Dr. Nadhim M.Jawad Ali
Department of Public Health
College of Veterinary Medicine
University of Basrah
Second Class- Animal nutrition

Lipids

It is a group of compounds that do not dissolve in water, but they dissolve in organic solvents such as benzene, ether, and chloroform, so it is called ether extract. It includes fats, oils, phospholipids, sterols, waxes, dyes, and fat-soluble vitamins. Lipids are composed of carbon, hydrogen, and oxygen, but they are relatively richer in the elements carbon and hydrogen. Some of them also contain nitrogen and phosphorus, and fats and oils are considered sources of energy in the body of animals and plants and as structural elements necessary for various reactions in the processes of intermediate metabolism.

Fatty Acids: What Are They?

Fatty acids are the main players in lipid nutrition. This is due to their diversity in structure, composition, and metabolizability. The molecular composition of a fatty acid includes a hydrophilic carboxyl group (−COOH) and a hydrophobic methyl group (−CH3) at opposite terminals of a hydrocarbon backbone (see Figure 1).

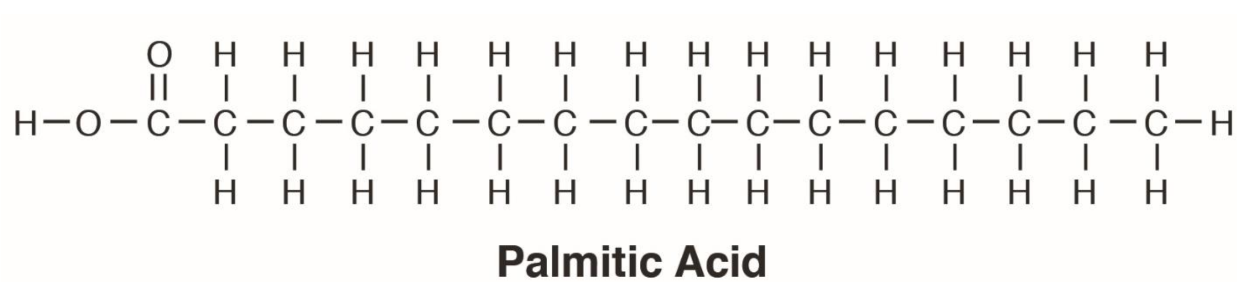
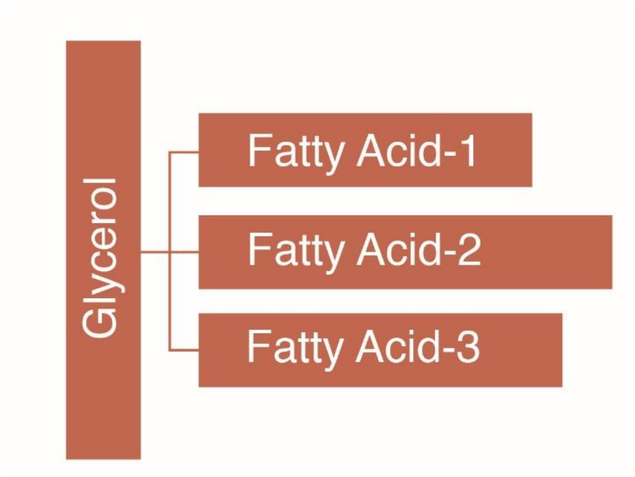


Figure 1. Fatty acid structure with hydrocarbon chain showing carboxyl and methyl end

In most cases, three fatty acids are attached to the glycerol molecule and are called triacylglycerol. The three fatty acids in triacylglycerol can differ in chain length (i.e., total carbons in the fatty acid molecule) as well as in the number of double bonds.

A schematic representation of a triacylglycerol structure with three fatty acids on a glycerol backbone is shown below.



