Food Oils and Fats: Chemistry & Technology

Professor H N Mishra

Agricultural and Food Engineering Department

Indian Institute of Technology Kharagpur

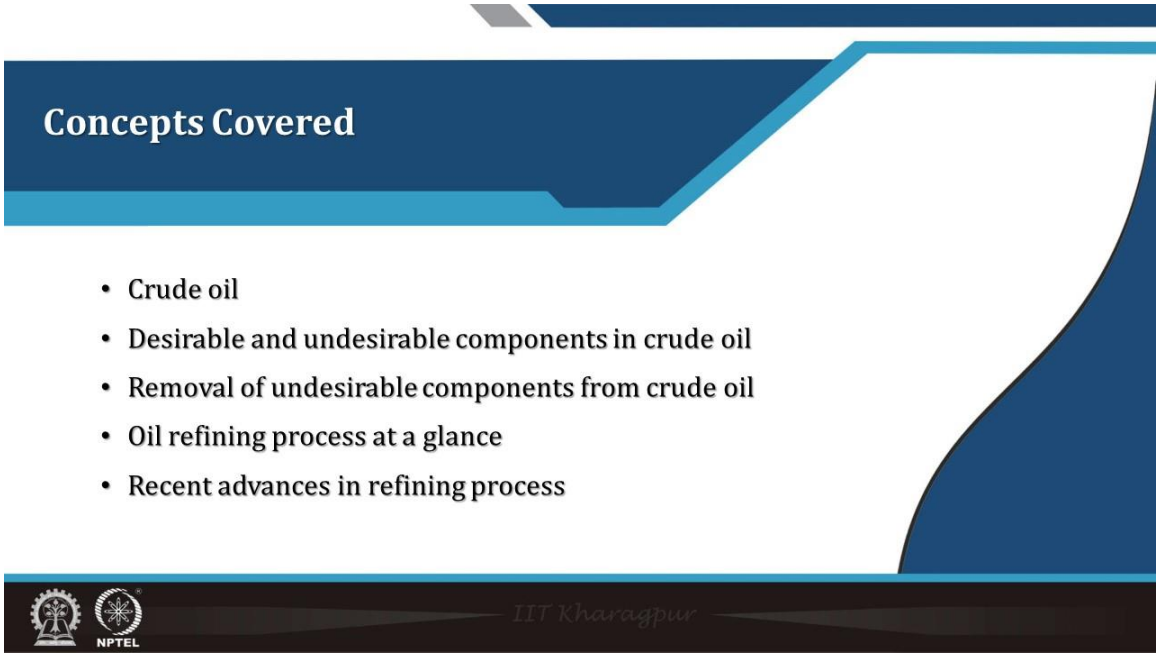
Module 6 : Edible Oils Refining

Lecture 26: Crude Oil Characteristics and Processing

Hello everybody. Namaskar. Now, we are entering the sixth module of this course ok. And this module 5 lectures will be devoted on Edible oil refining. You know that by the methods which we discussed in earlier modules whether it is a physical method or chemical method of oil extraction, mechanical or chemical means from all these process whatever the depending upon the type of the method used the oil which we get it is known as crude oil. And this crude oil contains certain undesirable components because of the nature of the method used.

So, before sending it for it further food uses these crude oils need to be properly refined it is passed through various processing stages. Even sometime it at least in some cases in some oils like virgin olive oils etcetera they are at filtered. So, there are different processes these crude oils are subjected to depending upon the nature of the impurities present in it. So, now in these modules we will discuss one by one what are

the different impurities, how these are removed, how the oil is made of a good quality for food purposes.



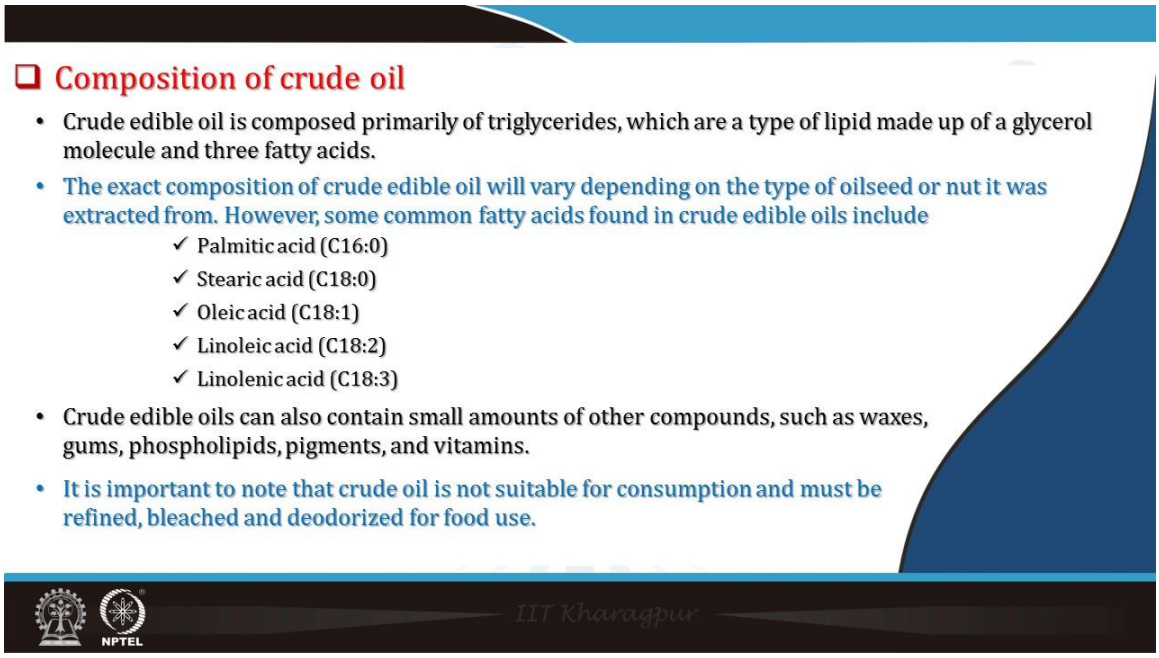
So, in the lecture 26th in today's lecture in the next 25 to 30 minutes we will discuss about what are the characteristics of the crude oil and it is what are the process, what are the various components present in the crude oil. What is crude oil? Desirable and undesirable components in crude oil, removal of undesirable components from crude oil, oil refining process at a glance and then recent advances in the refining process that we will discuss in today's lecture ok.

Crude oil

- Crude edible oil refers to oil that has been extracted from plants or seeds but has not yet undergone any refining or processing.
- It may contain impurities such as dirt, shells, and other plant matter, as well as potentially harmful substances like pesticides and heavy metals.
- The colour, taste, and odour of crude edible oil can vary depending on the type of oilseed or nut it was extracted from and the method of extraction used.
- It typically has a high acidity level, high peroxide value and high moisture content. It also has a high free fatty acid (FFA) content.
- It also may contain high levels of waxes and gums which can affect the quality of oil.

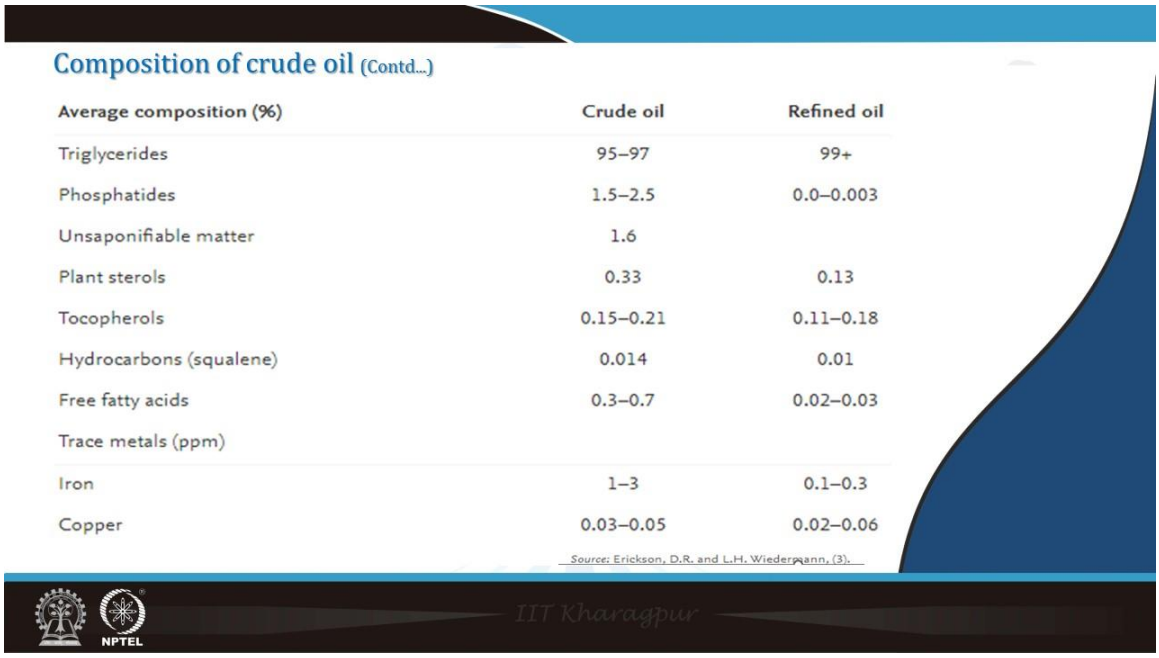
So, as I told you the crude oil it refers to the oil that has been extracted from plants or seeds, but the oil has yet not undergone the refining or processing. It may contain impurities such as dirt, shells or other plant matters as well as potentially harmful substances like pesticide, heavy metal etcetera it might be there in this. The colour, taste and order of crude oils can vary depending upon the type of oil seeds or nut that was extracted and from the method of the extraction that was used.

