

Session 4.8 – Oil Extraction Technology

Extraction of Vegetable Oils



Basic approaches :

- **Mechanical Oil Extraction**
 - cold pressing means no heat applied
 - hot pressing - external heat is applied
- **Solvent Extraction**
 - organic solvent (hexane, isopropyl alcohol)
 - supercritical solvent (carbondioxide)

Common Oil Seeds



Sunflower



Safflower



Canola/Rapeseed



Flax



Soybean

Oil percentage in common oil seeds

	Moisture content (%)	Oil/fat content (%)	Yield of oil (%)	Uses for by-products
Seeds and beans				
Cotton	5	15-25	-	Animal feed
Rape	9	40-45	25	Animal feed (needs detoxifying)
Mustard	7	25-45	-	-
Sesame	5	25-50	45	-
Sunflower	5	25-50	20-30*	Animal feed Hulls used for chicken litter, presscake for animal feed
Safflower	5	30	-	Animal feed
Nuts				
Coconut (fresh)	40-50	35-40	55-62	See Figure 8
Copra	3 – 4.5	64-70	-	-
Groundnut (shelled)	4	28-55	40*	Food, snacks, soup
Palm kernel nuts	-	-	45-49	Animal feed
(shelled)	-	46-57	47-51	Animal feed, fuel (shells)
Shea nut	-	34-44	15-45*	Fuel
Shea nut	-	-	60	
Fruits				
Oil palm	-	56	11-20	Fuel, lighting
Avocado	69	11-28	40-44	-
Olive	50-70	-	25	Animal feed, fuel

Mechanical oil extraction

Mechanical oil extraction (expression) is a solid-liquid phase separation method which is applied to cooked seed flakes.

It can be executed **by batch**, mainly hydraulically, and **by continuous**, mainly mechanically, working presses.



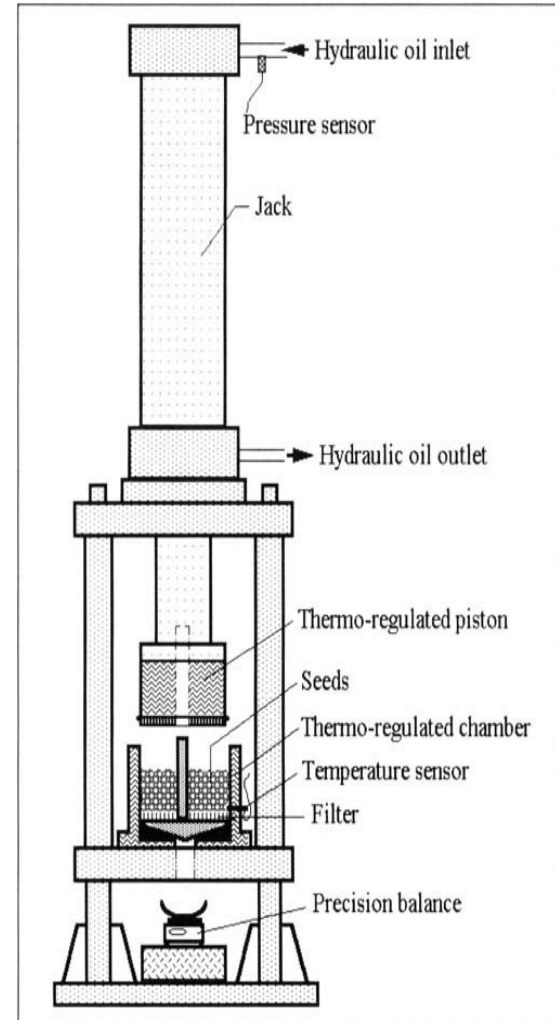
HYDRAULIC PRESSES

- Oil can be extracted by pressing softer oilseeds and nuts, such as groundnuts and shea nuts.
- Pulped or ground material is loaded into a manual or hydraulic press to squeeze out the oil.
- This is more efficient at removing oil than traditional hand squeezing, allowing higher production rates.

Hydraulic Presses (Contd..)

- Presses have a number of different designs, which can be grouped into screw (expellers) or hydraulic operation.
- Both types can be manual or motor driven.
- In all types, a batch of raw material is placed in a heavy-duty perforated metal 'cage' and pressed by the movement of a heavy metal plunger.
- The amount of material in the cage varies from 5-30 kg with an average of 20 kg

Hydraulic Presses (Contd..)



