**Food Oils and Fats: Chemistry & Technology**

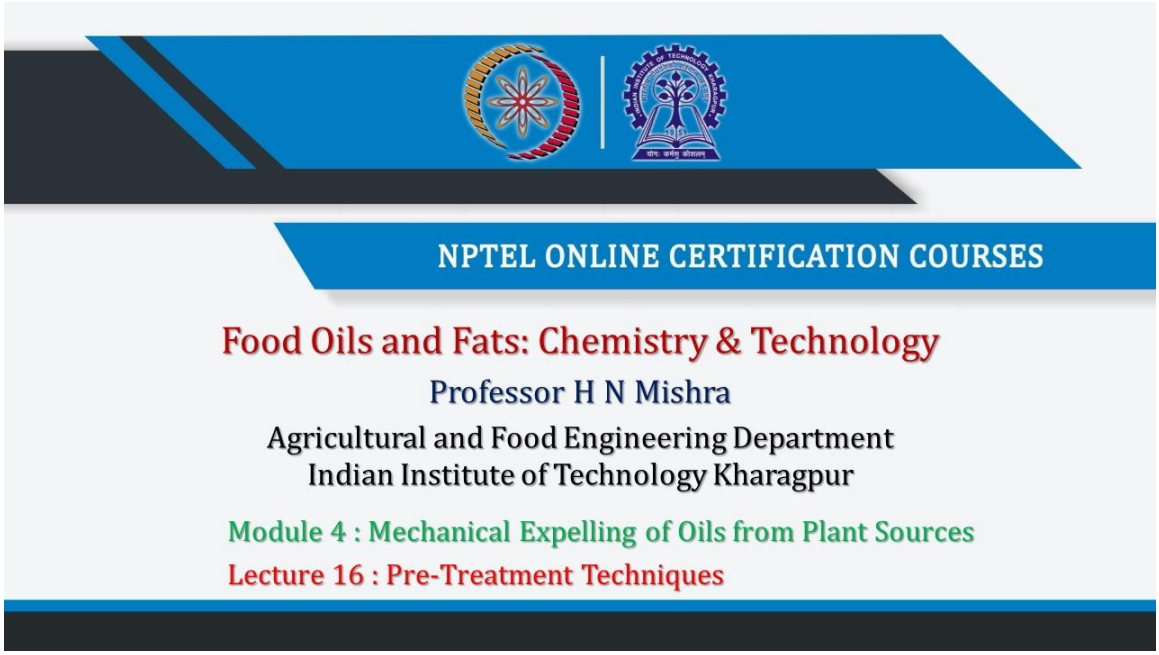
**Professor H N Mishra**

**Agricultural and Food Engineering Department**

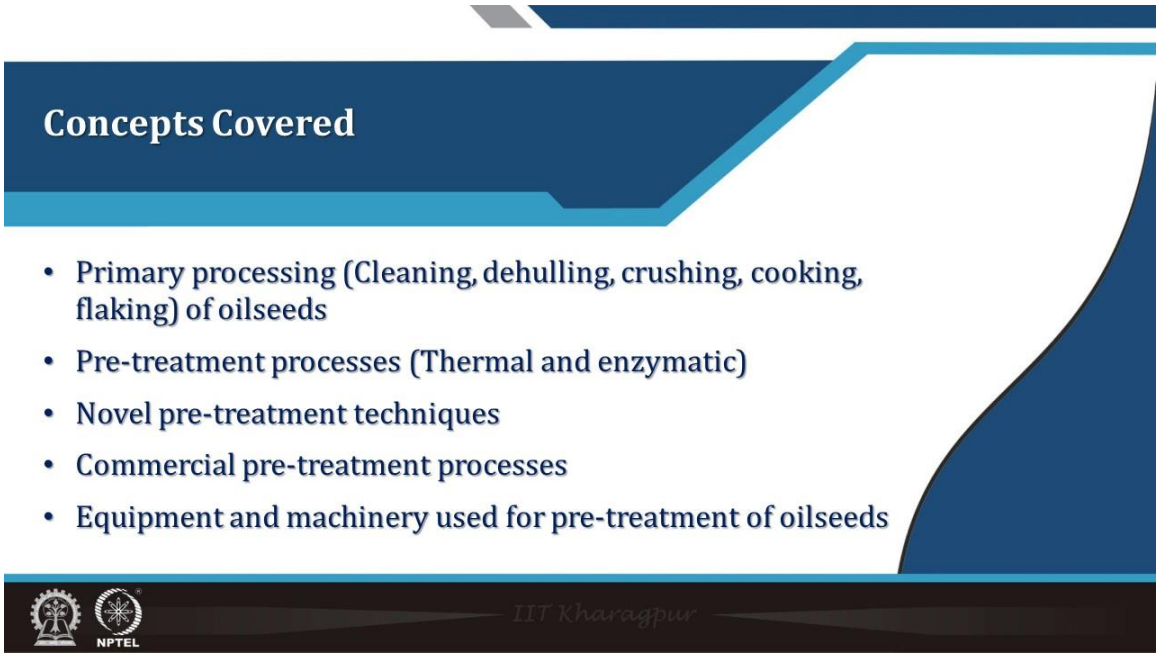
**Indian Institute of Technology Kharagpur**

**Module 4 : Mechanical Expelling of Oils from Plant Sources**

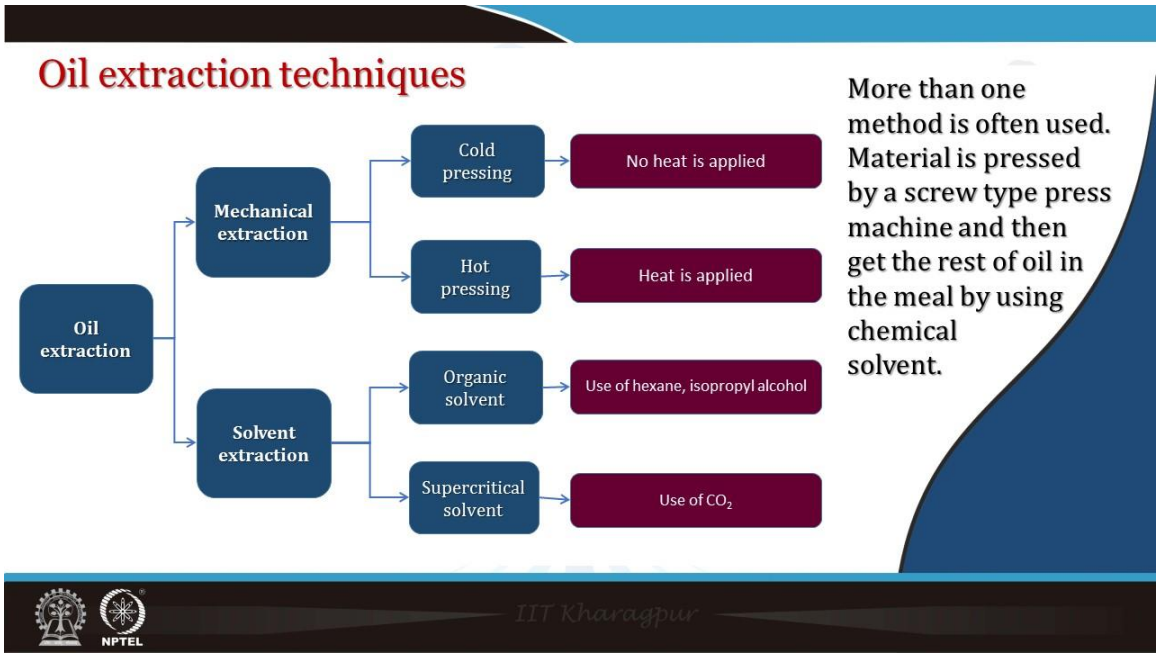
**Lecture 16: Pre-Treatment Techniques**




Hello, everybody. Namaste. Now, we are entering in the fourth module that is the fourth week ok. And so far in the earlier 3 weeks in 15 lectures, we discussed various aspects of nature and occurrences of the oil, their chemistry, their physical, chemical, nutritional and other properties ok. Now, we are entering into other aspects of the course that is important aspect that is how to recover these oils and fats from the various sources ok. That in the earlier class, we told you that is the one major source is the plant source. So, this week 5 lectures, we will devote on getting the oil or extraction various methods of extraction of oil from the plant sources ok.

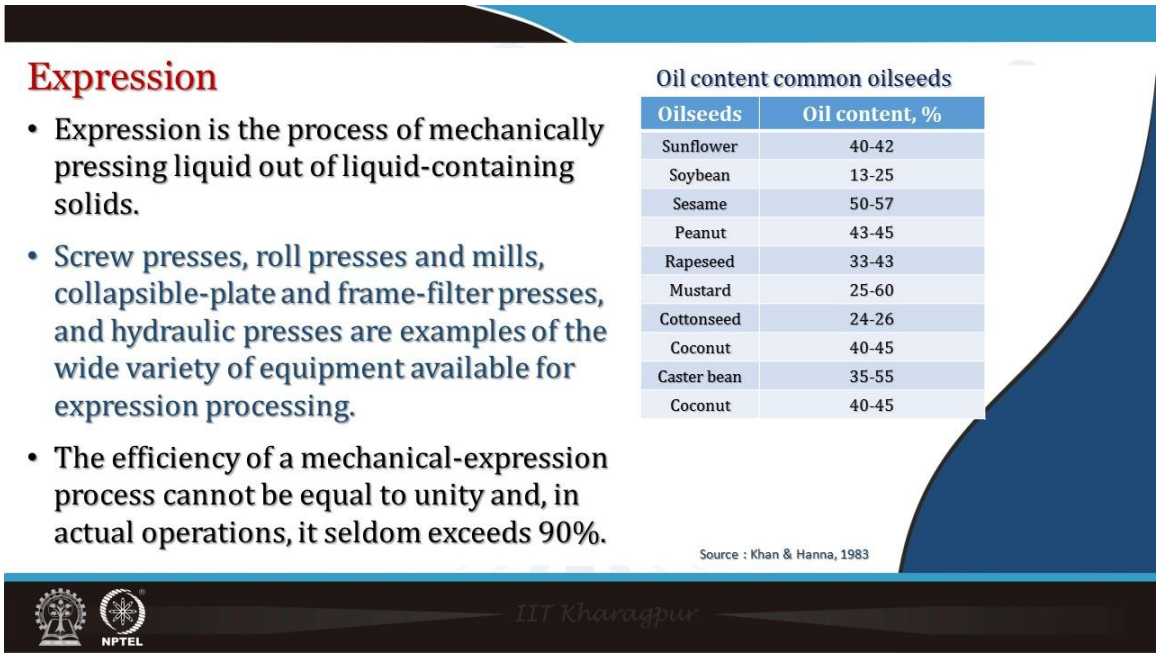



Then in this lecture is the pretreatment techniques various oil seeds before subjecting to the actual extraction process, they are to be preprocessed or pretreated that they are brought into the form in which the can be subjected for the oil extraction to get the oil of good quality, oil seed they are given certain pretreatments. So, in this half an hour, we will discuss about their pretreatment techniques methods like what are the various primary processing techniques like cleaning, dehulling, crushing, cooking, flaking etcetera. Then thermal and enzymatic pretreatment processes, novel pretreatment techniques, then what are the various treatment processes used by the industry and also finally, we will have some idea some discussion about the common equipment and machinery used in the pretreatment of oil seed.