It typically has a high acidity level, high peroxide value and high moisture content. It may also contain high free fatty acids content depending upon the extraction processes. It may also contain high levels of waxes and gums which can affect the quality of oil. So, these materials may be removed before the oil is passed subjected to food preparations, food uses ok.

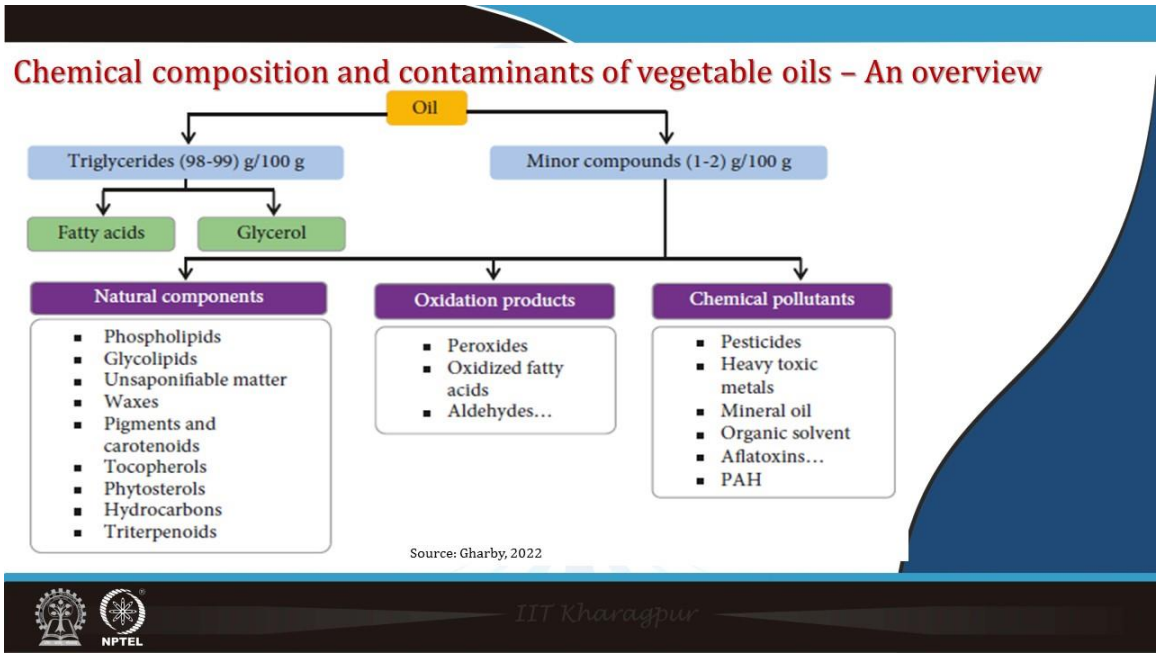


So, the composition of crude oil in general ok, as you know that in earlier classes we discussed that is oil basically is a triglyceride ok. So, it should be primarily the composed of triglycerides which are a type of lipid made up of a glycerol molecule and three fatty acids ok. So, the exact composition of the crude oil will vary depending upon the oil type or type of the oil seed or nut that was used for the extraction the raw material. Some common fatty acids which are found in the common or crude food oils include palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid. Crude oil can also contain a small amounts of other compounds like such as waxes, gums, phospholipids, pigments and vitamins. It is important to note that crude oil is not suitable for consumption and it must be refined, bleached and deodorized for before it is sent for food uses ok.

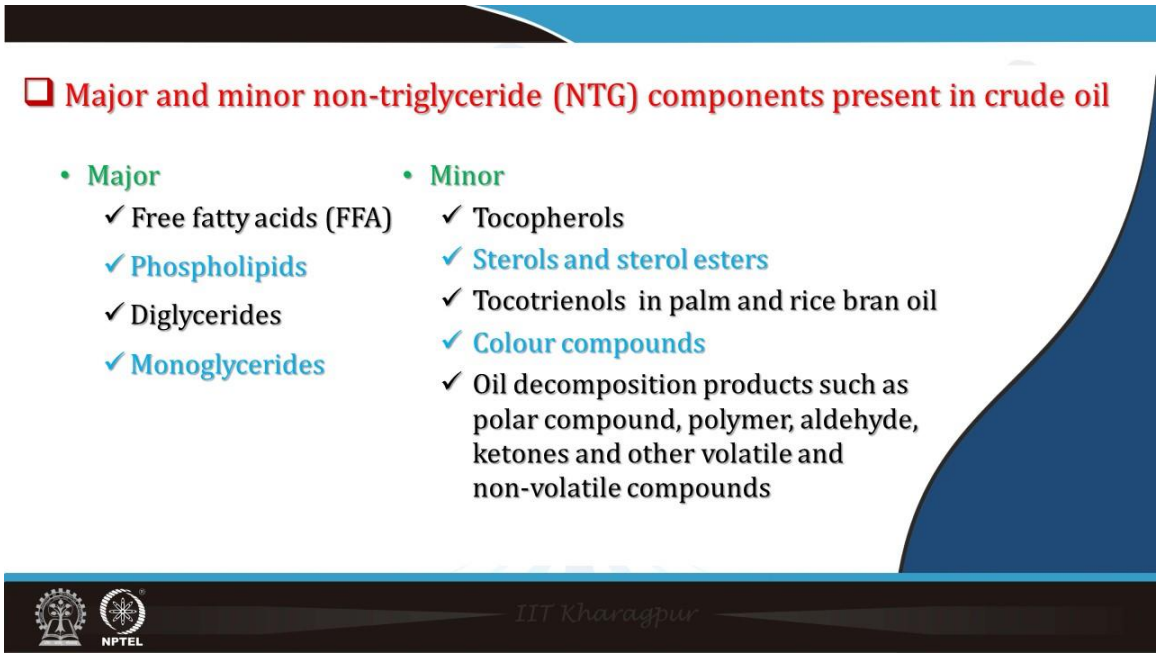
However certain oils even it is a that is they can be because in the mustard oil, people like the pungent taste of the mustard oil. So, it is just some even filtered double filtered mustard oil even olive oil that is natural olive oil. So, they are also given some sort of refining treatment may be not all ok.



So, this table gives you an idea of average composition of various components present in the crude oil and when it is refined how it changes what are the removed during refining process. Like triglyceride you see crude oil may contain around 95 to 97 percent triglyceride depending upon the process used and of course, after the refining it is go it goes may be 99 99.9 percent or so, there is maximum amount of the impurities are removed. So, the impurities may be considered as phosphatides 1.5 to 2.5 percent and after the refining it comes to as low as 0.003 percent. Then unsaponifiable matters it is around 1.6 percent and it is a nil it is almost completely refined. Plant sterols 0.33 in the crude oil where in the refined oil it may be 0.13. Tocopherols in the crude oil it is 0.15 to 0.21. So, it is also the idea is because tocopherol it is a vitamin E it is antioxidant. So, in the refining process the it should be process should be such that these desirable come these are the valuable component in the oil. So, they can be retained. So, here 0.11 to 0.18 hydrocarbon like succulent etcetera 0.014 may be 0.01 it is almost removed. Then free fatty acids 0.3 to 0.7 it should be brought down 0.02 to 0.03 or minimum. Space metals that is iron may be 1 to 3 ppm it may be that is it is brought to 0.1 to 0.3 ppm and copper from 0.03 to 0.05 ppm it is brought down to 0.02 to 0.06 ppm in the crude refined oil.