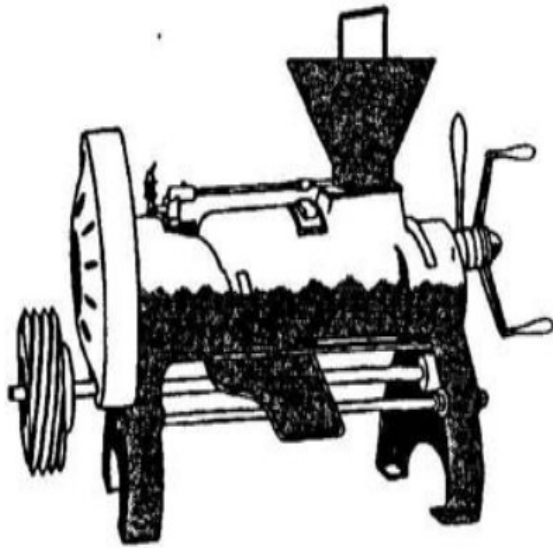
Hydraulic Presses (Contd..)

- **Open-type presses:** the fresh material, previously prepared and wrapped in press-cloths, is placed between the plates that should be corrugated to assist drainage and overcome cake creepage. In a standard process, it takes 2 minutes to feed the press, 6 minutes to reach maximum pressure, 20 minutes to drain and 2 minutes to remove solids, a total of 30 minutes per batch.
- **Closed-type presses:** in this type, the oilseed is enclosed by a strong perforated steel cage that can apply much more pressure than an open press. Removing oil from the interior of the grain is attained by the pressure applied by a piston placed close to the cage and hydraulically operated. Oil flows through channels that increase in size from inside to outside the cage, thus avoiding any clogging with solid particles (Williams, 2005).

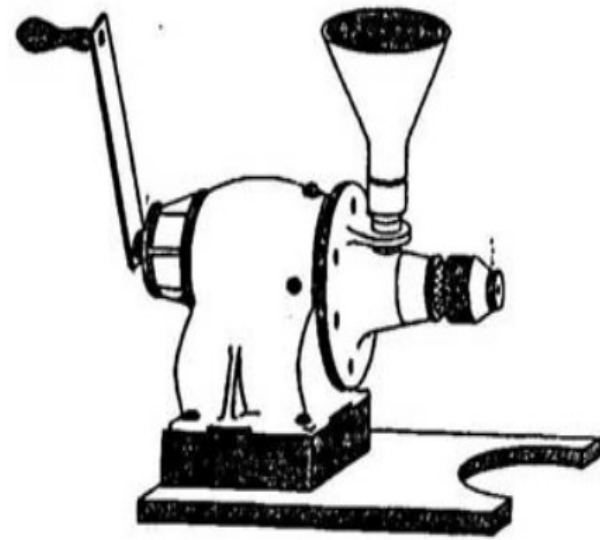
EXPPELLERS

- Expellers are continuous in operation and work by grinding and pressing the raw material as it is carried through a barrel by a helical screw.
- The pressure inside the barrel, and hence the yield of oil, are adjusted using a 'choke' ring at the outlet.
- Some designs also have an electric heater fitted to the barrel to increase the rate of oil extraction.
- The equipment has higher production rates than similar sized presses but is more expensive to buy and operate.

Expeller (Contd..)