Because these pretreatment are very very important operations and it not only influences the quality of the oil and meal which we get and also that is the quantity oil yield and so on ok. So, what are the various oil extraction techniques here in this slide it is given that is the more than one method is often used for the getting the oil ok. That is the there are two common methods are there which are used by the industry for the extraction of oil that is one is the mechanical extraction, other is the solvent extraction. The mechanical extraction includes cold pressing where the no heat is applied or hot pressing where sufficient or significant amount of heat is used for getting better yield as well as better recovery of the oil. Then in the solvent extraction process there is a commercial process which uses organic solvent like hexane, isopropyl alcohol, so, petroleum ether, etcetera ok.

Other method that is the super critical fluid extraction process that using super critical carbon dioxide for extraction of the oil ok. So, these are some of the methods which are used by the industry for extraction of oil from the oil bearing plant material plant sources of oils ok.




And sometimes because all these methods there the recovery yield is a varies like the mechanical extraction, cold extraction it gives less yield, hot extraction gives more yield than the cold extraction, but solvent extraction it gives further more yield than that of the mechanical extraction. And both the extraction processes etcetera they influence as I told you that is on the oil recovery as well as the quality both quality and quantity of oil and yield. So, the and what are the parameters that are used in these process.

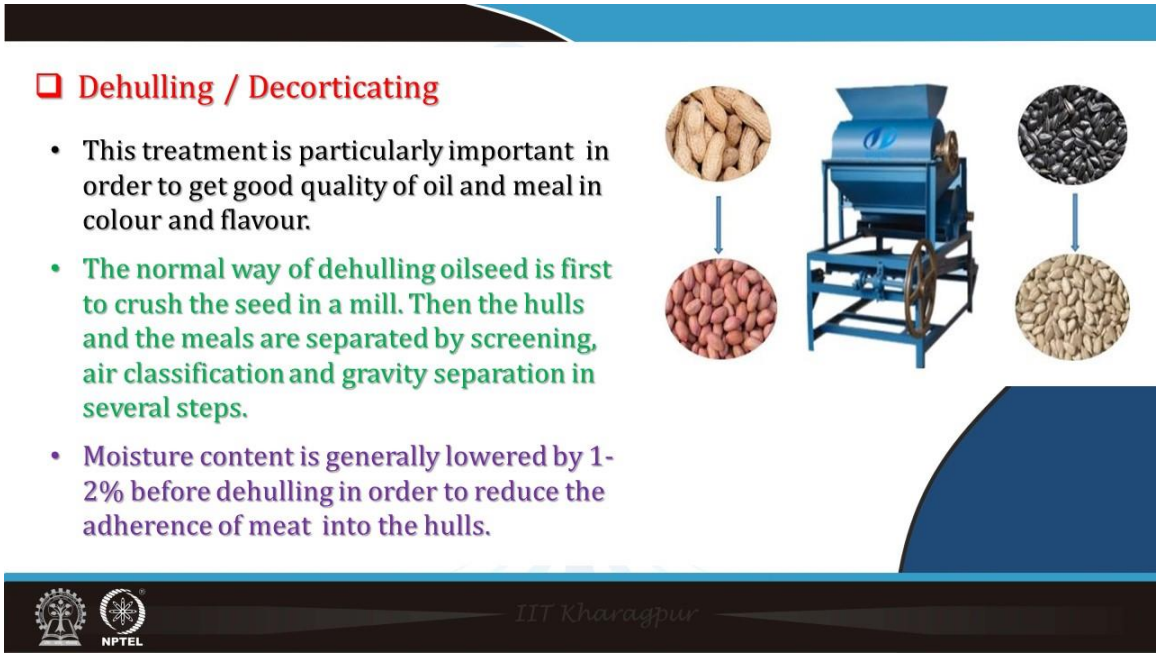
So, many a times even industry also uses pre press solvent extraction method like that is the both a combination of mechanical extraction as well as solvent extraction both is used that is whatever easily can be extracted by mechanical pressing that is obtained by mechanical pressing and then the reminder is sent to the solvent extraction and everything. So now, that we will discuss that like mechanical expression in this like mechanical expression it is expression is a process of mechanically pressing liquid out of the liquid containing solids and in this case liquid containing solids are oil seeds oil seeds that is they contain liquid that is oil. So, a screw presses, roll presses and mills, collapsible plate and frame filter presses, hydraulic presses are the examples of wide variety of equipment which are available for expression and processing or expressing the oil from the oil seeds. The efficiency of a mechanical expression process cannot be equal to unity and in actual operation it seldom exceeds 90 percent. So, by the mechanical

expression you cannot generally we generally do not get more than 90 percent recovery of the oil.


Now, as I told you that the pretreatment because the let us say soybean seed or sunflower seeds or groundnut seed, peanut etcetera they contain the oil. So, they have certain that is the seed coating they are out or wholly they are husky they are all these things. So, they are subjected to some preprocessing treatment and these includes like one important pretreatment or preprocessing seed cleaning that is in this case that the foreign materials such as stems, leaves, other seeds, sand and dirt etcetera are removed by screening and aspiration. There are standard methods available for the seed cleaning ok. So, those are using those things that is these even the permanent magnets are electromagnets which might be there in the by some contamination from the field or during threshing yard etcetera it may get contaminated.

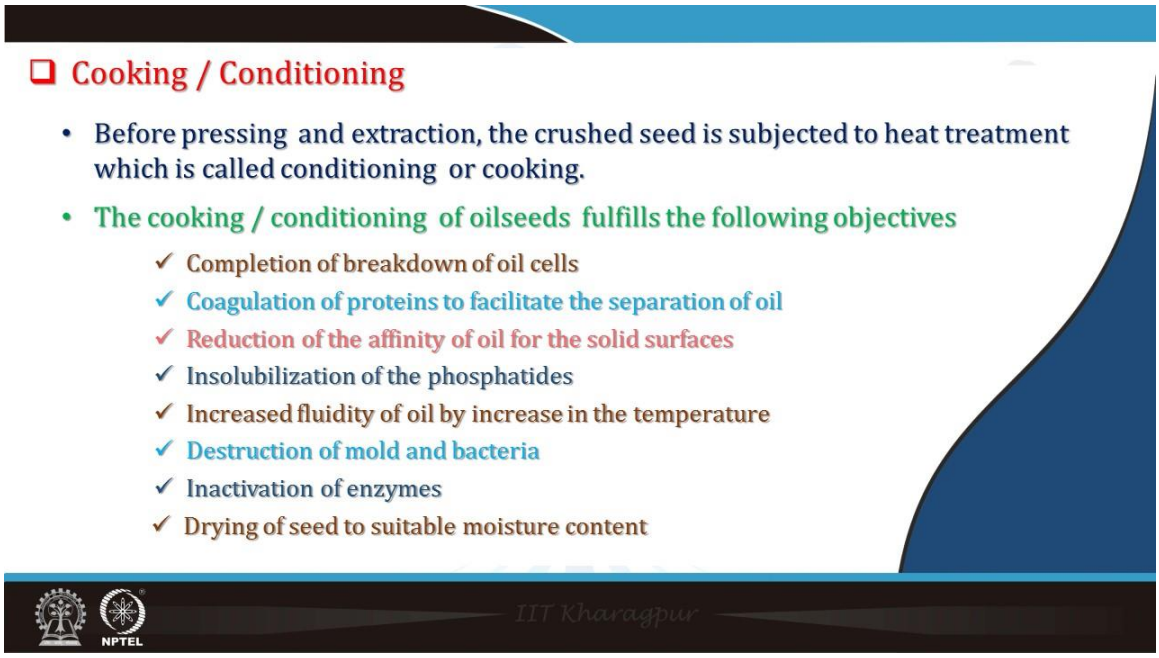
So, they are used by using the magnets etcetera. And this operation that is seed cleaning is usually carried out at the extraction plant just before processing just before sending in order to say if they make sure that whatever the material is entering the in the extraction plant that is clean it has no foreign matter no impurities. Because if there are impurities present in it, it will adversely affect the quality of the oil. So, proper seed

cleaning will reduce maintenance cost, it will increase capacity and also it will improve the oil and meal quality.




The next operation is dehulling or decorticating like you see in the groundnut, in the sunflower oils etcetera castor oil all those things seed dehulling operation is or decorticating is used. This treatment is particularly important in order to get good quality of oil and meal in its, particularly its colour and flavour. The normal way of dehulling oil seed is first to crush the seed in a meal alright and then the hulls and the meals are separated by screening, air classification and gravity separation in several steps. And generally the moisture content of the oil seed is lowered by 1 to 2 percent before dehulling and this is done in order to reduce the adherence of the meat with the hull. So, that it dehulling operation becomes easy that is hulls are easily removed by simple passing between two rollers etcetera as you can see here this is the hopper and there are the rollers the between two rollers. So, one can adjust the clearance etcetera and that is by some interaction they are the decorticated or dehulled.