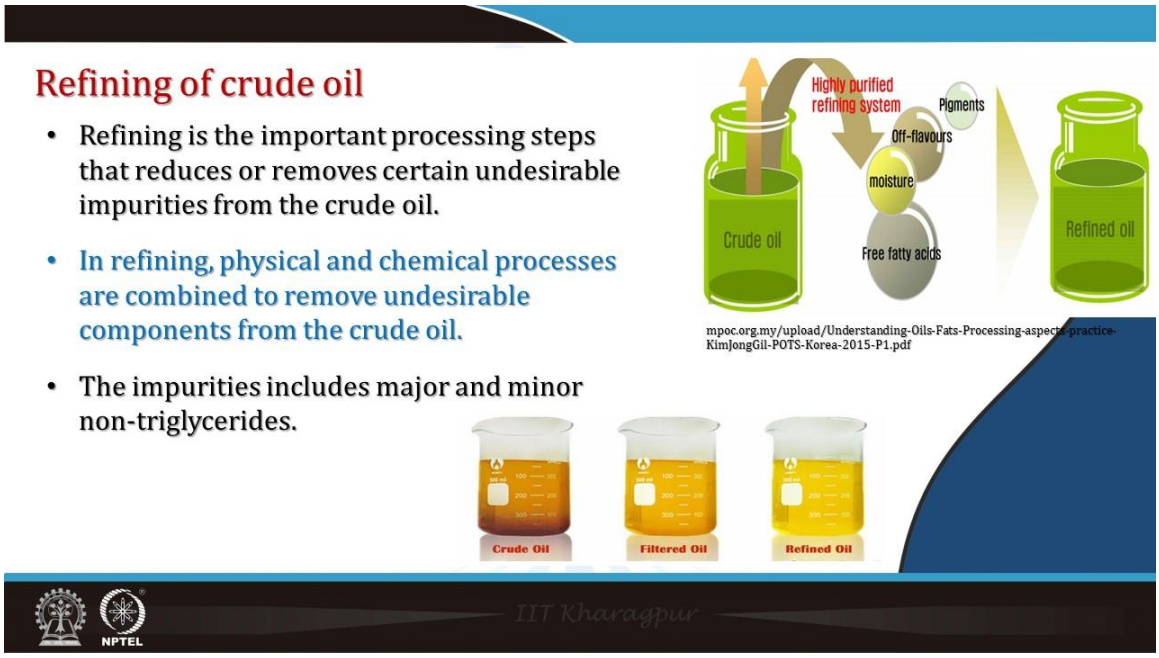


So, the chemical composition and the contaminants of the vegetable oil if you take an overview as I told you earlier also the oil contains around 98 to 99 gram per 100 gram of triglyceride ok. And, this triglyceride includes fatty acid and glycerol and then remaining 1 to 2 percent is the minor components like minor component may be natural components like phospholipids, glycolipids, unsaponifiable minor matters waxes, pigments, carotenoids, tocopherol, phytosterol, triterpenoids, etcetera. Then oxidation product that is which results from the oxidation of the fatty acids or other triglycerides etcetera the peroxides oxidized fatty acids aldehydes. And, then chemical pollutants also may be present there in the oil depending upon the process that is used for its extraction that is pesticides, heavy metal, toxic metals, mineral oils, organic solvent, aflatoxin, PAH etcetera. So, these components might be present in this ok.

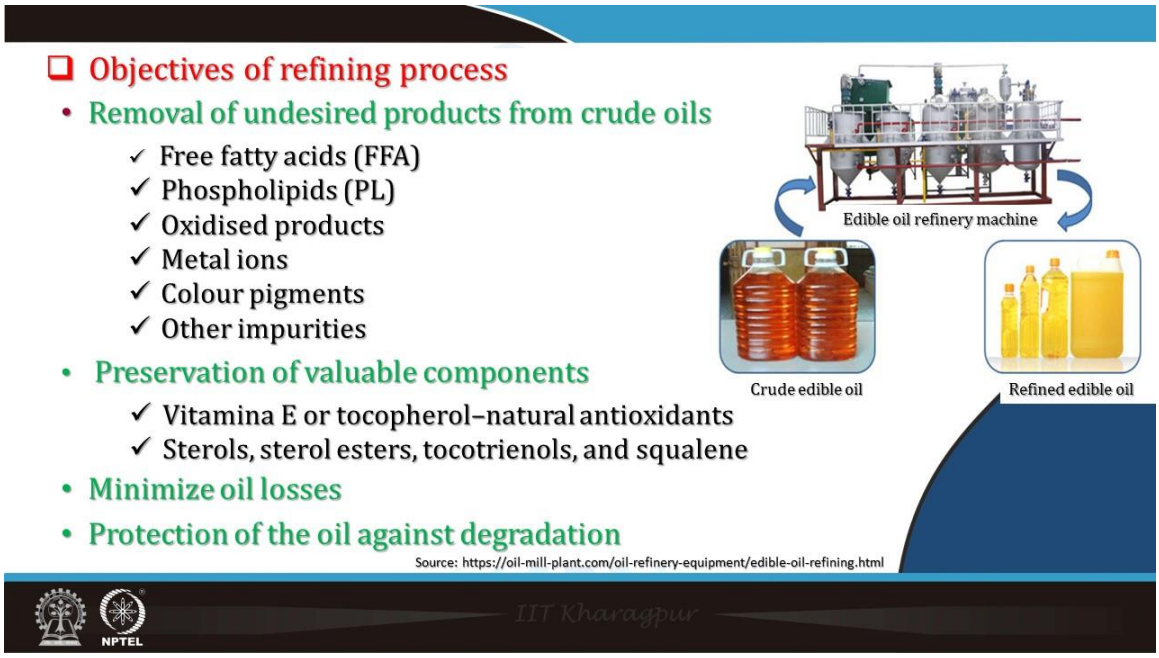


So, just again these if we can categorize into this major and minor non triglyceride component in the present in the crude oil because triglyceride is basically if you talk about pure oil it should it is a mixture of mixed triglycerides only. So, anything other than triglyceride can be considered as a undesirable matter or but of course, there are some like tocopherols, vitamin E etcetera might be desirable component, but others.

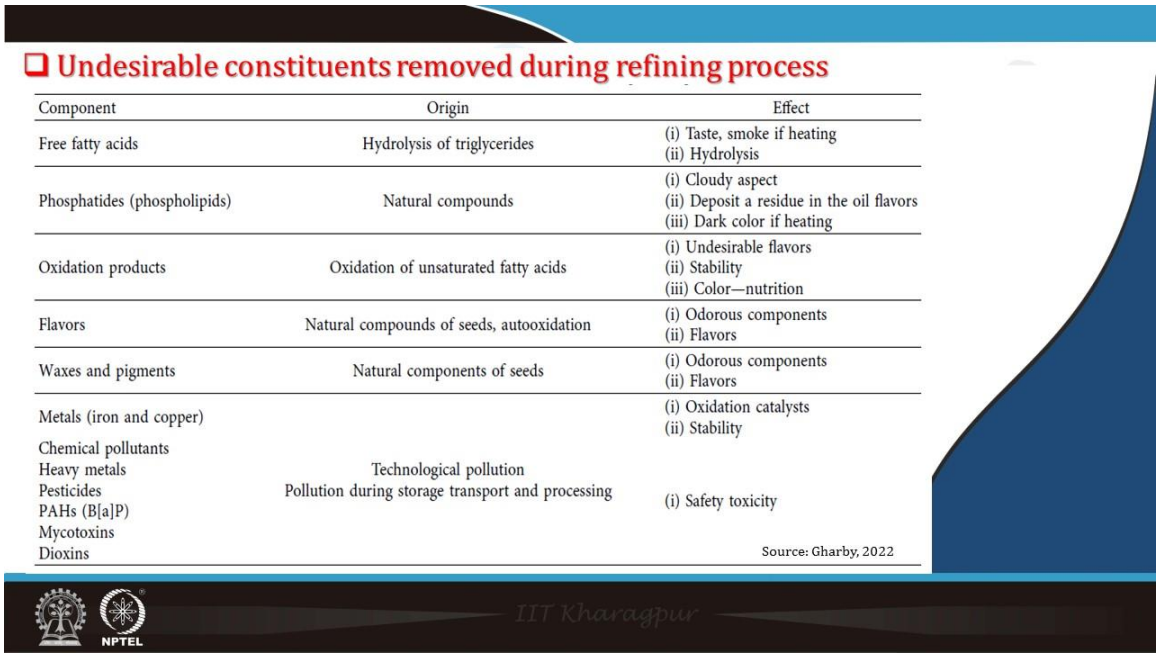
So, the you can say major non triglyceride components in the oil may be considered free fatty acids, phospholipids, diglycerides and monoglycerides. Phospholipids are naturally present and these free fatty acids they may be result of the hydrolysis of the triglycerides, FFA and then diglycerides and monoglycerides. Then other minor components may be tocopherols, sterols and sterol esters, tocotrienols in palm and rice bran oils, color compounds like chlorophylls etcetera they may get extracted during the extraction process and oil decomposition products such as polar compounds, polymer, aldehydes, ketones and other volatile and non-volatile compounds. So, these might be present in the oil.



So, obviously, the refining means there is the removal of these non triglyceride components which are undesirable which are which can affect our health adversely ok. So, refining is the important processing step to reduce or removes certain undesirable impurities from the crude oil as you can. So, you see here in the picture that is crude oil which has a that is all these various component which we showed earlier. So, it removes that is moisture, free fatty acid, off-flavors and pigments etcetera. So, the refined oil is free from all these things ok. So, it refining it may be either physical process refining process, chemical process that is even physical and chemical process also sometime are combined to remove the undesirable components from the crude oil. The impurities which include major and minor non triglyceride compounds described in the earlier slide. So, you can see even the crude oil, filtered oil and properly refined oil that there is a difference in the colour and clarity of the oil can be sealed ok.



