Food Chemistry I

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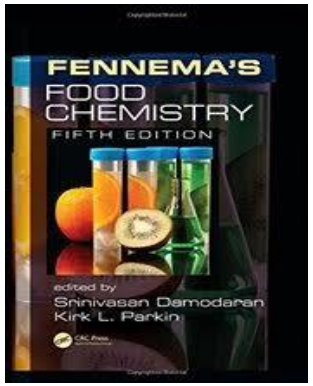
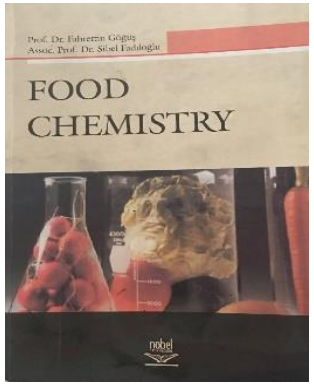
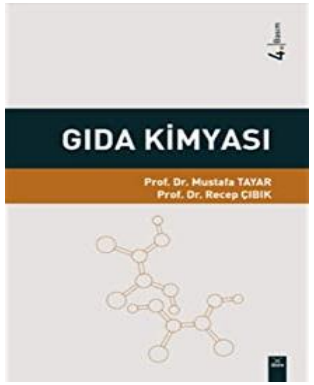
1. 

2. 

3. 

1. Fennema O.R., Ed: Damodaran S. and Parkin K.L. 2017. *Fennema's Food Chemistry*, CRC Press Taylor & Francis Group Boca Raton, FL, USA.
2. Göğüş F. and Fadıloğlu S. 2006. *Food Chemistry*, Nobel Akademik Yayıncılık, Ankara.
3. Tayar M. ve Çıbık R. 2013. *Gıda Kimyası*, Dora Basın-Yayın Dağıtım Ltd. Şti., Bursa.

Properties of Lipids

* Oils (liquid),
* Fats (solid)
* Similar substances

lipids

* naturally-occurring molecules
* soluble in organic solvents
* insoluble or only sparingly soluble in water

* Food lipids play an important role in food quality by contributing to attributes such as texture, flavor, nutrition, and caloric density.

* Lipids: Glycerin triesters of saturated and unsaturated fatty acids with double carbon numbers (C_4–C_{24}). All edible lipids have the same skeleton.

* They consist of C, H and O and can contain a small amount of P and N.

*

Triacylglycerols 95-99%

lipids in foods

1-5% Fatty acids
tri-, di-, and monoglycerides
Phospholipids
Fat-soluble vitamins
Sterol-containing metabolites

Lipids :

* major energy source for human body
* protect human body from mechanical damage and heat loss
* the carriers of fat-soluble vitamins and the precursors of many bioactive molecules
* contain essential fatty acids (linoleic acid, arachidonic acid), are appetizing and have digestive properties

The daily human need for lipids is 50-70 grams. Half of it should be covered with animal sources and the other half with vegetable sources.

Lipids can be classified in three different ways according to :

* their origins

  (plants and animals)

* physical properties

  (solid, semi-solid and liquid)

* chemical structure and compositions

  (simple, compound and derived)

CLASSIFICATION of LIPIDS

according to origin

Plants

seed oils (olive oil, coconut oil, corn oil, sesame oil, peanut oil etc.)

Oil (crude oil) is separated by peeling, pressing, solvent extraction and separation from oilseeds. Crude oil contains various foreign substances.

Animals

Milk oil, body butter (lard, fish oil etc.)

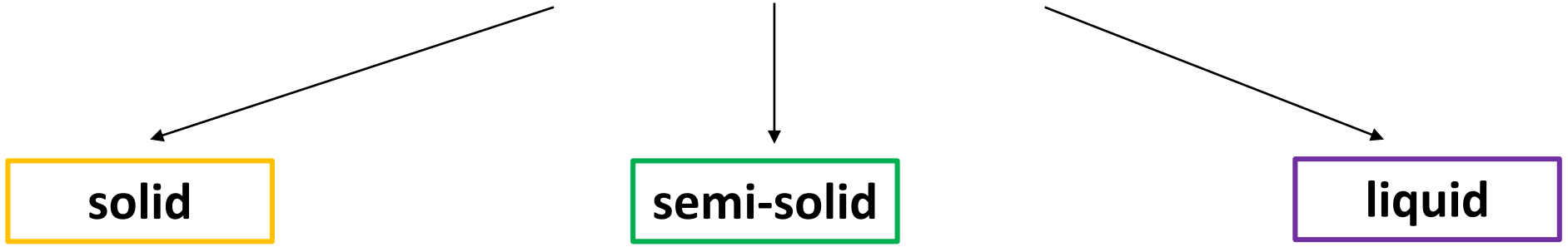
Lipids occur in all animal species, including insects, under the skin, between the muscles and in small amounts in the brain, liver and bone marrow.

Liquid oils have a drying property. It is ***divided into three parts according to its drying properties:***

1. Non-drying oils: They have a low iodine index and < 90 (olive oil)
2. Semi-dry oils: iodine index ~ 90-130 (corn, cotton seeds, soybean oil)
3. Oil drying: iodine index > 130 (sunflower oil)

CLASSIFICATION of LIPIDS

according to their physical properties



There is no difference between the oils in liquid or solid form at room temperature. The difference depends physically and on the amount of saturated or unsaturated fatty acids in their structure. It is known that at least 20 fatty acids are present in natural oils.

CLASSIFICATION of LIPIDS

Based on chemical structure and composition, lipids can be divided into simple lipids, compound lipids, and derived lipids.

