Organic Chemical Technology
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Lecture - 05
Vegetable Oils and Processing

Welcome to the MOOCs course organic chemical technology. The title of today's lecture is vegetable oils and processing. In this lecture, we will be discussing about manufacturing process of a few types of specific vegetable oils and then a few common steps of processing of vegetable oils we are going to see. However, before going into the details of today's lecture, we will be having a kind of recapitulation of what we have discussed in the previous lecture. We started with the definitions of oils where we had edible oils and then essential oils. Then we see that edible oils are nothing but mixtures of long chain fatty esters something like glycerides etc. and the derivative such as like you know long chain fatty alcohols something like a glycerin or glycerol. So, these are nothing but the oils edible oils especially. So, these oils are not only used for the edible purpose for cooking etc. but also used for industrial applications also. Several of industrial applications are also using so many of vegetable oils something like coconut oil, almond oil etc. So then essential oils are nothing but you know a mixture of aromatics which are used in cosmetics, pharmaceuticals etc. and then we started discussing about chemical composition of these oils, right edible oils you can take something like you know glycerides something like something like this. So now here these radicals long chain free fatty acid radicals whatever are there they not necessarily be same they would be different R1, R2, R3 would be different right and then most of these compounds are unsaturated.

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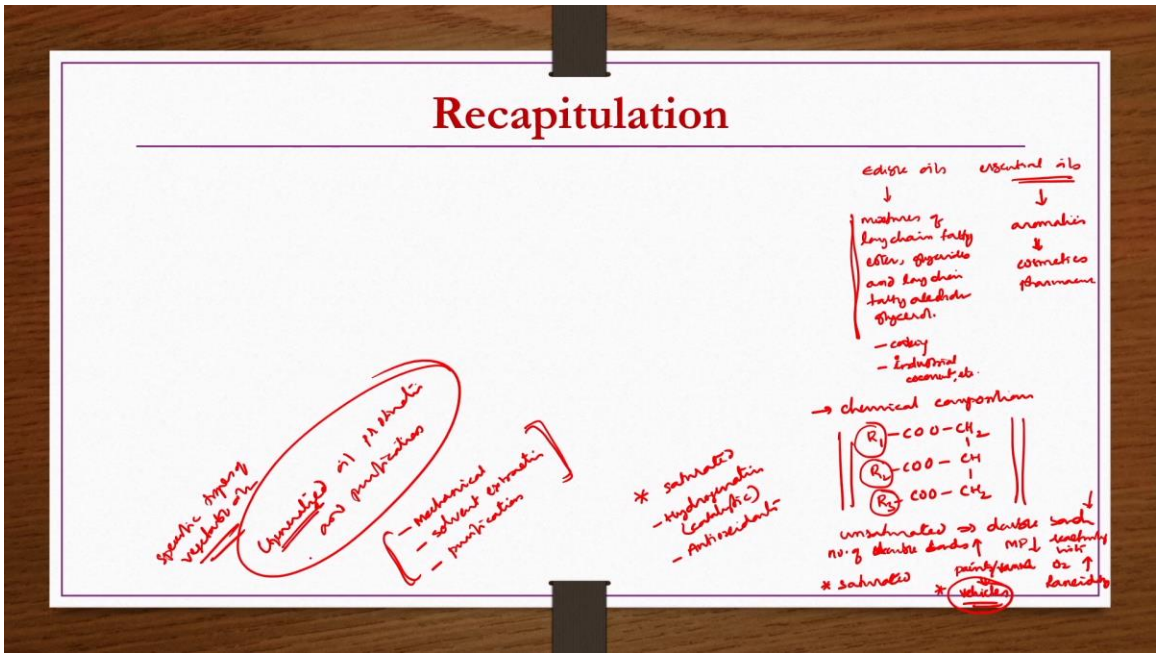

That means there would be double bonds right if the number of double bonds increases then what happened the melting point of oil decreases and then reactivity with oxygen or air increases right or rancidity takes place. So for edible fats etc. rancidity is not good so then what you prefer to have you prefer to have saturated this R1, R2, R3 etc. you prefer to be saturated okay even if they are unsaturated there are some industrial applications like you know in paints and varnishes what you do you use unsaturated compounds or whatever these fatty acids etc. are there they use them as a vehicles or the liquids or solvent which would be carrying the pigments to form the paints or varnishes right. So, these kind of applications are also there unsaturated ones are there. However it is better to make these bonds saturated from applications point of view if required then two best approaches are hydrogenation which is catalytic activity or occurs in the presence of catalyst only provided required temperature and pressure but there are also some kind of approach like antioxidants okay. So, this is the basic introduction of the entire so called oils and fats industry that we how the oils are being produced and how the processing or purification of crude vegetable oils usually been done in the industries that introductory part this is how we have you know understood. Then we started discussing about the technical compounds of the oil extraction processes then we realized that there are approaches mechanical approaches to extract the oils from the vegetable seeds and then there is also another approach called solvent extraction then followed by a purification steps etc. these things we have seen and then these steps you know how they occur a kind of generalized approach. Generalized oil production and purification flow chart we have seen right so that we going to discuss now again as a recapitulation right but after that what we will be doing we will be discussing production of a specific types of vegetable oils etc. we are going to discuss in today's lecture okay. So before going to the production

of specific type of vegetable oils we will have a recapitulation of the generalized flow chart which provides you know information how the oil is being extracted either by mechanical process or by solvent extraction process or both followed by the purification right and then we get into the new topics of today's lecture.

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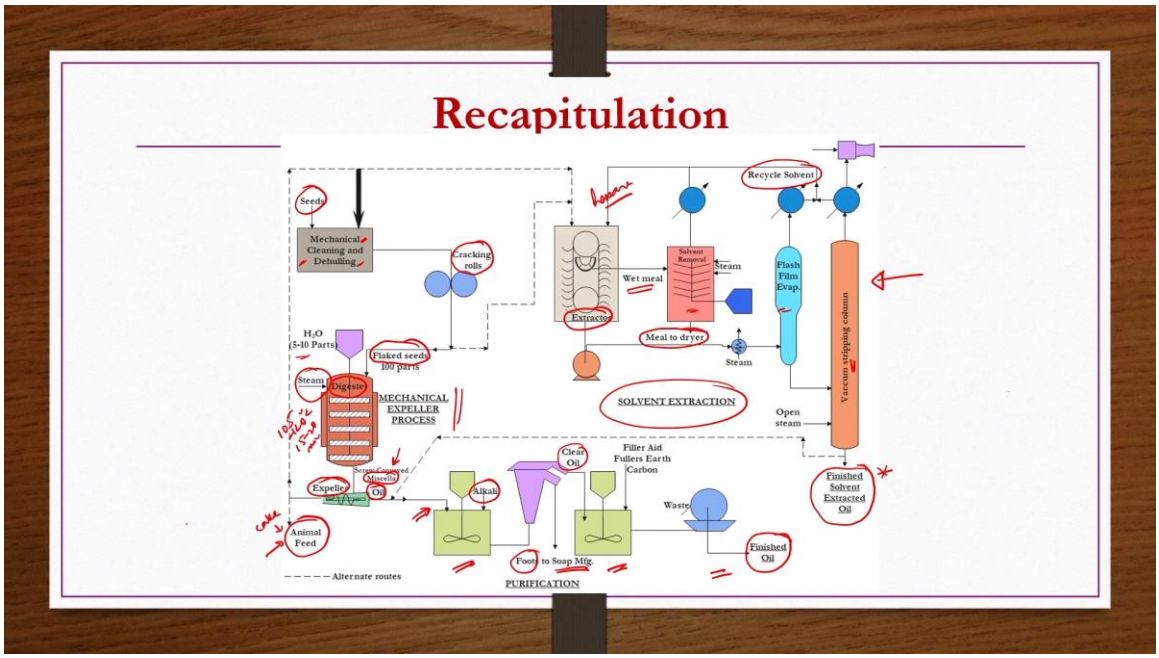

Now we quickly look at the generalized flow chart for the production of oils which we have already discussed in the previous lecture. So, what we do we take vegetable oil seeds then by mechanical means we clean them and do the dehulling after cleaning and dehulling we pass them through cracking rolls they can be corrugated rolls or you know smooth rolls whatever it depends on the type of oil right that you are processing. Why do we do that so that we can get the flaked seeds why do this why do we do flaking of the seeds why cannot we take directly after drying. So, because we have to digest them we have to cook them in a digester using the steam right so when you do the digestion using the steam if you have the flaked seeds in 0.25 to 0.35 mm size then what happens that permeation of the steam into the seeds takes place easily and then cooking would be done effectively right. So around 100 parts of seeds if you take flaked seeds if you take 5 to 10 parts of water you take and then you do the cooking in a digester using the steam at around 105 to 120 degrees centigrade for 15 to 20 minutes right. So then whatever the mixture or meal that you get that you process through an expeller so that to get a crushed crude oil and then whatever the cake is there that cake you get and then you use it as a feed for the animal right. Whatever the oil that you get which is crude after mechanical process this is whatever we have done this is nothing but the mechanical process all right mechanical expeller process. So, all these steps are only mechanical steps are there so this

is known as the mechanical expelling process. So, from this mechanical extraction process whatever the crude oil that you get that you do you know purification by alkali treatment where you try to remove the foods by centrifugation right. The clear oil you further take it to the adsorption column so that to remove further impurities are there or not whereas the foods you take to the soap manufacturing. After the adsorption clear oil if at all still some impurities of the you know hulls or flakes etcetera vegetable seeds flakes etcetera are still remaining in small quantities they will be removed in a rotary drum you know filter press. How this works etcetera that we have already seen so after this process you get the finished oil right. So now this is the mechanical method followed by the purification if you wanted to do the solvent extraction which is explained here in this part of the flow chart. After the cracking whatever the flakes seeds are there that you can take to a extractor right if you are doing only solvent extraction process right. As we mentioned this mechanical and then solvent extraction processes they can also be done in combination in fact most of the oil industries nowadays they are doing in combination so that you know yield of oil quantity is increased right. So, under such conditions what you do cake whatever you are taking as animal feed if the quantity of the oil is sufficiently high in this cake more than 5 percent or something like that. That cake also you mix along with the you know flakes seeds here and then take it to the extraction column. How it works etcetera we have already explained. So, to this extraction column what you do you need to give a solvent because it is a solvent extraction the solvent is required hexane solvent in general used. Of course, there are other solvents are also possible but hexane is the most efficient one. So then after this process whatever the wet meal is there that you take to the steps of solvent removal flash evaporation and then vacuum stripping column etcetera in order to recover the solvent from the wet meal. Once you recover the solvent from the wet meal that recovered solvent you can reuse as a solvent to the extraction column by recycling it. Whereas the meal after the solvent removal is there so that you can take it to the toaster or desolventenizer or you can take it as animal feed or you can use for the other purposes also. So, from this vacuum stripping column what you get you get finished solvent extracted oil from the bottom from the top you get the solvent. So, this oil again it has to be processed for the purification steps as explained here. This finished oil finished solvent extracted oil that may be containing some amount of solvent also may be stresses may be only a few percentages less than 1 or 2 percent something like that. But however solvent is there so that one you call it as micellar. But micellar again you take it along with the oil that is coming from the mechanical method and then do the purification steps.