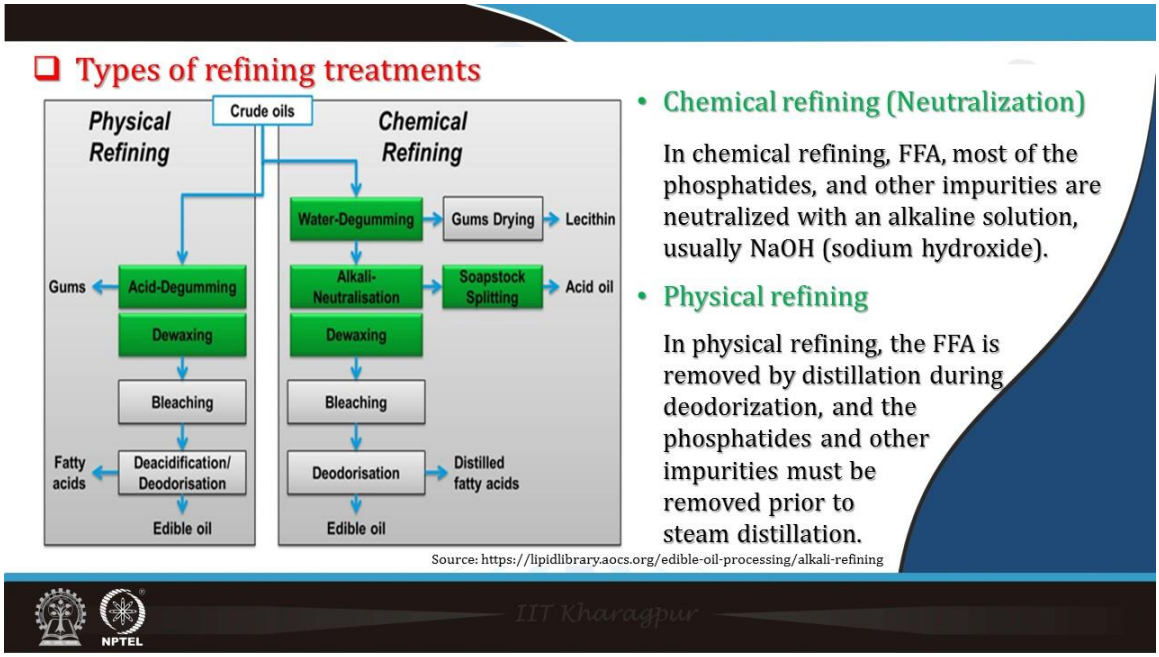
So, the objectives of the refining process is removal of undesirable or undesired non-triglyceride products from the crude oil that is these are the free fatty acids, phospholipids, oxidized products, metal ion, colour pigments and other impurities ok. That is one first and foremost objective of the refining process is that and at the same time as I told you earlier also that is the refined oil should contain that is the other preservation of valuable component like vitamin E or tocopherol which are natural antioxidant present particularly in plant oils. So, the refining process parameters should be used in such a way that is these natural components are kept there they are not removed also sterols, sterol esters, trocotrienols and etcetera these are the valuable component bioactive health promoting component. So, they should be retained in the oil. Removal of undesirable components, preservation of valuable components, minimization of oil losses and protection of the oil against degradation that is another very important that is the to increase the shelf life of the oil, product its degradation during storage and transformation these are the major objective of the refining process ok.



So, again here you see that what are the undesirable components in the removed during the refining process that is include like free fatty acids and how this free fatty acids are found that depends upon the extraction process if the temperature, moisture etcetera all this they may cause hydrolysis of the triglycerides ok. And if there are more free fatty acids in the oil it may influence taste, smoking point etcetera if eating hydrolysis. So, all these things are the effect and therefore, the free fatty acid must be removed even the smoke point of oil with even 1 percent of more fatty acid in the cotton seed oil or any other oil the smoke point is seriously depressed.

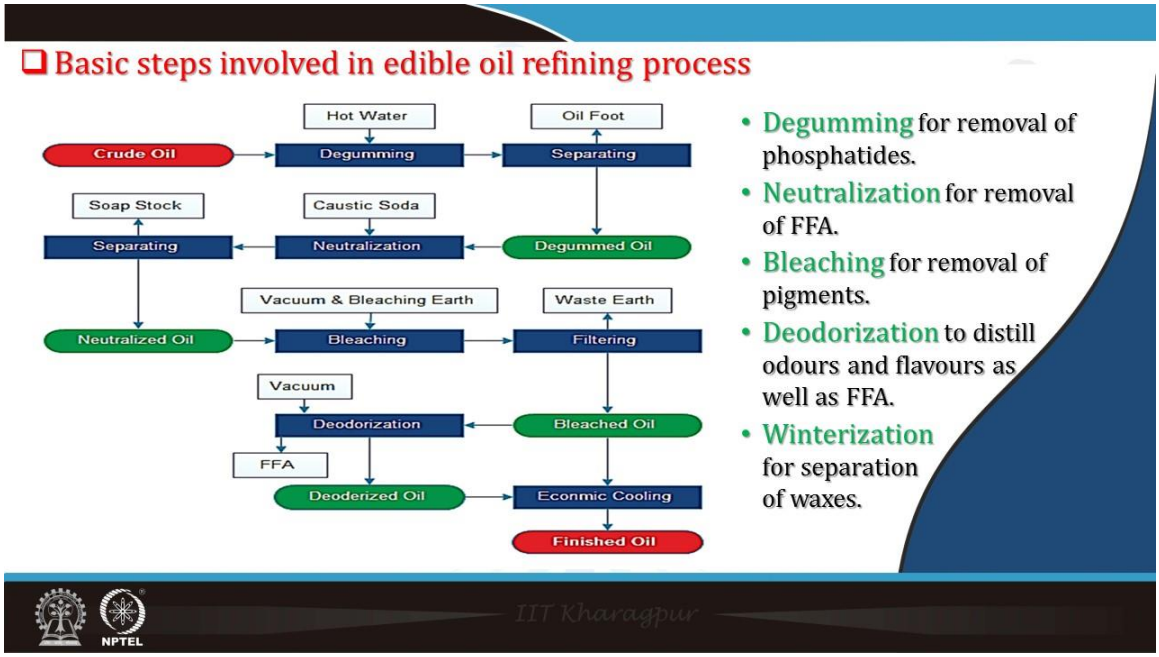
So, that is very important that is the free fatty acid should be removed. Similarly phosphatides are which are phospholipids they are a natural compound that is they are gums they give cloudy aspect to the oil, deposit residue in the oil flavors and dark color upon heating. So, they also give a adverse appearance to the oil they must be removed. Similarly, oxidation product that is the oxidase various aldehyde, ketones etcetera and other such products peroxide, peroxidized fatty acids etcetera which are the result of the oxidation of unsaturated fatty acids. So, they again give the rancidity and the arrow flavor they adversely affect the stability or they adversely affect the color etcetera of the product they should be removed.

Then flavor that is the natural compounds of the seed auto oxidation process which give the flavor they should be address component they are all removed. Then waxes and pigments that is natural components of the seed they may naturally present in the some seeds and they come in the oil. So, they also are removed. Then metal are like iron or copper particularly that is the chemical pollutant, heavy metal, pesticide, PAH, mycotoxin, dioxin etcetera what is made to remove all this that they are the technological pollution during storage transport and processing and they should be removed during refining process.



So, the typical now if you see the typical refining treatment it may be two types one is the physical refining other is the chemical refining. The in the physical refining stages that is acid degumming, de-waxing, bleaching and deacidification and deodorization process during this in acid degumming gums are removed and in fatty acid are removed into de acidification and deodorization process and you get edible oil. So, basically in the physical refining process it is a basically distillation is done. The free fatty acids are removed during distillation during deodorization and the phosphatides and other impurities are removed prior to steam distillation. So, that is basically physical no chemical is involved here whereas, in the chemical refining the free fatty acids that is and most of the phosphatides and other impurities are neutralized with an alkaline solution

usually sodium hydroxide or so, so they are removed. So, here that is overview of the what are the when we talk about oil refining.



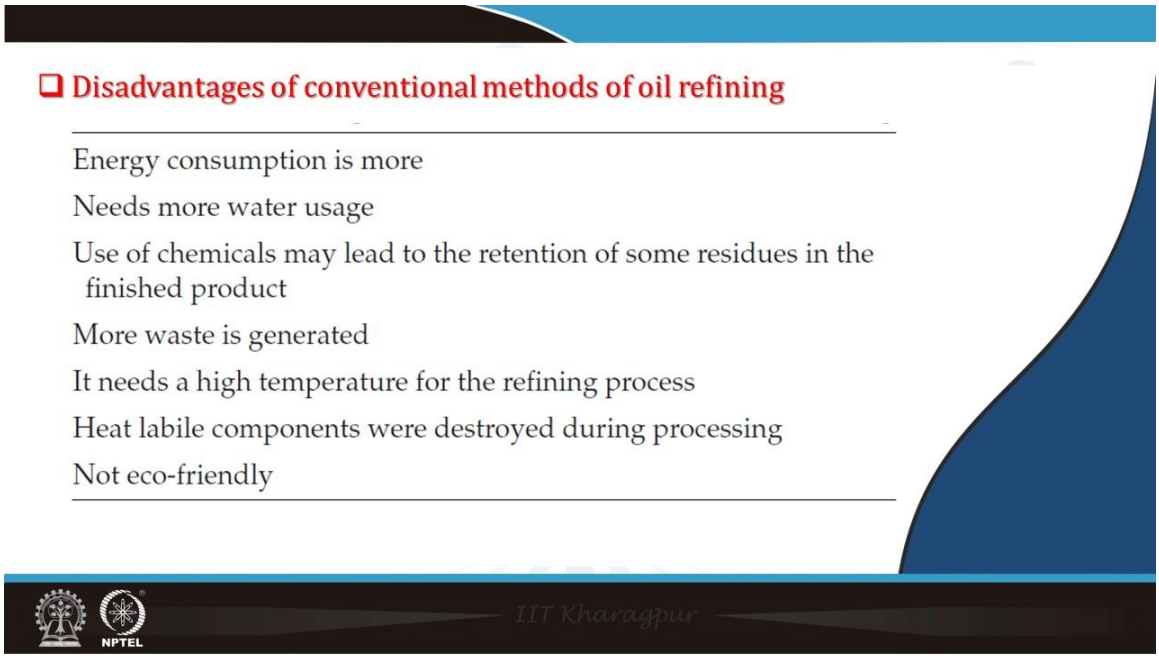
So, these are the basic steps of the oil refining that you can say crude oil that is it is degumming. Degumming is one where the removal of phosphatide gums is done either by hot water or by acidic water etcetera either on the extraction plant or refining plant wherever we will take up all these details in the next lectures, but there is the degumming is done and then this degummed oil you get. Then degummed oil is subjected to neutralization that is the alkali neutralization which is for the removal of so, free fatty acids. So, that is also known as chemical refining that is neutralization for with the caustic so, use of caustic soda. So, when you add sodium hydroxide into the oil it reacts with the fat earlier in the earlier classes we discussed this you get soap stock, this soap stock is removed separated and you get neutralized oil, neutral oil which is free from free fatty acids.

