



FATS and OILS

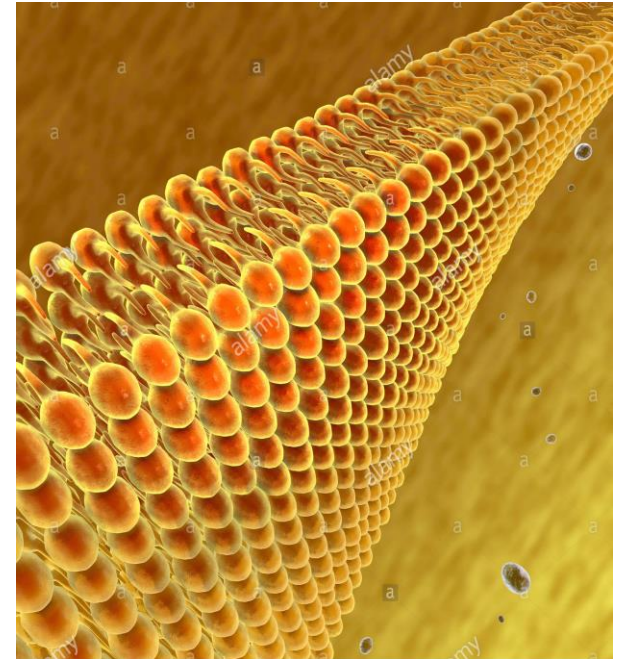
FE 461

Enzymes in Fats and Oil Industry

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LIPIDS

- Lipids are a diverse group of compounds sharing the common property of being hydrophobic (soluble in non-polar solvents, insoluble in water).
- They are organic compounds, contains C, H, and O.
- Lipids include
 - ❖ Fatty acids,
 - ❖ Fats and oils,
 - ❖ Steroids (cholesterol, steroid hormones, bile salts)
 - ❖ Waxes,
 - ❖ Phospholipids
 - ❖ Terpenes, and
 - ❖ Tocopherols



Lipids (Continued)

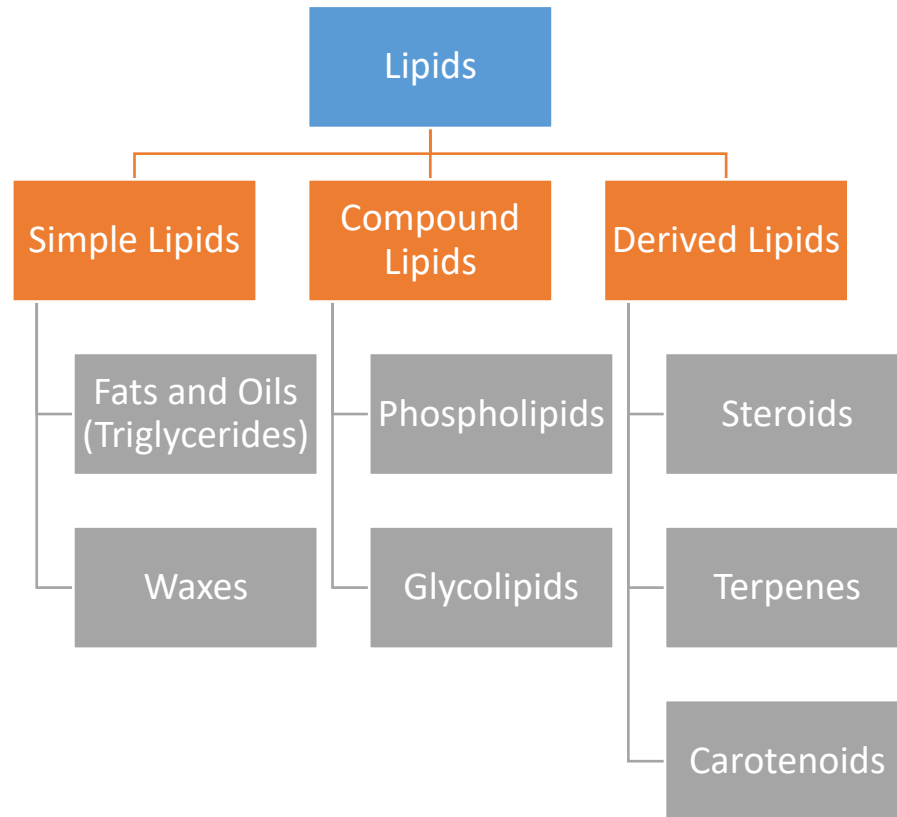
Most of lipids are derivatives of fatty acids.

