Vegetable Oil Processing

CONTENTS

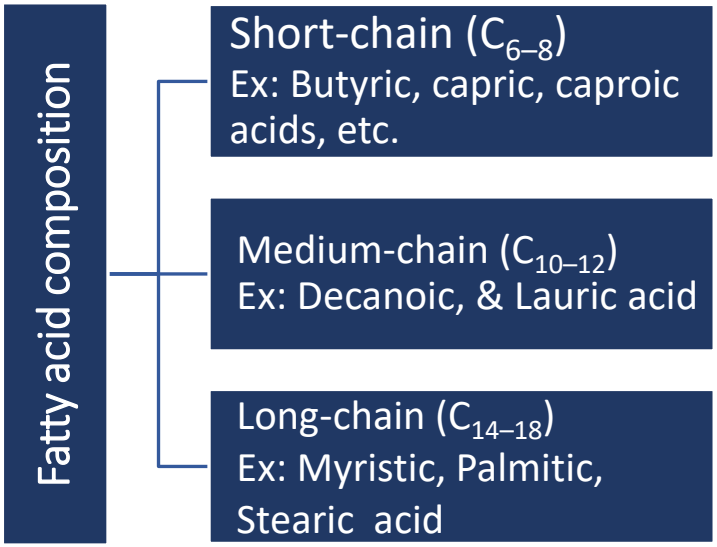
1. Introduction

- An essential component of our everyday diet :
  - ✓ Adds taste and mouthfeel to food
  - ✓ One and only source of **fat-soluble vitamins** and **essential fatty acids**.
- General source of vegetable oil are fat and oil rich crops such as mustard, soyabean, avocado, palm, sunflower, etc.
- Processing of oilseed crops at factory level involving-
  - **Pre-processing** of oilseed
  - **Extraction** of crude oil
  - **Refining** of crude oil.

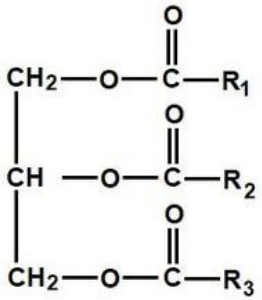
1(a). Different major sources of vegetable oil

#	Oil producing sources	Oilseed production (m. tons) in India (2022)
1.	Soyabean	18.75
2.	Groundnut	9.72
3.	Mustard/ Rapeseed	11.95
4.	Sunflower seed	0.87
5.	Safflower seed	0.22
6.	Sesame seed	0.18
7.	Niger seed	0.16
8.	Castor seed	2.45
9.	Linseed	0.34

1(b). Vegetable Oil's Fat Profile



Classification of fatty acid



Triglyceride

- Good source of **fat-soluble vitamins** and **essential fatty acids**.
- They are all triglycerides.
  - Oils containing short-chain fatty acids are in a **liquid state** (at room temperature), but
  - oils with a large amount of medium-chain or long-chain fatty acids are in a **semi-solid to solid form**.
- The plant oils may be saturated (completely hydrogenated) or unsaturated having one, two, or three double bonds of the cis-configuration.
- If fatty acids have **≥2 double bonds**, it is known as PUFA, including **essential fatty acids.**

2. Raw Material

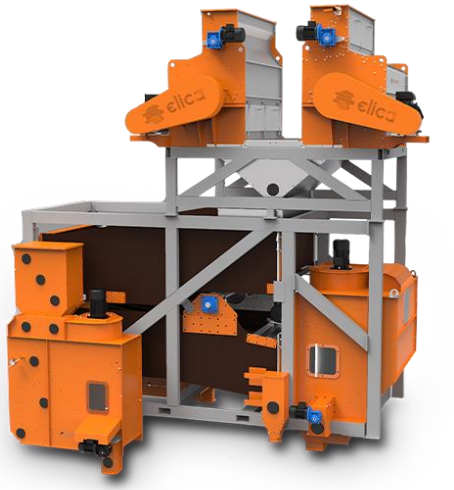
1. Oilseed (base material)
2. Solvent (Generally hexane)
3. Acid (Phosphoric Acid/ Citric Acid)
4. Caustic Soda
5. Bleaching Clay & Activated Earth,
6. Antioxidants, And
7. Essential Oils (Natural preservative)

3. Pre-Processing Methods

1. **Grading & sorting:** To remove stones and moldy seed/nuts.
2. **Cleaning/ Washing:**
   - To remove plant stems, sticks, leaves, and foreign material before storage.
   - Done using a combination of rotating or vibrating coarse screens, reels, and aspiration
   - Magnetic devices are used to remove metal contaminants from seeds.
   - Destoner to remove stones present in seeds or nuts.
3. **Drying:**
   - Moisture content in oilseed received at the factory is 13 percent. Hence, drying is done up to a moisture content of 10%.
   - Large, vertical, **open-flame grain dryers** with multiple columns are generally used.