Powered Oil Expeller



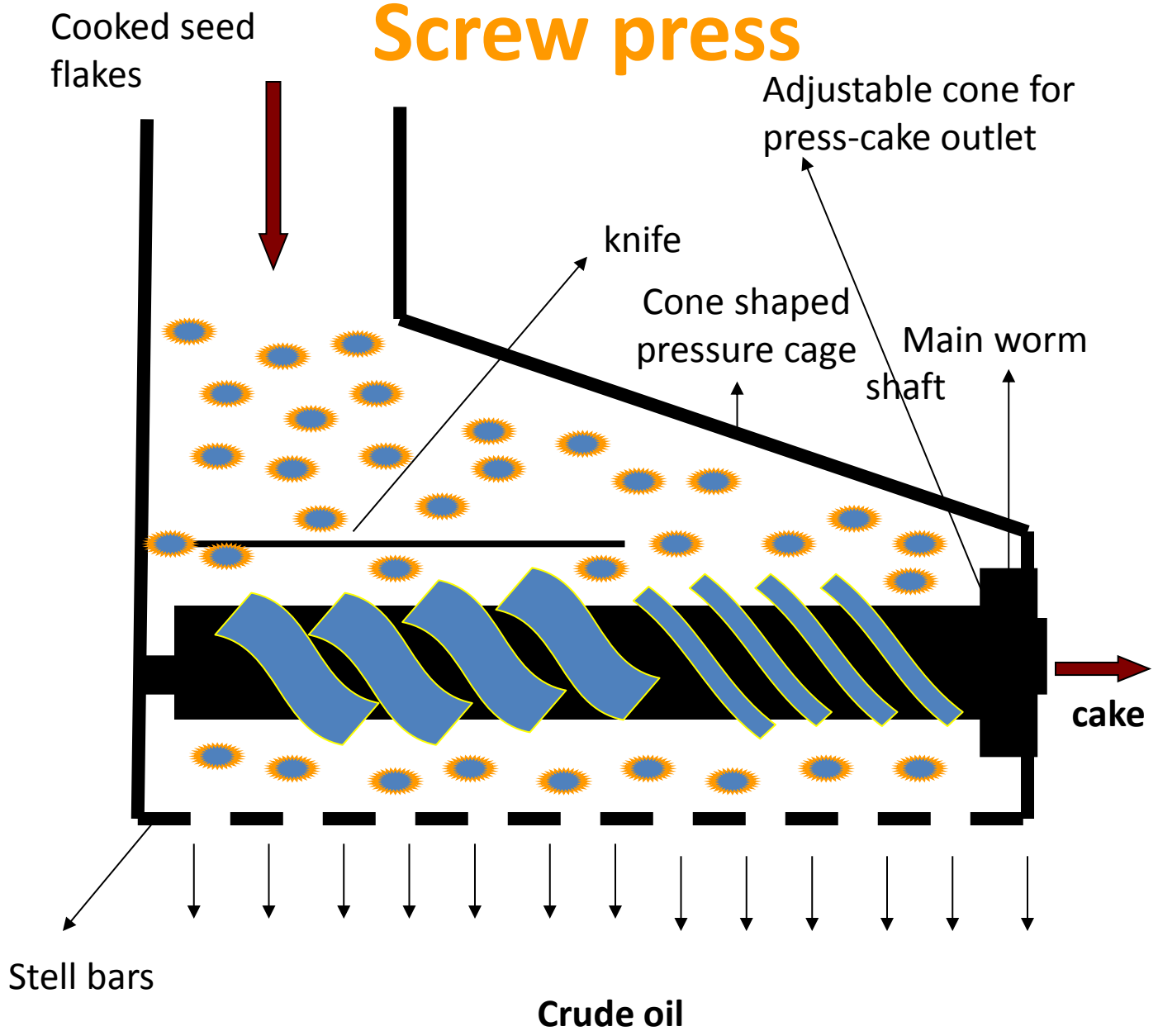
Manual Oil Expeller

Screw presses;

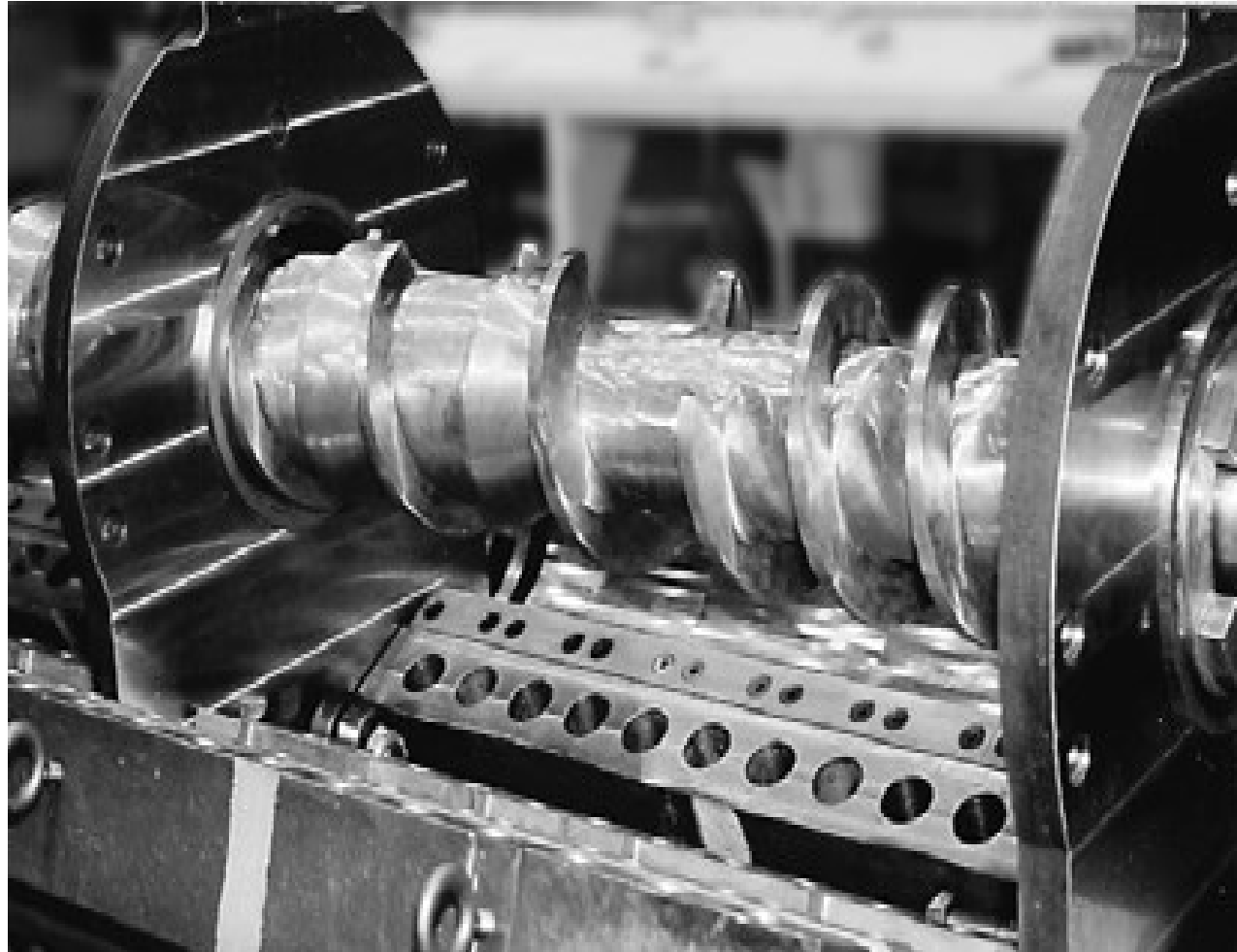
In oil industry, screw presses (expellers) are mostly utilized for expression. The main parts of continuous-screw press are;