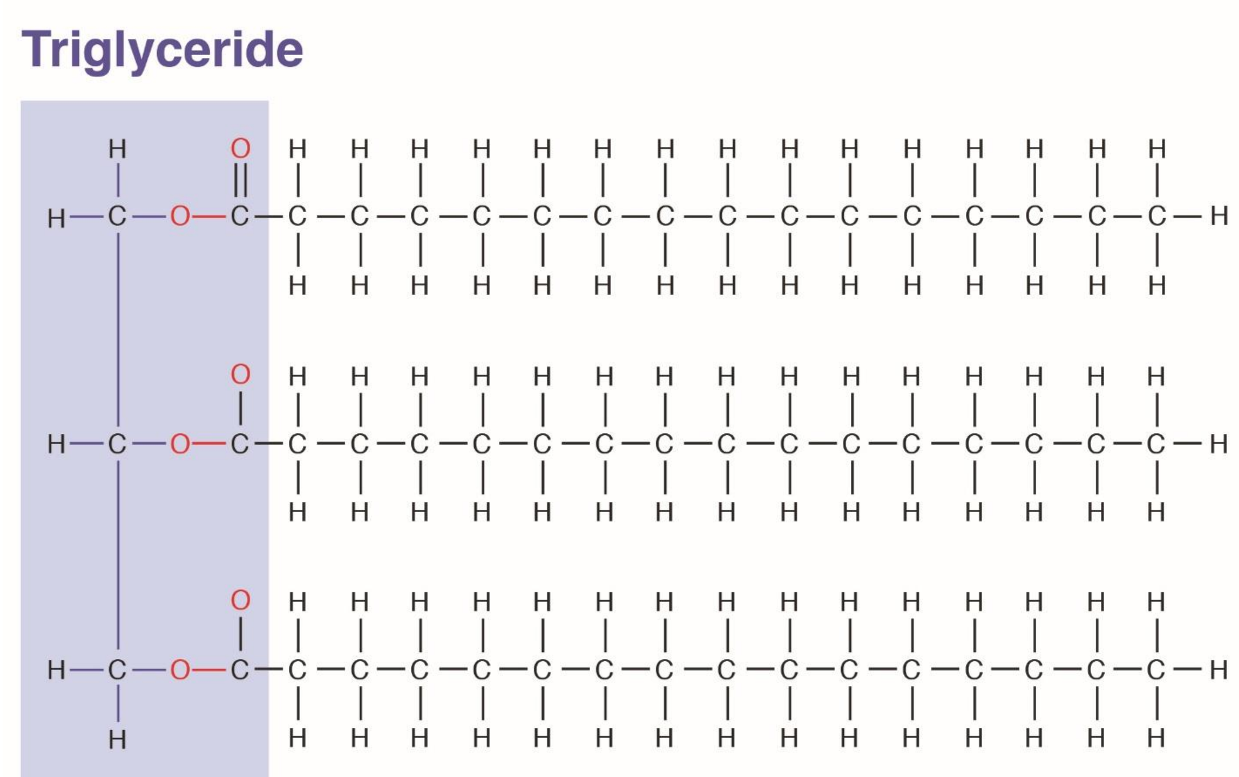


Figure 1

Fatty acid composition and structure determine the physical property and nutritional quality of fats. For example, when there is a predominance of saturated fats in the triacylglycerol, fat tends to solidify (e.g., fat around a piece of meat), and when there is a predominance of unsaturated fats, fat tends to liquefy (e.g., salad oil).

Physical Properties: Fatty Acids

- An increase in saturation makes fats more solid.
- An increase in unsaturation makes fats more liquid or decreases their melting point.

Fatty acids are classified into three families based on the presence (or absence) of double bonds in the hydrocarbon chain. These include saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids (PUFAs).

Natural fatty acids in fat:

They are the component of most lipids and are found in the fats of plants and animals. The melting point of solid acids is higher than 15 degrees Celsius.

- Saturated = no double bonds
- Unsaturated = presence of double bonds (could be one or two)
- Polyunsaturated = more than two double bonds

Saturated fatty acids are "saturated" with hydrogen or straight chains with no double bonds (e.g., palmitic acid, C16:0). When there is a predominance of saturated fats in the glycerol moiety, the triacylglycerol tends to be solid. This is because due to their straight chain nature, they tend to "pack" very tightly in the membrane (e.g., tallow or beef fat; Figure 2).