3. Pre-Processing Methods (Cont.)

4. Dehulling: Oilseed and nuts contain less than 1% oil content, dehulling removes the maximum quantity of hulls from the oilseed. Ex: 45% from cotton seed.



5. **Size Reduction and Flaking:**

- Cracking and flaking increase the **surface area** for increased contact between the solvent and the seed.
- Cracking mills having two sets of cylindrical corrugated rolls in series are used for size reduction and
- Flaking mills having two large-diameter rolls turning in opposite directions and forced together by hydraulic cylinders are used for flaking.
- Flake thickness: **0.25-0.37 mm**

3. Pre-Processing Methods (Cont.)

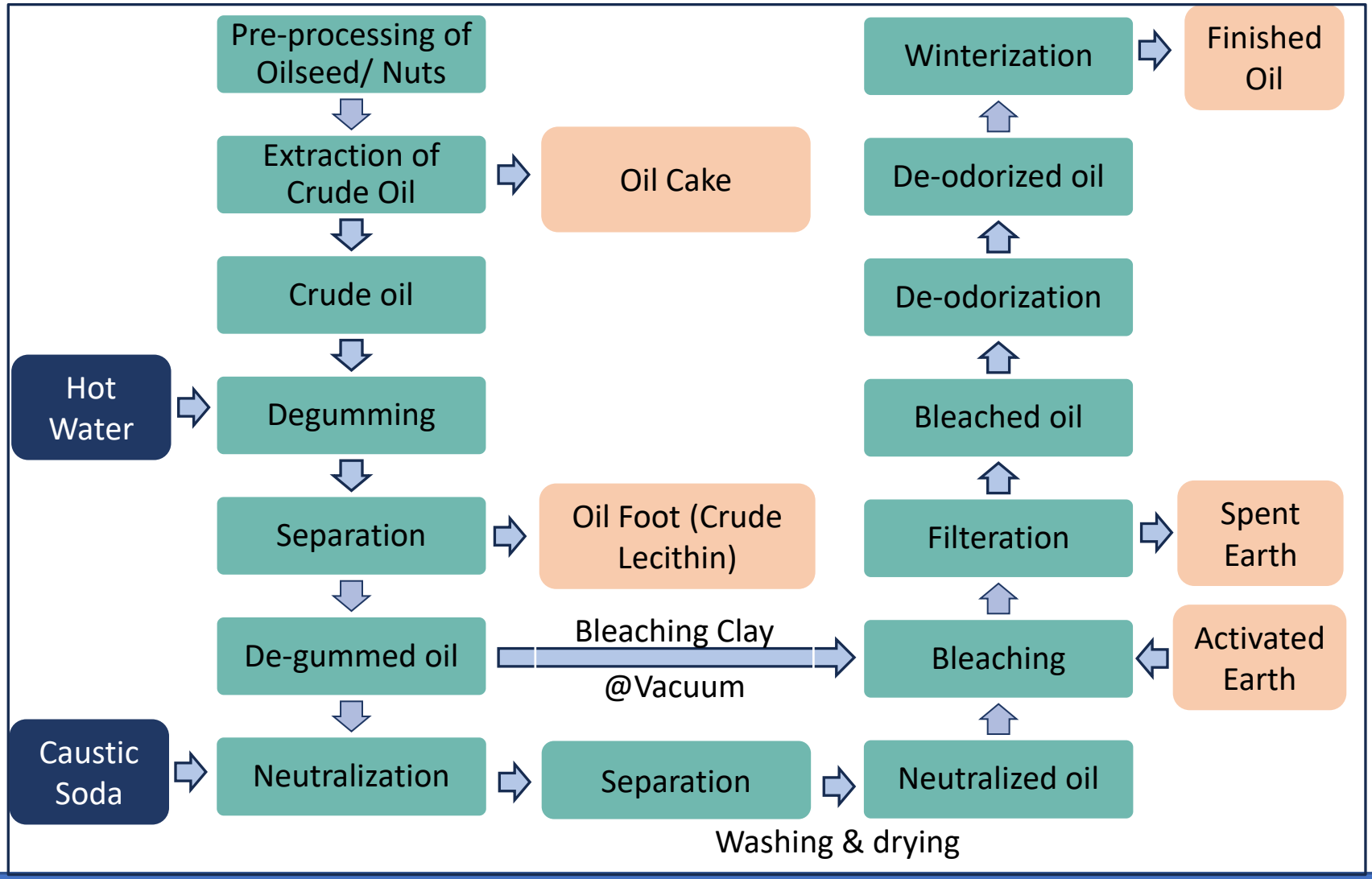
5. Conditioning & tempering (*Optional)