- *Seed feeder,*
- *Cone-shaped cage*
- *Adjustable cone for press-cake outlet*
- *Worm (pressure and feed)*

Screw press



Shaft Arrangement- Screw Press



Advantages and disadvantages of the expeller process

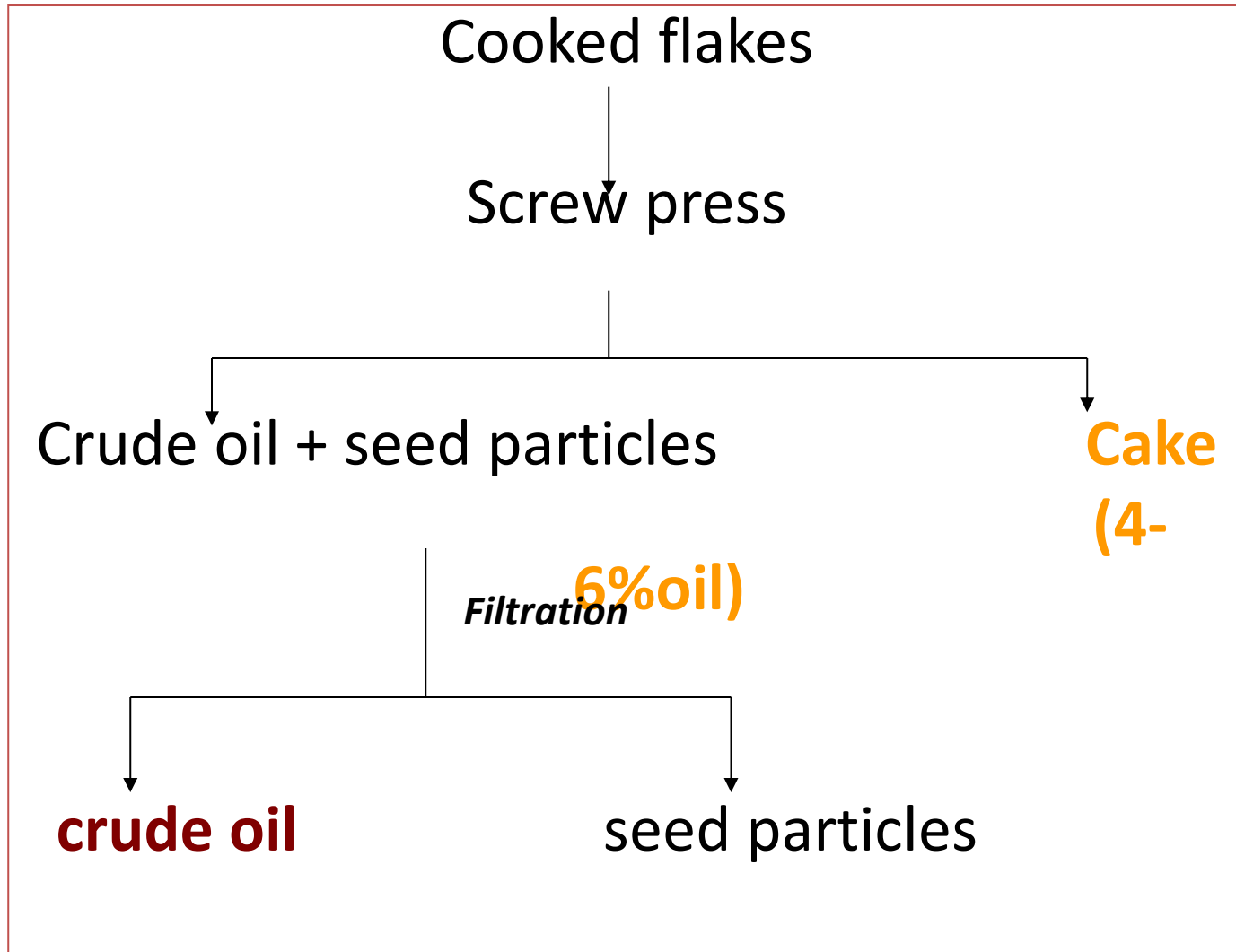
Expellers can be used with almost any kind of oilseeds and nuts. The process is relatively simple and not capital-intensive. While the smallest solvent extraction plant would have a processing capacity of 100-200 tons per day, expellers are available for much smaller capacities, from a few tons per day and up.