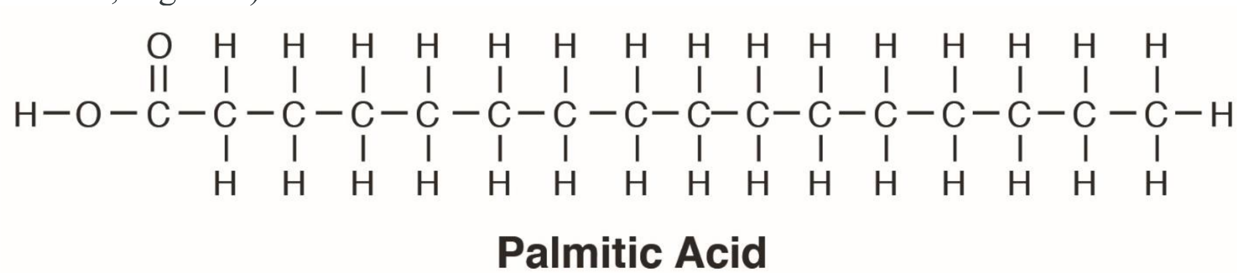


Figure 2. Saturated fatty acid with no double bonds

Unsaturated fatty acids contain one or more double bonds between adjacent carbon atoms in the hydrocarbon chain.
Unsaturated fatty acids may be either mono (one double bond) or polyunsaturated (more than two double bonds). When there is a predominance of unsaturated fats, the

triglyceride tends to be liquid because unsaturation gives a “bend” in their structure and they cannot pack as tightly as saturated fats (e.g., vegetable oil).

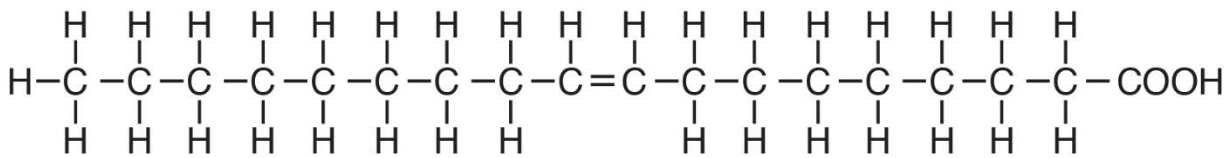


Figure 3. Unsaturated fatty acid

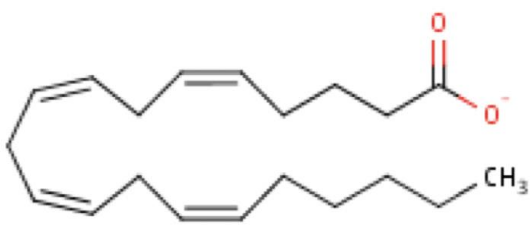


Figure 4. Polyunsaturated fatty acid

Polyunsaturated fatty acids are commonly called “PUFA” and contain two or more double bonds. Due to these extra double bonds, PUFAs tend to be more “round” when compared to the straight chain structure of a saturated fat (e.g., Figure 2 vs. Figure 4). These double bonds also change the physical nature of the fat, making it more liquid than straight chain saturated fat. In addition to the number of double bonds, the position of double bonds in the carbon-carbon chain is also important in nutrition and in the metabolism of lipids; this is explained below.

Nutritionists designate the term *omega* (ω) or “n” to denote the position of double bonds in the carbon chain in a PUFA. The omega carbon is the first carbon with a double bond counting from the methyl end (CH3) of the carbon chain. The two PUFA classifications are omega-6 (also called n-6, or ω-6) or omega-3 (n-3, or ω-3). For instance, omega-3 fatty acid will have the first double bond at the third carbon when counted from the methyl (CH3) end (Figure 5a) and omega-6 fatty acids will have the first double bond at the sixth carbon when counted from the methyl (CH3) end (figure 5b). The locations of the double bonds are also indicated by the Greek letter Δ, “delta,” in some chemistry or biochemistry textbooks. The delta term denotes the position of double bonds from the carboxyl end. However, the term omega, or “n,” is the one that is commonly used by nutritionists.