Then after dehulling once you get these dehulled materials then it need to be crushed ok. And this crushing is basically done in a roller meal to facilitate the next operation like cooking and extraction ok. And here basically the we reduce the particle size and which improves the efficiency of the process and both the quality of the oil and also recovery ok. Usually one or more pairs of rolls are used which may be smooth or corrugated. The rolls in one pair can be run at equal speed or different speed, but mind it the clearance between these two rolls should be adjusted properly according to the size of the grain alright. And you should not mill it or crush it to a very fine very fine particle size ok. Because if there is a too intense crushing it will produce large amount of fines and which will lead to difficulties in the extraction process as well as with the clarification of the oil. So, these fines there when you pressing in the extraction process they will fine will close and it will become a some sort of coarse material and it will create hindrance in the flow of the oil ok. Also these fines may come some of the fines may come into the oil they may flow along with the oil and come in with the oil and which create the problem during clarification or increases the clarification process its cost and other things ok.

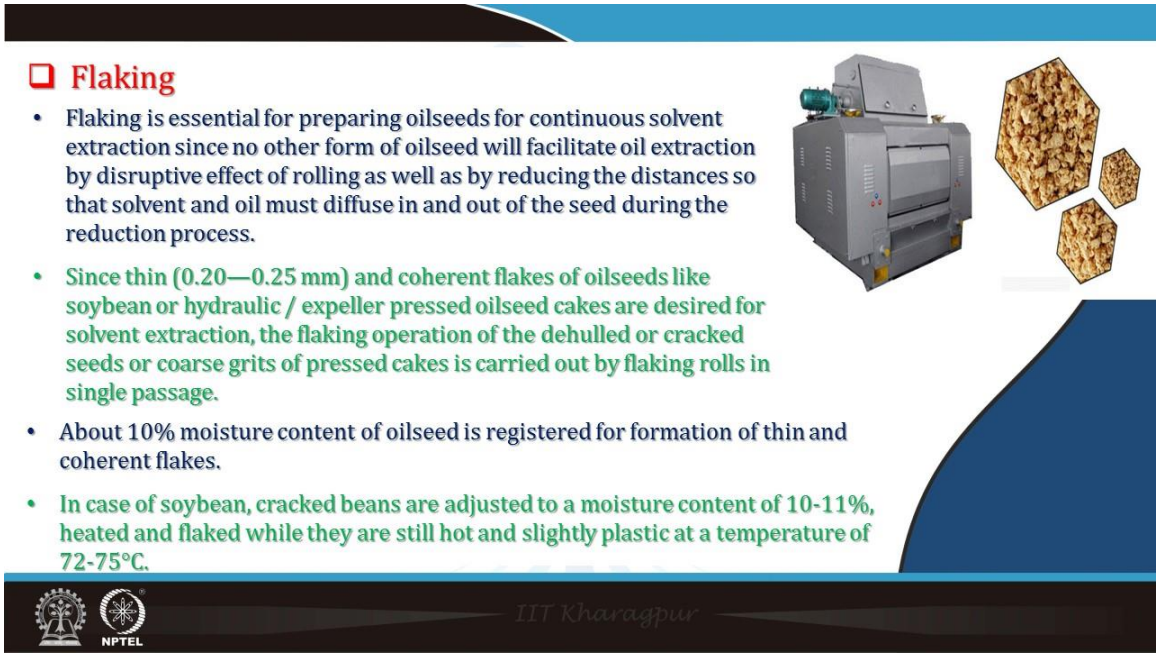



Then following this crushing the next very very important operation is the cooking or conditioning that is before crushing and extraction the crushed seed is subjected to heat treatment which is called conditioning or cooking ok. This cooking or conditioning of the oil seed fulfills the objective like completion of the breakdown of the oil cells. You have seen in the earlier classes that these phospholipids are triglycerides they are present inside the some cellular membranes and inside oil globules are there. So, this cooking breaks those membrane fat globule membranes etcetera cell membrane etcetera and it releases the oil. Also that the protein body that is heat calculates the protein and which facilitates the separation of the oil. There is a reduction of the affinity of the oil for the solid surfaces ok.

So, its fluidity will be increased by this cooking by heating in also heat results into the insolubilization of the phosphatides there is a because of heat these phosphatides they become insolubilized and then their separation becomes easy in the refining or degumming processes. Also this conditioning or cooking results in increased fluidity of oil by increase in the temperature. There is a destruction of mold and bacteria if there are any contaminated oil seeds then this these are removed they are destroyed they are inactivated enzymes are inactivated ok and which obviously, has a better effect in the oil that is if you enzymes are inactivated. So, hydrolytic resins etcetera can it will be

beneficial in that similarly the molds etcetera which are some contaminated. Then these molds if they are removed it will otherwise this mold they may cause ketonic rancidity and other things which we discussed earlier ok.

Then also there is a during heating and conditioning there is also there is the heaters normally there are pressure cookers where there are various chambers where the temperature, pressure and moisture control operations are provided ok. Oil seed is normally enters in the top kettle it goes to the in the bottom kettle it is heated given proper condition and the top kettle that is where that some moisture is removed in the bottom kettle from the bottom kettle the moisture is removed. And depending upon whether the oil is subjected to the straight expelling process or straight solvent extraction or prepress solvent extractions the moistures and temperature and other conditions are properly adjusted in the cooker and then depending upon again also that which is the type of the oil seeds and what is it is a texture or hardness and other things and right ok.




Then after the cooking is next operation is the flaking ok. It is essential for preparing oil seed for continuous solvent extraction process that is after the pressing if it has to go for the solvent extraction then these cooked conditioned oil seeds they had to be made into a thin coherent flakes and this basically improves that the flaking process

improve the miscibility that is the process that is the mixing of the or proper flow of the solvent through these prepared materials.

So, that is for that purpose that is the also flaking increases the surface area ok and it helps the continuous solvent extraction and no other form of oil seed will facilitate oil extraction by disruptive effect of rolling as well as by reducing the distances. So, that the solvent and oil must diffuse in and out and the of the seed during the reduction process. So, this flaking is very as either in the even sometime after mechanical expressing whatever the material is obtained like in the case of prepress solvent extraction process. So, after a screw spelling or mechanical spelling whatever the oil seed is obtained that is oil seed meal or cake it passed through some sort of flaking unit which is again having a two rollers and in this rollers their clearance and their speed can be adjusted to get a thin flax etcetera as you can see here which comes out and it will then it is passed through the solvent extraction. Like since thin level may be 0.2 to 0.25 mm and coherent flax of oil seeds like soybean or hydraulic expressed oil cakes are desired for solvent extraction the flaking operation of the dehulled or cracked seeds or coarse grits of prepressed or pressed cake is carried out by flaking rolls in single pass. And about 10 percent of the moisture content of the oil seed is registered for formation of thin and coherent flax. In case of soybean cracked beans are adjusted to a moisture content of 10 to 11 percent heated and flaked while they are still hot and slightly plastic at a temperature of about 72 to 75 degree Celsius.

## Thermal Pre-treatment

### Roasting

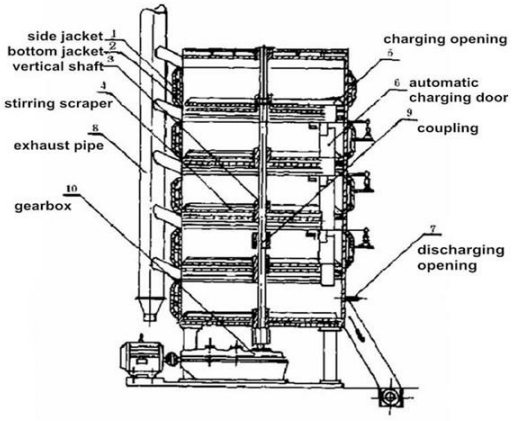
- Roasting, also known as dry air roasting, is one of the simplest thermal treatments for oilseeds.
- Oilseeds are heated in an oven (usually equipped with a rolling bucket) by conduction (internal walls) or convection through heated air currents at temperatures between 125 °C and 250 °C.
- Roasting processes involve simple equipment and are easy to operate with a high capacity.
- However, roasting processes can be slow and inefficient and may produce hazardous substances when the oilseed is unevenly heated.



Then there are other way of that is giving the pretreatment like thermal pretreatment where some roasting is given roasting also known as dry air roasting is one of the simplest thermal treatment for oil seeds. There are some roasters etcetera given here and the oil seeds are heated in an oven usually is usually equipped with a rolling bucket by conduction or convection through heated air currents at temperature between 125 to 250 degree Celsius depending upon the type of seed etcetera.

And then roasting parameters improve simple equipment and are easy to operate that roasting processes involve simple equipment and are easy to operate with a high capacity. However, roasting process can be slow and inefficient and may produce hazardous substances when the oil seed is unevenly heated. So, the roasting condition that proper that is there has to be arrangement as usual that complete oil seed etcetera they should be properly heated evenly heated.

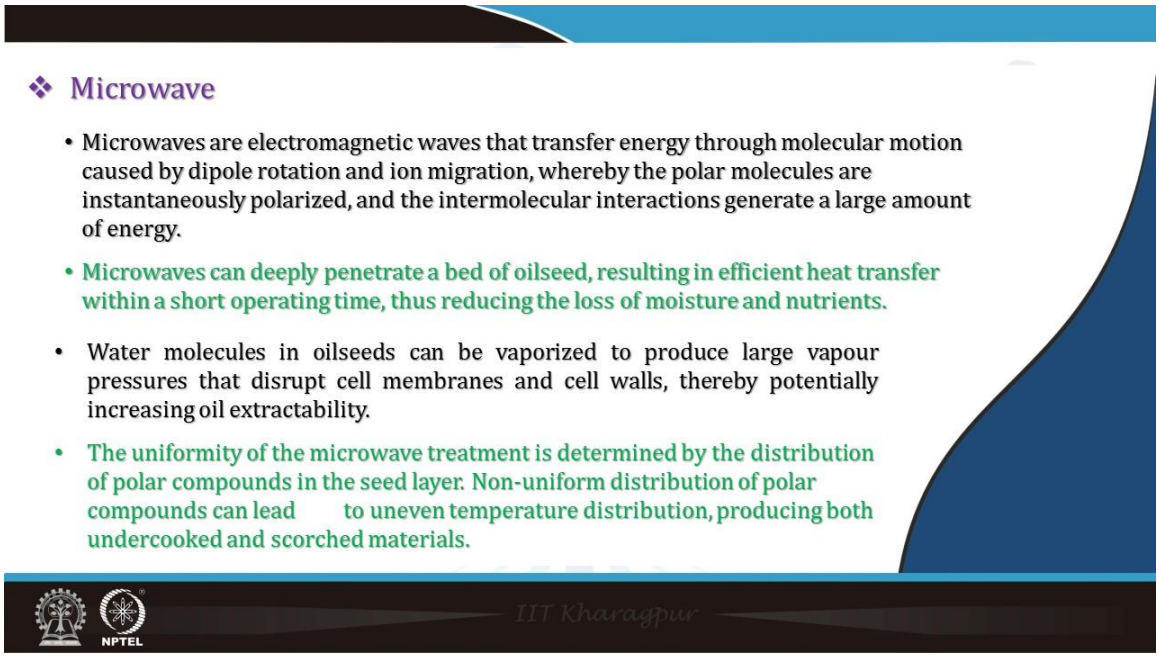
❖ Steaming




- Steaming is a moist-heat method that uses steam to transfer energy and heat materials.
- Steam treatments are typically conducted at temperatures below 100 °C; thus, compound degradation can be mitigated; however, the oilseed moisture content can increase.
- In addition, the presence of water, which is highly polar, could result in the loss of certain polar nutrient compounds, such as polyphenols.