Types of lipids:

- Lipids with fatty acids
 - ❖ Fats and oils (triglycerides)
 - ❖ Phospholipids
 - ❖ Sphingolipids
 - ❖ Waxes
- Lipids without fatty acids
 - ❖ Steroids

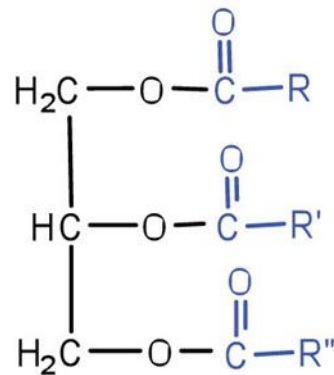
Lipids (Continued)

Most of lipids are derivatives of fatty acids.



FATS and OILS

- Glycerol esters of fatty acids, which make up 99% of the lipids of plant and animal origin, have been traditionally called **fats and oils**.
- The main components of edible fats and oils are triglycerides (>95%). The minor components include mono- and diglycerides, free fatty acids, phosphatides, sterols, fat soluble vitamins, tocopherols, pigments, waxes, and fatty alcohols.



- Triglycerides (% 95-100)
- Phospholipids (% 0.3-2)
- FFA (% 0.3-5)
- Other minor compounds (<%3)

Types and Sources of Fats and Oils

Edible fats and oils can be obtained from two main sources: plant (olive, palm, corn, soybean, etc.) and animal (cow, goat, sheep, fish, etc.).



What are the differences between fats and oils?

Chemically oils and fats are same

FATS

1. Solid at room temperature
2. Relatively more saturated
3. Relatively higher melting point
4. More stable
5. Most from animals (lard, butter, margarine)

OILS

1. Liquid at room temperature
2. Relatively more unsaturated
3. Low melting point
4. Less stable
5. From plants (Olive oil, soybean oil, sunflower oil)



Why FATS and OILS are important?

- Important dietary components
 - Provide high energy value (9kcal/g)
 - Carry the fat-soluble vitamins (A, D, E, K)
 - Carry the essential fatty acids
- Important ingredient in food preparation
 - Texture,
 - Facilitate aeration,
 - Carry flavors and colors
 - Improve palatability of foods
- Important functions in the body
 - Provides insulation to maintain body temperature
 - Protects organs against impacts
 - Assist the storage and transportation of essential fat-soluble vitamins



Role of Fats and Oils in Food Industry

Texture & Flavor

Fats and oils are crucial for providing desirable textures, mouthfeel, and enhanced flavors in various food products.

Extended Shelf Life

They act as natural preservatives and prevent rancidity, thereby extending the shelf life of many packaged foods.

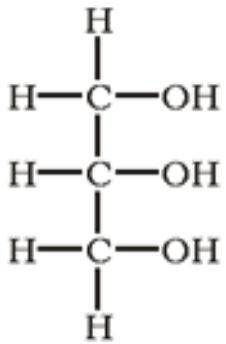
Emulsification

They aid in stabilizing emulsions and improving the overall consistency of salad dressings, dressings, sauces, and baked goods.

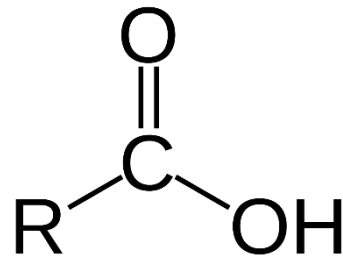


Chemical Structure of Fats and Oils

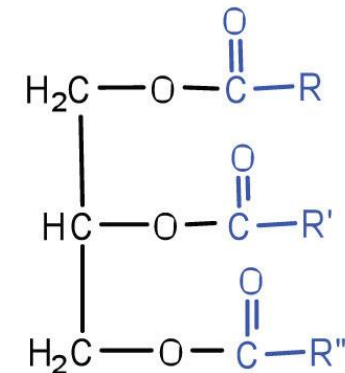
- Most fats and oils occur in the form of triglycerides, in which three fatty acids are attached to the glycerol.
- Fatty acid contains the carboxyl group (COOH) and an aliphatic carbon chain of variable length.



