to preferential reactivity at one or more of the positions. Phosphorylation, for example, always takes place at carbon atom sn-3 rather than at carbon atom sn-1.Although triacylglycerols are predominant, .mono- and diacylglycerols do occur naturally, but in much smaller amounts Triacylglycerols differ in type according to the nature and position of the fatty acid residues.Those with three residues of the same fatty acid are termed simple triacylglycerols, as illustrated above.When more than one fatty acid is concerned in the esterification, a mixed triacylglycerol results:

CH2.O.CO.R1

CH.O.CO.R2

CH2.O.CO.R3

Mixedtriacylglycerol

R1,R2 and R3represent the chains of different fatty acids. Naturally occurring fats and oils are mixtures of such mixed triacylglycerols. Soya bean oil has been estimated to contain about 79 per cent of mixed triacylglycerols compared with 21 per cent of the simple type. Comparable figures for linseed oil are 75 and 25 percent, respectively.Triacylglycerols with residues of one fatty acid only do occur naturally; laurel oil, for example, contains about 31 per cent of the triacylglycerol of lauric acid

Most of the naturally occurring fatty acids have an even number of carbon atoms, which is to be expected in view of their mode of formation .The majority contain a single carboxyl group and an unbranched carbon chain, which may be saturated or unsaturated. The unsaturated acids contain one (monoenoic), two (dienoic), three (trienoic) or many (polyenoic) double bonds.

Fatty acids with more than one double bond are frequently referred to as polyunsaturated fatty acids (PUFA). The unsaturated acids possess different physical and chemical properties from the saturated acids: they have lower melting points and are more chemically reactive.

The presence of a double bond in a fatty acid molecule means that the acid can exist in two forms, depending upon the spatial arrangement of the hydrogen atoms attached to the carbon atoms of the double bond.When the hydrogen atoms lie on 4 the same side of the double bond, the acid is said to be in the cisform, whereas it is said to be in the transform when the atoms lie on opposite sides, as shown here :

Important Functions of Lipids:

(1)-Fats serve as food reserve in both plants and animals. Hibernating animals store extra fat prior to onset of winter. Migratory birds also do so before migration.

(2)- They function as concentrated food because as compared to carbohydrates they yield more than twice as much energy per unit weight (9.3 kcal/gm: 4.5 kcal/gm).

(3)- Fats can be converted to carbohydrates. Therefore, fats stored in oil seeds (e.g., Groundnut, Mustard, Castor, Sun-flower, Cotton, and Coconut) not only provide energy but also raw materials for growth of embryo. (4)- In seeds and spores lipids help in thermal insulation, protection from ultraviolet radiations and loss of water.

(5)- Vitamin A, D, E and K are soluble in fats. The latter not only act as their carriers but also protect them from oxidation.

(6)- In animals fat occurs as droplets inside cells called adipocytes. Adipocytes of cold blooded or poikilothermic animals have higher amount of unsaturated fatty acids as compared to warm blooded or homoeothermic animals. Fatty or adipose tissue forms an insulating layer below the skin of animals for protection against low temperature. Whale has a very thick layer of subcutaneous fat called blubber. Animals of colder regions also have a thick fatty layer for insulation, e.g., Polar Bear.

(7)- Subcutaneous fat rounds off the body contours of animals and human beings. In animals the fats produce a shock absorbing cushion around eye balls, gonads, kidneys and other vital organs.

(8)- Edible oils extracted from many seeds are used in cooking. Animal fats present in milk yield butter and ghee. (9)- Plant oils are used as low cholesterol fat. They are also hydrogenated to form vegetable ghee.

(10)- Soap was previously manufactured from animal fat. Now-a-days plant fats are used for this purpose.

(11)- Drying oils having unsat-urated fatty acids are used in paint industry. 5

(12)- Waxes form a protective layer over the animal fur. They protect the floating leaves of aquatic plants against wetting. In land plants they reduce the rate of transpiration.

(13)- Myelin sheath around nerve fibres takes part in insulation.

(14)- Phospholipids, glycolipids and sterols are components of cell membranes.

(15)- Fragrance of many plant products is due to fat-like substances called terpenes.

(16)- In birds, oil from preen gland is used to lubricate feathers and protect them from wetting. Hair are similarly lubricated in mammalian skin. It prevents their felting. The skin is also protected from drying up.

(17)- Desert animals employ fat as source of metabolic water, e.g., Kangaroo Rat, Camel. Kangaroo or Desert Rat does not drink water. Camel uses fat stored in its hump for obtaining metabolic water during extreme desiccating conditions.

What is Lipogenesis ?

Lipogenesis is a term used to describe a process of fatty acid and triglyceride synthesis from glucose or other substrates. This specific biosynthesis takes place predominantly in the liver, while its occurrence in the adipose tissue is of minor significance – even under conditions of substantial carbohydrate overfeeding.

Although our understanding of biochemistry and hormonal regulation of lipogenesis stems from in vitro research on rodents, the biological importance, activity and tissue distribution of the lipogenic pathways show considerable variation among different species. In humans, lipogenesis plays an important role in physiologic and pathophysiologic conditions.

Steps in lipogenesis:

Different human cells show the ability to convert carbohydrates (but also amino acid carbons) into fatty acids via a biochemical pathway known as de novo lipogenesis. The initial step for such fatty acid synthesis is acetyl-CoA carboxylation to malonylCoA with the help of the enzyme acetyl-CoA .

carboxylase, which is mostly taking place in liver cells, but also in skeletal muscle and adipose tissue. Further events include an iterative integration of malonyl-Coa carbons into a fatty acid chain which results with the synthesis of a palmitic acid, representing an 6 energy-consuming process.

Additional action of elongase and desaturase enzymes can lead to the synthesis of stearic acid.

De novo lipogenesis from carbohydrate is associated with significant amounts of energy lost as heat, irrespective of whether synthesized fat is oxidized or stored in form of a triglyceride. The process is activated by insulin and inhibited by hyperglucogonemia (excess glucagon secretion) and by cellular energy deprivation through 5′ AMP-activated protein kinase by glucagon.

Carbohydrates in the form of glucose, glycogen and lactate are considered to be the major precursors for de novo lipogenesis in the fetus and neonate. De novo synthesis of fatty acids in fetal lung has been studied extensively as the synthesis of surfactant is pivotal for normal pulmonary function at birth.

Lipid Catabolism:

Triglycerides are a form of long-term energy storage in animals. They are made of glycerol and three fatty acids. Phospholipids compose the cell and organelle membranes of all organisms except the archaea. Phospholipid structure is similar to triglycerides except that one of the fatty acids is replaced by a phosphorylated head group.

Triglycerides and phospholipids are broken down first by releasing fatty acid chains (and/or the phosphorylated head group, in the case of phospholipids) from the threecarbon glycerol backbone. The reactions breaking down triglycerides are catalyzed by lipases and those involving phospholipids are catalyzed by phospholipases. These enzymes contribute to the virulence of certain microbes, such as the bacterium Staphylococcus aureus and the fungus Cryptococcus neoformans. These microbes use phospholipases to destroy lipids and phospholipids in host cells and then use the catabolic products for energy.