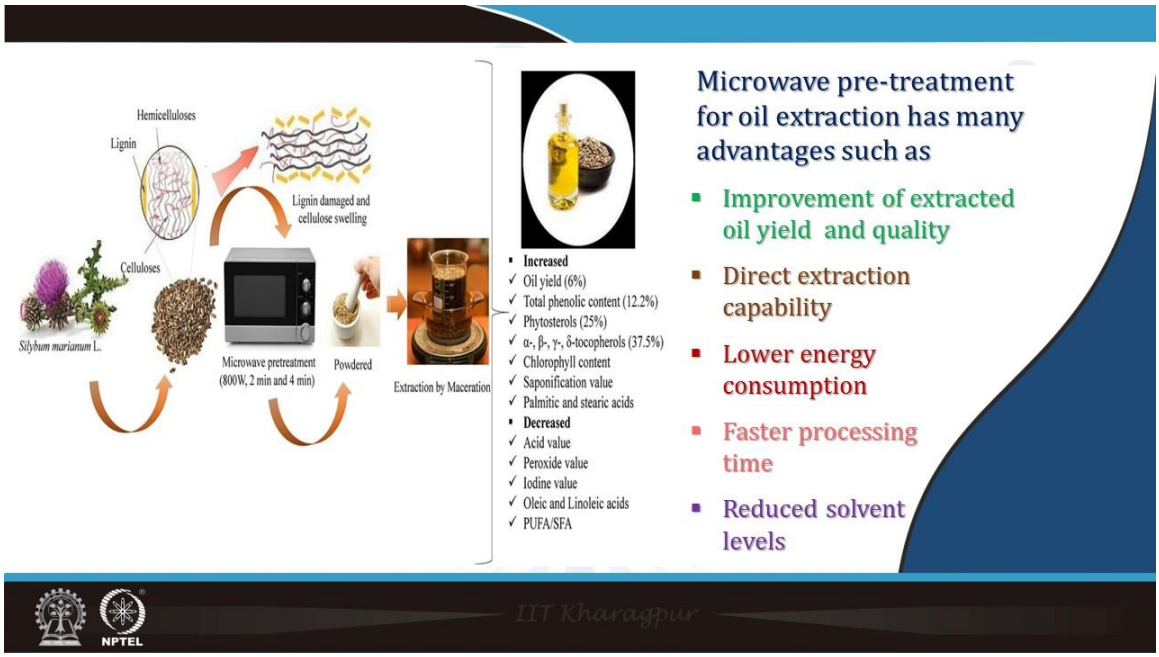


Then steaming is another way is a moist heat method that uses the steam to transfer energy and heat materials. Steam treatments are typically conducted at a temperature below 100 degree Celsius thus compound degradation can be mitigated. However, the oil seeds moisture content can increase. In addition the presence of water which is highly polar could result in loss of certain polar nutrient compounds such as polyphenols etcetera is a equipment that is system given for the steaming process where you see that the charging opening here the materials are charged at this stage it comes and the there is where the steam exhaust pipe etcetera is there and steam in this chamber the material unit is moving around it is a it is coming into the contact with the steam and get properly heated steamed or steam heating. And then finally, it comes into discharge.




Then microwave thing microwaves are electromagnetic waves that transfer energy through molecular motion caused by dipole rotation and ion migration whereby the polar molecules are instantaneously polarized and the intermolecular interactions generate a large amount of energy. Microwaves can deeply penetrate a bed of oil seeds resulting in efficient heat transfer within a short operating time thus reducing the loss of moisture and nutrients.

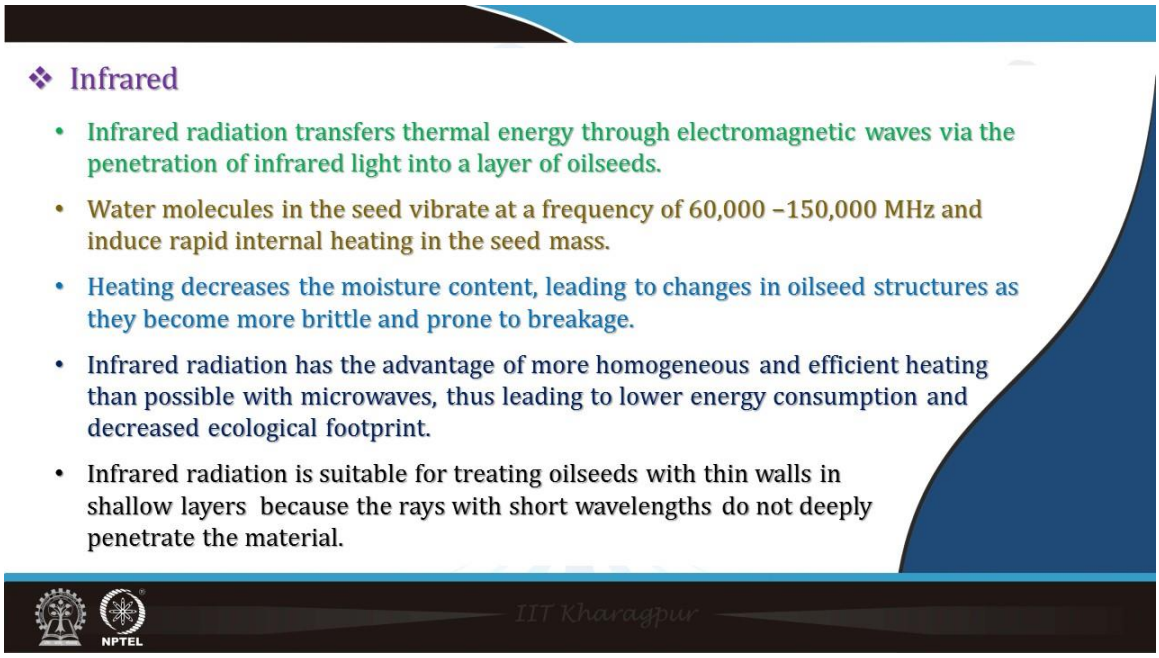
Water molecules in the oil seed can be vaporized to produce large vapour pressures that disrupt cell membrane and cell walls thereby potentially increase the oil extractability. The uniformity of the microwave treatment is determined by the distribution of polar compounds in the seed layer. Non-uniform distribution of polar compounds can lead to uneven temperature distribution which produces both undercooked and scorched material. So, the proper control of the microwave process is required.




This microwave pretreatment of oil extraction has many advantages such as improvement in the extracted oil yield and quality both.

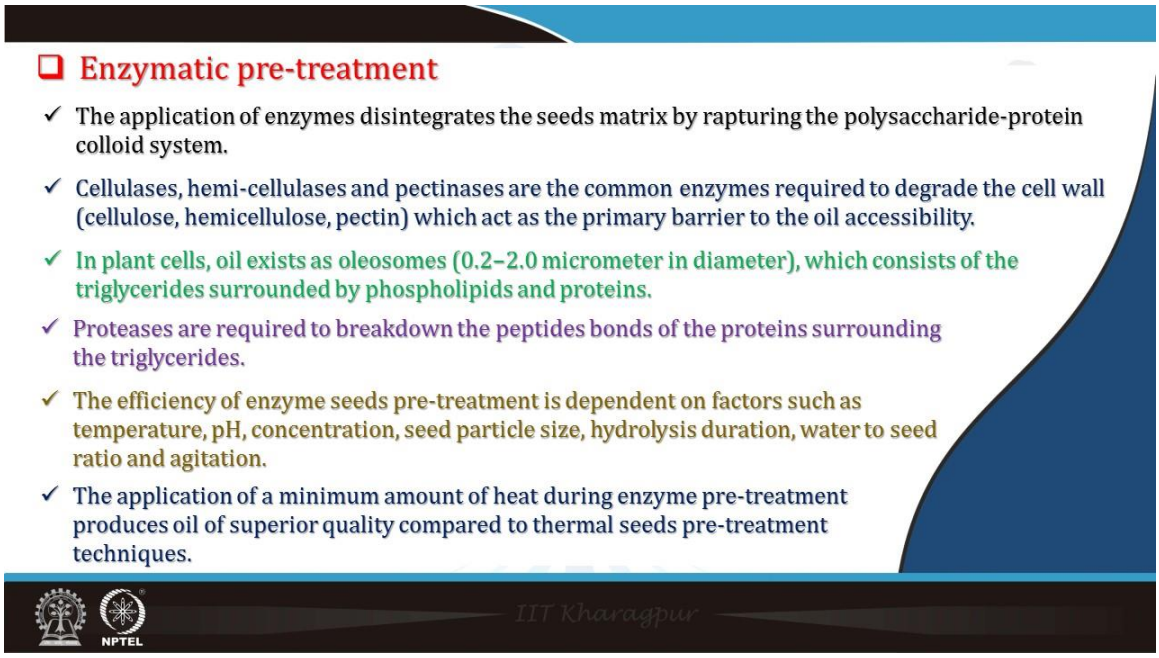
There is a direct extraction capability by other microwaves at the pores that is the oil get better extraction. There is a lower energy consumption, it is a faster processing time and reduced solvent levels that is the solvent that is if you give the microwave treatment and then give the solvent extraction process this solvent requirement is also reduced considerably.