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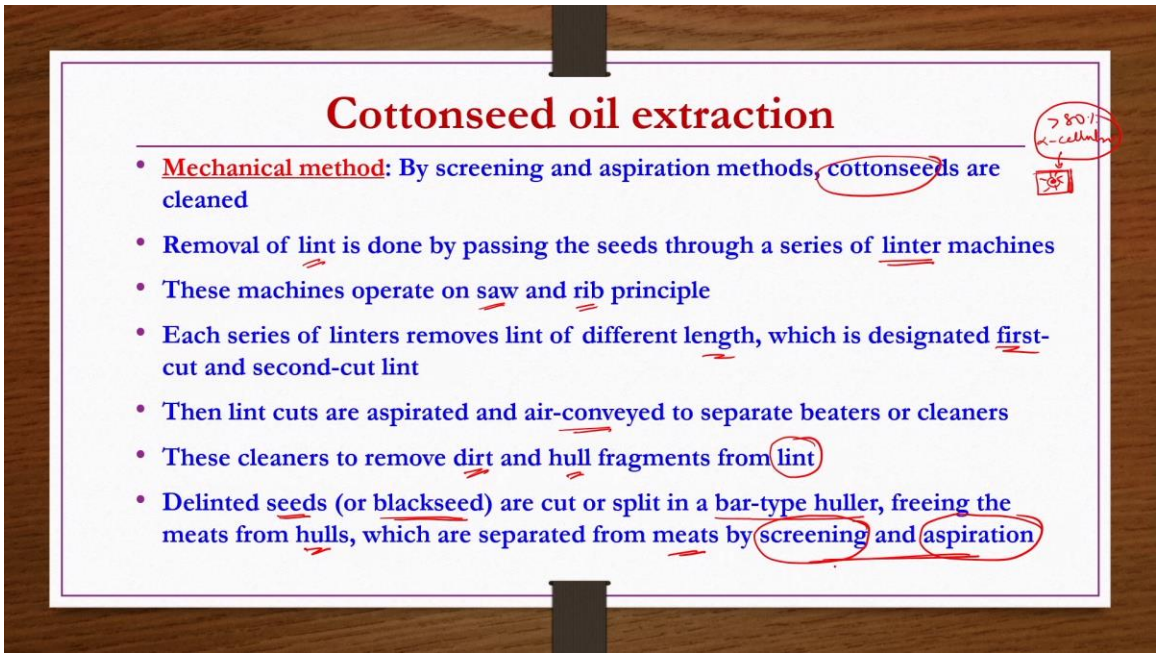

Now in this lecture we are going to see in detail about a few types of vegetable oils production especially let us say here we are calling expeller how does it work what are the different types of expellers etcetera there it is necessary to understand. So we do not go into the all the details of expellers but we take a sufficient details so that you know we could understand what does mean by expeller and how does it required for the oil industry. Similarly, extractor also we see for a particular type of vegetable oil we see in detail about the extraction column and then purification of the solvent etcetera again.

So let us start with cotton seed oil extraction. Here again two methods are there mechanical method and then solvent extraction method both the methods we see and then we see details of a component important component that are involved in these processes. So, in the mechanical method by screening and aspiration you can do the cleaning of the cotton seeds. This cotton seeds usually you know black in color but that may be containing hull as well as the lint also may be there. So, these lints are very rich in alpha cellulose maybe more than 80 percent so that can be used for some other application so you cannot throw them also. Even the hulls are also used for different purpose like you know roughage in the animal feed etcetera. So, whatever the cotton seeds including the lint, hulls and then black seed all of them are having certain market value. So, you cannot afford to waste any of them. So, for that process because of such reasons cleaning is also very essential and important step in the cotton seed oil extraction. Once the cleaning has been done the removal of lint is done by passing the seeds through a series of linter machines where the lints are being removed. These machines usually work on saw and rib principle. Each series of linter removes different lengths of lint which may be designated as first cut and second cut lint something like that. The lint cuts are aspirated

and air conveyed because these are very less in weight so then it is better to do the aspiration and then air conveying to separate from the you know to separate beaters or cleaners. This cleaners will also remove the dirt and hull fragments from the lint. So now after this step you get almost like a clear clean lint you get which is rich in alpha cellulose that you can use for the other applications. So after this process where the lint is also been removed hull it has been hulled and then dirt also removed. So, then you have a clean de-linted seeds which are nothing but black seeds that main portion black in color and that main part of the seed is whatever there that black seeds you get. They are usually cut as split in bar type huller freeing the meats from hulls if at all there are meats of course they would be and then these are further separated from meats by screening and aspiration. Screening how it is done etc those things we have discussed in the first week of the course where we were talking about the unit operation. So we are not getting into the details of them. They are also part of a different subjects not part of this particular subject.

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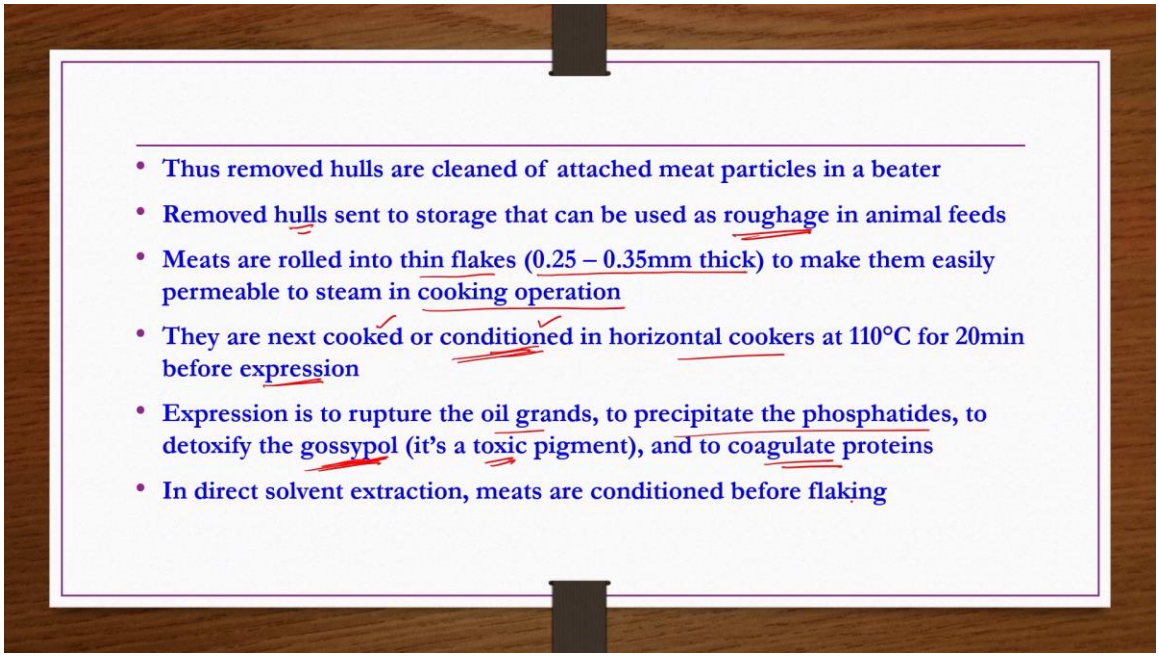

Thus, removed hulls are cleaned of attached meat particles in a beater. Removed hulls are sent to storage that can be used as roughage in animal feeds. So out of 3 parts of the cotton seeds that is cotton seed, black seed, hull and then lint. Lint separated which is used for the alpha cellulose so appropriate applications are there hulls are used as roughage in animal feeds. Then meats are rolled into thin flakes so that you know you get 0.25 to 0.35 mm thick to make them easily permeable to steam in cooking operation. So, digester step whatever we have seen you know it has to be digested whatever the seeds are there. Flakes of the seeds have to be cooked in the presence of steam at around 15

minutes and then at around 110 degree centigrade. So that steam permeation into the seed has to be taken place properly. So, for that purpose these flakes are essential or the flakes shape of the seeds are essential rather the flakes. They are next cooked and then conditions. What do you mean by conditioning? So, conditioning is nothing but in these seeds usually proteins would also be there. If these proteins are not separated before the expelling process or pressing process the extraction of oil may not be sufficiently good enough or it will not be effective. It will not be economically feasible. So that much you know protein contents may be there in some of the cases. Up to 40 to 50 percent protein contents may be there in the oil seeds which may not be aiding for the oil production. So, they have to be separated. So, what are the steps are there depending on the percentage of the proteins that are present. If the percentage is high then you have to do the digestion and then drying etc those kind of steps. If the percentage of protein is less around 5, 6 percent only then you can simply dry them and then do the required expelling process or pressing in the expellers etc that you have to do. So those processes are nothing but the conditioning. So, these are next cooked or conditioned in horizontal cookers at 110 degrees centigrade for 20 minutes before the expression or pressing the seeds to extract the oil before that one you have to do. Expression is to rupture the oil grains to precipitate the phosphatides to detoxify the gossypol. Gossypol is nothing but a kind of pigment which is very toxic so it has to be removed and to coagulate proteins. In the direct solvent extraction meats are conditioned before flaking. Now we are talking about the mechanical ones. So, if you do only solvent extraction the meats are conditioned before the flaking. So, if you are doing the mechanical process after flaking you do the required conditioning.