The main disadvantage of the screw-press process is its relatively low yield of oil recovery. Even the most powerful presses cannot reduce the level of residual oil in the press-cake below 3 to 5%. In the case of oil-rich seeds such as sesame or peanuts this may still be acceptable. Furthermore, most of the oil left in the cake can be recovered by a stage of solvent extraction. Such two stage processes (pre-press/solvent extraction) are now widely applied. In the case of soybeans, however, a 5% residual oil level in the cake represents an oil loss of about 25%. Solvent extraction of the cake would not be economical, because of the bulk of material which must be processed. Oil content of pre-pressed-solvent extracted cake is less than 1%.

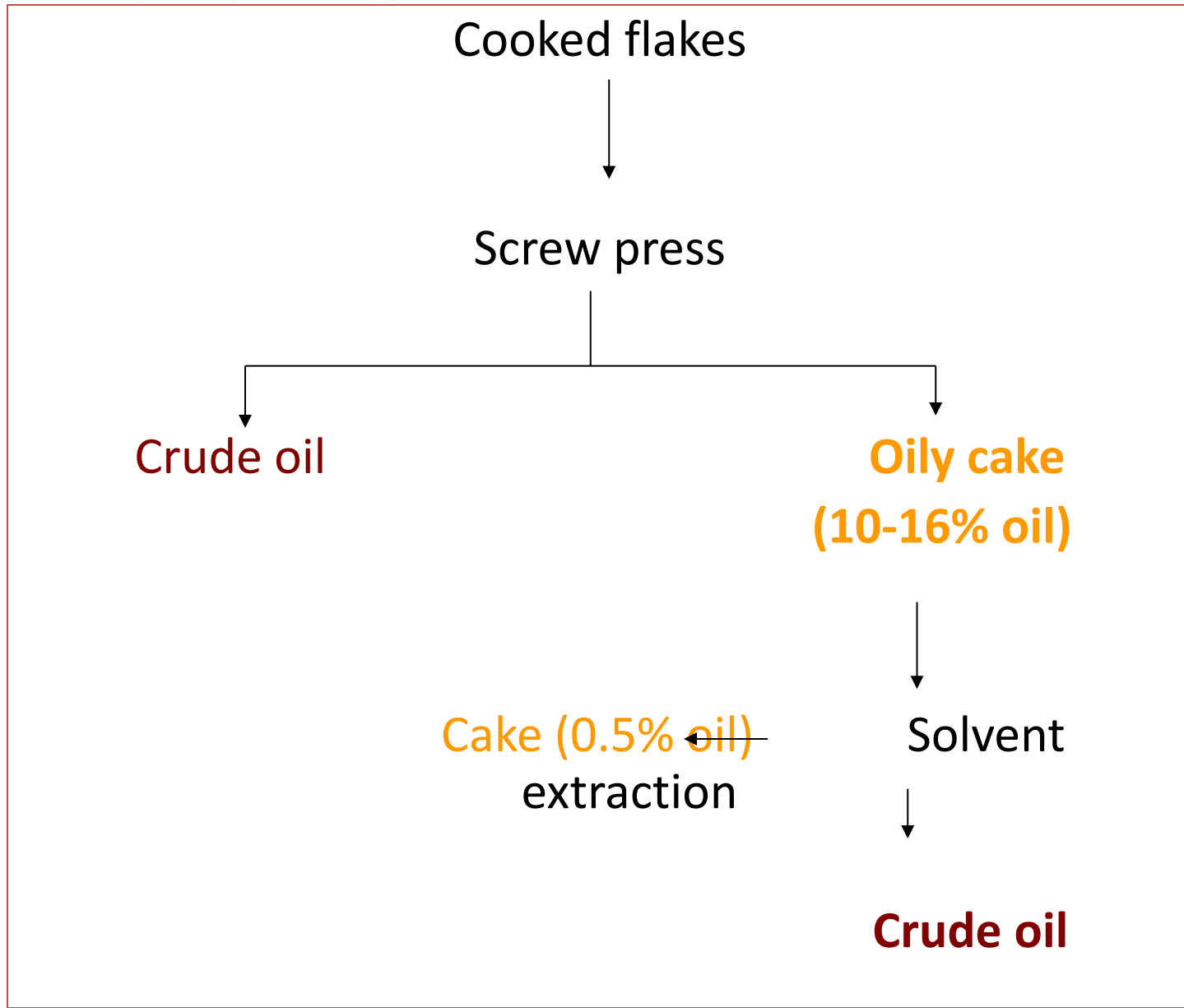
Disadvantages of Expeller Presses

- The first is the poor storage stability of the press-cake, due to its high oil content.
- The extreme temperatures prevailing in the expeller may impair the nutritive value of the meal protein.
- At any rate, expeller press-cake is not suitable for applications requiring a meal with high protein solubility.

Crude oil production (mechanical expression)



Crude oil production (pre-pressing extraction + solvent extraction)



Solvent Extraction of Oils (solid-liquid extraction- leaching)

The lowest levels of residual oil after pressing are 3-8%; exhaustive removal of the oil present in the cake by mechanical means alone is impossible. The residual oil in cake , therefore, only be removed by a different approach, this being solvent aided extraction.

Solvent Extraction Classification

Depending on the phase of the mixture and the extraction agent, extraction can be divided into the following types:

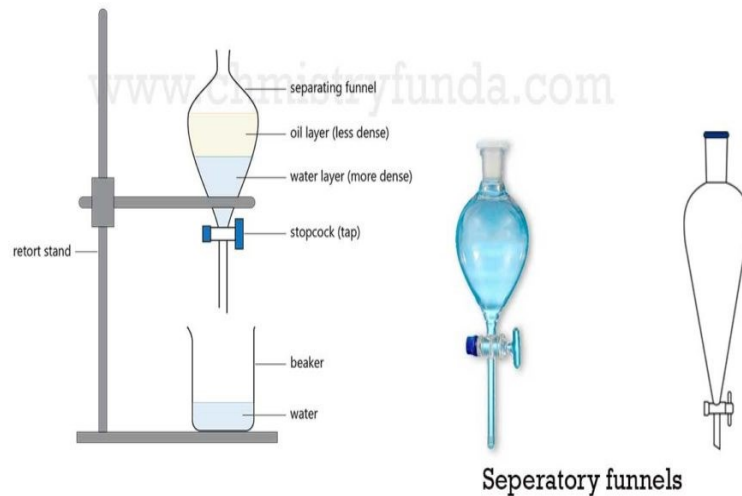
- Liquid - liquid extraction, where a solvent extracts a solute from a liquid phase;
- Solid - liquid extraction, or leaching, where a solvent extracts a solute from a solid phase;
- Supercritical extraction, where a fluid under supercritical conditions is used as the solvent.