- To denature proteins, release oil from the cells, and inactivate enzymes (as some enzymes in the hydrolysis of compounds soluble in oil produce toxins),
- Improves flaking performance and extraction efficiency.
- Steps involved:

  Step 1: heat at 68–122^{o}F for <5 minutes.

  Step 2: Contact live steam at 248^{o}F
- Done using rotating drums with an internal steam coil.

4. Processing: Process Flow Diagram



4.1 Extraction of Oil

1. Mechanical Extraction

- The oldest methods of extraction
- Done either by using an expeller, hydraulic presses, or screw presses. Where seeds are fed into an in-between barrier that breaks seeds using applied pressure
- Good-quality oil is produced
- Lower the initial investment cost
- Efficient method, though very low oil yield
- Require highly trained personnel to operate.

4.1(a) Difference between expeller and cold press

#	Parameters	Expeller	Cold press
1.	Machine type	Mechanical extraction; Mechanical presses	Meticulous process; Hydraulic presses
2.	Extraction Condition	Crushing & grounding without usage of chemicals or solvents	Crushing and squeezing seeds at low temp. Without chemicals
3.	Taste	Rich; nutty undertones	Lighter, more subtle
4.	Smoke point	Higher	Lower
5.	Cooking type/ Use of oil	Ideal for high-heat cooking like frying and sautéing.	Not suitable for high heat cooking, but great for dressings, dips etc.
6.	Nutrient value of oil	Keep some of the antioxidants and essential fatty acids	Keeps high levels of omega-3 fatty acids and vitamin E

4.1 Extraction of Oil (Cont.)

2. Chemical Extraction (Solvent Extraction)

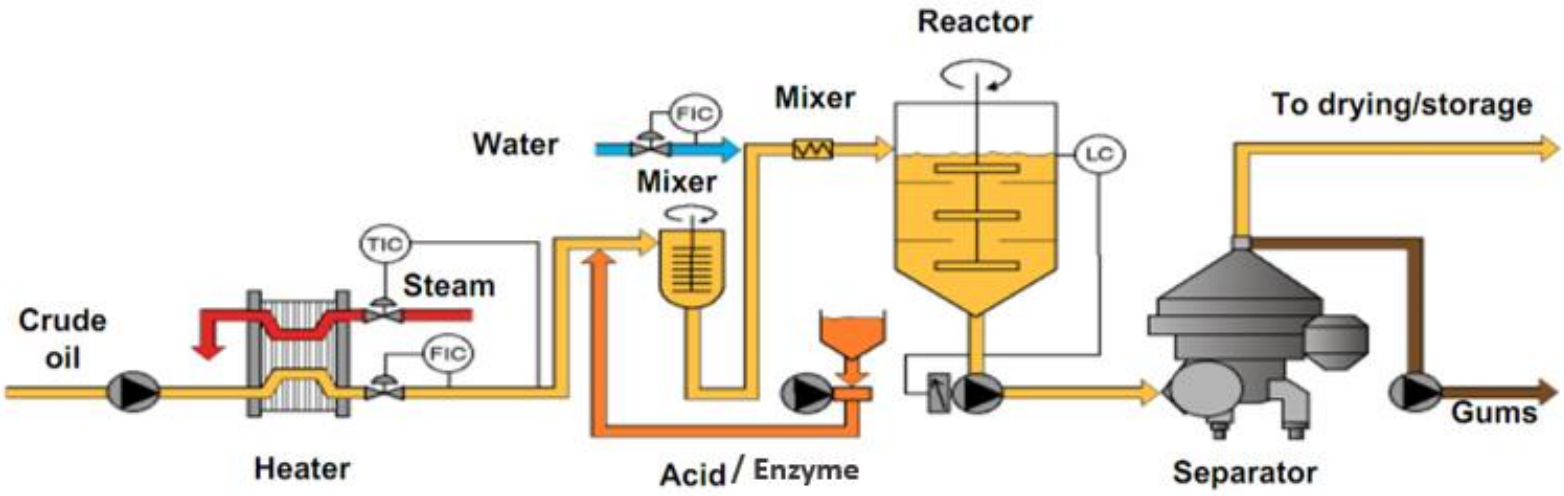
- Extraction of oil with the help of some inert solvent, known as chemical extraction, can be done in batch or continuous methods.
- Extraction depends on the ability of the solvent to dissolve oils.
- Have a 90%–98% oil recovery rate
- It involves three steps:
  - **Cleaning and conditioning,**
  - **Oil extraction, and**
  - **Separation of the miscella**
- It requires high energy, high investments, and solvent (hexane) may be hazardous and can cause health problems.
- Solvents: **n-hexane**, ethanol, methanol, chloroform, petroleum ether, etc.