In fact, the microwave treatment is a reported to increase the oil yield, total phenolic content in the oil, phytosterol, alpha, beta, gamma, delta, tocopherol, chlorophyll, saponification value, palmitic and stearic acid, etcetera. These are the increased you get a better recovery of all these in the oil, but the also the acid value, peroxide value, iodine value, oleic and linoleic acid and polyunsaturated fatty acid etcetera, there yield sometime get reduced.




Then infrared heating, infrared radiation transfers thermal energy through electromagnetic waves via the penetration of infrared light into a layer of oil sheets.

Water molecules in the sheet vibrate at a frequency of 60,000 to 150,000 megahertz and induce rapid internal heating in the sheet mass. So, this heating decreases the moisture content leading to change in oil sheet structure as they become more brittle and prone to breakage. Infrared radiation has the advantage of more homogeneous and efficient heating than possible with microwaves and thus leading to lower energy consumption and decreased ecological footprint. Infrared radiation is suitable for treating oil sheets with thin walls in the shallow trays or shallow layers because the rays with short wavelength do not deeply penetrate the material.

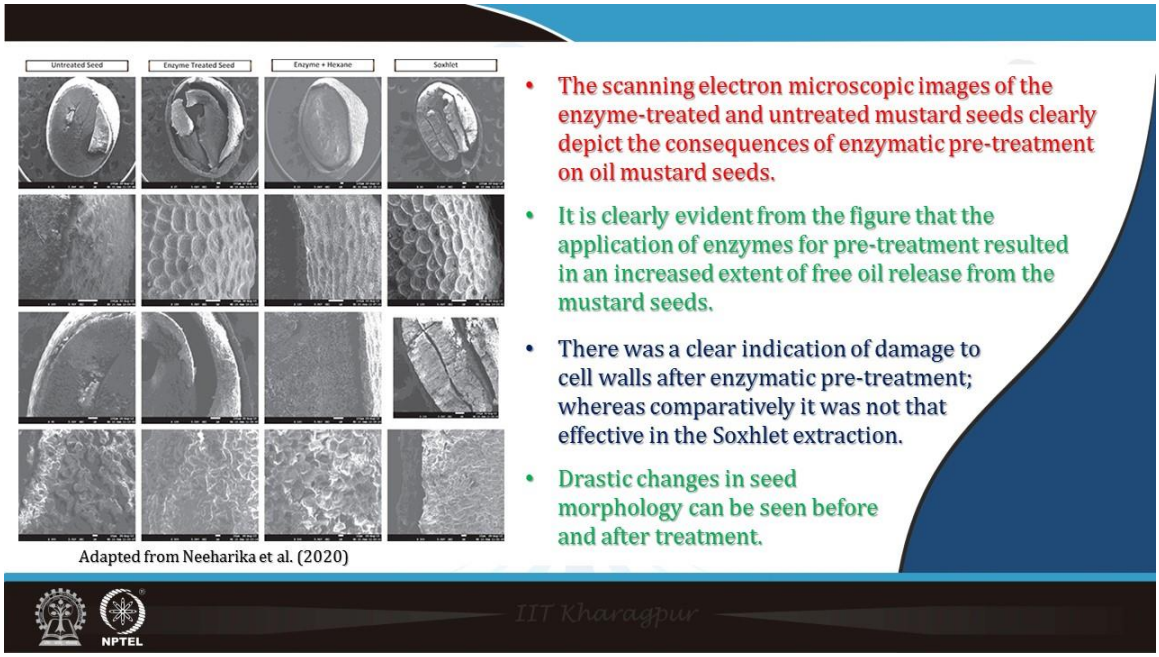



In enzymatic pretreatment in another potential treatment which is can be used this application of the enzymes disintegrates the seed matrix by rupturing the polysaccharide protein colloids system.

Celluloses, hemicelluloses and pectinases are the commonly used enzymes which are required to degrade the cell wall like cell wall consist of cellulose, hemicelluloses, pectin etcetera, and so, these enzymes act primarily as a primary the cell wall which act as a primary barrier to the oil accessibility. So, these enzymes break those cell walls and therefore, it increases the oil mobility ok. In the plant cells oil exists as a oleosomes that is your 0.2 to 2.0 micrometer in diameter, which consist of the triglyceride surrounded by phospholipids and proteins. So, the proteases are required to break down the peptide bonds of the proteins surrounding the triglycerides.

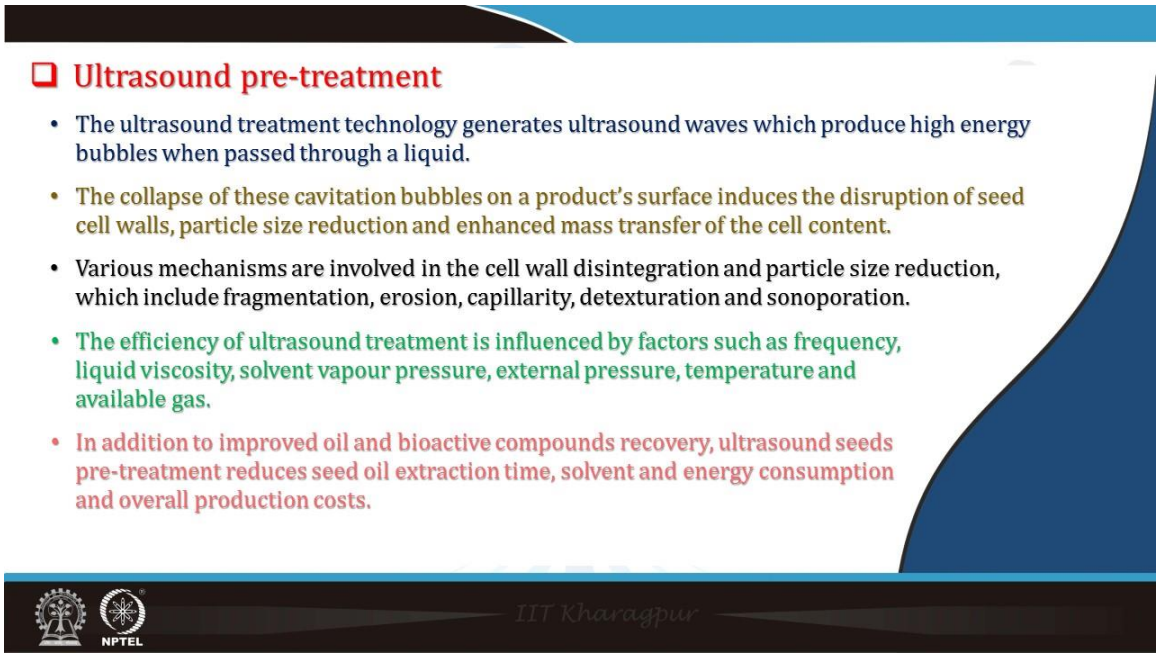
The efficiency of enzyme seeds pretreatment is dependent on the factor such as temperature, pH, concentration, seed particle size, hydrolysis, duration, water to seed ratio and agitation because the proper environment, proper conditions for the enzyme to act is required to be given. The application of a minimum amount of heat during enzyme pretreatment produces oil of superior quality compared to the thermal seed pretreatments ok. Because if the more excessive heat is given it may adversely affect some the oil

quality even sometime this triglyceride the heat additional heat may cause degradation at the esterification of the ok.



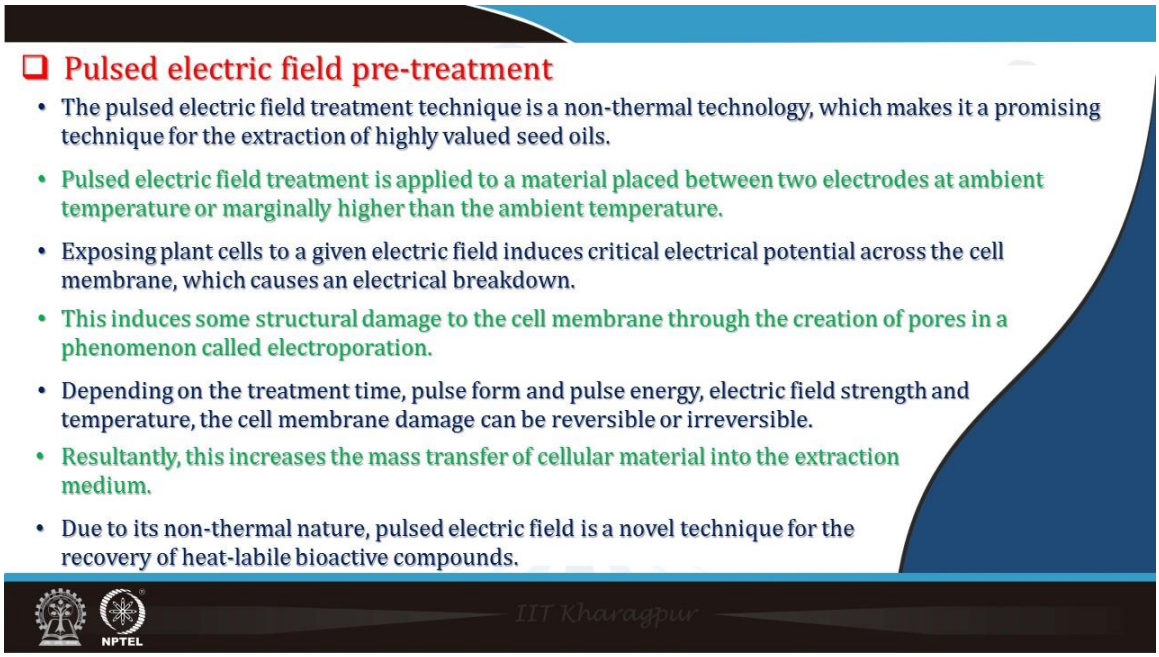

So, the scanning electron microscope this is the pictures which is adopted from Neeharika et al. that is the literature and here it shows that images that is enzyme treated untreated mustard seeds are shown here and these figures clearly show that the application of enzymes for the pretreatment resulted in an increased extent of free oil release from the mustard seed. And there was a clear indication of damage to the cell wall after the enzymatic treatment as you can see here in this figure ok.

