Lipids

Definition of Lipids

Overview

- Lipids are naturally occurring organic compounds that are insoluble in water but soluble in non-polar organic solvents such as ether, chloroform, benzene, and acetone.
- They are hydrophobic or amphipathic molecules with essential structural and functional roles in biological systems.
- Lipids comprise diverse molecular types, classified by chemical structure and function.



- Major categories include fats and oils (triglycerides), phospholipids, steroids and sterols (e.g., cholesterol), waxes, and fatty acids with their derivatives.
- Lipids originate mainly from plant and animal sources and are important in pharmaceutical development.
- They play key roles in drug formulation and delivery (e.g., liposomes, solid lipid nanoparticles), nutraceuticals, bioactive natural product research, and pharmacological activity, such as the anti-inflammatory effects of essential fatty acids.

Key physicochemical characteristics of lipids:

- Hydrophobic nature due to long hydrocarbon chains
- Insoluble in water but soluble in organic solvents
- Some lipids are solid at room temperature (fats), while others are liquid (oils)
- Lipids can undergo hydrolysis, oxidation, and saponification
- In pharmaceutical formulations, lipids are used as emollients, surfactants, bases in ointments and suppositories, and drug carriers, often improving the bioavailability of lipophilic drugs.

Sources Of Lipids

- Lipids are obtained from both plant and animal sources.

- The selection of source often depends on the type of lipid desired, its purity, and its application in pharmaceuticals.

Plant Sources

- Plants synthesize various lipids including vegetable oils, phospholipids, and waxes.
- Common plant-derived lipids include:
    - **Olive oil** *(Olea europaea)* – Rich in monounsaturated fatty acids like oleic acid
    - **Castor oil** *(Ricinus communis)* – Contains ricinoleic acid; used in laxatives
    - **Coconut oil** *(Cocos nucifera)* – High in saturated fatty acids, especially lauric acid
    - **Palm oil** *(Elaeis guineensis)* – Contains palmitic and oleic acids
    - **Soybean oil** *(Glycine max)* – Rich in polyunsaturated fatty acids (PUFAs)
    - **Linseed oil** *(Linum usitatissimum)* – Rich in α-linolenic acid
    - **Sunflower oil** *(Helianthus annuus)* – High in linoleic acid
    - **Jojoba oil** *(Simmondsia chinensis)* – A liquid wax ester, used in cosmetics

Animal Sources

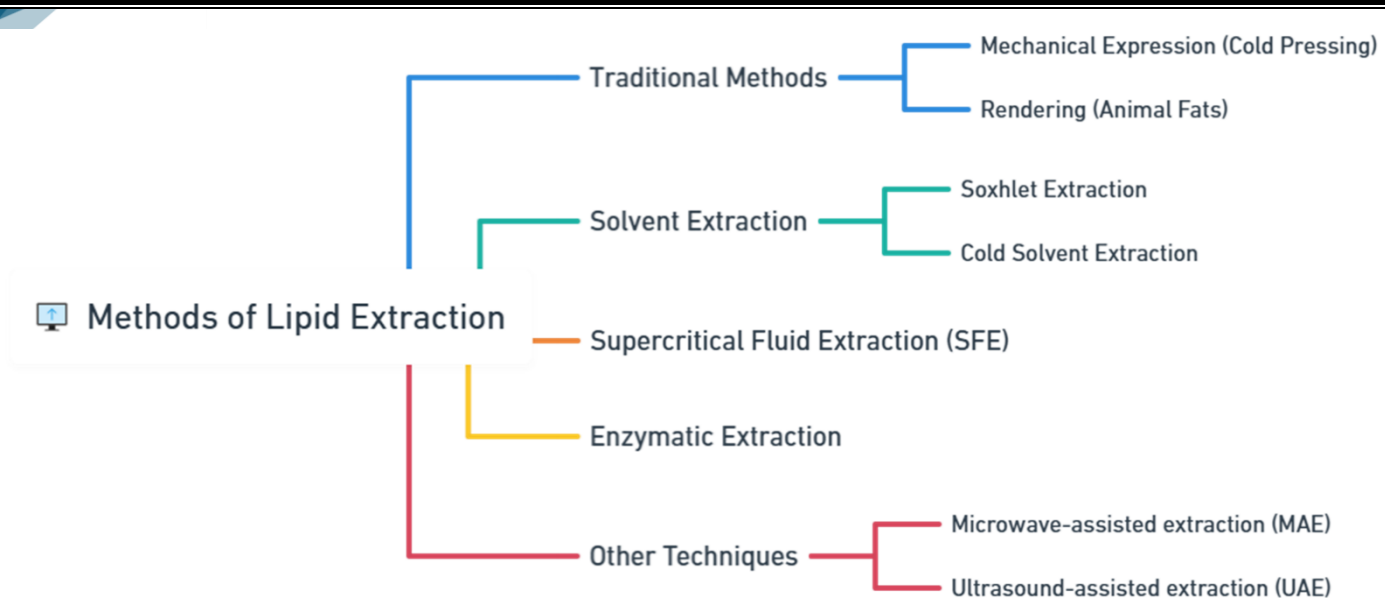
- Animal-derived lipids include fats, oils, waxes, and sterols.
- Some commonly used lipids from animal sources:
    - **Lard** – Fat obtained from pigs; used in ointment bases
    - **Tallow** – Fat from sheep or cattle
    - **Cod liver oil** – Rich in omega-3 fatty acids, vitamins A and D
    - **Lanolin** – Obtained from wool; used in dermatological formulations
    - **Beeswax** – Used in ointments, creams, and cosmetics
    - **Cholesterol** – Obtained from animal tissues; important precursor for steroid drugs

