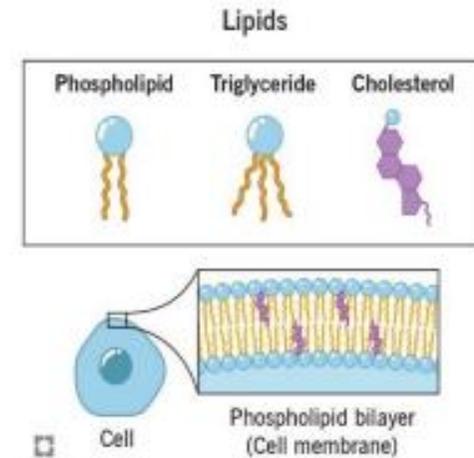
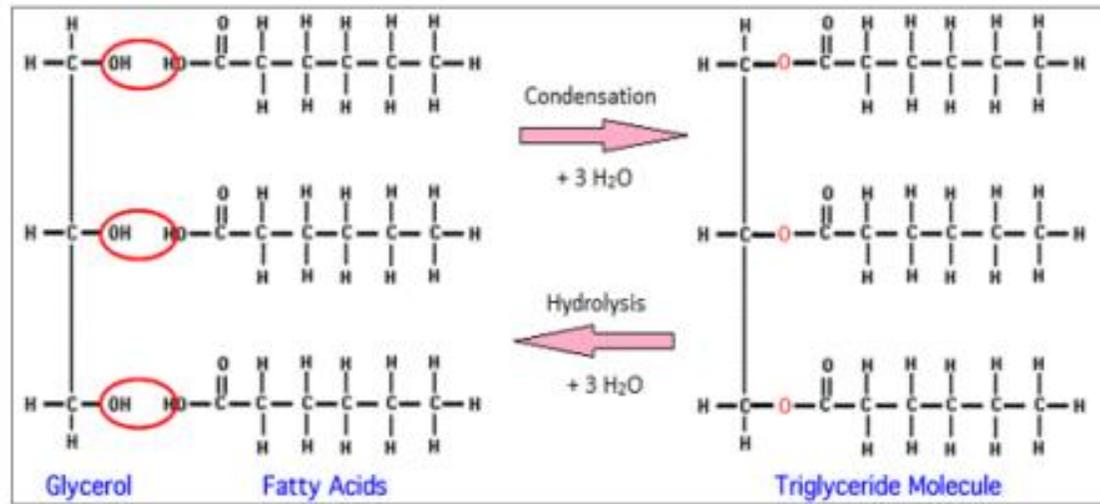


# Fat and oils



## I. Structure

Lipids include diverse types such as triglycerides, phospholipids, and sterols, whose structures range from long fatty-acid chains to ring-shaped molecules that are mostly hydrophobic but may contain small polar regions.



Type	Structure	Physical state	Origin	Functions
<b>Triglycerides</b>	Glycerol + 3 fatty acids	Saturated → solid (fat) Unsaturated → liquid (oil) mono- and polyunsaturated)	- Animal fats (butter, lard) - Plant oils (olive, sunflower) - Marine oils	- Energy storage (major reserve) - Insulation and protection - Metabolic fuel
<b>Phospholipids</b>	Glycerol + 2 fatty acids + phosphate group + polar head	Usually unsaturated liquid (amphipathic molecules) fluid membranes	Present in all living cells (plants and animals)	- Main component of cell membranes (bilayer) - Emulsifiers - Cell signaling
<b>Sterols</b>	Four-ring structure (steroid nucleus)	Solid (waxy)	- Animal sterol: cholesterol - Plant sterols: phytosterols	- Membrane stability and fluidity - Precursor of hormones, vitamin D, bile acids

## II. Technology process

### II.1. Extraction

Method		Principle	Process Steps	Advantages	Disadvantages
Mechanical Extraction	Cold Pressing	Physical pressing at low temperature (<50°C)	<ol style="list-style-type: none"> <li>1. Crush seeds/fruits</li> <li>2. Press without heating</li> <li>3. Separate oil from solid cake</li> </ol>	<ul style="list-style-type: none"> <li>-Preserves nutrients</li> <li>-Better flavor &amp; aroma</li> <li>-Lower oxidation</li> <li>-“Virgin/Extra-virgin” quality</li> </ul>	<ul style="list-style-type: none"> <li>- Lower oil yield</li> <li>- More expensive</li> </ul>
	Hot Pressing	Pressing after heating (70–120°C)	<ol style="list-style-type: none"> <li>1. Heat raw material</li> <li>2. Press under high pressure</li> <li>3. Filter/centrifuge oil</li> </ol>	<ul style="list-style-type: none"> <li>- Higher oil yield</li> <li>- Easier separation</li> <li>- Faster process</li> </ul>	<ul style="list-style-type: none"> <li>- Loss of nutrients</li> <li>- Oxidation and flavor alteration</li> <li>- Often requires refining</li> </ul>
Solvent Extraction		Dissolution of lipids using a non-polar solvent (hexane)	<ol style="list-style-type: none"> <li>1. Crush seeds</li> <li>2. Mix with hexane → forms miscella</li> <li>3. Filter solid residue</li> <li>4. Distill to remove solvent</li> <li>5. Recover/recycle hexane</li> </ol>	<ul style="list-style-type: none"> <li>- Very high yield (up to 99%)</li> <li>- Efficient for industrial production</li> </ul>	<ul style="list-style-type: none"> <li>- Uses chemical solvents</li> <li>- Requires distillation</li> <li>- Risk of solvent residues</li> </ul>