Simple lipids are compounds consisting of fatty acids and alcohols and include fats, oils, and waxes.

Compound lipids contain many other groups in addition to fatty acids and alcohols. Glycerophosphonolipids, sphingomyelins, cerebroside, and ganglioside are the examples of compound lipids.

Miscellaneous (Derived) lipids are the derivatives of simple and compound lipids and have the common properties of lipids. Steroids, hydrocarbons, carotenoid, and fat-soluble vitamins are examples of this group.

Simple lipids (fatty acids, alcohols and waxes)

Fatty acids are composed of hydrocarbon chains with a carboxylic acid on one end of the molecule. Based on the presence or absence of double bonds, fatty acids are divided into **saturated** and **unsaturated** fatty acids.

When esterified to a long chain fatty alcohol they are called **waxes** and when bound to glycerol they are called **glycerides**.

Compound lipids
(Phospholipids, Sphingolipids, Glycolipids, Lipoproteins)

Phospholipids: These are lipids that contain phosphoric acid in their structure. The presence of the polar phosphate group on phospholipids makes these compounds surface active. This surface activity allows phospholipids to arrange in bilayers that are critical for the properties of biological cell membranes.

Sphingolipids: Sphingolipids commonly contain a sphingosine base. Common sphingolipids include sphingomyelin (a sphingophospholipid), ceramides, cerebrosides, and gangliosides.

Glycolipids (cerebocytes): These are complex lipids that have glucose and galactose in their structure and play a role in the function of cells.

Lipoproteins: These are parts of lipids in combination with proteins.

Miscellaneous lipids (Sterols)

Sterols: Sterols are derivatives of steroids. These nonpolar lipids all have three six-carbon rings and a five-carbon ring that is attached to an aliphatic chain. Sterols have a hydroxyl group attached to carbon 3 of the A ring. Sterols are found in both plants (phytosterols) and animals. Cholesterol is the major sterol found in animal lipids.

CHEMICAL COMPOSITION OF LIPIDS

TRIGLYCERIDES

It is formed during the esterification of triglycerides, glycerin and three fatty acids.

Triglycerides are divided into two depending on the composition of the fatty acids in their structure.

If all three fatty acids have the same structure in the triglycerides

simple triglyceride

When it consists of two or three different fatty acids

mixed triglyceride

MONO- AND DIGLYCERIDES

Mono- and diglycerides are mono- and diesters that are formed from fatty acids and glycerin. They are important compounds as "emulsifiers". But it is widely used in food.

FREE FATTY ACIDS

These are fatty acids that are not esterified with glycerin in oil. The content of these fatty acids decreases during the refining process.

Sterols are compounds that contain 8-10 carbon side chains and an alcohol group in addition to the steroid skeleton. They are present in free oils, in the form of esters of fatty acids and in the form of glucosides and make up the majority of the non-saponifying substances of many fats and oils. Herbal sterols consist of a mixture commonly known as phytosterols.

FATTY ACIDS

The major components of lipids are the fatty acids that contain an aliphatic chain with a carboxylic acid group.

The majority of fatty acids in nature contain 14–24 carbons. While some fats contain small amounts of fatty acids with <14 carbons, significant levels of short-chain fatty acids are mainly found in tropical oils and dairy fats.

Fatty acids are generally classified as either saturated or unsaturated, with the latter containing double bonds. A fatty acid can also contain a single double bond (monounsaturated) or many double bonds (polyunsaturated).

Saturated fatty acids:

Saturated fatty acids contain an unbranched carbon chain.

Unsaturated fatty acids:

Fatty acids with one or more double bonds at different positions in the carbon chain are referred to as "unsaturated fatty acids". Due to the double bonds, unsaturated fatty acids are chemically more reactive than saturated fatty acids. This reactivity increases with the number of double bonds in the chain. All unsaturated fatty acids show strong oxidation, polymerization and addition.

Essential fatty acids:

Linoleic acid, linolenic acid and arachidonic acid are important fatty acids. These acids are called "essential fatty acids". Because these could not be synthesized in organisms.

Physical and Chemical Properties and Quality Control Criteria of Lipids

Physical Properties

Pure oils and fats are odorless and colorless, but processed fats and oils often display yellow-green color due to the incomplete decoloration of such pigments as carotenoid and chlorophyll.

Melting point: Fats have different melting points depending on the amount of unsaturated and saturated fatty acids they contain.

Density: The density of fatty acids and glycerides reduces with the increase of carbon chain length and the decrease of degree of unsaturation.

Refractive Index: The refractive index tends to increase with the chain length, the number of double bonds, and the conjugation of double bonds.

Turbidity Point: Although the oils are heated with solvents and cooled again after melting, they become blurred and harden at a certain temperature.

Smoke Point: The smoke point refers to the temperature at which a lipid begins to produce smoke, which indicates the decomposition of the lipid.

Flash Point:The flash point of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air.

Fire Point: The fire point, a higher temperature, is defined as the temperature at which the vapor continues to burn for over 5 seconds after being ignited.

Chemical Properties

Saponification number: The saponification value is the weight of KOH required to saponify 1 g of oil in mg.

Acid Value: The acidity of an oil is the amount of ml of a 1N NaOH solution that is required to neutralize the free fatty acids present in 100 g of oil.

Iodine index: This is the amount of iodine in grams that binds 100 grams of oil.

Reichert-Meissl and Polensky Indexes: These indexes indicate the amount of 0.1 N NaOH solution as ml, which is required for the neutralization of water-soluble volatile fatty acids (butyric acid, capric acid, capric acid), which are released during the hydrolysis with H_2SO_4 after distillation of 5 g of oil.