Microbial and Marine Sources (Advanced/Modern)

- In advanced pharmaceutical applications, microalgae and marine organisms are being explored as sources of unique lipids like:
    - Omega-3 fatty acids (e.g., DHA and EPA from microalgae and fish)
    - Specialized lipids from fungi or yeasts used in lipid-based delivery systems

Method Of Extraction of Lipids

- The method of extraction depends on the type of lipid, source material, and intended use.
- Proper extraction techniques ensure the preservation of bioactivity, purity, and stability of lipids, especially for pharmaceutical and nutraceutical applications.



1. Traditional Methods

A. Mechanical Expression (Cold Pressing)

- Involves physically pressing the plant seeds or animal tissues to release oil without the use of heat or chemicals.
- Common for oils like olive oil, coconut oil, and almond oil.
- Advantage: Retains natural flavor, color, and nutrients.
- Disadvantage: Lower yield; sometimes less pure.

B. Rendering (for Animal Fats)

- Common for extracting fats from animal tissues (e.g., lard, tallow).
- The animal tissue is heated to melt fat, which is then separated.
- Often used in the preparation of ointment bases.

2. Solvent Extraction

1. Soxhlet Extraction

- Utilizes a solvent (e.g., hexane, ether, chloroform, ethanol) to repeatedly wash the plant or animal material.
- Provides high yield and efficiency.
- Suitable for both volatile and non-volatile lipids.
- Used commonly for fixed oils and waxes from seeds.

Process:

1. Dried and powdered sample is placed in the thimble of Soxhlet apparatus.
2. Solvent is heated, evaporated, and condensed back onto the sample.
3. Solvent dissolves the lipid and siphons it back into the boiling flask.

4. Process continues until exhaustive extraction is achieved.
5. The solvent is removed by evaporation to yield the lipid.

2. Cold Solvent Extraction

- Useful for extracting thermolabile lipids (e.g., certain essential fatty acids).
- Typically uses non-polar solvents at room temperature.

3. Supercritical Fluid Extraction (SFE)

- A modern and eco-friendly technique.
- Uses supercritical CO_2 (SC-CO_2) as the extraction solvent.
- Ideal for extracting high-value lipids, especially for pharmaceuticals and nutraceuticals.
- **Advantages**:
  - No toxic solvent residues
  - Operates at low temperatures, preserving lipid structure
  - High selectivity and purity
- **Applications**:
  - Extraction of omega-3 fatty acids from fish oil or microalgae
  - Extraction of phytosterols and carotenoids

4. Enzymatic Extraction (Emerging Technology)

- Uses lipases and other hydrolytic enzymes to break down cell walls and release lipids.
- Environmentally friendly and selective.
- Used in biotechnology for producing structured lipids or modified fats.

5. Other Techniques

- Microwave-assisted extraction (MAE)
- Ultrasound-assisted extraction (UAE)
- These are hybrid techniques that use microwaves or ultrasound to enhance the penetration of solvents, increase yield, and reduce time.

Chemistry Of Lipids

- The chemistry of lipids is complex and diverse, reflecting their varied structures and biological functions.
- Lipids are not polymers like proteins or polysaccharides, but are rather small molecules built from fatty acids and other components such as alcohols, glycerol, sphingosine, and sterols.
- They can be broadly divided into simple lipids, compound lipids, and derived lipids.

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