Then it is subjected to another that is the bleaching in the bleaching step there is the pigments etcetera which are might be present into the oil they are removed either vacuum methods or by adding bleaching earth into it. Then this if the earth is used then it is filtered and you get bleached oil and bleached oil then next subjected to the deodorization treatment where it is oils are distilled to the remove odors and flavors as

well as free fatty acid. In fact, refined oil even that is the various any technical people also those are the trained testers also they should not be able to identify the actual origin of the oil if it is properly refined ok. It should be the refined oil should be the blend in taste and flavor. So, you get deodorized oil and finally, it is then winterization that is winterization whatever some waxes etcetera which has not been removed earlier here the oil is cooled down and then the waxes are separated upon cooling.

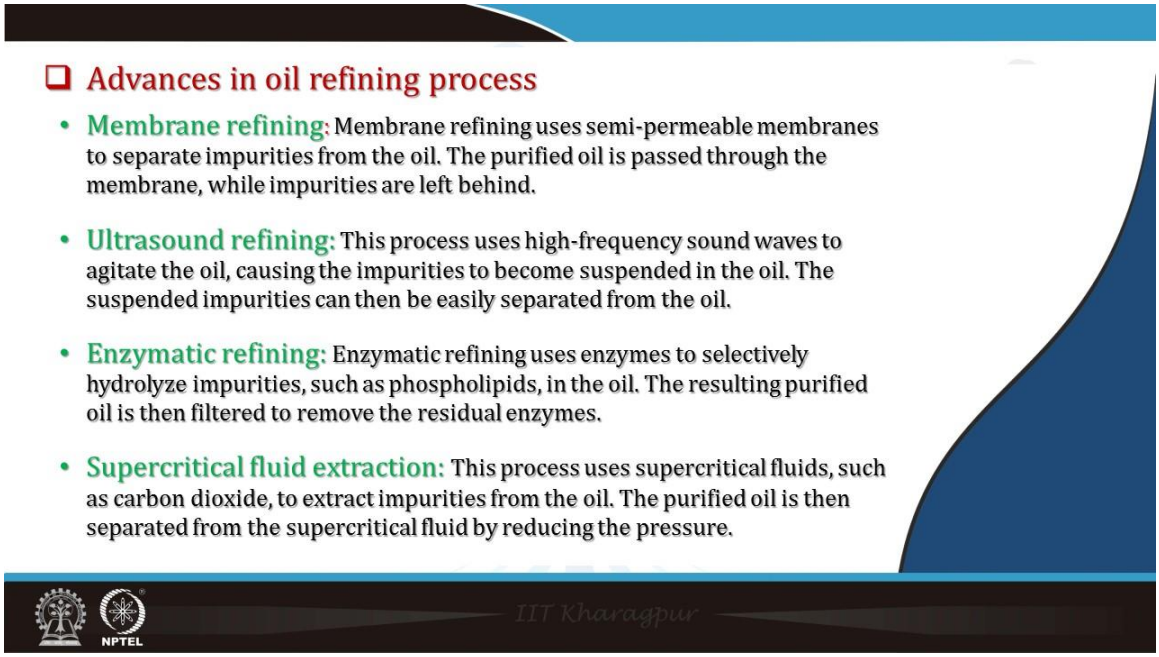
So, that is called winterization. So, these are the different important steps degumming, neutralization, bleaching, deodorization and winterization refining and finally, we get the refined oil or finished oil which is removed all the sort of undesirable components are removed from the oil.

So, details of the process technology equipment etcetera of all these steps like degumming, neutralization, bleaching, deodorization, winterization etcetera we will take up in the next classes lectures.



But here we will I will just discuss that whatever the disadvantages of the conventional method these are all conventional method and then I will speak about something of the novel method for refining as well. So, energy consumption in the more in the conventional methods. So, needs more water uses that is used for chemicals may

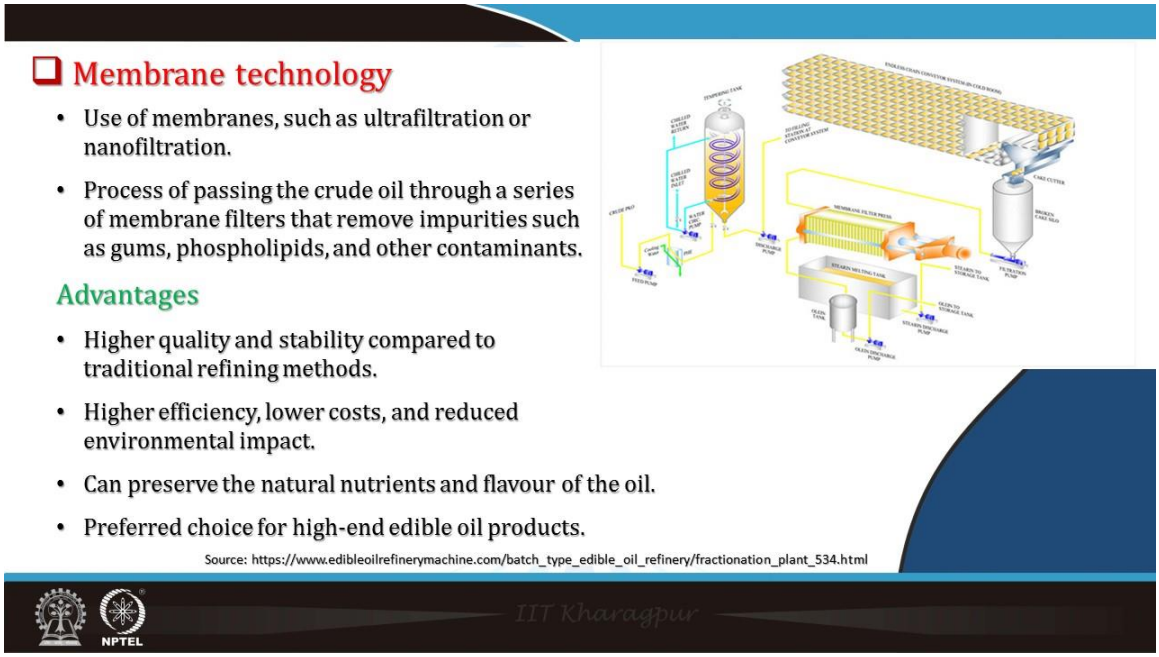
lead to the retention of some residues in the finished product, more waste is generated it needs the high temperature for the refining process which sometime even again adversely affects the quality and heat labile components are destroyed during processing and they are all these conventional process of refining are not ecofriendly. So, there is again like other cases in the extraction we discuss here also there is a need to adopt more and more less energy consuming method or more novel technologies for the refining as well. So, the traditional methods we will take up in the next lectures in details which is followed by the industry.



Today let me briefly cover that what are the novel method or advances in the refining process like the same method which are used for extraction etcetera. They can also be novel methods can be used for refining like membrane refining uses semi permeable membranes to separate impurities from the oil, the purified oil passes through the membranes while impurities are left behind then ultrasound assisted refining this process uses high frequency sound waves to agitate the oil causing the impurities to become suspended in the oil and then suspended impurities can you then be easily separated from the oil. Then even enzymatic refining where it various enzymes are used to selectively hydrolyze impurities such as phospholipids etcetera in the oil and the resulting purified oil is then filtered to remove the residual enzymes. Then supercritical

fluid extraction technology this also uses the supercritical fluid such as carbon dioxide to extract impurities from the oil.