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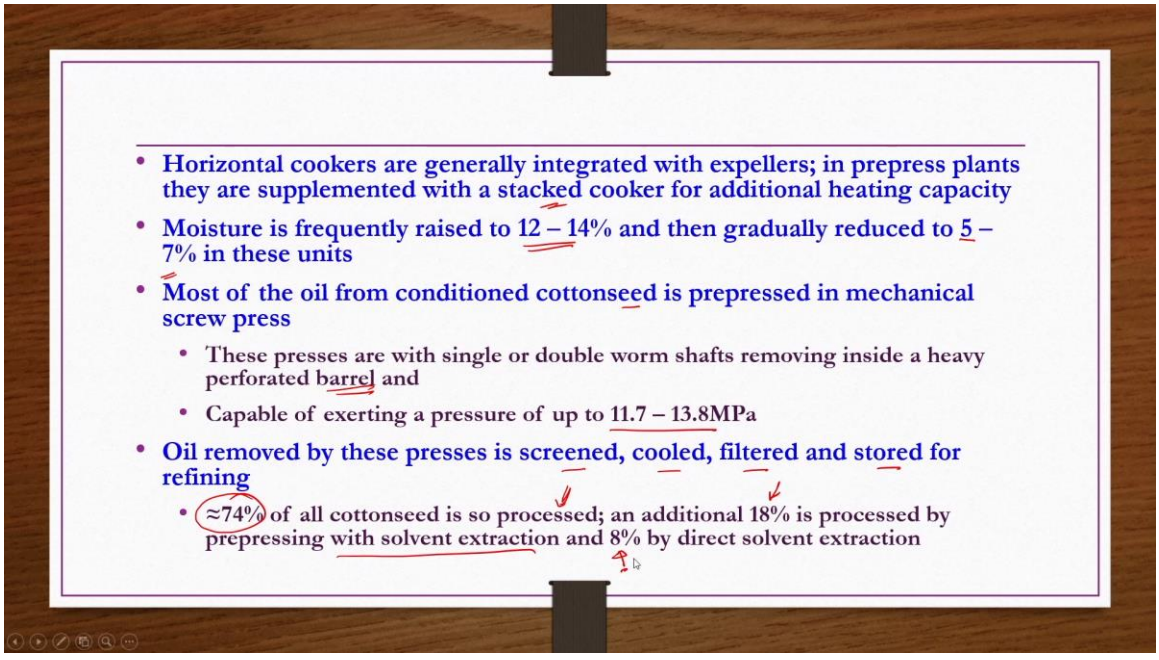

Then horizontal cookers are generally which are integrated with expellers. In pre-pressed plants they are supplemented with a stacked cooker for additional heating capacity. Then moisture is frequently raised to 12 to 14 percent and then gradually reduced to 5 to 7 percent in these units. Most of the oil from conditioned cotton seed is pre-pressed in mechanical screw press. These presses are single or double worm shafts revolving inside a heavy perforated barrel. We are going to schematically discuss them in the next slide where we will be having a cut view of the expellers as well. And capable of exerting pressure up to 11.7 to 13.8 MPa. Oil removed by these presses is screened, cooled, filtered and stored for refining. Approximately 74 percent of all cotton seed is processed by the mechanical methods. Additionally, 18 percent is processed by pre-pressing with solvent extraction and then 8 percent only by direct solvent extraction.

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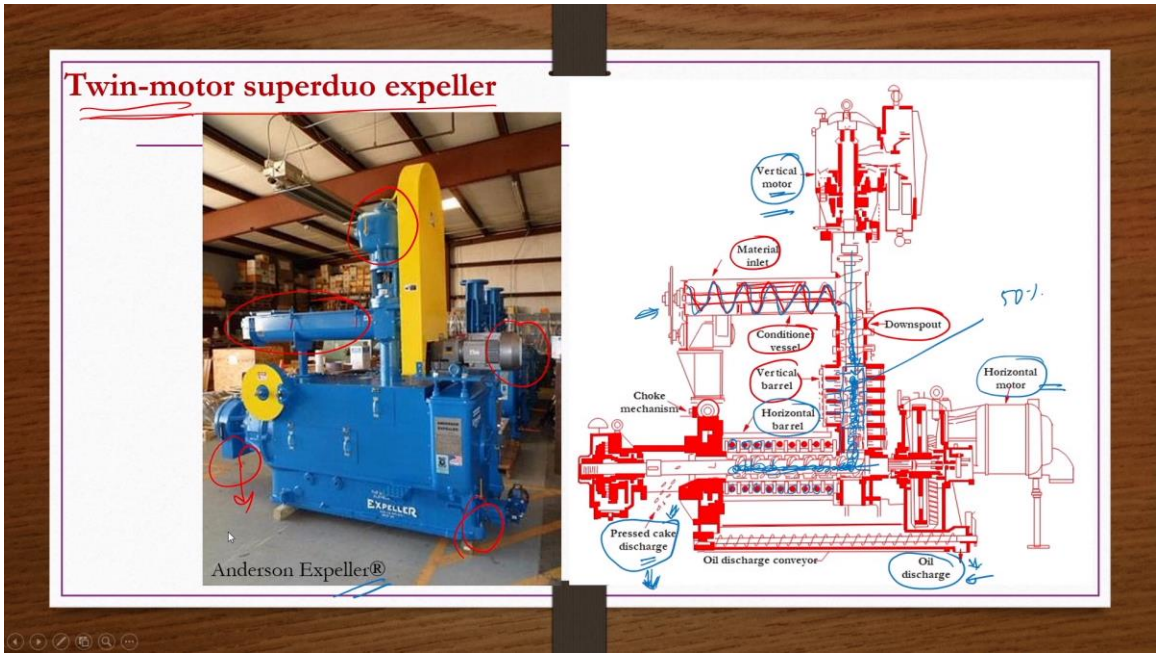

Now we see how the pressing of the flaked seeds takes place in expeller to get the or to extract the oil from the oilseeds. We are taking a twin motor superduo expeller. It is having two motors that is the reason it calls twin motor superduo expeller. If you see cut way of this particular expeller then you can realize here. So now here in this expeller we are going to discuss all the steps of conditioning, extraction of oil by expression in two steps and then collection of the cake etc. all those things we can see in a diagram here and then clearly understand. So here in the diagram cut way of the expeller is provided here. We have material inlet here. So, the material is a solid material. Transportation of the solid material in a horizontal column is very difficult. So best option is the screw conveyor. So, the solid material that you take here so that screw conveyors it rotates like this. So, when the screws are moving then what happens? You know that material passes

along with the screws and then discharges to the other level. So because this is whatever the central tube kind of thing is there that rotates actually that rotates to that one the screws or you know blades kind of things are provided like this. Helical screws are provided like this. So, when the rod rotates these helical screws will also rotate and then correspondingly material passes to the next level. In this one there is a conditioning section also. If required the conditioning something like you know whatever protein coagulation etc. drying etc. those things are required that can also be done. So once the conditioned material whatever is there that comes to a downsprout from where it enters vertical barrel. So, this material comes here into the vertical barrel. So, this is nothing but this particular section is vertical barrel. So, this is a perforated one. So, the material when it comes here the vertical motor operates and then this one comes down gradually and then presses the material like this. When the material is pressed here the material is nothing but the flaked seeds. So, when these are being pressed here they will be undergoing expression and then you know whatever the oil is there that is coming out. That oil comes out through the perforated region of the barrel. These barrels whatever vertical or horizontal both of them are perforated one. Through this perforated portion of the barrel you know that oils comes out and then that oils you know gradually drains into the bottom and then gets discharged. Now here in the vertical barrel approximately 50 percent of oil is extracted by the vertical pressing. So, but while these pressing conditions are such a way that the continuously the remaining cake which is having 50 percent of you know oil still containing in a continuous manner without reducing the pressure that would be coming and then entering the horizontal barrel is shown here this horizontal barrel. This is also perforated one. Now this horizontal motor will operate so that the material whatever is coming here that would be pressed and then crushed and then whatever the oil is there that oil passes out of the barrel through the perforated area. So this whatever the red dots are there they are nothing but the you know oil coming out you know through the perforation. Here in the vertical ones you know like bar they are shown because they are cut view. So, the oils are coming like this. So those oils again after this second step pressing in horizontal barrel whatever the oil is there that comes out and then mixes with the oil that has been extracted in the vertical barrel mixed with that one and then comes out as a oil discharge. Now by this step almost like you know remaining oil whatever was present in the cake that also been removed. So almost 95 more than 90 percent of the oil is being removed and then whatever the pressed cake or de-oiled cake is there that is taken as a discharge as a cake from the other side. This again depending on its oil content if the oil content is still high it can be refed here in this process and then redo or this can be you know processed in a solvent extraction method in combination method if you are using and then you know further extraction of oil from the cake will also be taking place if still it is having oil content and that is optional. So now here this is called as a twin motor so vertical motor and then horizontal motor are there. Now here this comes at certain speed and then top shaft or vertical motor operates at certain speed

and then horizontal motor also operates at certain speed and then at what speed the material inlet material is coming they all have to be properly engineering way calculated and then whatever the discharge rates are there they should also be calculated according this operating of the speed of the vertical and then horizontal motor and then screw conveyor has to be you know maintained. So, they are all part of the engineering calculation of the design so that we are not going into the details of those things because that is not part of the course. So now this is about how twin motor superduo expeller works. So, such kind of expellers are used in the cotton seed they are also used for the extraction of other types of vegetables as well. So, one commercial expeller is shown here Anderson expeller so now you can see here exactly the same thing. So here is a vertical motor and then here it is the horizontal motor the material is being come coming here and then being crushed and then this is nothing but your screw conveyor to take the material inlet and then it is also provided with the conditioning vessel. So here the oil would be collected from the bottom here whereas the discharge cake would be collected from the bottom here.

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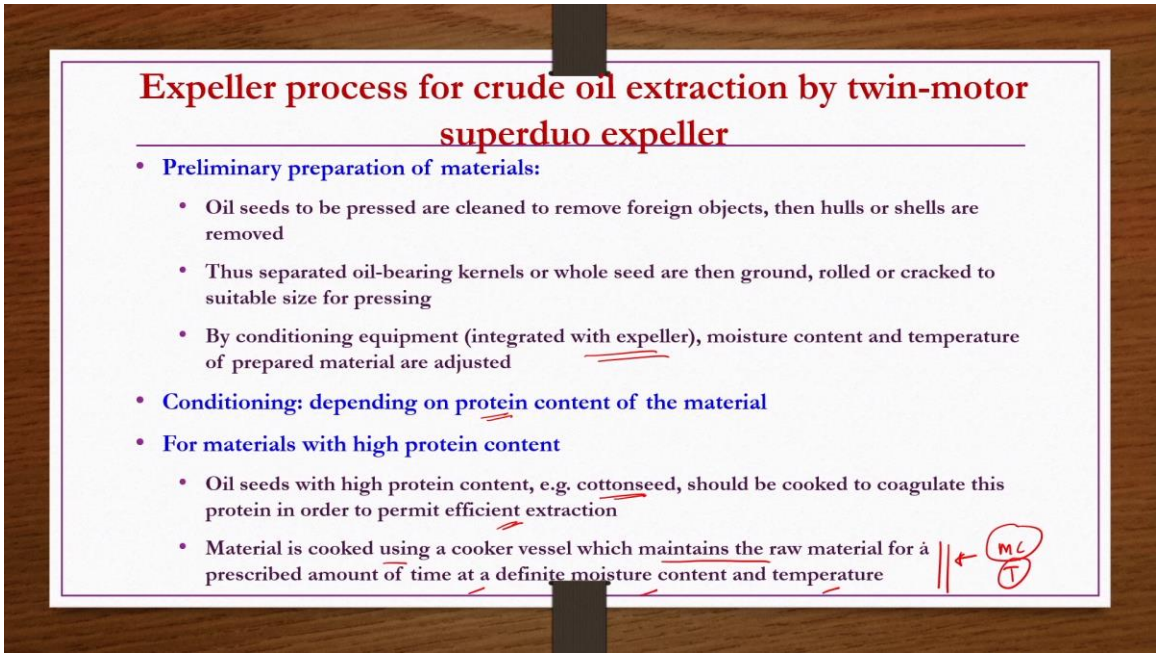