4.2 Refining

- Before starting vegetable oil processing, oil is being tested to find out which processing needs to be used for the refining of crude oil.
  - **% FFA**
  - **Phospholipids %**
  - **Moisture content,**
  - **Insoluble impurities and**
  - **Colour**
- Major steps involved:
  1. Degumming
  2. Neutralization
  3. Bleaching
  4. Deodorization
  5. Winterization

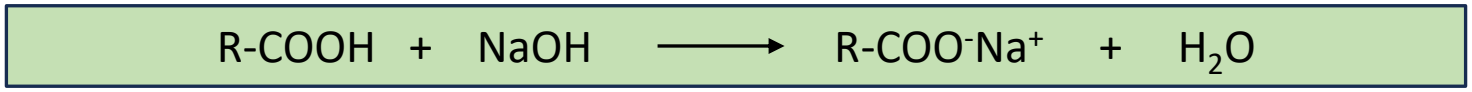
3.2(a) Degumming

- Eliminate “gums” or “mucilage” (composed of mainly phospholipids as well as carbohydrates, proteins, and trace metals).
- Precipitated gums is removed after mixing using centrifugal separation.
- Can be done using
  1. Hot water **@ 60 - 70℃**
  2. Acid **(phosphoric or citric acid)** and Hot water @60 - 70℃
  3. Enzyme **(phospholipase)** and Hot water @60 - 70℃



4.2(b) Neutralization

- Vegetable oil contains high amount of free fatty acids (FFA) which can degrade the chemical quality and organoleptic quality of the oil during storage.
- Why?- Due to the action of hydrolysis and oxidation, resulting in undesirable color and odor in the finished product.
- What? - To eliminate these FFA up to a recommended level - caustic soda or physical refining using steam distillation is recommended.



#	Vegetable oil	Type of FFA	FFA g/100g of oil (max.); FSSAI	Acid Value
1.	General veg. oil	Oleic acid	0.7- 10	≤ 6
2.	Palm oil	Palmitic acid		≤ 10
3.	Palm kernel	Lauric acid		3.0 - 10.0 (gen. 5)
4.	Coconut oil	Lauric acid		≤ 6

4.2(b) Neutralization (cont.)

- In addition to neutralization and elimination of FFA,
- Additional compound such as
  - excess of phosphoric acid,
  - residual proteins,
  - residual gums,
  - carbohydrates,
  - oxidation products from FFA,
  - traces of metals, and
  - pigments etc., can also be removed.
- As soap is insoluble in oil, it can easily be removed using mechanical separation methods. And can be further used for manufacturing of soap bars.