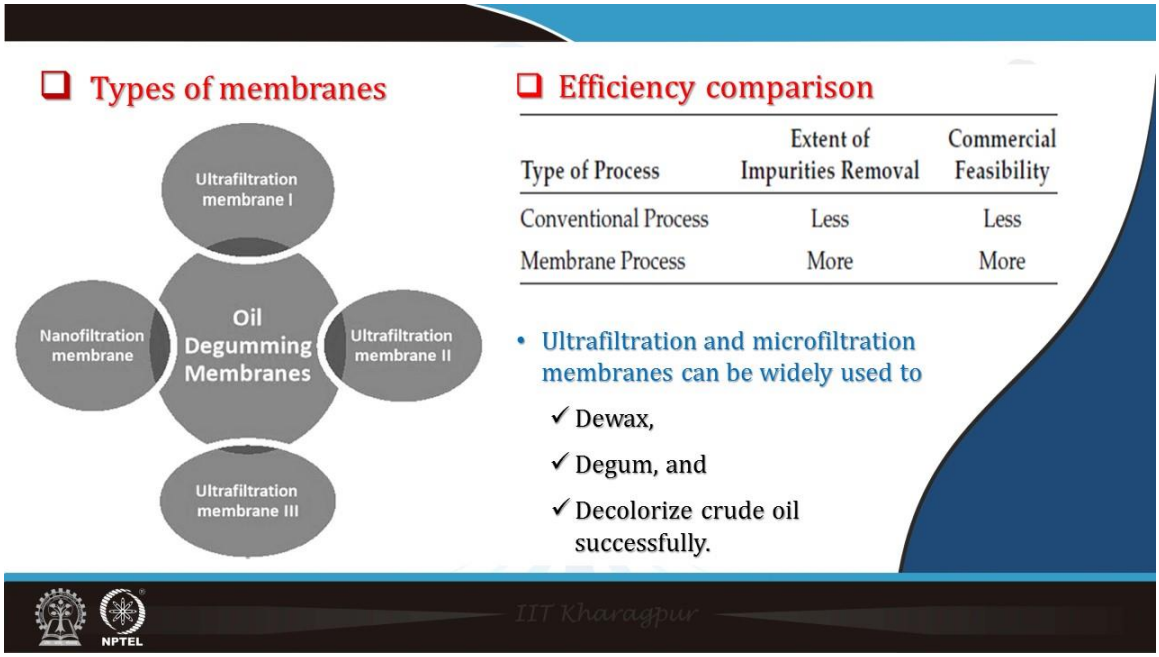
So, the purified oil is then separated from the supercritical fluid by reducing the pressure. So, the details again details of all these processes equipment, process, principle, technical details are covered in my other NPTEL course like novel technologies of food processing and shelf life extension application of these process in the or the extraction of the oil I discussed in earlier lecture. So, in this today how these process can be used in the refining of the oil let us see briefly.



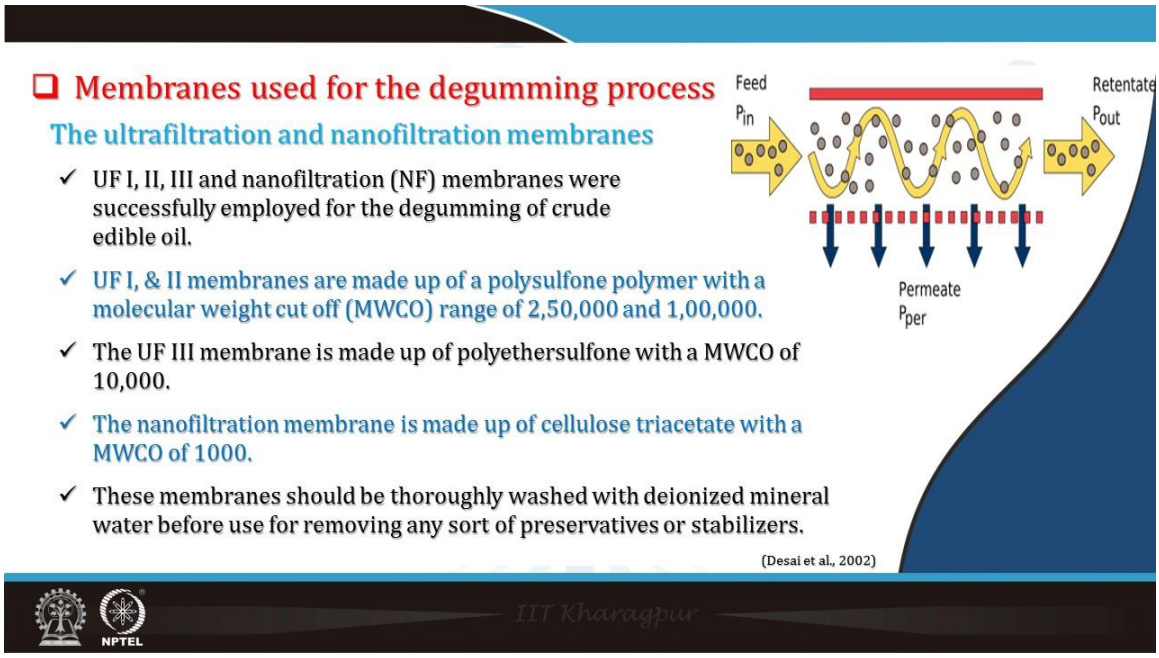
So, the membrane technology you know this is a separation process it uses some sort of selective membrane and which where and the which the material is passed. So, in this case oil containing undesirable components these are passed over the membrane.

So, the undesirable components are retained on the membrane and the oil passes through. So, accordingly the membrane is selected like that. So, process of passing the crude oil through a series of membranes filters and removes the impurities such as gums, phospholipids and other component. The advantages of this process include higher quality and stability compared to the traditional refining method, higher efficiency, lower cost and reduced environmental impact and this can preserve the natural nutrients and

flavor of the oil and it is a preferred choice for high end edible oil product because there is no temperature involvement in the oil. So, the quality of the product is very good.



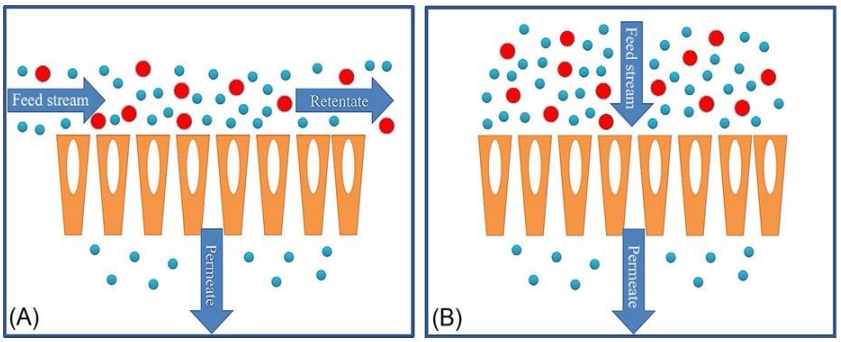
So, these are various type of membrane which are used in the case of oil dig up in process and oil refining process that is ultrafiltration membrane, nano membrane, multifiltration membrane two different types of ultrafiltration membrane depending upon because here the membrane as I told you depending upon the size of the particles etcetera are there even has to take up the different membranes of different pore sizes and different molecular weight cut off. So, ok. So, the efficiency if you compare the conventional process and membrane process even extent of impurity removal is more in the membrane process also the commercial feasibility is more. So, ultrafiltration and microfiltration membranes can be widely used to remove wax, gum or even to decolorize crude oils successfully ok.



Which are membrane they used for the dig up in process include ultrafiltration 1, 2 and 3 and nano filtration membranes which are the ultrafiltration 1, 2 and 3 membranes are made up of a polysulfone polymer with a molecular weight cut off of in the range of 2 lakhs 50,000 to 1 lakhs ok.

The ultrafiltration 3 membrane is made up of a polysulfone and with a molecular weight cut off of 10000. The nano filtration membrane is made up of a cellulose triacetate with a molecular weight cut off of 1000 ok. So, these membranes should be thoroughly washed with deionized mineral water before use for removing any sort of preservatives or stabilizers. So, basically the technology is that is the oil containing the impurities is passed through these membranes ok. So, this retentate is used as impurities and the permeate that is oil is obtained and the basic thing is that you have to find a suitable membrane here for the depending upon the what are the various impurities.

Modes of filtration

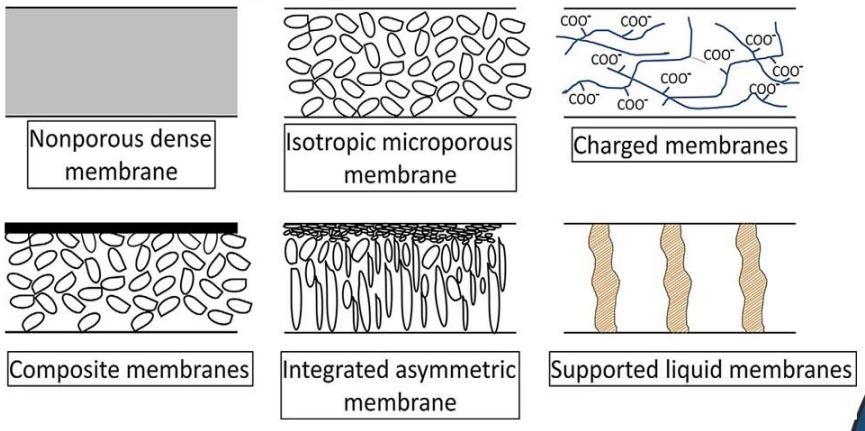


Schematic diagram of types of filtration modes
(A) Cross-flow and (B) Dead-end filtration