Whereas, the comparatively it was not that effective in the Soxhlet extraction ok. So, drastic charges in the seed morphology can be seen before and after the treatment you can see here that is these are the untreated seeds, these are the enzyme treated, here enzyme plus hexane and this is only Soxhlet extractor and you can see the difference in all this ok.



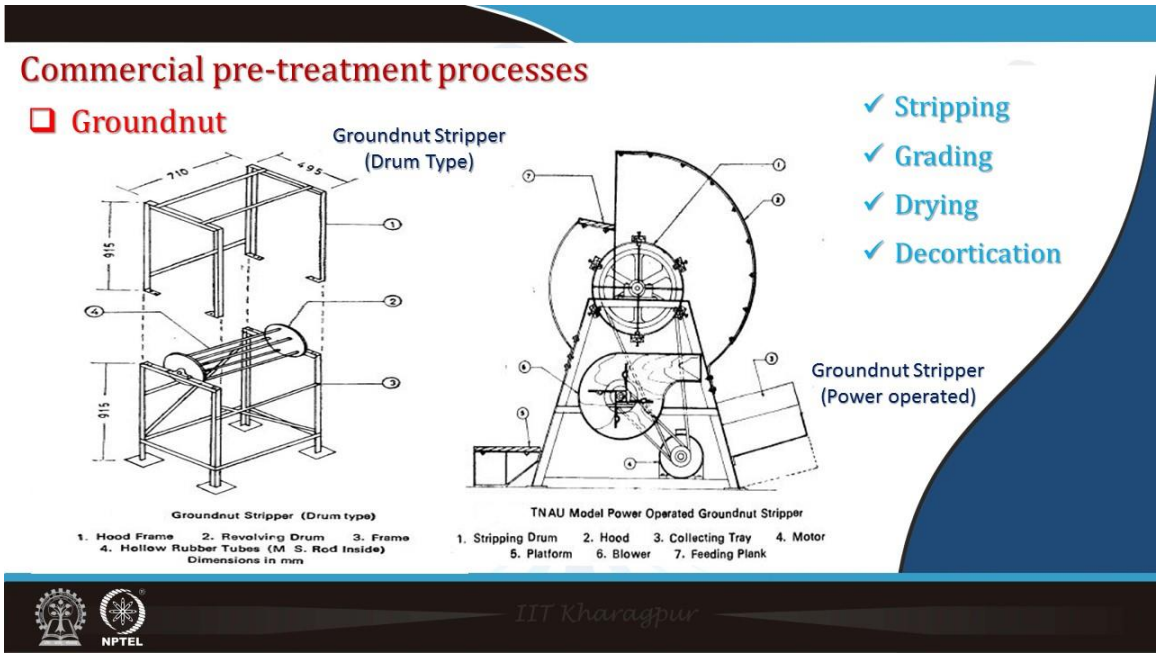

And ultrasound pretreatment ok, this ultrasound pretreatment technology generates a ultrasound waves which produces high energy bubbles when passed through a liquid. The collapse of these cavitation bubbles on a product surface induces the disruption of seed cell walls, particle size reduction and enhanced mass transfer of the oil content. Gas mechanisms are involved in the cell wall disintegration and particle size reduction which include fragmentation, erosion, then capillarity, detexturation and sonoporation.

The efficiency of ultrasound treatment is influenced by factors such as frequency, liquid viscosity, solvent vapour pressure, external pressure, temperature and available gas. In addition to improved oil and bioactive compound recovery, ultrasound seeds pretreatments reduces seed oil extraction time, solvent and energy consumption and overall production cost.

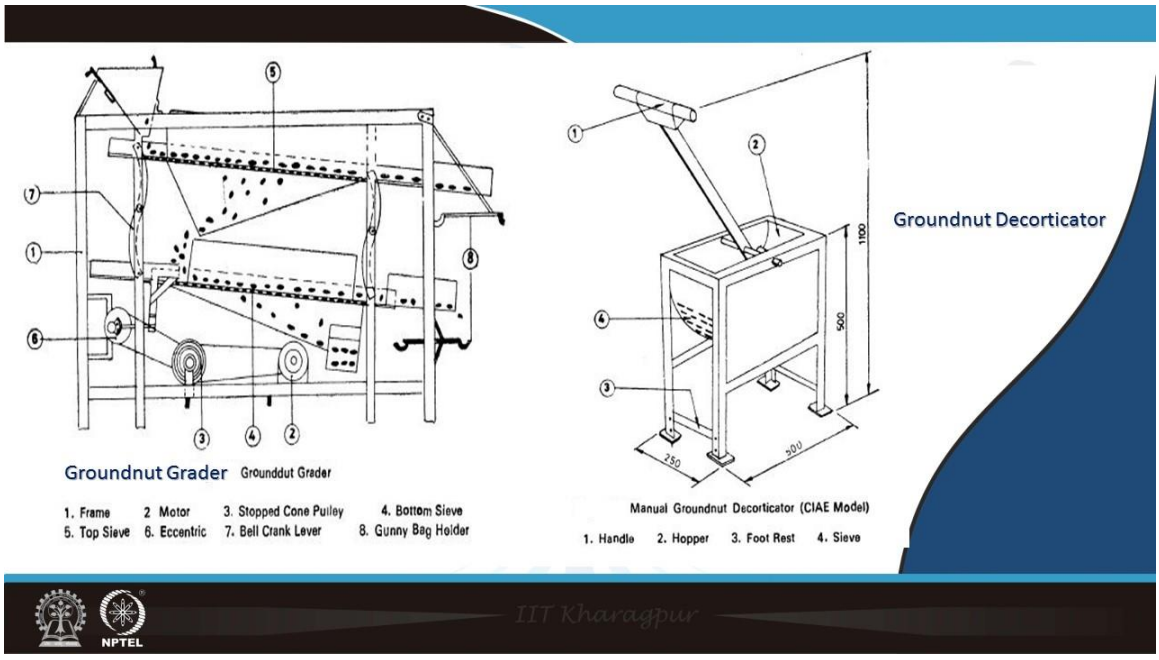



Then pulse electric field treatment is another very important treatment which can be given to oil seeds. PEF treatment technique is a non thermal technology which makes it a promising technique for the extraction of the high value seed oils. Even pulse electric field treatment is applied to a material which are placed between two electrodes at ambient temperature or marginally higher than the ambient temperature.

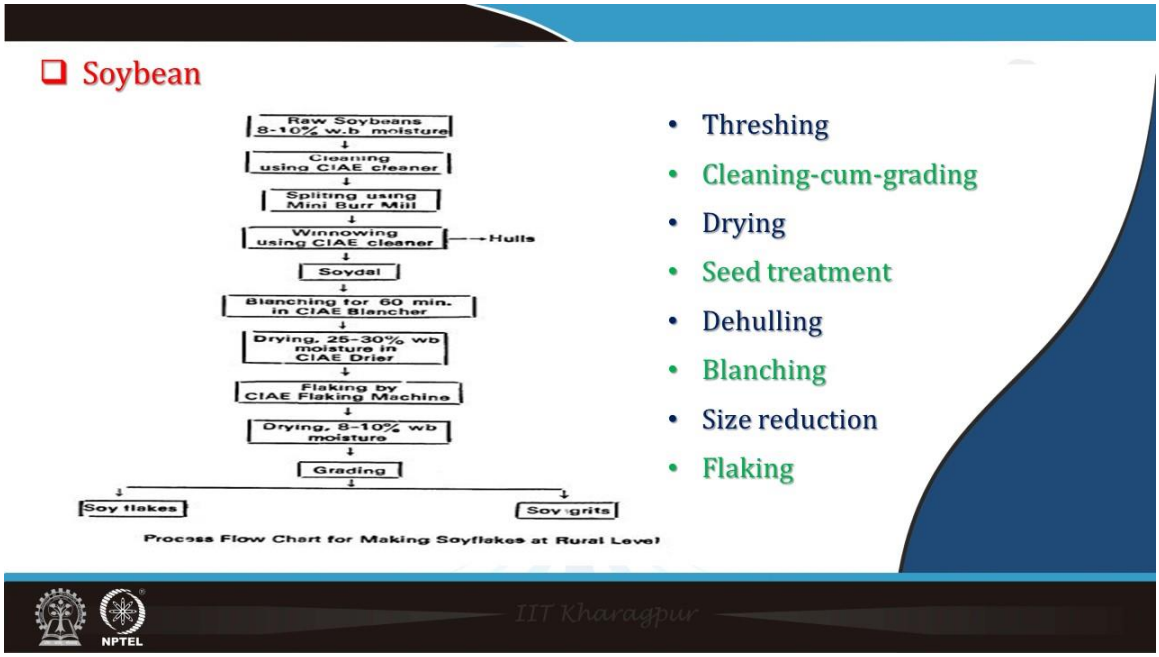
So, exposing plant cells to a given electric field induces critical electrical potential across the cell membrane which causes an electrical breakdown. And this induces some structural damage to the cell membrane through the creation of pores in a phenomena called electroporation. And depending upon the treatment type, pulse from the pulse energy, electrical field strength and temperature, the cell membrane damage can be reversible or irreversible and resultantly this increases the mass transfer of the cellular material into the extraction medium. And due to this non thermal nature, the pulse electric field is a novel technique for the recovery of heat level bioactive compounds. And also that is the this electroporation which is created it improves the movability of the oil and you get a better yield, better recovery higher recovery of the oil that is if they are given a this PEF treatment and then subjected to normal extraction process either by solvent extraction or prepress you get a better high lead. And also the quality of the oil is better because.




Now there are some I will briefly elaborate the commercial pretreatment process which are used for normally ground nut oil extraction it is the stripping, grading, drying and decortication. These are the main operations which the ground nut is subjected to before it is subjecting to sending to the actual extraction process by milling or by pressing or solvent extraction or screw spilling. Here it is the schematic diagram design of a ground nut stripper or even a TNAU model of power operated ground nut stripper.