Structure of Glycerol

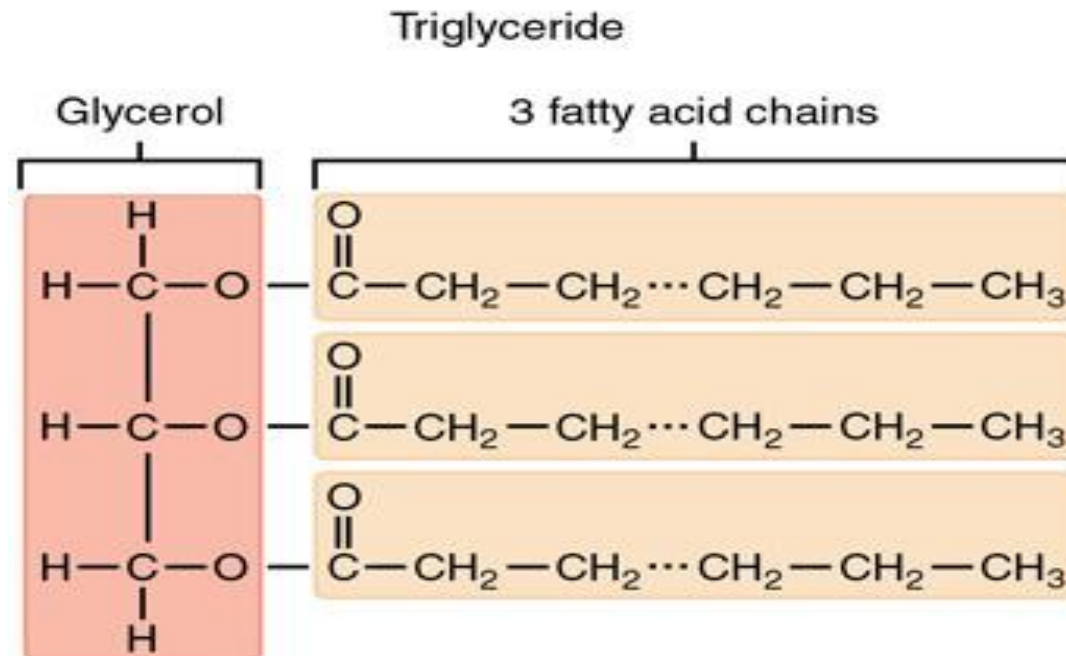


Structure of Fatty Acids



Structure of Triacylglycerol

- **Ester:** An ester bond is the connection between a fatty acid and glycerol in glycerides.
- **Glycerol:** A three carbon chain, with each carbon containing an alcohol group.
- **Triglyceride:** Three fatty acids attached to a glycerol molecule.
- **Fatty acid:** Carboxylic acids with a long hydrocarbon chain attached

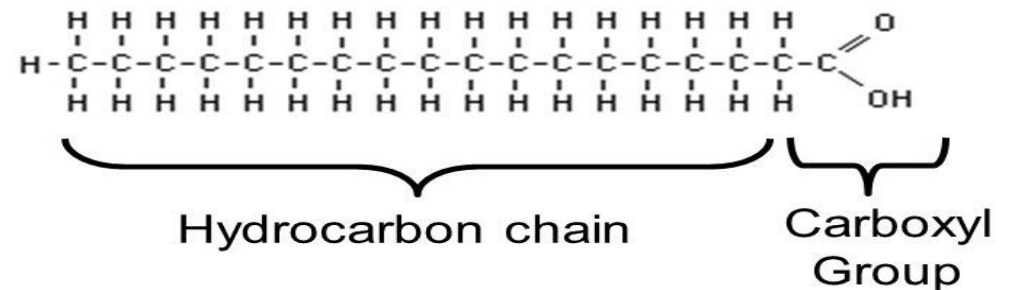
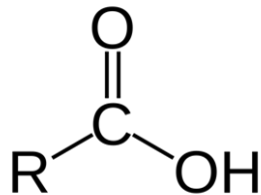


Fatty acids

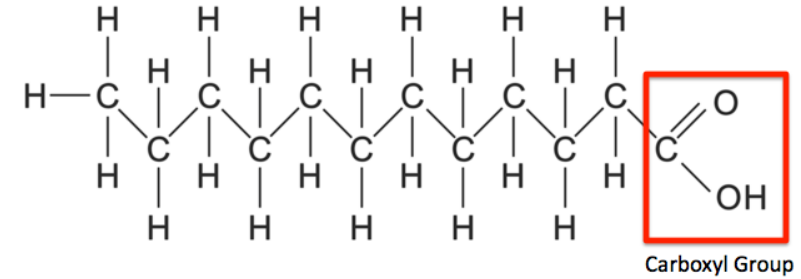
Fatty acid is a carboxylic acid often with a long, unbranched aliphatic chain, which is either saturated or unsaturated.

- Fatty acids differ in:

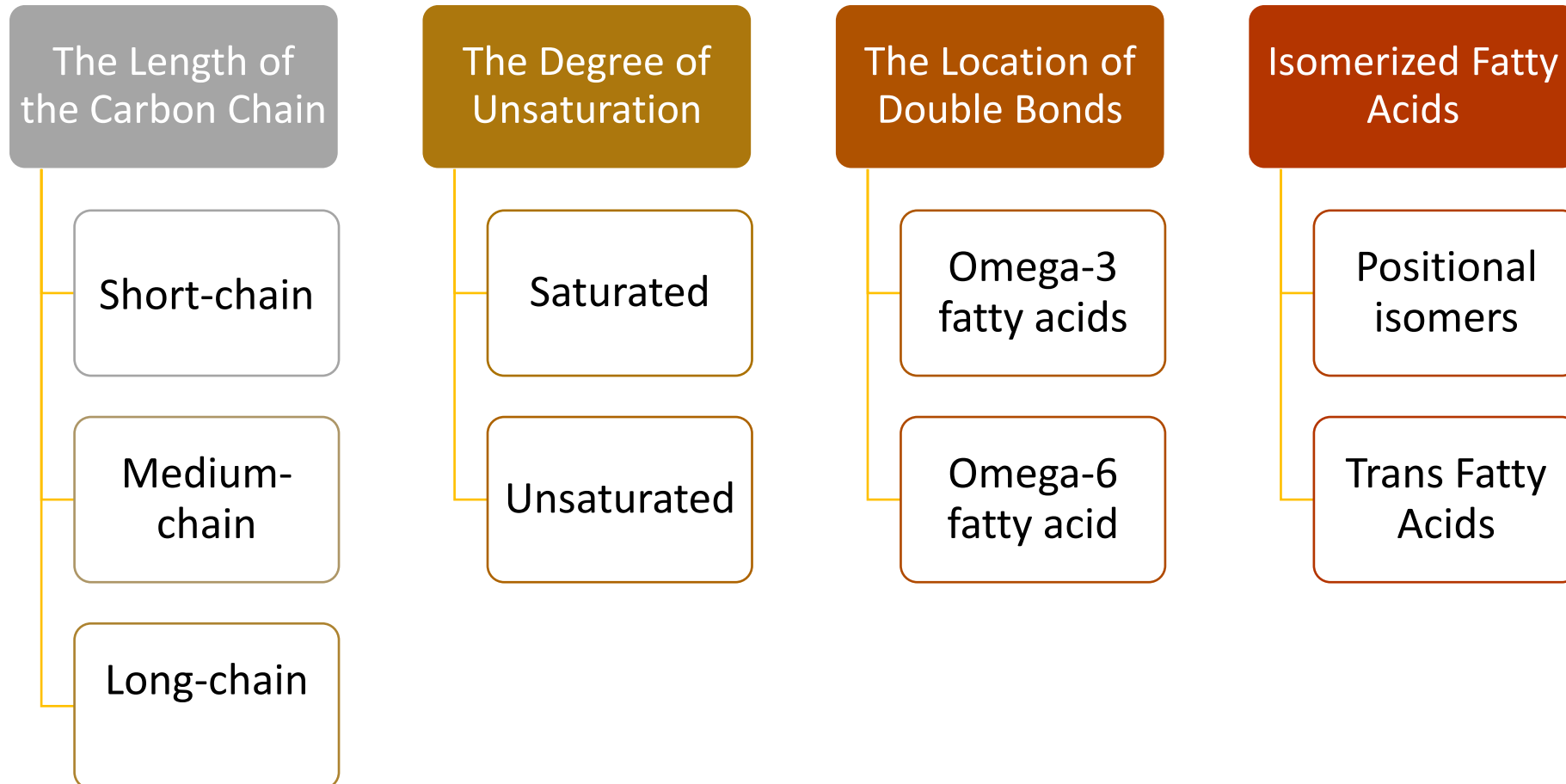
- (1) carbon chain length,
- (2) number of double bonds,
- (3) location of the double bonds,
- (4) the configuration of the hydrogen atoms attached to the carbon atoms joined by the double bond, *cis* or *trans*.



Fatty acids (Continued)



TYPES OF FATTY ACIDS



Fatty acids (Continued)

Short Chain Fatty Acids (SCFA)

- Saturated fatty acids with C2:0 to C6:0
- Gives fewer calorie values per unit weight
- Liquid at room temperature and vaporize readily at high temperatures

Ex: Butyric acid, Caproic acid, Propionic acid



Fatty acids (Continued)

Medium Chain Fatty Acids (MCFA)

- Saturated fatty acids with C8:0 to C12:0
- Quick energy and absorption
- Provides lower energy (8.3 cal/g) than long chain fatty acids (9.2 cal/g)

Ex: Caprylic acid, Capric acid, Lauric acid



Fatty acids (Continued)

Long Chain Fatty Acids (LCFA)

- Saturated fatty acids with C14 to C24
- Absorbed and metabolized more slowly than either medium or short chain acids
- Highest energy source

Ex: Palmitic Acid, Stearic Acid, Oleic Acid

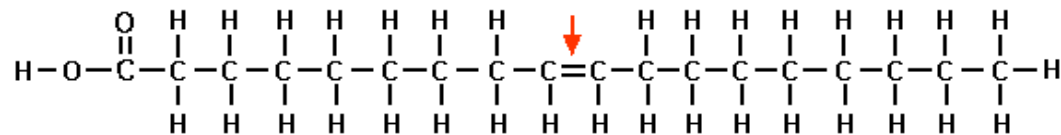


Fatty acids (Continued)