Source: Asad et al., 2020

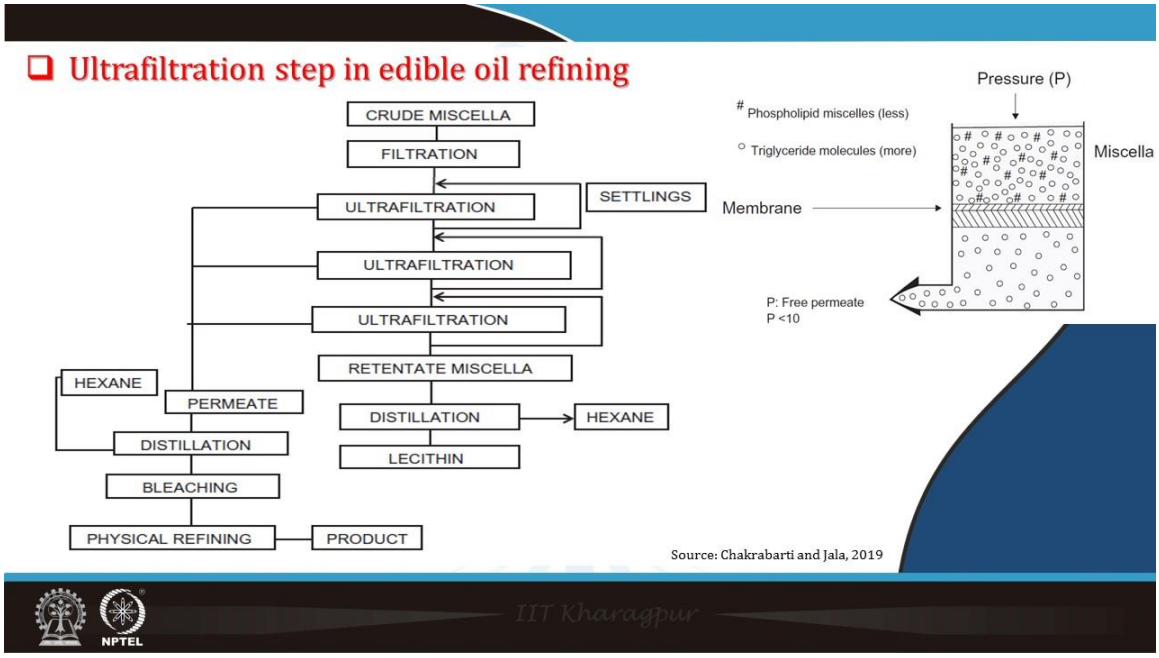
So, the it is the just this slide shows you the mode of filtration that is it may be a cross flow filtration or it is a dead end filtration the material is moving here. Obviously, it is better it is a has a less pore blocking factors and clogging of the membrane etcetera is less a problem in the cross flow filtration and in the dead end that is the material goes vertically. So, it has some problem sometime after sometime this the materials are retained at the surface they become compressed and they act as a they reduce the flux.

Membrane morphologies

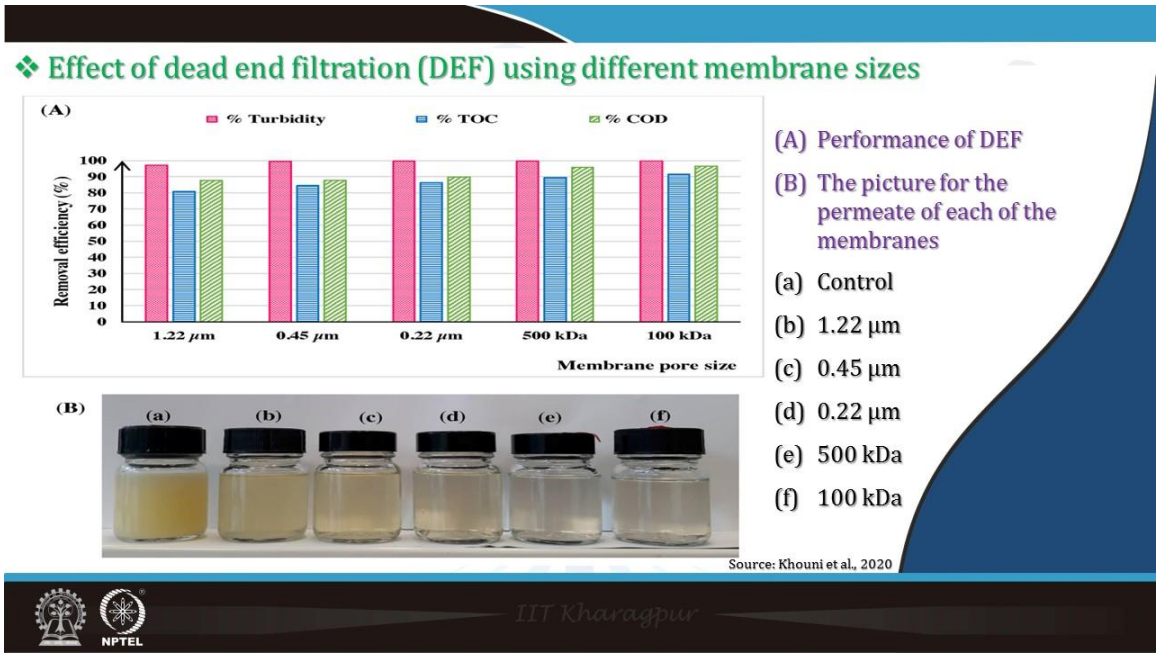


Schematic diagrams of membranes with different morphologies

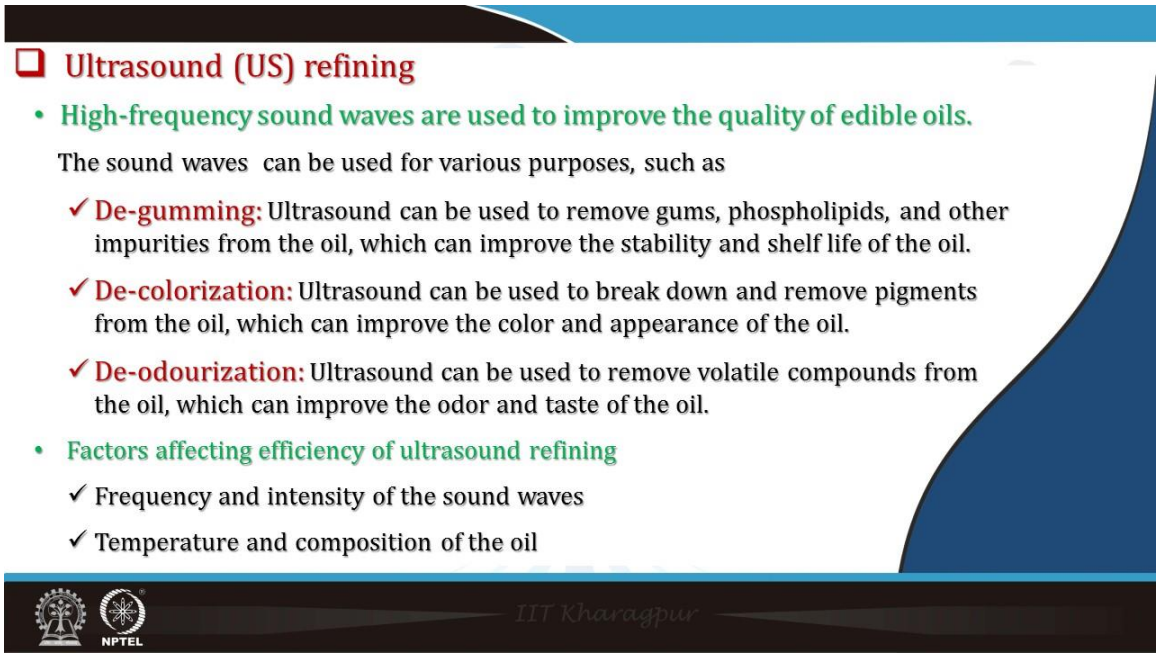
These are the various membrane morphology like nonporous dense membranes, isotropic microporous membranes, charged membranes or composite membranes, integrated asymmetric membrane or supported liquid membranes etcetera. There even charged membrane or functional membrane sometime there is they depending upon they are provided certain charged particle molecule and which they make the whole the even the they allow the smaller molecules to pass through or they bind the charge a lot because this oppositely charged particles are there functional groups they retain they interact with the certain groups and then retain them in the. So, these are the various types of membranes details are this has been discussed in my earlier course ok.