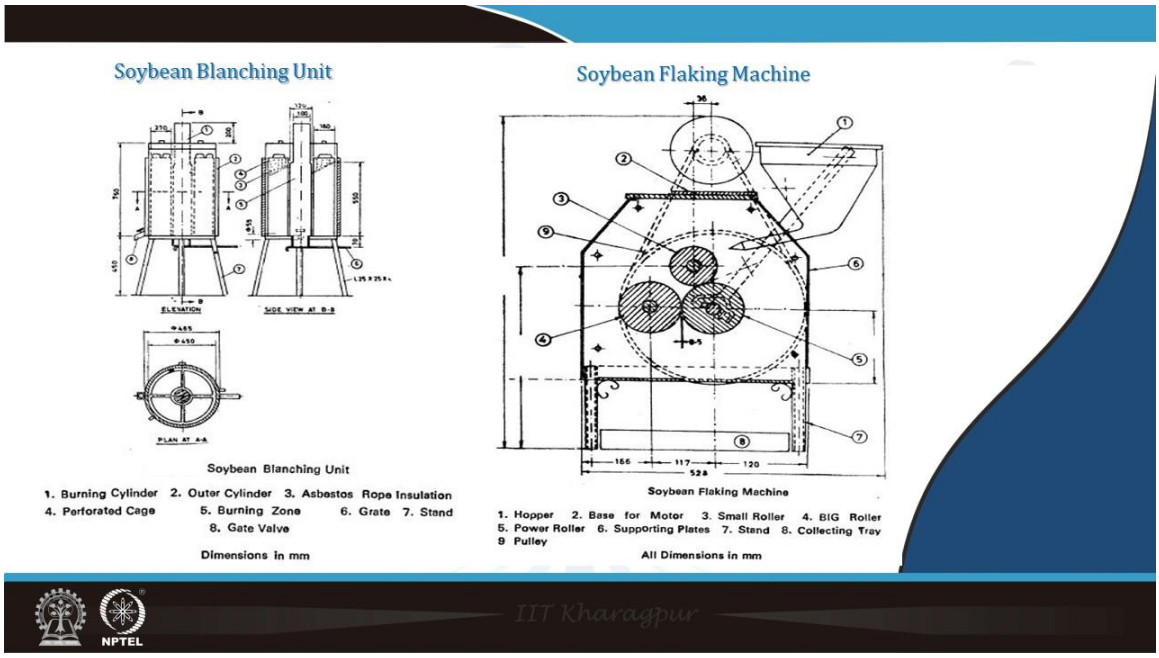


This is these are the designs are the ground nut decorticator ok which is manual operated as well as a power operated manual operated decorticator this is the CIAE model ok.

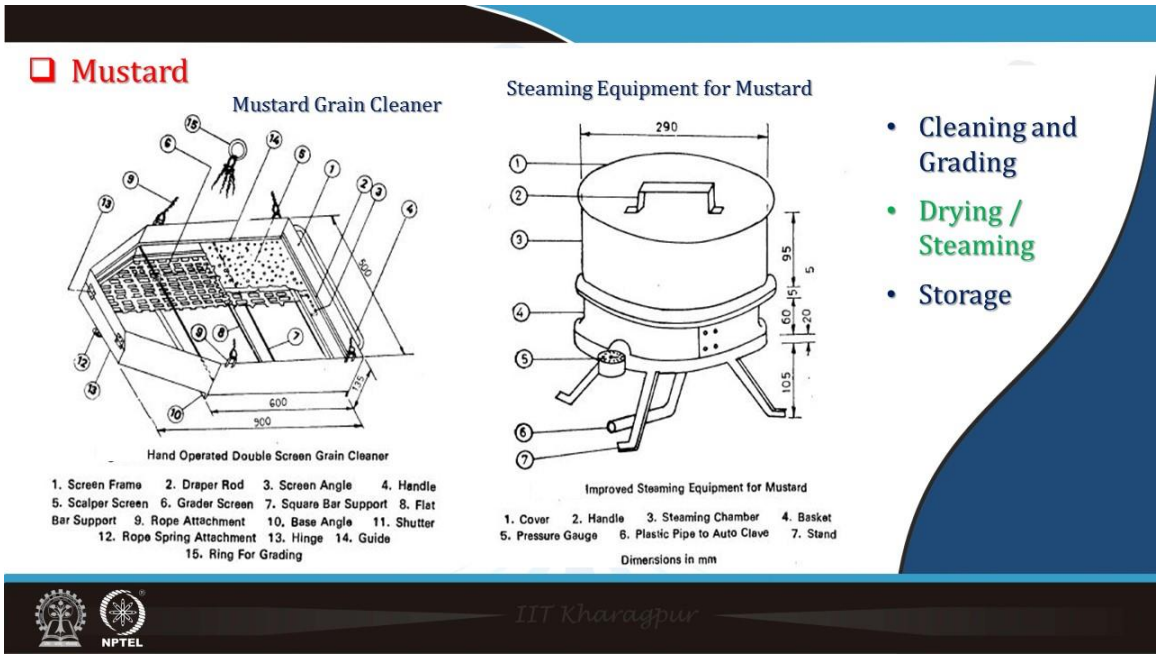



Then in the soybeans, soybeans are subjected to different operations like threshing after threshing that is the cleaning, come grading, then drying, there is a seed treatment dehulling after that it is blanched to because soybean they contain large amount of lipoxygenase enzyme.

So, the soybean must be blanched to inactivate the lipoxygenase enzyme otherwise there may be a grainy flavour and also this lipoxygenase may cause, catalyse the auto oxidation process. So, that is it is blanched and then size reduction and flaking. So, these are the normal methods of the again so, soy flakes or soy grits are obtained. And then these are passed through the oil extraction process either by mechanical expressing or by solvent extraction.

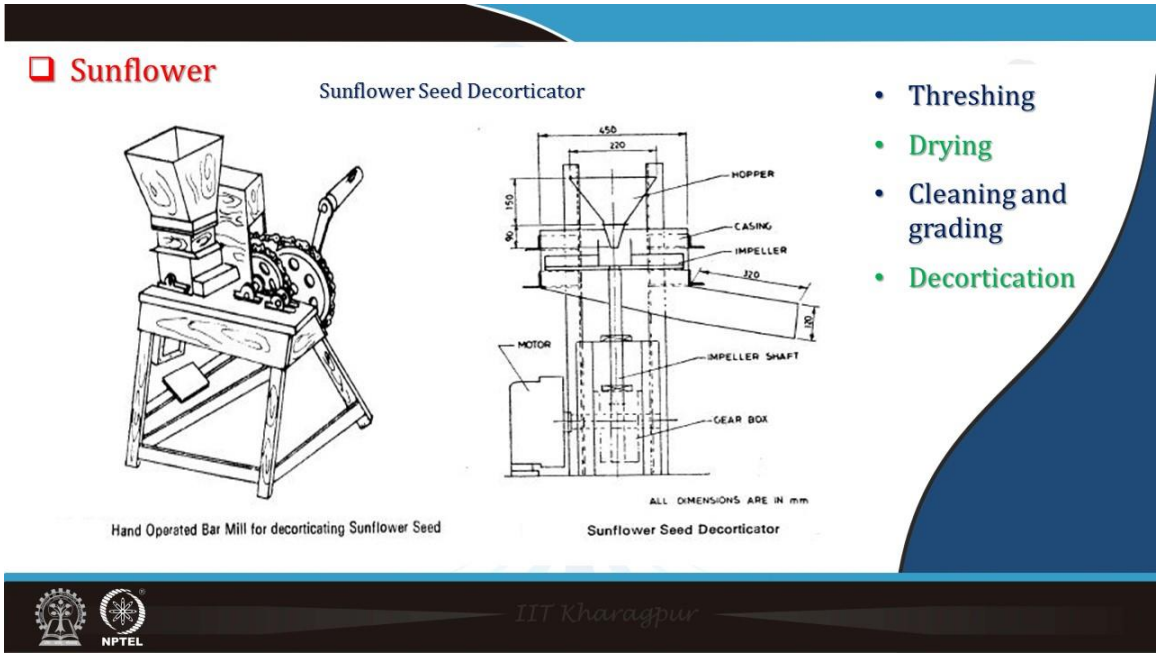



These are the schematic of the soybean blanching unit as well as soybean flaking machine the design etcetera given all dimensions in these are in millimetre.




Then for the mustard the common operations are cleaning and grading, drying and steaming and storage of course, because of the small size of the mustard seed and they are very soft in nature. Normally the dehulling of the mustard seed is not done by the industry and that is one still challenge that is to develop a good size and good quality and

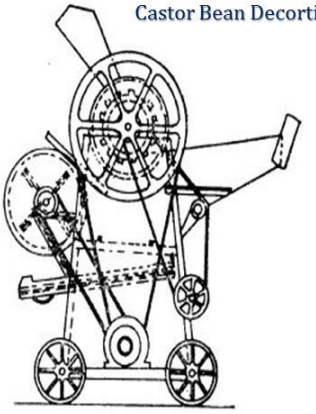
efficient dehuller for the the rape seed or mustard if it is developed. And if it is dehulled before sending for pressing or extraction then the oil quality particularly from the and usability of the cake is improved ok. Otherwise this seeds that is they these oil seeds mustard seed coat etcetera it contains certain compounds which are not good for health that is why this mustard seed cake is not edible to human is not used for human consumption ok. So, although there are that is the if the dehuller good quality dehuller which can remove the seed from the mustard seed, seed coat and without any crushing etcetera without oil losses that will be a good work.



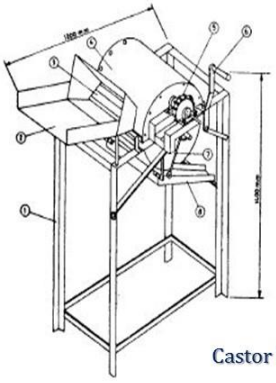

Then sunflower must be this is a pressing drying, cleaning and grading and decortication these are the pretreatment limited to the sunflower.

## Castor

Castor Bean Decorticator



G. A U. Gastor Bean Decorticator



Castor Bean Shellar

Castor Shellar

1. Frame 2. Feeding Chute 3. Cylinder 4. Cylinder Cover
5. Drive Mechanism 6. Crank 7. Clearance Adjustment
8. Discharge Chute

- Cleaning
- Decortication
- Crushing
- Steaming
- Drying



In the custard cleaning, decorticating, crushing, steaming and drying are the normal operations to which the castor seed is subjected to before their extraction ok. This is a as of the GAU custard bean decorticator are also the picture of the custard bean sheller the schematic diagram ok.