### II. Refinement steps

#### 1. Degumming

Phospholipids can cause emulsification and sedimentation, leading to haziness and poor storage. Removal is essential for oil destined for further refining or bottling. Degumming is the hydration and removal of phospholipids (gums) by mixing the crude oil with water or acid solution then centrifuging.

#### 2. Neutralization (Alkali refining)

Free fatty acids react with an alkaline solution (often sodium hydroxide), forming water-soluble soaps that are then separated. Neutralization lowers oil acidity, improves taste and aroma, and increases stability by removing precursors to degradation.

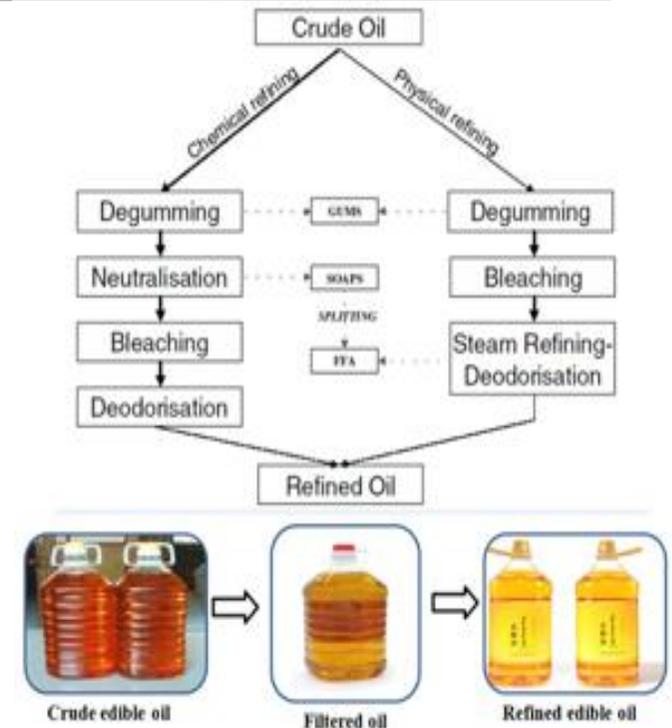
#### 3. Bleaching

Physical adsorption using bleaching clays (activated earths), carbon, or silica removes colored pigments (carotenoids, chlorophyll), trace metals, and oxidation products.

Enhanced product appearance and oxidative stability; removal of pro-oxidant metals delays rancidity.

#### 4. Deodorization

High-vacuum steam distillation at 180–260°C strips volatile odor, flavor compounds, and residual free fatty acids. Produces bland, neutral oils suitable for commercial food use. Removes trace contaminants.