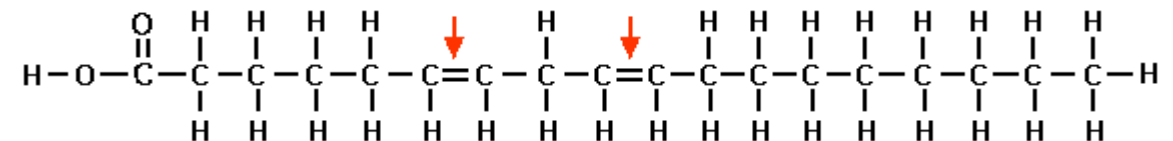
Unsaturated Fatty Acids

The fatty acids that contain double bonds between the carbon atoms are termed *unsaturated-*

- (1) *Monounsaturated fatty acids: contain only one double bond*
- (2) *Polyunsaturated fatty acids: contain two or more double bond*



Oleic Acid- Monounsaturated Fatty Acid



Linoleic Acid- Polyunsaturated Fatty Acid

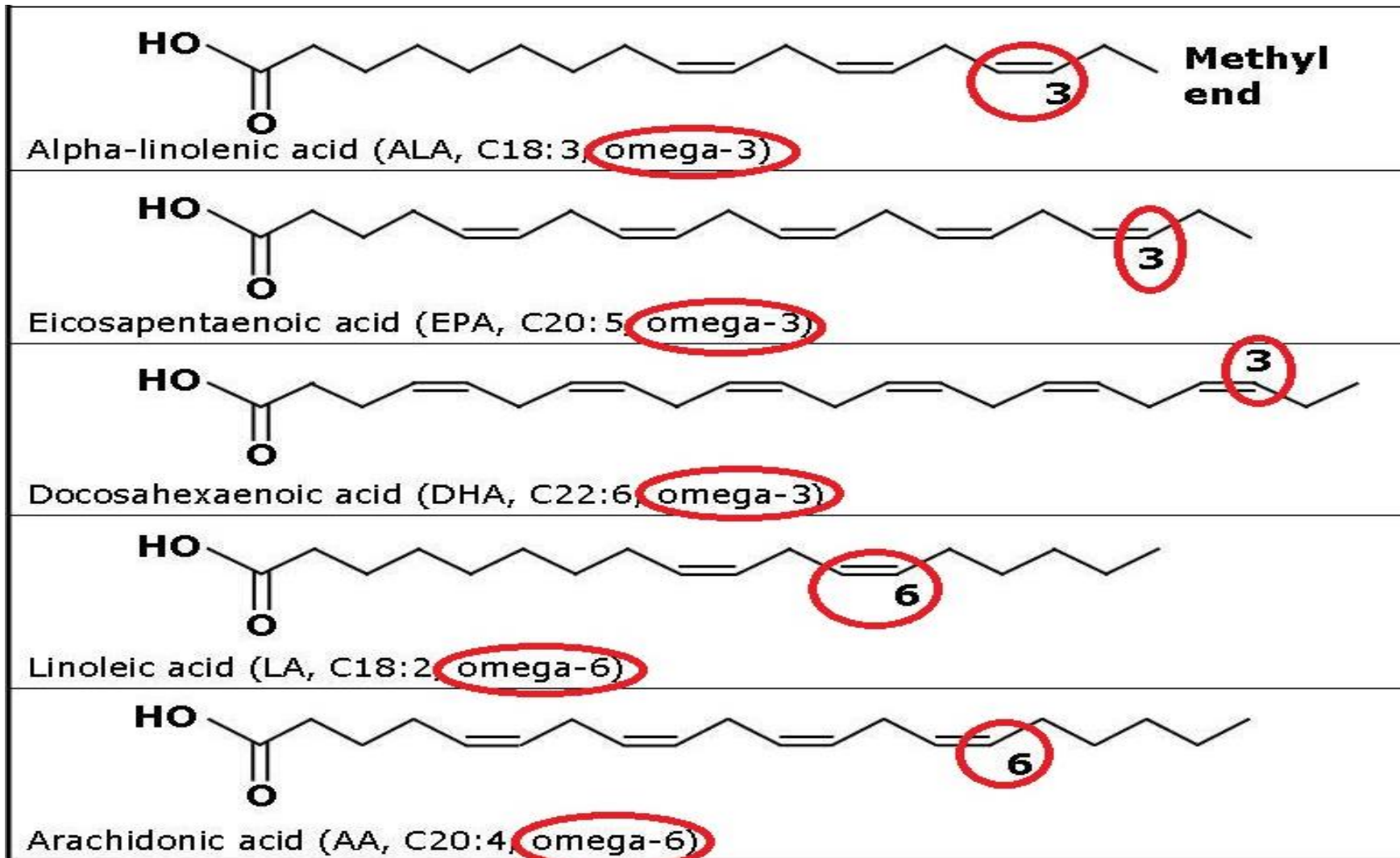
Fatty acids (Continued)

Omega 3 and Omega 6 Fatty Acids

Polyunsaturated fatty acids (PUFA) are identified by position of the double bond nearest the methyl end (CH₃) of the carbon chain; this is described as a omega number.