Liquid-Liquid Extraction

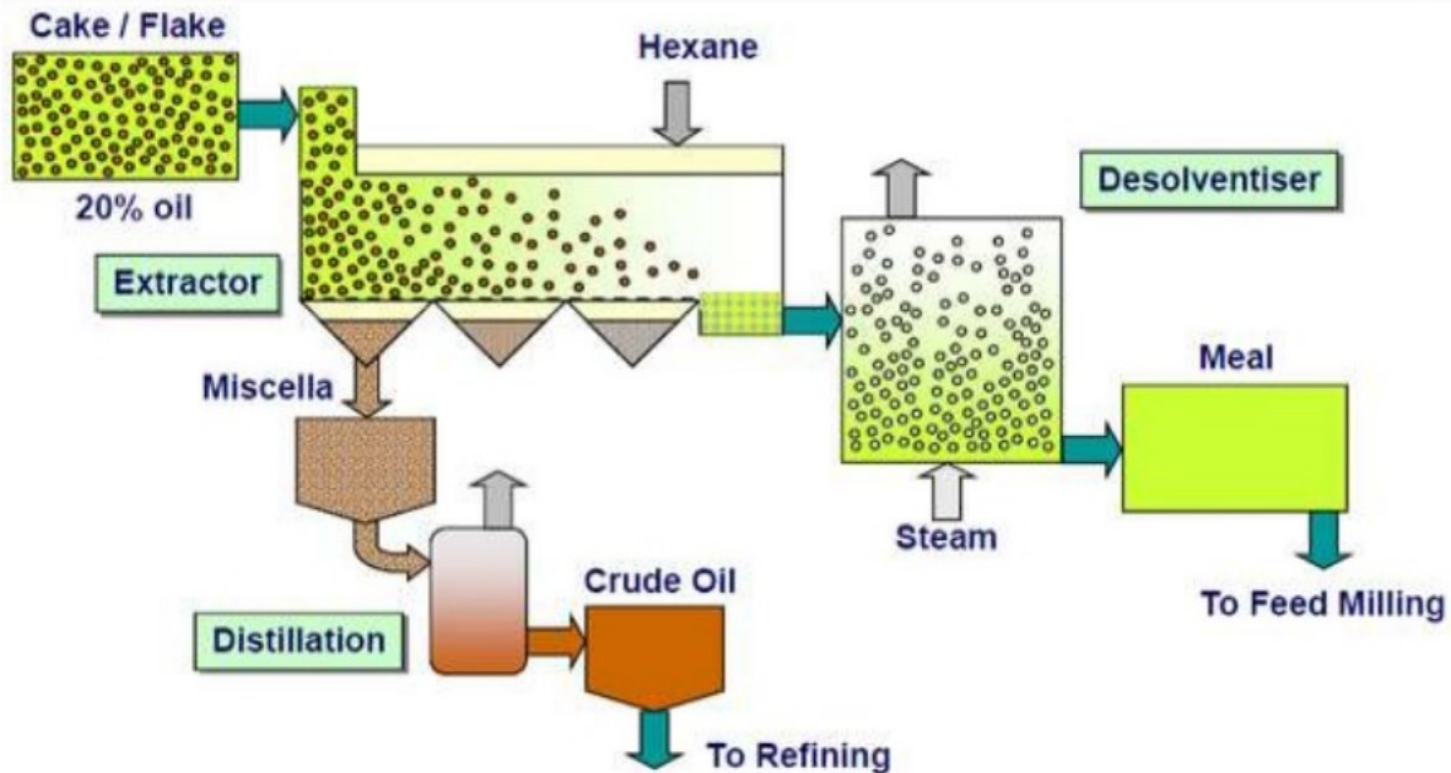
- It is the separation of impurities (solutes) from a liquid solution by contacting it with another immiscible liquid (solvent) in which the impurities have a high affinity.
- Driving factor for separation : Physical solubility differences, Chemical reaction.
- Solvent composition: Single component liquid, Mixture Liquid-liquid extraction
- Principle: Liquid-liquid extraction operations utilize the differences in the solubilities of the components of a liquid mixture.

Steps in Liquid-Liquid Extraction

- Contacting the feed with the extraction solvent.
- Separation of the resulting phases
- Removal/recovery of the **phase.**



Solid Liquid Extraction



Solid Liquid Extraction

- Solid–liquid extraction or leaching is a separation process affected by a fluid involving the transfer of solutes from a solid matrix to a solvent.
- Most commonly used unit operation: sucrose in cane or beets, lipids from oilseeds, proteins in oilseed meals, phytochemicals from plants, and functional hydrocolloids from algae, toxins in food or feed.
- Mechanism of extraction – Solid naturally contains a liquid phase or it becomes impregnated by the extraction liquid, so that liquid phase diffusion inside the solid is a major mass transfer mechanism during leaching.

Solid Liquid Extraction (Contd..)