So, whatever the things we discussed in the previous slide the same thing have been presented here as a text for understanding. So here three steps are there one is the cleaning or preparation of the material then followed by the conditioning based on the percentage of the protein followed by final extraction of the oil by twin motor expeller. So, all steps we are going to discuss here again. Preliminary preparation of materials oil ceased to be pressed or cleaned to remove foreign objects then hulls or shells are removed. Thus, separated oil bearing kernels or whole seed are then ground rolled or

cracked to suitable size for pressing by conditioning equipment which may be integrated with expeller in general. Moisture content and temperature of prepared material are adjusted. Now the second step is conditioning depending on the protein content of the material the steps are varying. If you have a high protein content material or the oil seeds that you take after the preparation of it if you have the more protein in the oil seeds that has to be removed otherwise extraction would not be efficient. Oil seeds with high protein content example like cotton seed that just we have seen should be cooked to coagulate this protein in order to permit efficient extraction. Material is cooked using a cooker vessel which maintains the raw material for a prescribed amount of time at definite moisture content and temperature. So, all these things like you know moisture content temperature etc they should be optimized and then that depends on material to material in general.

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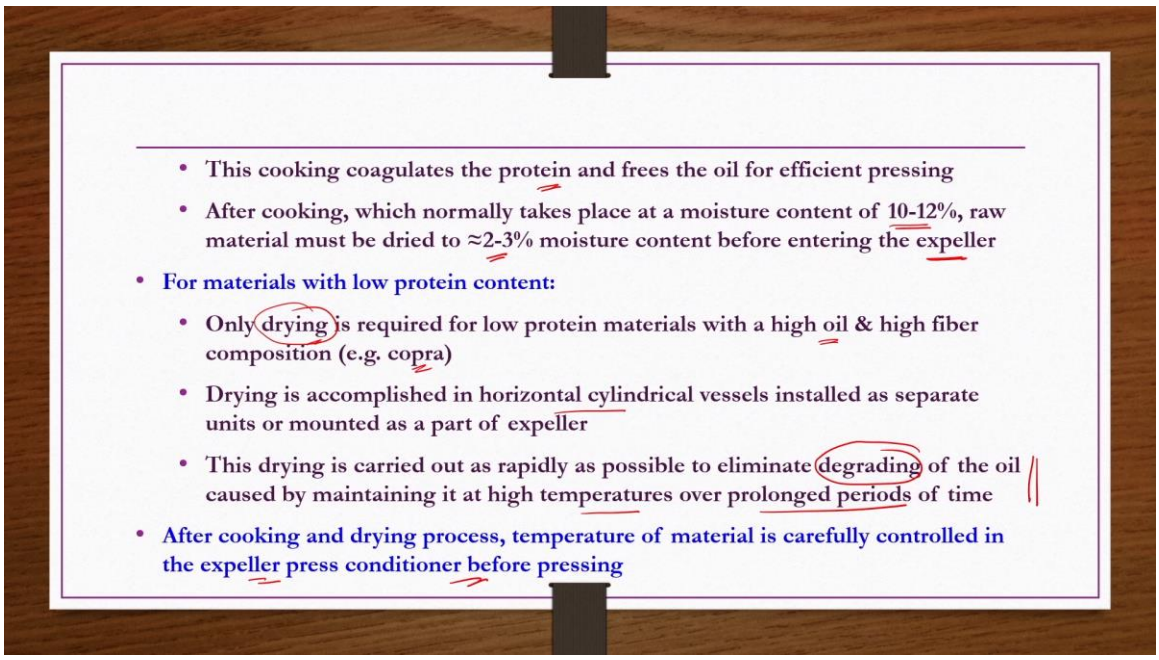

This cooking coagulates the protein and frees the oil for efficient pressing subsequently. After cooking normally which takes place at moisture content of 10 to 12 percent you have to make sure that the raw material must be dried to 2 to 3 percent of moisture content only. Then you allow this material to the expeller where both vertical and then horizontal extractions are taking place. So, that would be the you know required thing. If the materials are having low content low protein content then only drying is sufficient something like you know like you know like copra. Copra is nothing but the processed raw material from the coconut to get the coconut oil that we are going to discuss anyway. So, these materials usually have the high oil and high fiber composition. So, under such conditions if you do the drying itself is sufficient you do the drying then you do the

extraction by using the expellers. Drying is accomplished in horizontal cylindrical vessels installed as separate units are mounted as part of expeller. This drying is carried out as rapidly as possible to eliminate degrading of the oil caused by maintaining it at high temperatures over prolonged periods of the times. So often it is not good that you drying the material for long time and then high temperature because when you do that one degradation of the oil in general takes place. What do you mean by degradation of the oil? So, when you prolong period you expose to the atmosphere some kind of rancidation may etc takes place. Because those condition materials are already dried enough and dried at high temperature. So, moisture content would be less, oil content would be exposed more time to the air or oxygen etc then a rancidation may takes place. After cooking and drying process temperature of material is carefully controlled in expeller press conditioner before pressing.

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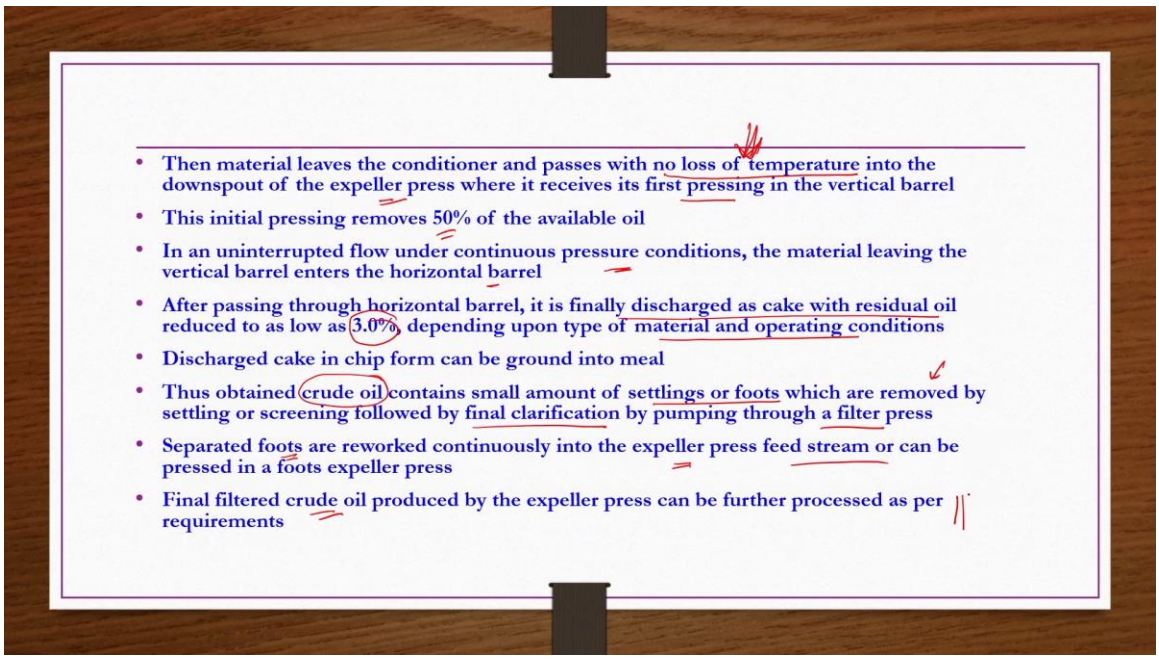

How the pressing occurs that just we have seen the material leaves the conditioner and passes with no loss of temperature into the downspout of the expeller press where it receive the first pressing in the vertical barrel. So, no loss of temperature is required that is the reason in general the material inlet section is also provided with the conditioning section. This initial pressing removes approximately 50 percent of the available oil. In an uninterrupted flow under continuous pressure conditions the material leaving the vertical barrel enters the horizontal barrel. After passing through horizontal barrel it is finally discharged as cake with a residual oil reduced as low as 3 percent depending on of course type of the material and then operating conditions as well. Discharge cake is in chip form and that can be ground into meal thus obtained crude oil contains small amount of

settling or foods which are removed and then used in the soap manufacturing industries followed by this removal can be done by settling or screening followed by the final clarification by pumping through a filter press or rotary drum filter press. Separated foods are reworked continuously into the expeller press feed stream or can be pressed in foods expeller press separately as well. Final filtered crude oil produced by the expeller press can be further processed as per the requirements whether you need to do hydrogenation or you need to do the anti-oxidation addition or you need to do the purification steps as we have discussed already. So that was about extraction of oil from the cotton seeds by using mechanical methods. Now how to do the same thing using solvent extraction method that we are going to see.