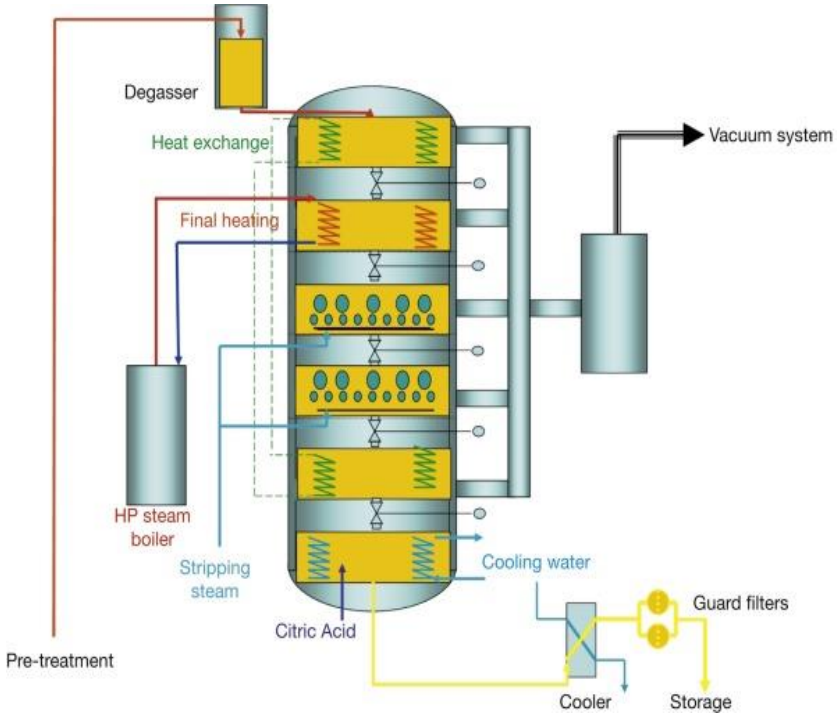
4.2(c) Bleaching

- Complex physical and chemical process
- Objective of bleaching:
  a. To reduce quantity of coloured pigments.
  b. Remove residues of phosphatide, soap, phospholipid contaminants, lipid peroxidation products, and other impurities.
- Bleaching agents used for decolouration of vegetable oils are:
  - Special silica
  - adsorption bleaching clays (most popular)
  - activated carbon/charcoal
  - Combination of two or more bleaching agent

Bleaching

4.2(d) De-odorization

- It is a simple distillation process, involving high temperatures.
- The odorization results:
  - Elimination of free fatty acids,
  - Removal of odors & off-flavor components,
  - Removal of contaminants (pesticides, light polycyclic aromatic hydrocarbons, and other volatile components), and
  - Additionally, it is also removing residues of mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH).
  - Improves the stability and color of the oil, whilst preserving its nutritional value.



4.2(e) Winterization

- It is also known as dewaxing
- As waxes are long-chain primary alcohols and long fatty acids, it has low solubility in oil but have high melting point due to which it crystalize during winter season.
- Its presence degrades quality (cloudy appearance) of oil .
- Winterization involves three steps:
  - Heating at 55^{O}C
  - Slow cooling up to 10–15°C and holding for hours
  - Filteration yielding cleared oil

- Examples of oils, where winterization is done are rice bran, canola, corn germ oil, sunflower, and olive pomace

4.2(f) Packaging

- The vegetable oils after processing is packed for supply in the retail market using various types of packages:
  1. **Rigid plastic container**; made up of Plastic like HDPE/PVC/PET materials, metal such as tin can,
     a. Institutional pack: 15 Kg
     b. Family pack: 2- 5 Kg



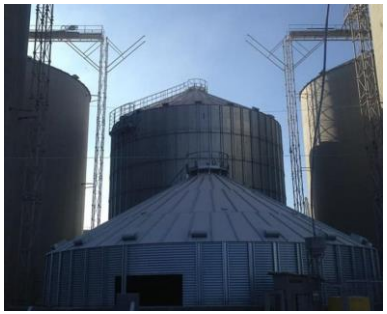

4.2(f) Packaging

2. **Semi- rigid packages**: Multilayered; Capacity- 200 mL to 1L
   a. Lined folded carton with laminates such as met. PET,/PE,/Al foil
   b. Nylon based bag-in-box package
3. **Flexible packages**:
   a. Mono-films: LDPE, HDPE, & PP pouches
   b. Two-layer films: Two-layer co-extruded films using LDPE/HDPE/PET/ ionomer/ PP etc.
   c. Three-layer film: LLDPE/LDPE/HDPE/EAA/metPET etc in composite structure and co-extruded form.
   d. Five layered film: LLDPE or HDPE or PP/PA/BA/PA/EAA etc., though Polyamide based co-extruded structure (most suited with FFS machine).



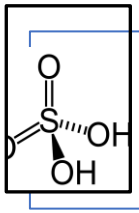

4.2(g) Storage at warehouses

- Conditions required for storage of vegetable oil:
  1. Storage temp: not more than 25 ^{O}C, to maintain this temp
     - Inert gases such as nitrogen or ammonia is applied to the vapour space of storage container (tanks)
     - Pallets are used to store in controlled room.
  2. Location: warehouse in air-tight container/pouch, with provision of light barrier.
- The best way to store finished vegetable oil is in a tank/barrels, from where it is transported for packaging in small SKUs.