- If PUFA has first double bond 3 carbons away from the methyl end (omega 3 Fatty Acids)
- 6 carbons from methyl end (omega 6 Fatty Acids)

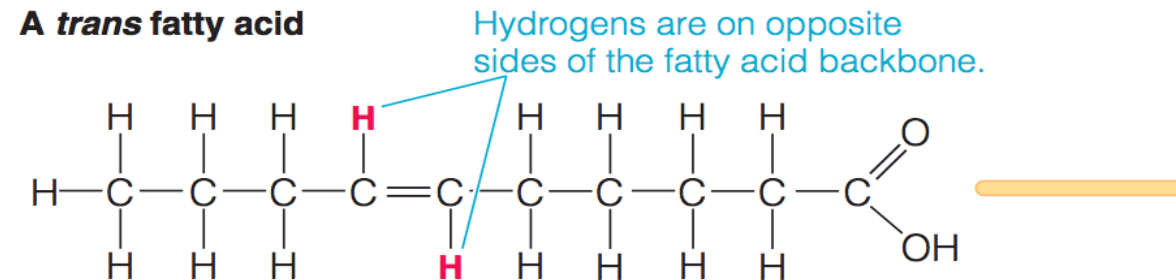
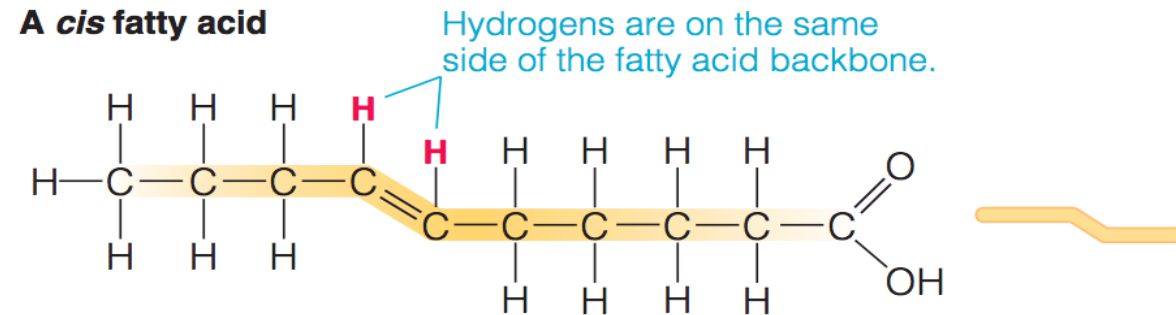
Fatty acids (Continued)



Fatty Acids (Continued)

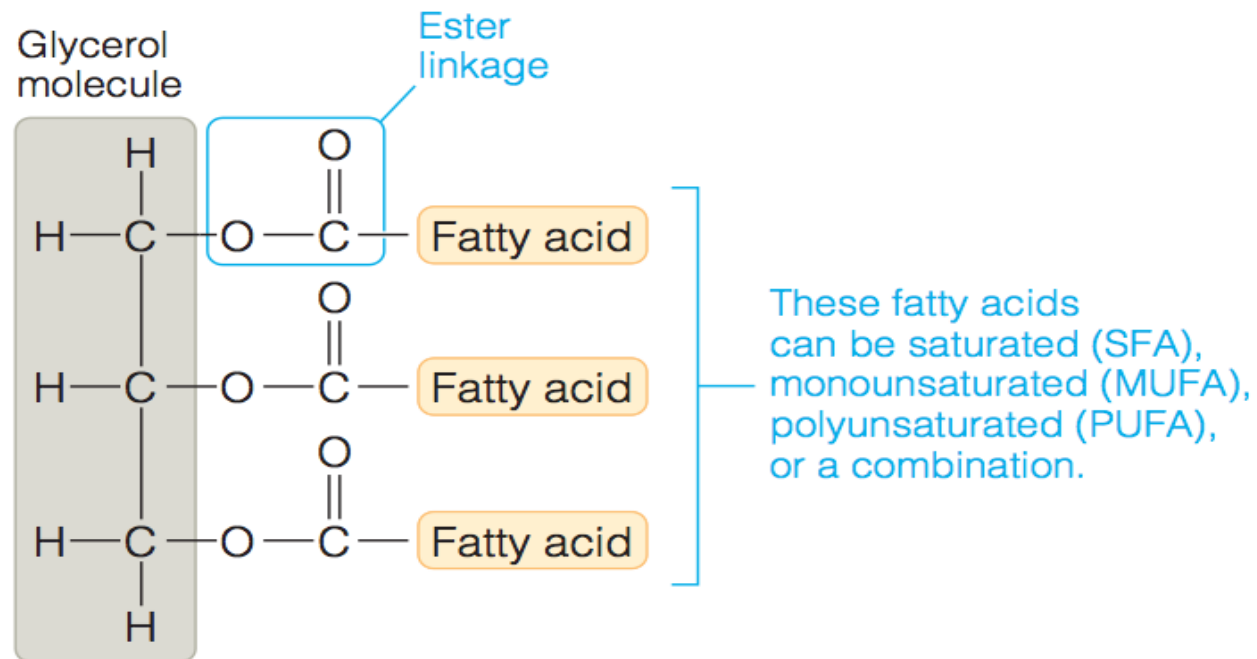
Cis and Trans-Isomers in Unsaturated Fatty Acids