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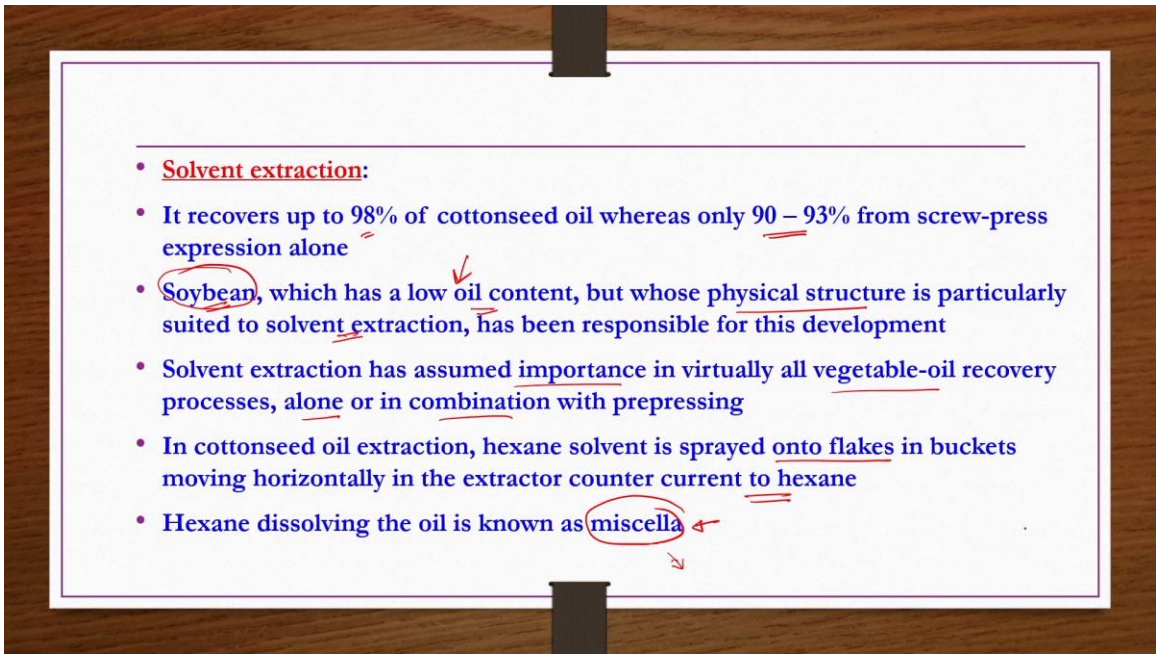

This method recovers up to 98 percent of cotton seed oil whereas only 90 to 93 percent from screw press expression alone. So, 5 percent, 5 to 8 percent is more here. Actually, soya bean which is having low oil content but physical structure is particularly suited to solvent extraction. So that is the reason the solvent extraction has been developed because soya beans the oil content is less and then when the oil content is less doing mechanical extraction may not be feasible. So that is the reason the solvent extraction method has been developed because the solvent can be recovered again and then recycled back. So by this solvent extraction method if you do the extraction of oil from the soya bean you can get almost 98 percent or even higher oil yield. So once this solvent extraction method was developed for the soya bean because of its physical structure as well as the oil content the same has been found to be suitable for many other oil industries getting oil from the different sources. So solvent extraction has assumed

importance in virtually all vegetable oil recovery processes either alone or in combination with pre pressing or mechanical methods. That is the importance of the solvent extraction method. In cottonseed oil extraction hexane solvent is sprayed onto flakes in buckets moving horizontally in the extractor counter current to the hexane we have already seen but once again we see schematically this one. Hexane dissolving the oil is known as the miscella. So from this miscella you recover the solvent and then reuse it and then crushed or solvent extracted finished oil you further do the hydrogenation etc as per the requirement.

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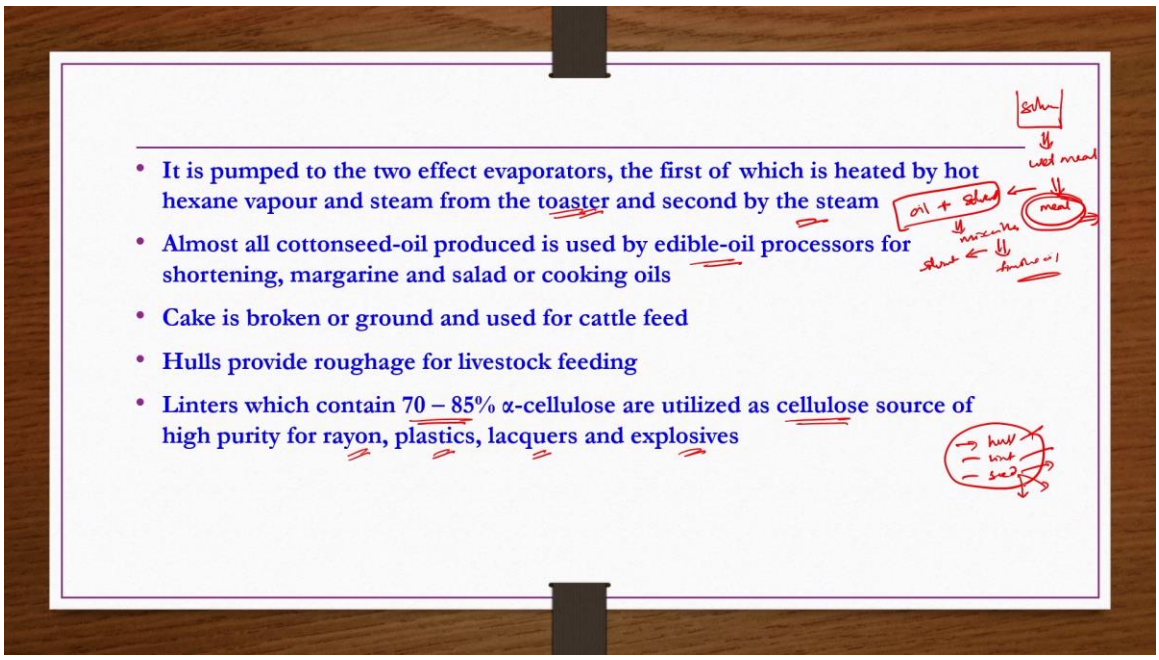

This miscella is pumped to the two effective operators in order to recover the solvent. In the first evaporator which is heated by the hot hexane vapour and steam you know some purification takes place. So how this hot hexane vapour and steam are coming they are coming from the toasters. Toasters are nothing but desolventonizer of the meal or actually after the solvent extraction whatever the wet meal you get. So from here if you remove the solvent that meal is going to be useful for the other purposes because it is very rich in the protein but the solvent whatever is we are calling it is also having you know oil it is actually oil rich phase. So, this oil rich phase with solvent is there whatever that is nothing but the miscella. This you do the purification to remove the solvent and then finished oil you get here. So, for this removing of the or recovery of the meal from the wet meal you have certain kind of toasters. Almost all cotton seed produced is used by edible oil processes for shortening margarine and salad or cooking oils purpose. Cake is broken or ground and used for cattle feed. Hulls provide roughage for the livestock feeding and then linters which contains 70 to 85 percent alpha cellulose are utilized as

cellulose sources of high purity in the textile industries to make the rayons or in the plastics industries or in the paints and varnishes industries as lacquers or even in the explosives also it is used. So now you see hull, lint, seed all three components of cotton seed are you know very essential. So, all of them are having certain applications. So, this cleaning and purification is also very essential step in the in this particular oil production by cotton seeds.

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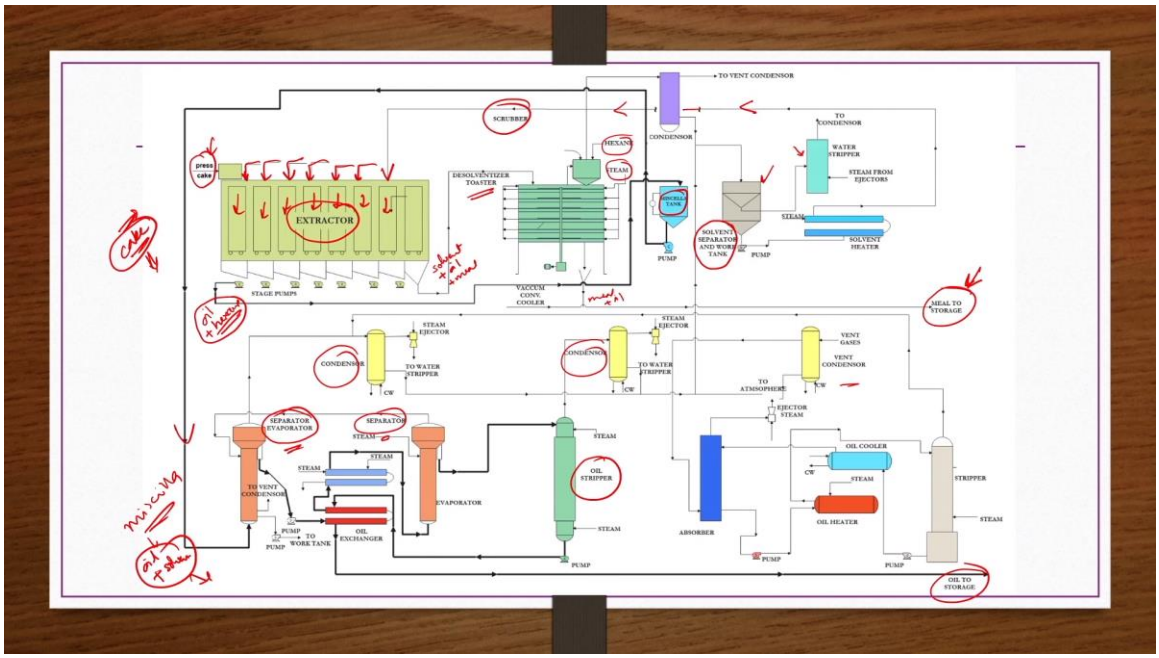

Schematically if you see the same thing here so you have a extractor. To this extractor press cake is coming. Press cake in the sense either you do the pressing of the seeds and then give them as a feed to the extractor or if you are using in combination with mechanical methods whatever the cake that is coming from the mechanical method where you get almost 90 to 90 percent or 80 percent of the oil extracted and then remaining 10 to 20 percent of oil only there in that cake. Let us say that is also essential so you cannot throw it so that you are processing so that cake is to be taken as a feed here either way. So, if you are doing only solvent extraction here what you do the seeds that you press it and then whatever the cakes are forming because of the pressing that you take into the extractor as a feed. So these extractors you know taken here and then solvent is being sprayed from the top. It is one of the representation only. So other representation we have seen previously in the previous lecture. We are going to see one different types of representation in the next vegetable oil production in this class itself. So here the extraction takes place. So, when the extraction takes place whatever the oil rich phase with solvent hexane is there here hexane solvent is used. So that is nothing but miscella. So that is collected from the bottom and pumped to miscella storage tank. Whereas the

solvent rich phase plus some amount of oil and meal etc. may be there. The solvent now here it is not pure one. So that is also collected and then sent to desolventonizer toaster to which you providing the energy either by the steam or by the hot n-hexane solvent or by both. If you are using single effect evaporator or double effect evaporator you can use either of the heat sources because in this evaporation actually this toaster is nothing but the evaporator. For that you need energy that energy you can provide either by steam or using the hot n-hexane because n-hexane is already there so that can also be used for the heating purpose here in the evaporators. So, from here whatever the meal etc. that you collect which is having little amount of oil also so that is taken to the meal storage. So, after recovering the meal the next step is the from the miscella tank you take the micellar and then pump it to the purification steps here. So, you have the separator evaporator and separator etc. So here in this step or the steps that are shown in the bottom primarily you are trying to purify the oil because this miscella is rich in oil plus some amount of solvent or n-hexane is there. So that solvent you are trying to evaporate by this evaporators here again. So whatever the oil that is there so that oil you take to the oil stripper here you check the condition of the oil after the stripping of the solvent. If that oil is of sufficient requirement or the solvent quantity is negligibly small so then that you can take it to the oil storage or otherwise you redo the process again until that solvent in the oil reduces to the permissible limits. Whereas from the desolventonizer toaster whatever the solvent after removing the meal and oil content and taking the meal storage whatever the remaining solvent is there that is taken to a condenser. Then from the condenser it is taken to the solvent separator and work tank with the two tanks are there. So here the required solvent recovery is done that requires steps of solvent recovery after doing so that whatever the solvent is there so after scrubbing that solvent it is again sent back to the extractor as a reuse. So here in the process of this extractions you know lot of steam may be there or vent vapors would be there which would be at high temperature. So, a kind of condenser or you know cooling is required so for that you know different types of condensers or you know vent condensers are provided here. So now here again if you see solvent extraction followed by you know purification of the miscella or separation of the miscella into the oil and solvent those steps are there in addition to that one desolvent toaster step is also there. So this is about the cotton seed oil production from the solvent extraction method followed by the recovery of the solvent.