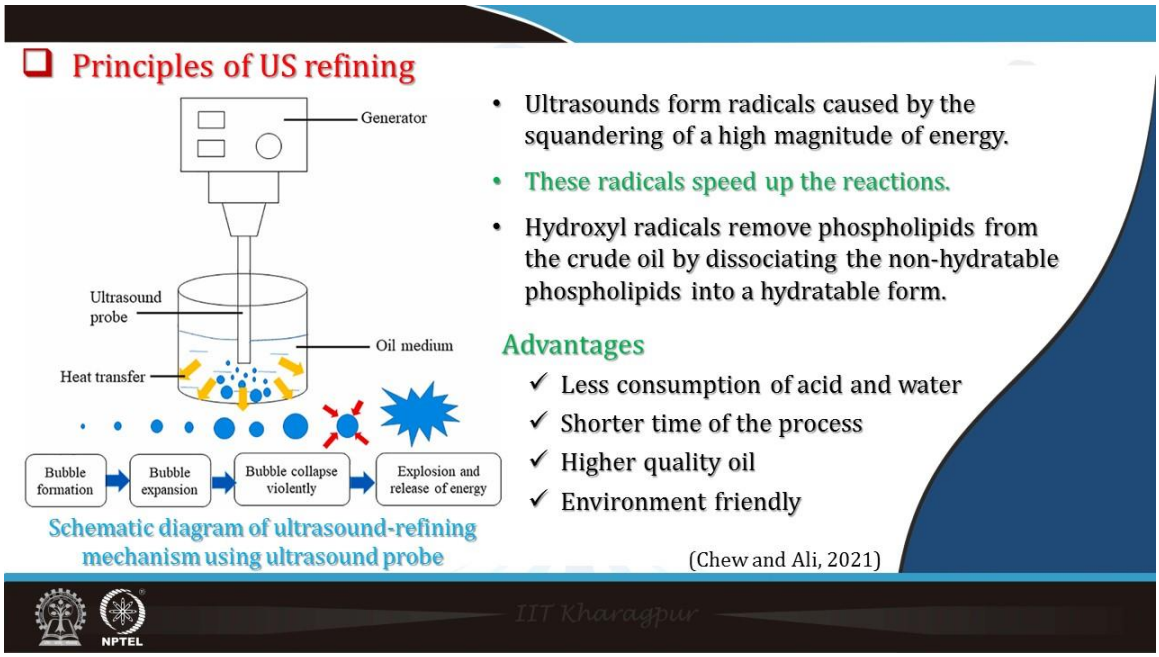
Then the next technology is the ultrafiltration step in edible oil refining process that is the crude oil is miscellized taken it is filtered then it is passed through various ultrafiltration technique that is membrane filtration different membranes etcetera. And you get permeate and the permeate is distilled physical refining you get the oil and the retentate which is there lecithin removed even the sometime gums etcetera which is there these gums they are phosphatides they are lecithin they can be further subjected to the processing and for the lecithin production. So, you see here there is a diametrically or schematically it is shown the this is the basically membrane the oil impurity is there miscella is kept here or oil. So, it is separated ok.



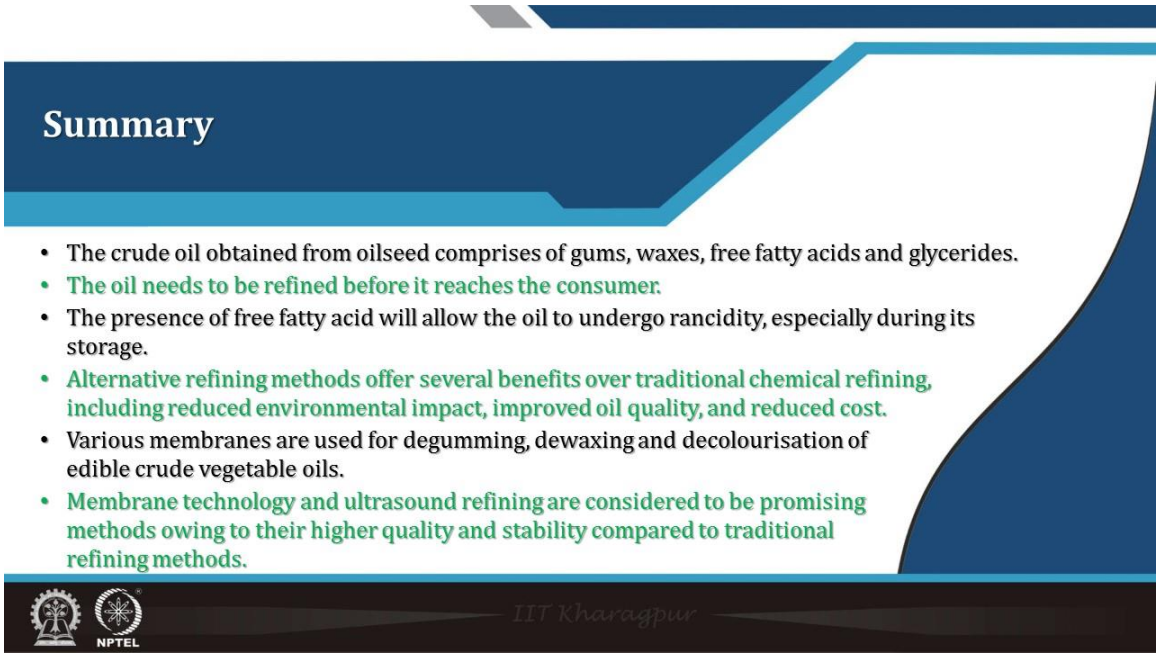
Then effect of you can see here dead-head filtration using different membranes of different pore sizes 1.22, 0.45, 0.22, and you see that is a control membrane and different size membranes ok. And accordingly you see that the oil clarity it is showing that how the so, even removal efficiency like percent turbidity, percent TOC and percent COD etcetera is shown here. And you can see that the pore sizes of the well they have the important membrane pore size they have important influence on the refining. So, that is very important criteria.



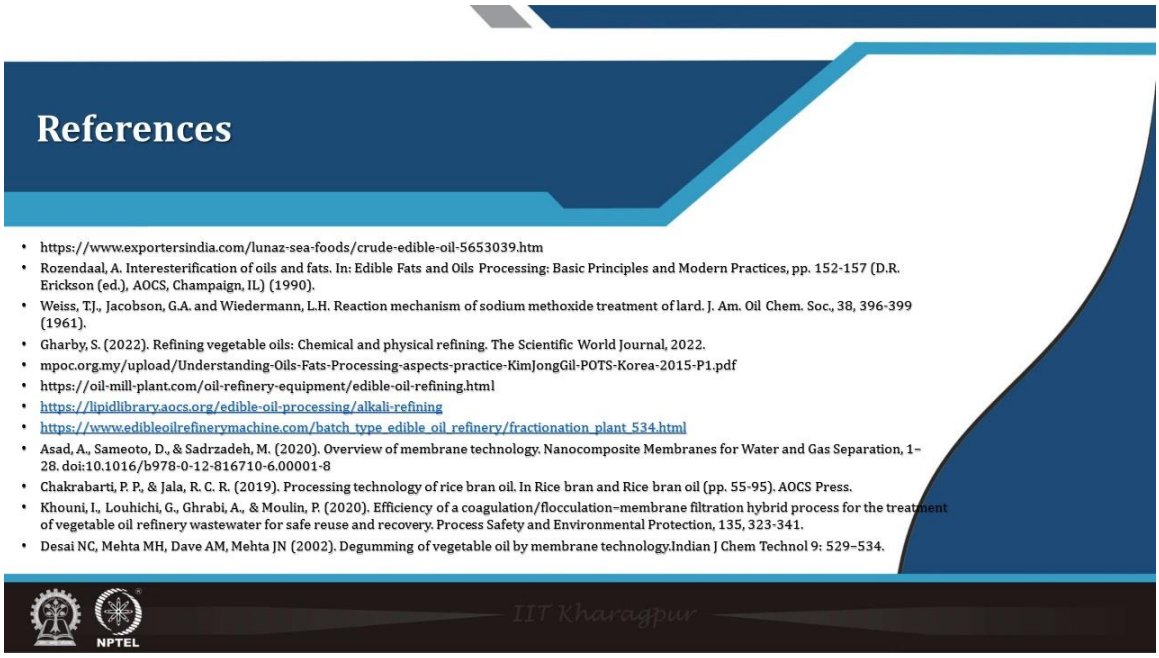
Then ultrasound assisted US refining this is a high frequency sound waves are used to improve the quality of edible oil in this case. The sound waves can be used to for various purposes such as for degumming, the ultrasound can be used to remove gums phospholipids and other impurities from the oil which can improve the stability and self-light the oil. Also it can be used for decolorization purposes to break down the and remove the pigments from the oil which can improve the color and appearance of the oil. Even deodorization like ultrasound can be used to remove volatile compound from the oil which can improve the odour and taste of the oil. Then the factors which affect the ultrasound refining include frequency and intensity of the sound waves, temperature and composition of the oil.



So, this is the principle of ultrasound refining the equipment here that is basically the ultrasound probes in earlier classes also we discussed this equipment etcetera. This ultrasound probe heat transfer this causes the bubble formation, bubble expansion, then bubble finally, collapse and then there is a explosion of the release of the energy. So, it is a schematic diagram of ultrasound refining process ok. That is the ultrasound form radical caused by the squandering of a high magnitude of energy. These radicals speed up the reactions and hydroxyl radicals remove phospholipids from the crude oil by dissociating the non-hydratable phospholipids into hydratable form. The advantages of this technology include less consumption of the acid and water, shorter time of the process, high quality oil and environmental friendly technology.



So, finally, we summarize this lecture by saying that that crude oil obtained from the oil seed come may contain various impurities like gums, waxes, free fatty acids, glycerides etcetera. So, these oil needs to be refined that is by the degumming subjected to degumming process, then in the alkali refining and neutralization, bleaching, deodorization, finally, winterization all those things to remove all those impurities and before the oil is sent for the food purposes food uses. Alternative refining methods offer several benefits over traditional chemical refining process including reduced environment impact factors, improved oil quality and reduced cost. That is even the traditional methods which are used for refining sometime they are energy intensive operations and they because of the pressure and temperature involved or even chemicals etcetera which are used they may have some issues with the oil quality. So, if there is advanced method, novel methods they can be used for refining except only problem with the novel method is that cost of the setup if that is in wise. So, they give very good quality refined various membranes such as which can be used for degumming, de waxing and decolorization of the edible oil. Membrane technology and ultrasound refining are considered to be promising methods owing to their high higher quality and stability compared to the traditional refining processes ok, but only thing if they are the proper in the membrane technology proper selection of the membrane and is a important criteria.



So, this I these are the references which are used in this lecture.

Thank you very much for your patience here. Thank you. Thank you.