- ❖ Cis-: If the hydrogen atoms are on the same side of the double bond
- ❖ Trans-: If the hydrogen atoms are on the opposite side



Physical Properties of Fats and Oils

The **chain length, degree of unsaturation, isomeric forms of the fatty acids, molecular configuration and processing variables** affect their physical, chemical and physiological functions (absorption and transportation).



Physical Properties of Fats and Oils (Continued)

Physical properties depend on the fatty acid components:

- Melting points
- Solubility
- Crystallization
- Polymorphism
- Density
- Viscosity
- Refractive index

HIGHER

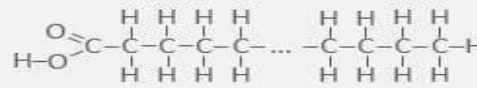
Melting Point of Fats

LOWER

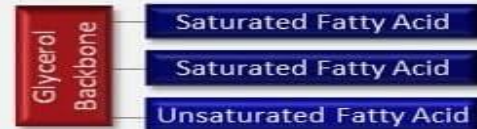


1

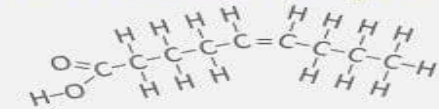
Saturated Fatty Acid



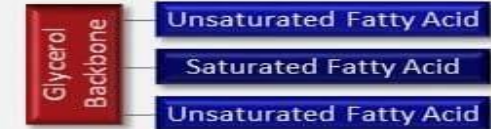
Higher concentration of saturated FA



Unsaturated Fatty Acid



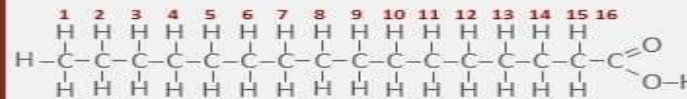
Higher concentration of unsaturated FA



2

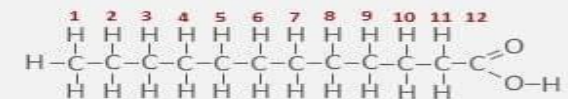
Longer Fatty Acid Chains

E.g. Palmitic Acid – 16 Carbons – 145°F (63°C)



Shorter Fatty Acid Chains

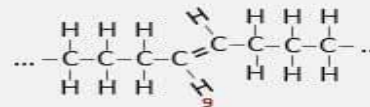
E.g. Lauric Acid – 12 Carbons – 110°F (43°C)



3

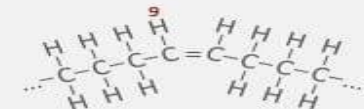
Trans Configuration

E.g. Elaidic Acid – 18 Carbons – 111°F (44°C)



Cis Configuration

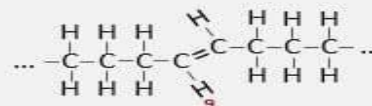
E.g. Oleic Acid – 18 Carbons – 57°F (14°C)



4

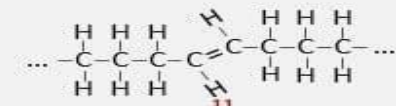
Location of the Double Bond

E.g. Elaidic Acid – 18 Carbons – Position 9
111°F (44°C)