Two Types of PUFA

1. Omega-6 (n-6, or ω-6) fatty acid
2. Omega-3 (n-3, or ω-3) fatty acid

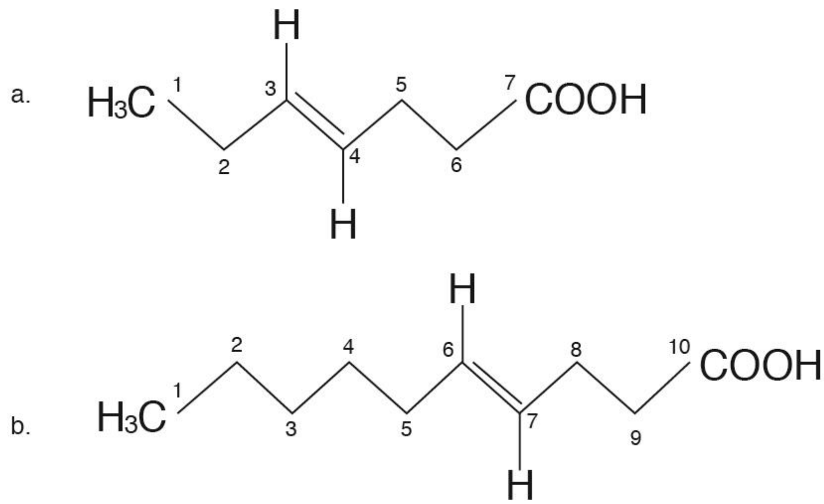


Figure 6.5. Basic structure of an omega-3 (a) and an omega-6 (b) fatty acid

Classification of lipids

First: simple lipids:

they are esters of fatty acids with various alcohols, including:

A. Fate

They are esters of fatty acids and glycerol. The difference in types of fats is due to the difference in fatty acids involved in the synthesis of fats.

Properties of fats:

1. Melting Point

Higher partial weight of fatty acids leads to higher melting point. Therefore, the melting point of unsaturated fatty acids is lower than the melting point of saturated fatty acids. Therefore, unsaturated fatty acids are liquid at room temperature, while saturated fatty acids are solid at room temperature.

2. Iodine Value

It is the number of grams of iodine that is included in the composition of 100 grams of fat. Unsaturated fatty acids are characterized by the presence of double chemical bonds that have the ability to combine with iodine, and the amount of iodine that combines with the fat depends on the degree of saturation of the fatty acids included in the composition of the fat.

3. Saponification Value

It is the number of milligrams of sodium or potassium hydroxide needed to soap one gram of fat, as the fat is decomposed with a basic solution to produce soap.

4. Hydrolysis

When fats are boiled in a basic solution, they decompose into glycerol and soap, or under the influence of lipase enzymes that decompose fats into mono- or di-glycerides and free fatty acids.

5. Oxidation

Saturated fatty acids are oxidized at the sites of carbon atoms linked to the double bonds, thus producing hydroperoxides.

6. Hydrogenation

It is the process of adding hydrogen to the double bond of unsaturated fatty acids and converting them to saturated fatty acids.

B. Waxes:

These are esters of fatty acids with monohydroxy alcohols.

Second: Compound lipids:

They are esters of fatty acids that contain other groups in addition to alcohols and fatty acids, and they include phospholipids, glycolipids, and aminolipids.

Third: Derived lipids:

These are substances that are derived from previous substances when they are decomposed and include fatty acids and sterols.

Digestion of lipid:

Lipid are broken down into glycerol and fatty acids. There is no evidence that there is an oxidation process in the rumen that breaks down fatty acids, but what happens is the process of converting saturated fatty acids into unsaturated fatty acids and vice versa. Therefore, fat can be added to the diet in liquid or solid form, while in animals with simple stomachs, fatty substances are added in solid form due to the absence of bacteria or protozoa that carry out the conversion, and thus the digestion of complex substances continues by means of enzymes secreted by bacteria.

$$\text{Lipids} \xrightarrow{\text{Lipase}} \text{Glycerol + F. A} \longrightarrow \text{Pyruvic} \longrightarrow \text{V. F. A}$$

$$\text{Unsaturated F. A} \xrightarrow{\text{Protozoa}} \text{Saturated F. A}$$

$$\text{Saturated F. A} \xrightarrow{\text{Bacteria}} \text{Unsaturated F. A}$$

The feed lipid enters the intestine in a state of free fatty acids, covering the feed particles in the form of thin layers. Likewise, the feed lipid that is not affected by microorganisms and the lipid of the cells of microorganisms that enter the intestine with the food mass enter the intestine, and are digested by the action of bile salts and pancreatic and intestinal secretions of enzymes.

However, most of the absorption occurs in the last three quarters of the jejunum, and the lipid leaves the cells of the intestinal mucosa to the lymphatic vessels in the form of small droplets.

Why Add Fats to Animal Diets?

Nutritionally, fats are excellent sources of energy and are essential to the survival of animals. Fats are the sole source of **essential fatty acids** (those that cannot be made by the body) for animals. Fats can also provide fat-soluble vitamins. However, this role is very minimal in livestock as feeds are supplemented with vitamins.

Physically, the addition of fats is associated with the improvement of feed quality, the reduction of dust in feed, the reduction of feed particle separation during processing, an increase in palatability, an increase in digestive lubrication (i.e., emulsification and rate of passage), and an increase in feed digestibility.