5. Risk Status of Veg. Oil processing

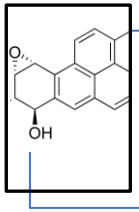
Some of food safety-based health risk



Mustard oil
- Erucic acid

Peanut oil
- Aflatoxin B1

Cotton seed
- Gossypol



Processed veg. oil
- PAHs (benzopyrene)

1. **Solvent residue** in oil: (≤5 ppm); Dizziness, vomiting, or even paralysis.
2. **Industry-specific risk**: Fire and explosion risks at processing stage due to leakage of hexane.
3. **Industry-specific food safety risk**; health risks of benzopyrene, aflatoxin B1, erucic acid and heavy metals (lead, arsenic, cadmium and chromium)
   - A. **Benzopyrene (a PAHs):** carcinogenic risk; a processing contaminants.
   - B. **Aflatoxin B1:** health risk in peanut oil.
   - C. **Erucic acid:** mustard oil; cardio- vascular diseases, lungs cancer, etc.
   - D. **Gossypol:** Cotton seed
   - E. Potential presence of pathogens and contaminants (e.g., Pesticide residue).

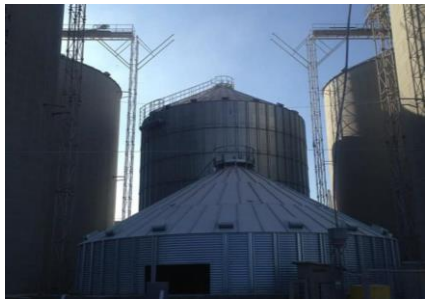
5(a). Possible solution for contaminants presence

1. Inspection or raw material (Ex: oilseed)

2. Proper storage of cleaned raw material

3. Use of both methods of extraction in combination

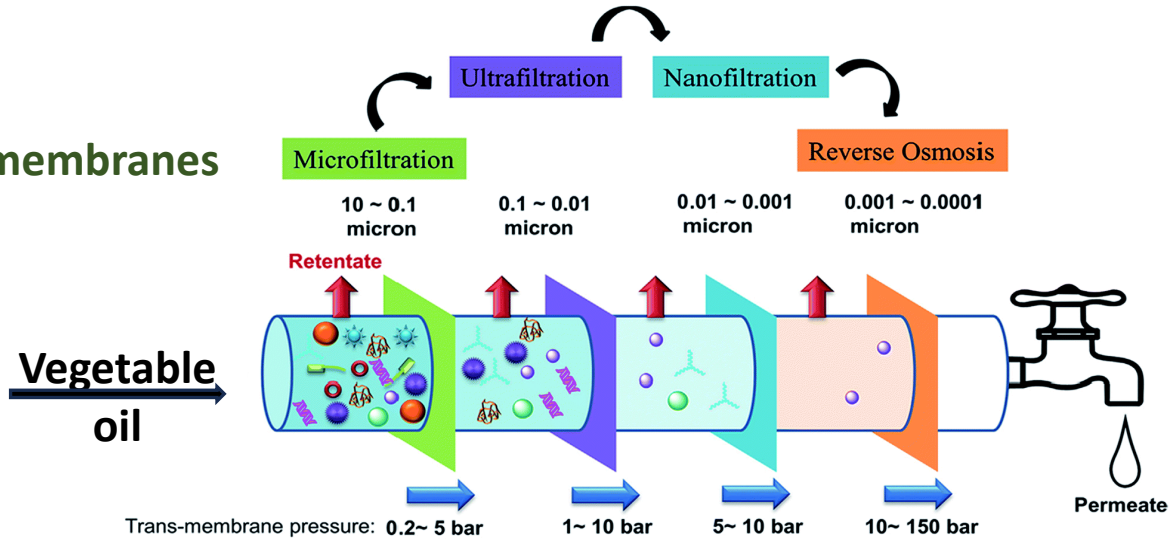
4. Use of natural components for refining



7. Advancement in Veg. Oil Processing

1. Membrane technology for vegetable oil processing

- Membrane processing, organic-solvent-nanofiltration has resulted in a 65% energy savings in the membrane de-solventizing of hexane oil miscella.
- It was found that it can be a better alternative to achieve degumming, deacidification, bleaching, dewaxing, catalyst recovery, etc.
- Hindrance for this technique in veg oil processing:
  - **Selectivity,**
  - **Productivity, and**
  - **Durability of the membranes**



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