## Olive

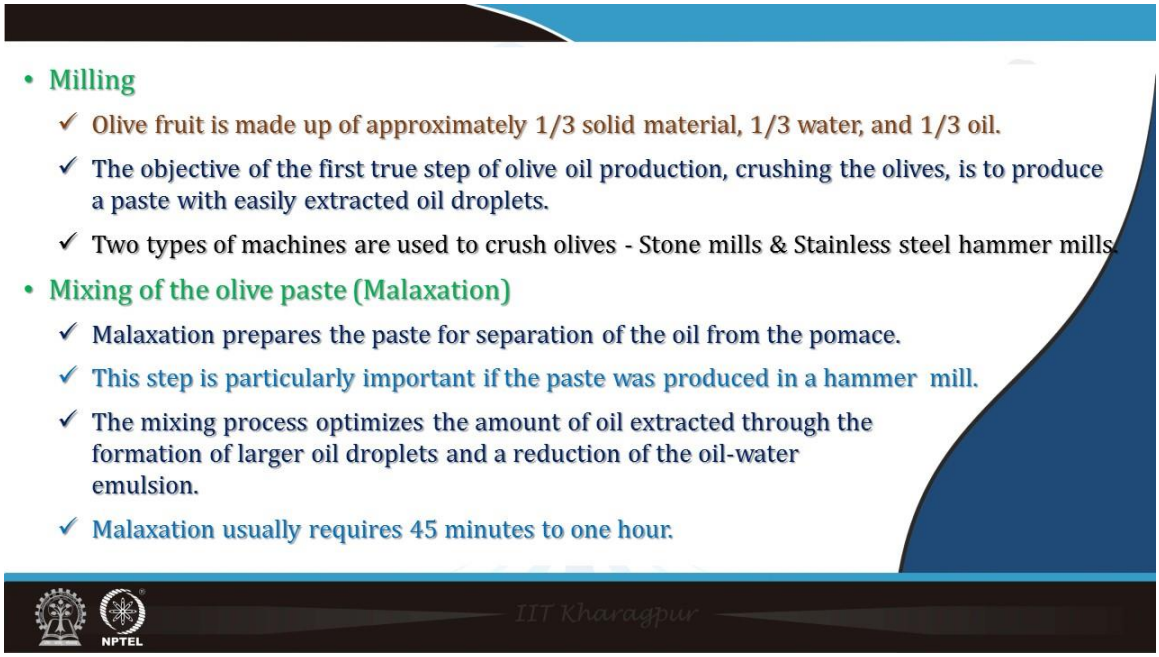
- Harvesting and transport
  - ✓ The optimal harvesting time is when oil levels are high in the olive fruit.
  - ✓ Harvest should begin before natural fruit drop.
  - ✓ The best way to transport the olives is in open-mesh plastic crates that allow air to circulate and prevent the harmful heating caused by the catabolic activity of the fruit.
- Fruit cleaning and washing
  - ✓ Fruit cleaning entails two operations - leaf removal and washing.



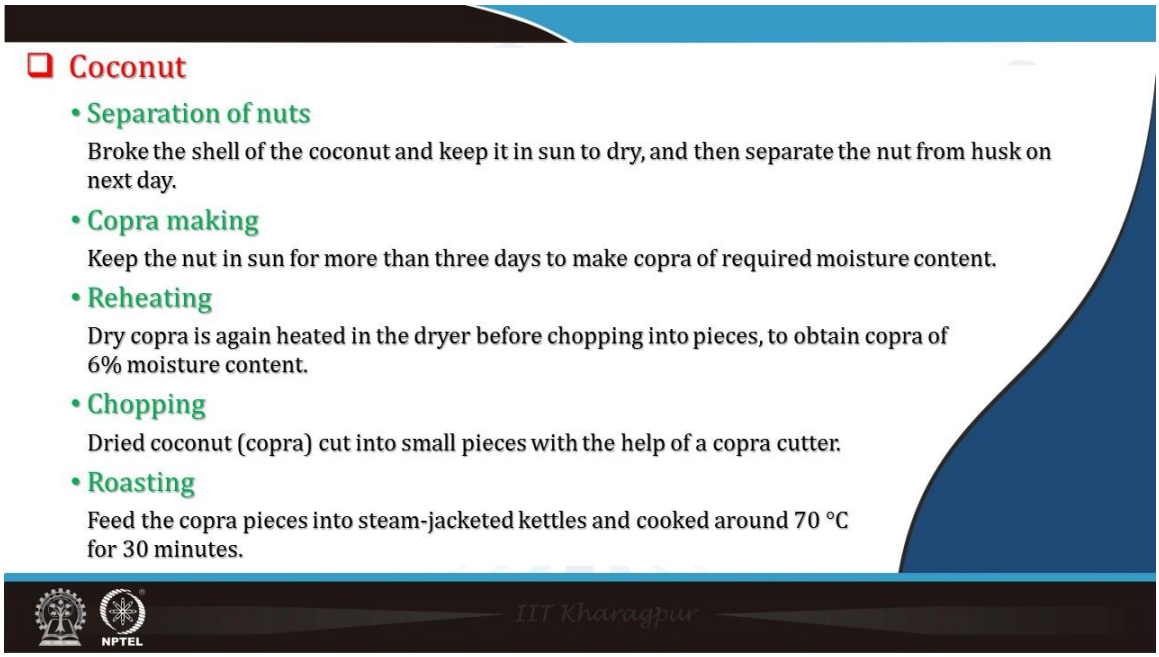
Then olive oil that is for olive oil the commercial pretreatment is given that is first is the after harvesting and transport the optimal harvesting time is when the oil levels are

high in the olive fruit, then harvest should begin before natural fruit drop. The best way to transport the olive is in open mesh plastic crates that allow air to circulate and prevent the harmful heating caused by the catabolic activity of the fruit. Otherwise if there is not proper air circulation, then the heat generated by the exothermic reactions, etcetera they may adversely affect the both. I will say they may spoil the oil speed and the oil quantity and quality will be adversely affected.

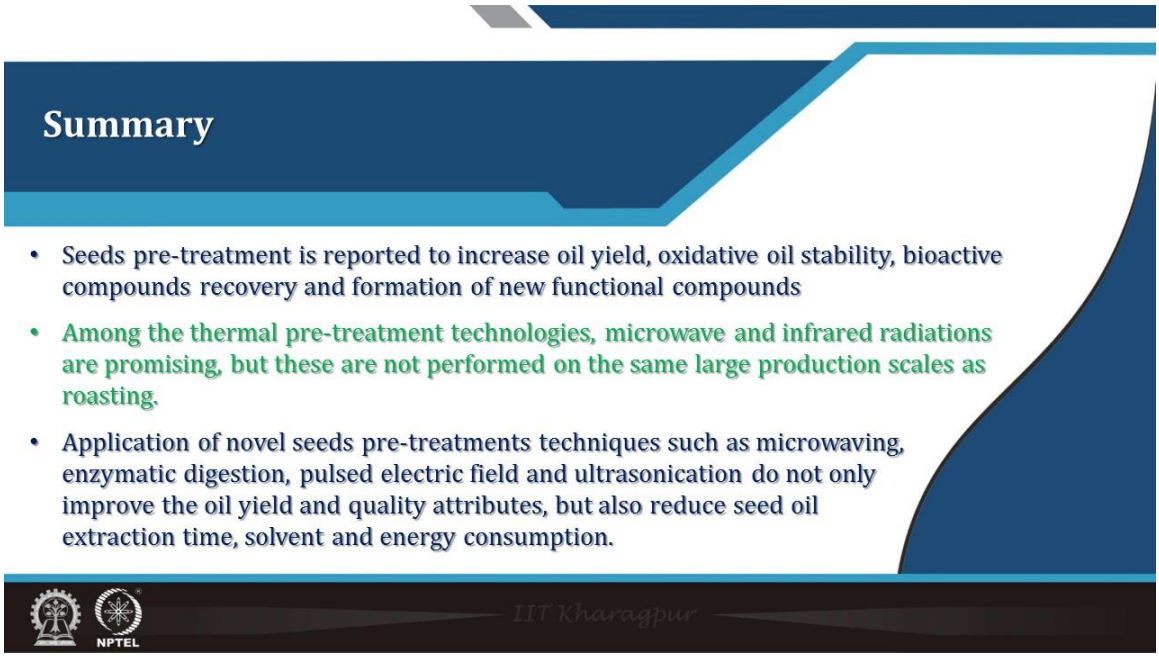
Then next operation is the fruit cleaning and washing that is it entails two operations one is the leaf removal and finally, the washing of the oil.




Then which is followed by milling olive fruit is made up of approximately one-third solid material, one-third water and one-third oil. The objective of the first two step of olive oil production that is the crushing of the olives is to produce a paste with easy extracted oil droplets. Two types of machines are used to crush olives that is stone mills or stainless steel hammer mills. Then mixing of the oil paste that is the malaxation that is the malaxation prepares the paste for separation of the oil from the pomace and this step is particularly important if the paste was produced in a hammer mill. The mixing process optimizes the amount of oil extracted through the formation of large oil droplets and a reduction of the oil water emulsion. Malaxation usually requires 45 minutes to 1 hour.




Then pretreatment given to the coconuts or the separation of nuts that broke the shell of the coconut and keep it in sun to dry and then separate the nut from the husk on next day. Then in the copra making keep the nut in sun for more than 3 days to make copra of required moisture content and then it is followed. Next operation is reheating where dry copra is again heated in a dryer before chopping into pieces to obtain copra of around 6 percent moisture content. Chopping of the dried coconut cocra is done into that is a small pieces with the help of a chopper cocra cutter. Then it is followed by roasting where that is in the roasting process the copra pieces are fed into the steam jacketed kettles and cooked around 70 degree Celsius for about 30 minutes.




Now, I will like to summarize this lecture by saying that seeds pretreatment is reported to increase oil yield, oxidative oil stability, bioactive compounds recovery and formation of a new functional compound. So, this seed pretreatment is a very very important operation for both oil yield and oil quality. Among the thermal pretreatment technologies microwave and infrared radiations are promising, but these are not performed on the same large production scales that of the roasting. Application of novel seed pretreatment techniques such as microwaving, enzymatic digestion, pulse electric field and ultrasonication do not only improve the oil yield and quality attributes, but also reduce seed oil extraction time solvent amount and the energy consumption.


These are the references that are used in this lecture.


Thank you very much for your patience here.