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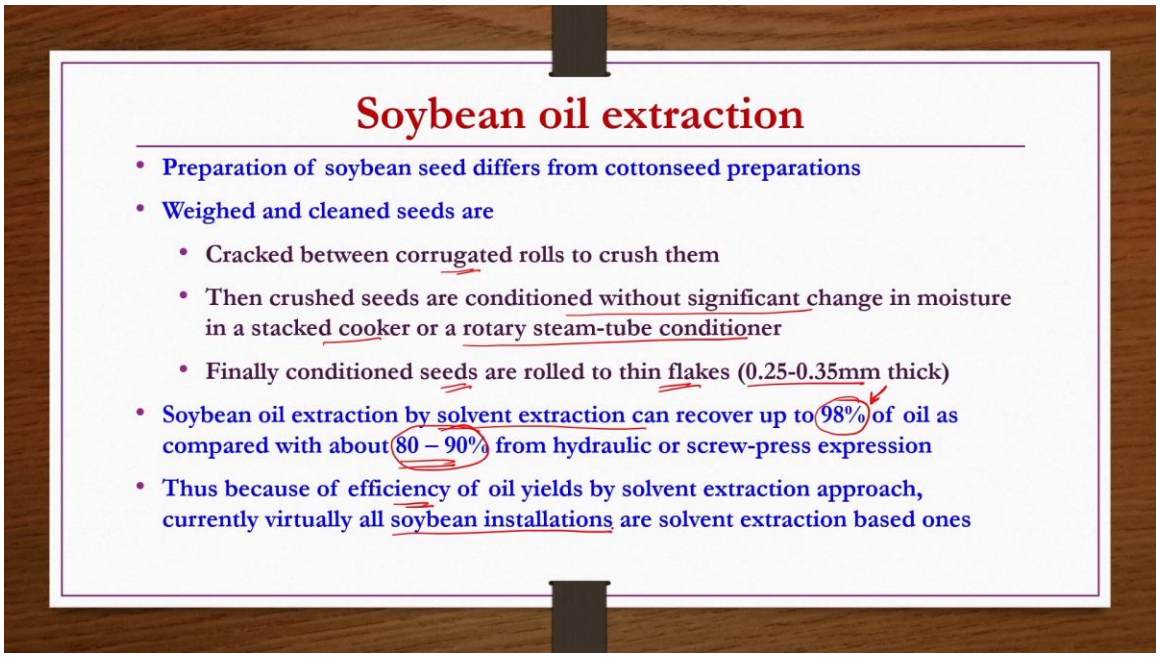

Next is soya bean oil extraction. Preparation of soya bean seed differs from cotton seed preparation how it differs that we have seen. Wade and clean seeds are cracked between corrugated rolls to crush them then crushed seeds are conditioned without significant change in moisture in a stacked cooker or a rotary tube conditioner. Finally conditioned seeds are rolled to thin flakes having 0.25 to 0.35 mm thick. Then soya bean oil extraction by solvent extraction can be done to recover up to 98 percent of the oil as compared to 80 to 90 percent of oil from hydraulic or screw press expressions. The soya bean oil content is usually less so mechanical approach cannot recover all of the oils whereas the solvent extraction method recovers almost up to 98 percent of the oil. Thus because of efficiency of oil yields by solvent extraction approach currently virtually all soya bean installations are solvent extraction based ones. However, combination of a mechanical and solvent extraction methods are also being adopted in several plants as well.

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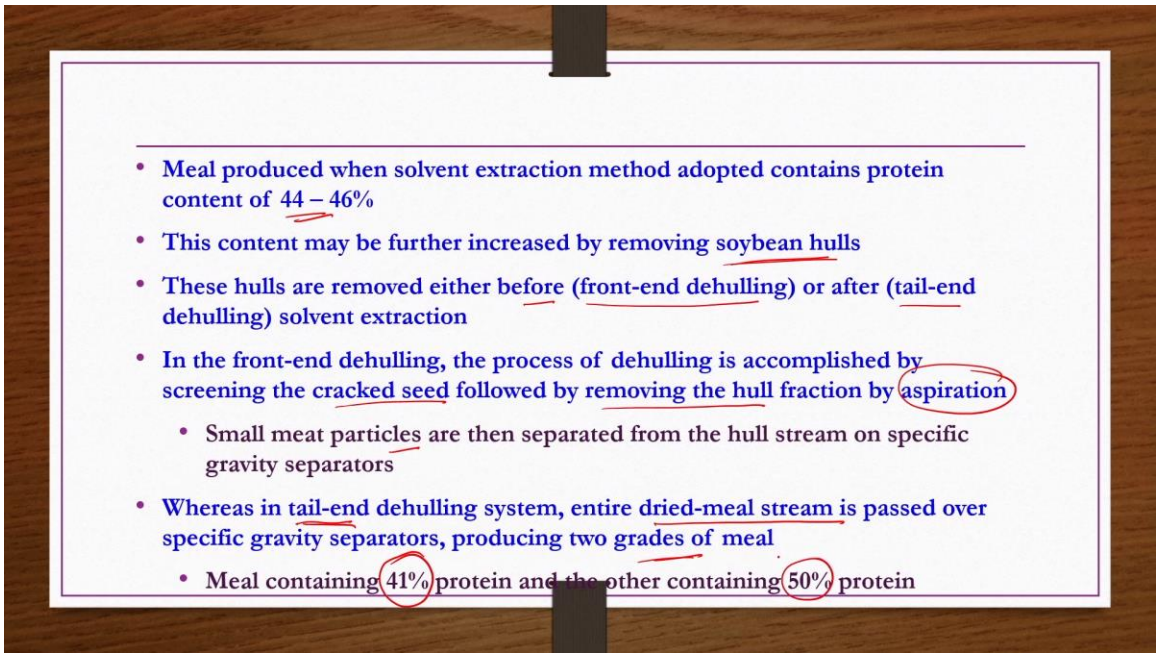

Meal produced when solvent extraction method adopted contains around 44 to 46 percent. So that is very high percent high protein percentage there if the protein percentage is very high. So, extraction by mechanical method is not possible. That is the reason the extraction of soya bean oil by mechanical methods it gives only 80 to 90 percent of the oil because of this high protein content. However, this protein content may be further increased by removing soya bean hulls. These hulls are removed either before or after solvent extraction step. If you are doing this removal before the solvent extraction they are known as front end dehulling. If you are doing after the solvent extraction the same is known as the tail end dehulling. In the front end dehulling the process of dehulling is accomplished by screening the cracked seed followed by removing the hull fraction by aspiration. Small meat particles are then separated from the hull stream on specific gravity separators whereas tail end dehulling system entire dried meal stream is passed over specific gravity separators producing 2 grades of meal. What are these 2 grades of meal? One containing 41 percent protein other one containing 50 percent protein.

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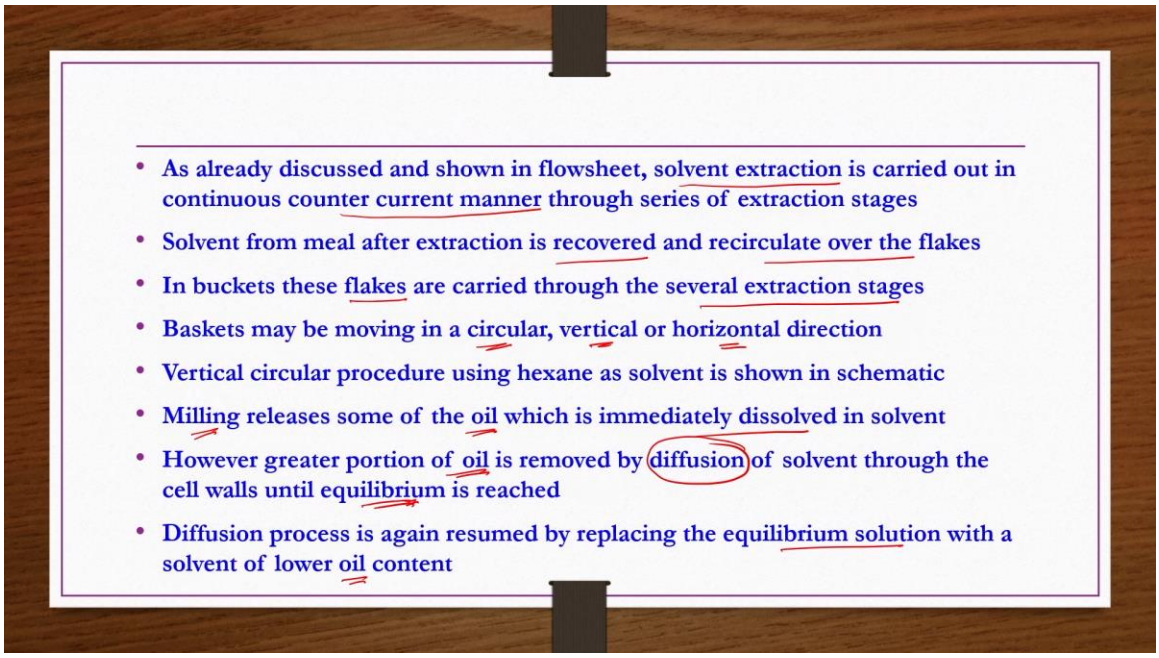

So as already discussed and then shown in the flow sheet in the next slide solvent extraction is carried out in a continuous counter current manner through series of extraction stages. Solvent from meal after extraction is recovered and recirculated over the flakes again so that to avoid the solvent losses. In buckets these flakes are carried through the several extraction stages pictorially we are seeing the same thing in the next slide anyway. Baskets may be moving in a circular, vertical or horizontal direction vertical one is shown in the next slide. Then milling releases some of the oil which is immediately dissolved in the solvent. However greater portion of oil is removed by diffusion of solvent through the cells or through the cell walls until the equilibrium is reached. Though the milling provides or releases some of the oil it releases only some of the oil. Major of the oil content is obtained by the diffusion of solvent through the walls of the cells and to the meat and then extracting the oil that occurs until the equilibrium is reached. Once equilibrium is reached then what you can do you can replace the equilibrium solution with a solvent having lower oil content because you are recycling it when you recycle the solvent after recovery or purification you may not be having completely pure solvent or you may not required also because you are reusing as a kind of solvent again within the process where the oil extraction is taking place. So if the solvent is having some amount of oil it is not going to be lost anyway. Otherwise for every batch if you are using fresh n hexane solution it is not going to be economically feasible process.