Location of the Double Bond

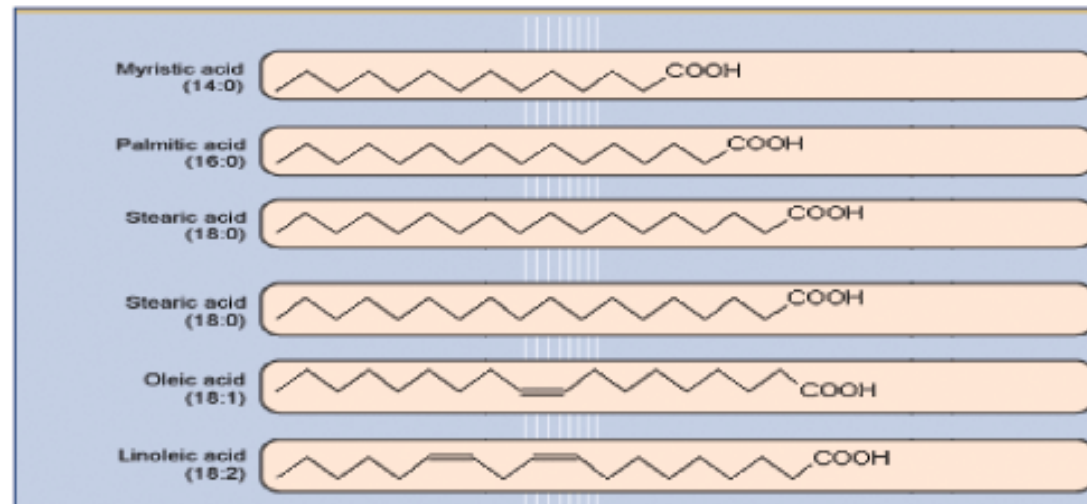
E.g. Vaccenic Acid – 18 Carbons – Position 11
113°F (45°C)



Why do fats melt at different temperatures?

Physical Properties of Fats and Oils (Continued)

- Melting point **increases as the carbons in the hydrocarbon chains of fatty acids increases** and **decreases as the number of double bonds increases**.



- **Oils:** Triglycerides rich in **unsaturated fatty acids** are generally **liquid at room temperature**.
- **Fats:** Triglycerides rich in **saturated fatty acids** are generally **semisolids or solids at room temperature**.

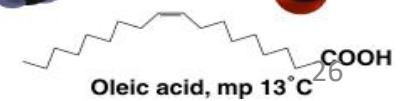
Physical Properties of Fats and Oils (Continued)



Stearic acid, mp 69°C

- **Hydrocarbon chains of saturated fatty acids:** strong dispersion forces between their chains; they pack into well-ordered, compact crystalline forms and melt above room temperature.

- **Unsaturated fatty acids:** cis configuration of double bonds, a less ordered structure and dispersion forces between them are weaker and melts below room temperature



HEALTH ASPECTS OF FATS AND OILS

- Fats are a major source of energy which supply about 9 calories per gram. Proteins and carbohydrates each supply about 4 calories per gram.
- Essential fatty acids
- Cis- and Trans- fatty acids
- Polyunsaturated fatty acids
- Monounsaturated fatty acids
- Saturated fatty acids

HEALTH ASPECTS OF FATS AND OILS (Continued)

- **Saturated fatty acids:** considered as harmful since they increases total cholesterol level and triglyceride levels. (Less than 10% of total energy intake per day).

- Sources: Animal foods such as meat, poultry and full fat dairy products
- Tropical oils such as palm and coconut



- **Monounsaturated fatty acids:** considered as beneficial for human health. Reduces LDL cholesterol and total cholesterol/ HDL cholesterol.

- Sources: Vegetable oils such as olive, canola, and peanut



HEALTH ASPECTS OF FATS AND OILS (Continued)

- **Cis-unsaturated fatty acids:** Decreases total cholesterol and triglyceride levels. Increases HDL level.
 - Sources: Most of the natural oil sources
- **Trans-unsaturated fatty acids:** Enzymes can not hydrolyze trans fats. Increases total cholesterol and the risk of coronary health diseases. Increases risk of breast and prostate cancer risk. Harmful for cardiovascular system. (Less than 1% of our total daily calories)
 - Sources: Potato chips, cookies, wafers, deep fried fish and chickens



HEALTH ASPECTS OF FATS AND OILS (Continued)

- **Polyunsaturated fatty acids:** Decreases cholesterol and decreases clot formations in veins. (6-10% of total energy intake per day)

Sources: sunflower, soybean, fatty fish oils



- **Essential fatty acids:** can not be synthesized in the body and required in diet for growth and maintenance of normal skin. Linoleic (an omega-6 fatty acid) and Linolenic acids (an omega-3 fatty acid) are essential fatty acids

HEALTH ASPECTS OF FATS AND OILS (Continued)

- **Omega-3 fatty acids:** Alpha-linoleic acid, EPA (Eicosapentaenoic acid), DHA (Docosahexaenoic acids). Reduces the risk of coronary heart diseases. Promotes nervous system's health and development (1-2% of total energy intake per day).
 - Sources: Flaxseed, walnuts, canola oil, soybean oil, dark green vegetables



- **Omega-6 fatty acids:** Linoleic acid. Decreases LDL cholesterol and heart diseases. (5-8% of total energy intake per day).
 - Sources: Soybean oil, safflower oil, corn oil, sunflower oil