### III. Transformation processes

Process	Molecular/ Chemical Changes	Purpose in industry	Effects on properties	Applications
<b>Hydrogenation</b>	<ul style="list-style-type: none"> <li>• Addition of H<sub>2</sub> to double bonds • Unsaturated → more saturated</li> <li>• Partial hydrogenation forms trans fatty acids</li> </ul>	<ul style="list-style-type: none"> <li>• Convert liquid oils → semi-solid fats</li> <li>• Increase oxidative stability</li> </ul>	<ul style="list-style-type: none"> <li>• Higher melting point</li> <li>• More solid texture</li> <li>• Longer shelf life</li> </ul>	Margarine, shortening, bakery fats, frying fats
<b>Interestérification</b>	<ul style="list-style-type: none"> <li>• Rearrangement of fatty acids on the glycerol backbone</li> <li>• No change in degree of saturation</li> <li>• Does <b>not</b> form trans fats</li> </ul>	<ul style="list-style-type: none"> <li>• Modify melting profile</li> <li>• Improve texture without trans fats</li> </ul>	<ul style="list-style-type: none"> <li>• Customized consistency</li> <li>• Controlled crystallization</li> <li>• Improved spreadability</li> </ul>	Modern margarines, chocolate industry, specialty fats
<b>Fractionation</b>	<ul style="list-style-type: none"> <li>• Separation of triglycerides based on melting point differences</li> <li>• Produces: Stearin (solid) + Olein (liquid) fractions</li> </ul>	<ul style="list-style-type: none"> <li>• Adapt fat to specific functional uses</li> </ul>	<ul style="list-style-type: none"> <li>• More stable liquid oils</li> <li>• Harder solid fats</li> <li>• Tailored functionality</li> </ul>	Palm oil products, frying oils, cocoa butter substitutes
<b>Emulsification</b>	<ul style="list-style-type: none"> <li>• Dispersion of fat droplets with <b>emulsifiers</b> (lecithin, mono/diglycerides)</li> <li>• Formation of stable <b>oil-in-water</b> or <b>water-in-oil</b> systems</li> </ul>	<ul style="list-style-type: none"> <li>• Create stable mixtures of oil and water</li> </ul>	<ul style="list-style-type: none"> <li>• Stabilized texture</li> <li>• Creaminess</li> <li>• Prevents phase separation</li> </ul>	Mayonnaise, margarine, salad dressings, ice cream
<b>Winterization</b>	<ul style="list-style-type: none"> <li>• Cooling to precipitate waxes and high-melting triglycerides</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure oils remain clear at low temperatures</li> </ul>	<ul style="list-style-type: none"> <li>• Improved clarity</li> <li>• Prevent cloudiness</li> </ul>	Salad oils, corn oil, sunflower oil
<b>Enzymatic Modification</b>	<ul style="list-style-type: none"> <li>• Enzymes (lipases) rearrange or hydrolyze fatty acids selectively</li> </ul>	<ul style="list-style-type: none"> <li>• Tailor fats for nutrition or functionality</li> </ul>	<ul style="list-style-type: none"> <li>• Specific modification</li> <li>• Cleaner reactions</li> </ul>	Infant formula fats, structured lipids
<b>Fractional Crystallization</b>	<ul style="list-style-type: none"> <li>• Controlled crystallization of fats to separate crystal forms</li> </ul>	<ul style="list-style-type: none"> <li>• Improve texture in confectionery</li> </ul>	<ul style="list-style-type: none"> <li>• Better melting behavior</li> </ul>	Cocoa butter equivalents, chocolate coatings

### III. Fats and oils in the food industry

#### 1. Textures in bakery and biscuit industry

When flour is mixed with water, proteins (gluten) form a strong, elastic network. Fats interrupt this network by coating the proteins. As a result, the dough becomes: more tender, less elastic, easier to shape, and more crumbly when baked (like sablé biscuits). At the molecular level Fat molecules surround gluten proteins and prevent them from sticking together. This reduces protein–protein interactions (hydrogen bonds, disulfide bonds), so the dough doesn't become tough.

##### Example

- In coconut cakes or sablé biscuits, the fat prevents a hard structure from forming → the texture becomes soft or crumbly.
- In puff pastry, solid fats create thin layers that puff up in the oven.



#### 2. Frying oils (chips, snacks, fast food)

When food is fried:

1. The temperature rises to 160–180°C.
2. Water at the surface evaporates quickly.
3. A crispy crust forms.
4. Oil enters the food and gives flavor and color.



At high temperature, the oil must stay stable. Unsaturated fats (with many double bonds) oxidize easily and become rancid (Oxidation is a chain reaction that produces aldehydes and ketones: bad smells). Oils like sunflower high-oleic or palm olein are used because they contain fewer reactive double bonds.

#### 4. Lecithin:

Lecithin is found in soybeans, eggs, and sunflower seeds. Its structure is “amphiphilic”: it has

- a water-loving head (phosphate-choline),
- two fat-loving tails (fatty acids).



**Lecithin (E322)**  
emulsifiant

Oil and water normally separate because the interface has high tension. Lecithin sits exactly at this interface: its tails go into the oil and its head stays in the water. This creates a protective film around oil droplets. It stops them from merging together (coalescing).

## Example

- In mayonnaise, lecithin from egg yolk keeps oil droplets stable in water.
- In chocolate factories in Algeria, lecithin helps reduce viscosity so the chocolate flows better.
- In margarine, lecithin helps water droplets stay evenly dispersed inside fat.

## Application : Industrial Mayonnaise production

1. **Preparing the water phase “aqueous phase”:** This includes: water, vinegar or lemon juice, salt, sugar, mustard (optional) and stabilizers (xanthan gum or modified starch)
2. **Addition of egg yolk**

Egg yolk contains: lecithin (phosphatidylcholine) and lipoproteins. These are amphiphilic, meaning they have a water-loving part and a fat-loving part. Lecithin positions itself at the interface between oil and water:

- hydrophobic fatty acid tails → insert into oil
- hydrophilic head → stays in water

This lowers interfacial tension, making it possible to break oil into tiny droplets.

3. **Slow addition of oil under high shear:** Oil (usually soybean, sunflower, or canola oil) is added very slowly while the mixer creates strong turbulence.
  - The oil is broken into millions of micro-droplets.
  - Lecithin surrounds each droplet and prevents coalescence.
  - The mixture becomes thicker as more oil droplets are trapped in the aqueous network.
4. **High-pressure homogenization :** Industrial plants often use homogenizers to create extremely fine droplets: Smaller droplets → more stable emulsion
5. **Deaeration and packaging:** Air bubbles are removed to prevent oxidation. The product is packed in sterile conditions.