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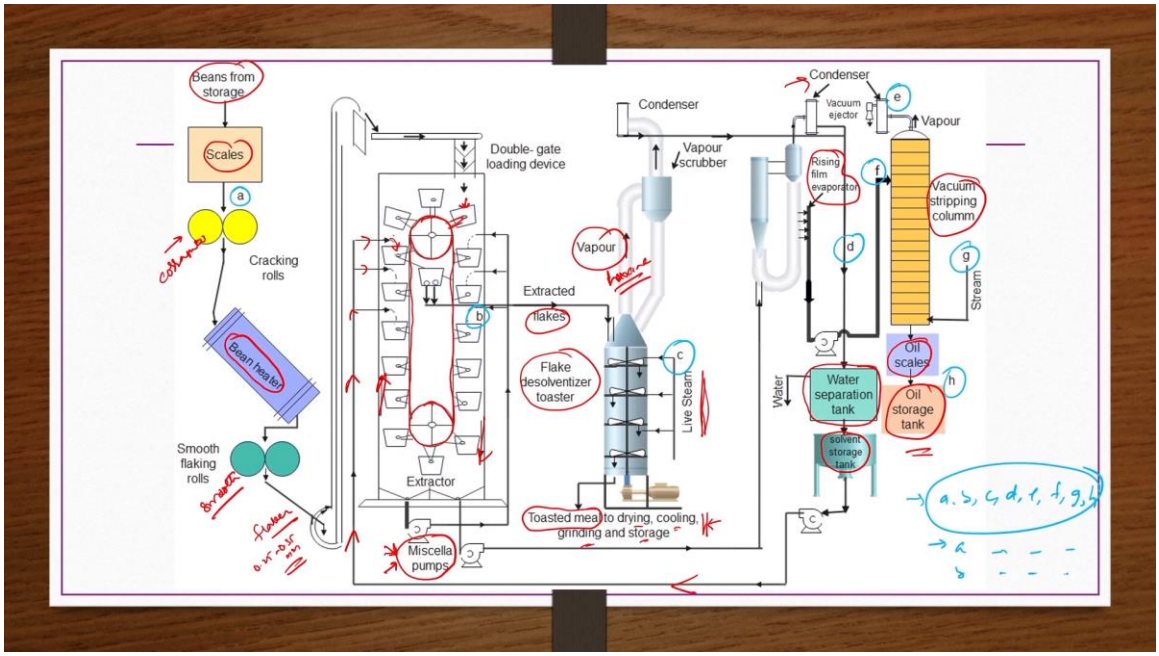

So, the pictorially the same process is shown here. Now here we discuss in detail so that we can easily understand the things. Whatever the beans are there from the storage you do the scaling and then pass through corrugated rolls or smooth rolls as per the requirement. Then whatever the flaked seeds are there you take to the bean heaters and then you pass through smooth flaking rolls. These are the corrugated ones whereas these are the smooth rolls. So, from here flakes you get which are having thickness 0.25 to 0.35 mm. So, when the thickness is so less then permeation of the solvent through the cell walls is going to be effective. So, these flakes or flaked oil seeds are taken to the top and then from the top they are dropped onto the buckets. These buckets are moving because they are connected to two rolls which are rotating and then these two rolls are connected by a shaft or belt and then to the shaft these buckets are being connected. That means these buckets are fixed to the shaft or rotating belt. So then when this belt rotates these buckets are also rotating accordingly. So here what happens when the material comes whatever the flaked seeds are there they comes here to those buckets solvent the solvents are also being supplied. So, let us say the material is coming here solvent is provided here. The solvent is provided to the buckets in which you are taking the flaked seeds. So then solvent extraction takes place and then this continues as it moves down up to this one. So, the moment it comes here the oil you know again it moves in the upward direction like this. So, the continuous process of taking the flaked seeds and then supplying the hexane to the buckets continuously takes place. So after equilibrium has established then whatever the extractor is there from there miscella is collected. This miscella is collected and then depending on its oil content and then n-hexane content if it is more in oil content then that you take to the rising film evaporator to remove the

solvent from the miscella and get pure oil or you know finished solvent extracted oil. If the n-hexane content is more in the miscella then what you do you try to pump the same thing to the buckets from one side you feed the n-hexane from the other side you feed the miscella to the buckets that depends on the composition of the miscella. If the miscella composition is rich in oil then you take to the rising film evaporator otherwise you do the recycling that is the basic. Because the after the extraction flakes are there those flakes are taken to flake desolventonizer toaster. Here what you try to do you try to supply the steam and then remove the solvent from here because out of these components of flakes and then extracted flakes out of the components hexane or the solvent that is the more volatile. If that comes into interaction with the steam it will evaporate and then vapors would form and those vapors would be condensed and collected. As you know almost if not pure n-hexane almost clear pure n-hexane you get. Whereas from the bottom toasted meal you get which you can do the drying, cooling, grinding and then storage for and then use it as a different purpose because it is a toasted meal. Other step let us say a miscella if it is rich in the oil then you take to rising film evaporator here again you try to supply the energy by steam so that the evaporation takes place and then when the evaporation takes place n-hexane is more volatile than the oil that is present in the miscella. So that would be that n-hexane would be coming as a top product and then that would be condensed and collected as a solvent and then it will be taken to the water separation tank because whatever the solvent you get after the rising film evaporator that may also contain some water from where it is coming because this water is coming from the seeds. Seeds may be having some contents of moisture so that may be joining with the solvent and then that has to be removed before recycling the solvent. After removing the water whatever the solvent is there that is taken to the solvent storage tank and then it is fed back again to the extractors as shown here. From the bottom of the rising film evaporator what you get? You get a phase which is rich in oil so that you pump to vacuum stripping column to check if at all still n-hexane is present that would be evaporated and then condensed and then mixed with the recovered solvent. Whereas the oils which would be heavier product they will be collected from the bottom of the vacuum stripping column and then taken to the oil storage tank. In this flow sheet other thing to observe is these notations like A, then B, then C, then D, then E, then F, G, H. These A, B, C, D, E, F, G, H these are streams what are their composition and then energy level etc those things are there. So, when you prepare a proper engineering or simplified engineering flow sheet you have to give the proper material and energy balance also. So then for that purpose you have this labeling of streams like this and then you try to write down what is the corresponding composition energy etc within the flow sheet. But however, it is not shown here.

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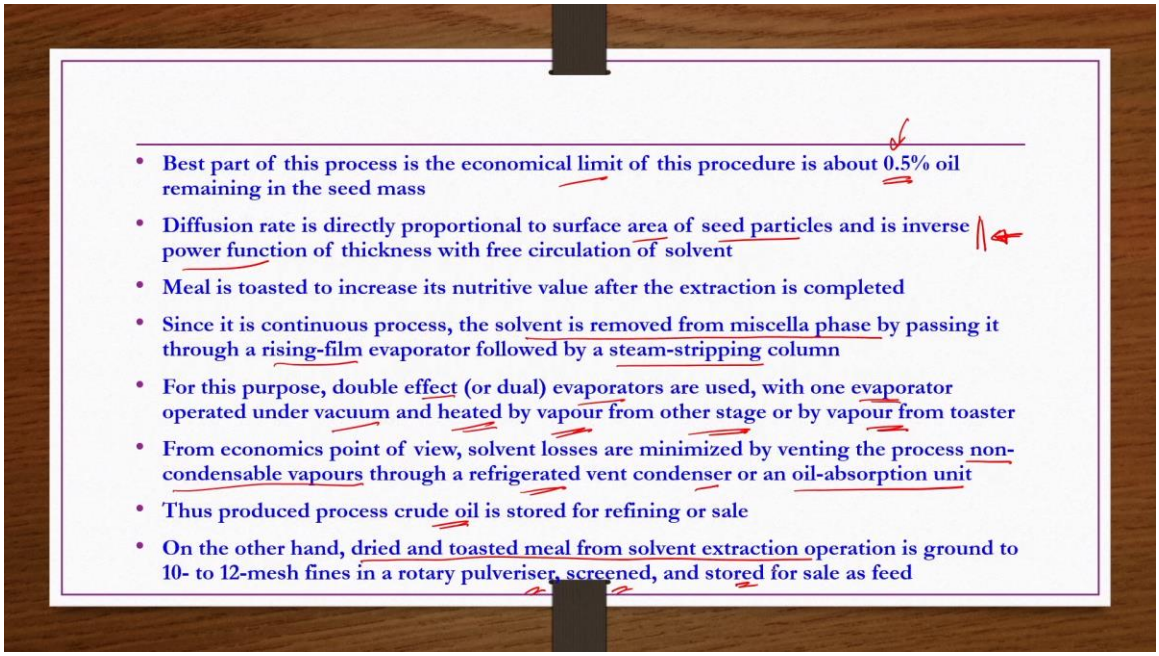

Now we see a few more details of the same process soyabean oil extraction by solvent extraction process. Best part of this process is the economical limit of this pressure which is about only 0.5 percent of oil remaining in the seed mass. Actually, the soyabean oil when you do the extraction in the seed the content of oil is very less compared to the other seeds around 40-45 percent only there. From there if you recover as much as possible it is going to beneficial and then that is the best part of this one. After solvent extraction in the remaining mass you get only 0.5 percent of oil. Diffusion rate is directly proportional to the surface area of the seed particles and it is inversely proportional to the power function of thickness with free circulation of the solvent. These numbers are coming from the engineering calculations of the process but that we are not doing in this course that is not part of the course. Meal is toasted to increase its nutritive value after the extraction is completed. Since it is continuous process solvent is removed from the miscella phase by passing it through a rising film evaporator followed by steam stripping column as just we have seen in the flow chart. For this purpose double effect or dual evaporators are used. One is one evaporator operated under the vacuum and then heated by vapor from other stage or by vapor from the toaster. From economics point of view solvent losses are minimized by venting the process non-condensable vapors through a refrigerated vent condenser or an oil absorption unit as we have seen in the flow chart. It is clearly shown in the flow chart. Thus, produced process crude oil is stored for refining or sale purpose. On the other hand, dried and toasted meal from solvent extraction operation is grown to 10 to 12 mesh fines in a rotary pulverizer screened and stored for sale as feed. So this is all about soyabean oil extraction. So, we have seen specifically cotton seed oil production as well as the soya bean oil production. Now quickly we see

couple of more which are similar process so we do not discuss by flow chart but we see important points of these vegetable oils.