- Extraction has been practiced in the vegetable oil industry for a long time. Oil from soybean, corn, and rice bran cannot be separated by mechanical pressing, therefore, solvent extraction is used for their recovery.
- Examples – Production of **olive oil, peanut oil**
- Extraction of **spice oils** and **natural flavor extracts**
- Extraction of sugar from **beet sugar** and **sugar cane**
- **Decaffeination** of coffee/tea

Choice of solvent

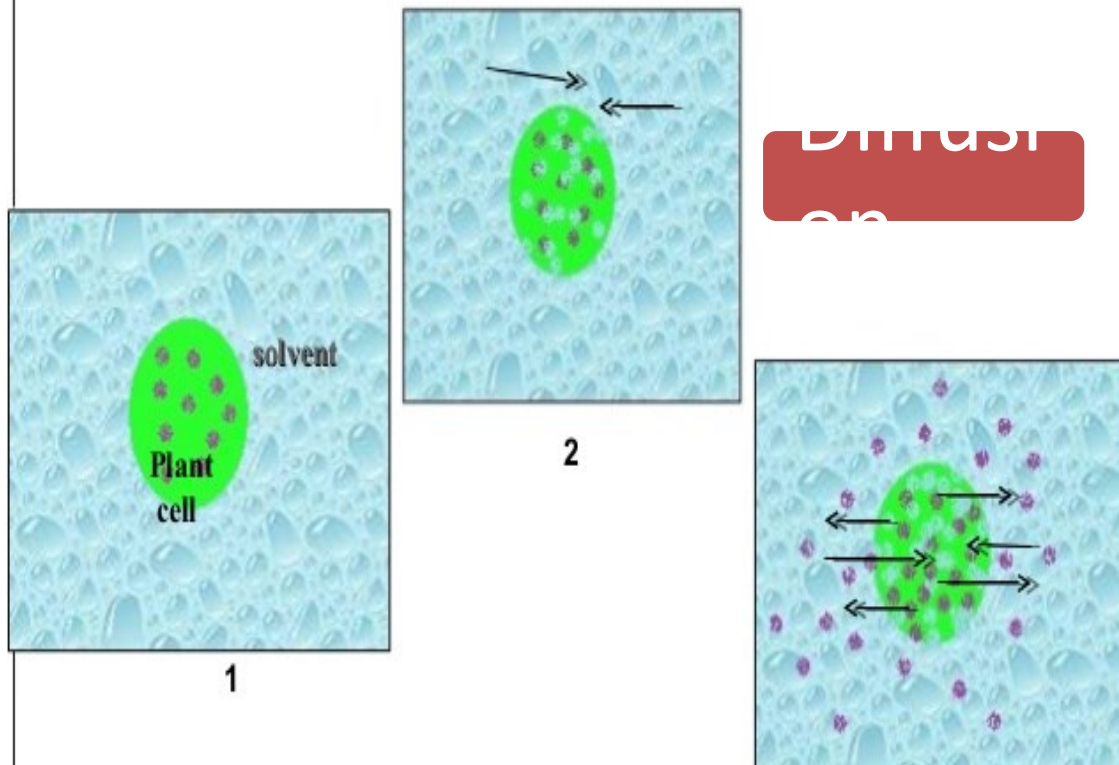
An ideal solvent for the extraction of oil from oil seeds should possess the following properties:

- **Good solubility** of the oil.
- **Poor solubility** of non-oil components.
- **High volatility (i.e. low boiling point)**, so that complete removal of the solvent from the miscella and the meal by evaporation is feasible and easy. Yet, the boiling point should not be too low, so that extraction can be carried out at a somewhat high temperature to facilitate mass transfer.
- **Low viscosity**.
- **Low latent heat of evaporation**, so that less energy is needed for solvent recovery.

Choice of solvent (Contd..)

- **Low specific heat**, so that less energy is needed for keeping the solvent and the miscella warm.
- The solvent should be **chemically inert** to oil and other components of the seed flakes.
- **Absolute absence of toxicity and carcinogenicity**, for the solvent and its residues.
- **Non-inflammable, non-explosive, Non-corrosive, Commercial availability in large quantities and low cost.**

Mechanism of Extraction :



General
Principle
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Extractio
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- **Basic principles of solvent extraction:**
The extraction of oil from oilseeds by means of non-polar solvents is, basically, a process of solid-liquid extraction. The transfer of oil from the solid to the surrounding oil-solvent solution (miscella) may be divided into three steps:
 - * diffusion of the solvent into the solid
 - * dissolution of the oil droplets in the solvent
 - * diffusion of the oil from the solid particle to the surrounding liquid

Contd..

- **Rate of diffusion** is inversely proportional to the square of the diffusion path.
- **Smaller particle size**, shorter residence time for the solids.
- Example – **Flaking** of soyabean seed.
- **Heating treatment** to inactivate lipoxygenase enzyme that cause oil oxidation – Example **Rice Bran**.
- Cane sugar extraction – **Hammer mills used to reduce the particle size** to twice the size of juice cells.
- **High solubility** of solute in the solvent is desirable.
- **Fast achieving of equilibrium stage** during extraction is desirable.