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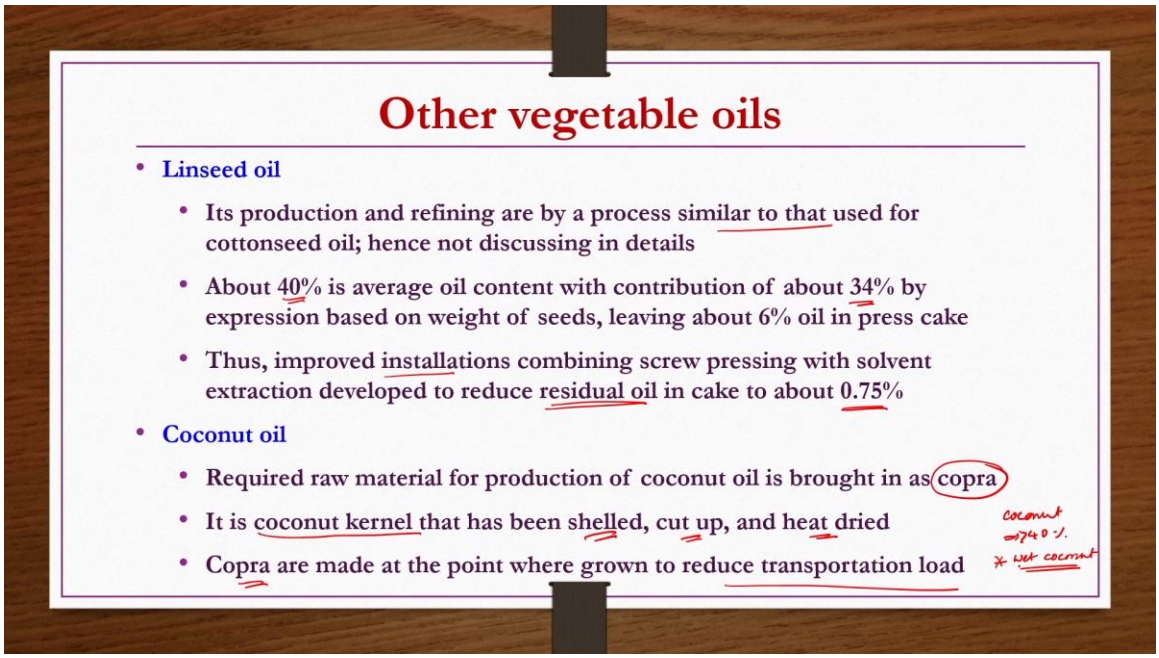

Linseed oil its production and refining are by a process similar to that used for cotton seeds so we are not discussing in detail. About 40 percent is the average oil content with contribution about 34 percent by expression based on weight of seeds leaving about 6 percent oil in press cake. Thus improved installations combining screw pressing with solvent extraction developed to reduce residual oil in the cake to about 0.75 percent only. When the oil content in the seed is less it is better to make sure that as much as you can extract and then in the residual cake there should be negligible oil present. So that is possible when you do the combination of the process that is combination of mechanical and solvent extraction process. Since this already we discussed details flow sheet etc similar to cotton seed we are not discussing again. Next is the coconut oil required raw material for production of coconut oil is brought in as copra which is nothing but coconut kernel that has been shelled, cut up and heat dried. Why are we doing this one? We do actually this copra making at the point where the plants or trees are grown so that to reduce the transportation load. In the coconut you usually see 40 to 45 percent or more moisture content would be there. If you are transporting you know that is that moisture content is not contributing to the oil. So, if you are transporting that entire one so then you are unnecessarily paying transportation charges for the 40 percent of the extra weight. So, what you do? You try to remove that one there in the plants growing stage only and then reduce that water content moisture content as much as possible so that the transportation cost reduces. Not only transportation cost if you keep this wet coconut for

long term without processing what will happen? You know deterioration of oil content will take place. So that is again not good.

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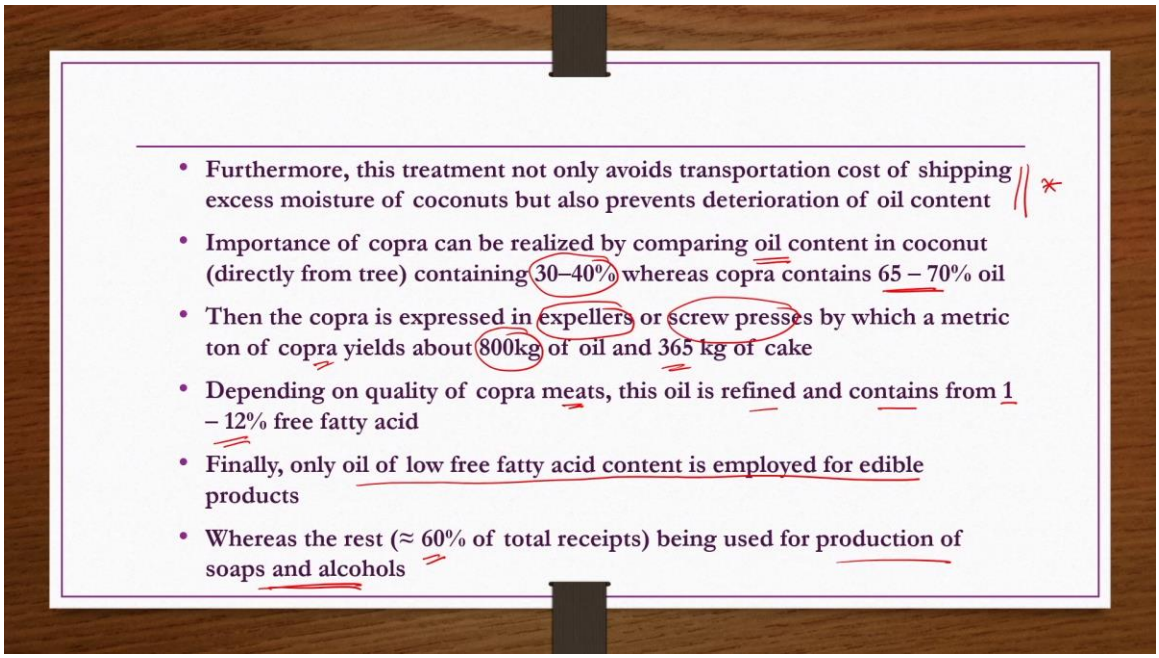

So, because of both the reasons these are being you know copra is being made at the plants growing area only. Importance of copra can be further realized by comparing oil content not only by the transportation and the deterioration of oil content in the wet stage storage but also other thing is that copra if you take around 65 to 70 percent oil content would be there. If you take the raw coconut only 30 to 40 percent oil content would be there in that one. Then the copra is expressed in expellers as we have already seen or screw presses by which a metric ton of copra yields around 800 kgs of oil and 365 kgs of the cake. Depending on quality of copra meats this oil is refined and contains 1 to 12 percent of free fatty acid which is good for the as a cooking oil. Finally, only oil of low free fatty acid content is employed for edible products whereas the rest remaining 60 percent of total receipts being used for production of soaps and alcohols in general.

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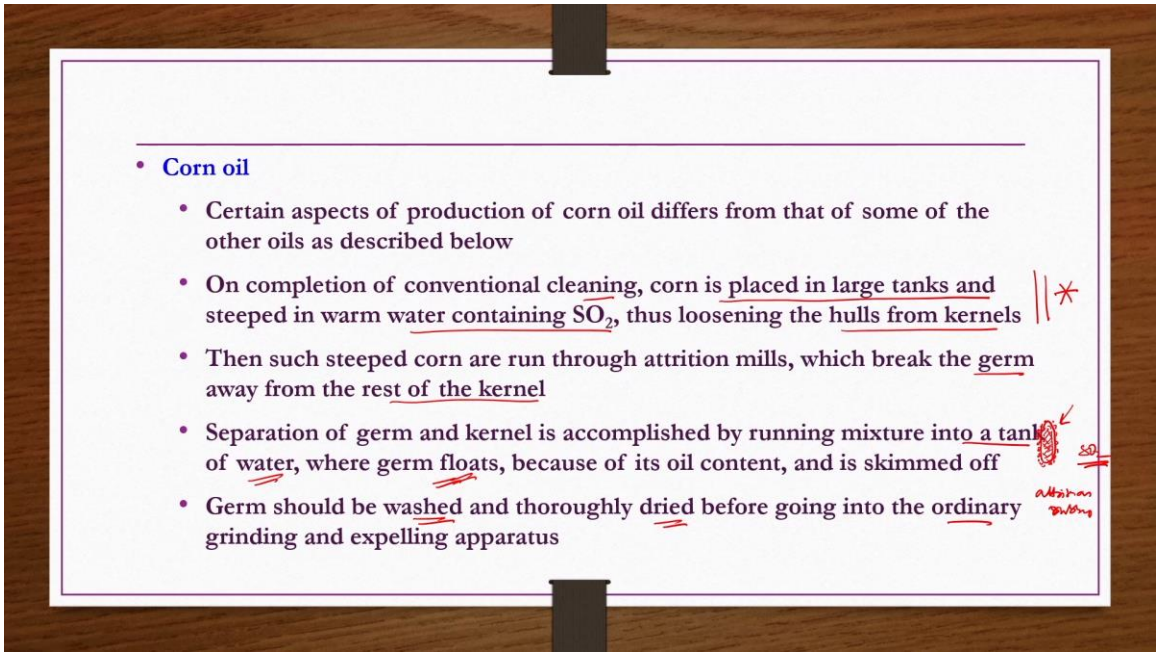

Next is the corn oil. Certain aspects of production of corn oil differs from that of some of the other oils that primarily in removing the germs. This is like shell, this is like maybe corn this thing. Now to this one these germs of the corns are there. They are you know attached to the surface very strongly that removal is very difficult. So for that what you do? You do cooking or soaking in a water container where SO2 is also provided. So that loosening of these germs would take place. So, on completion of conventional cleaning corn is placed in large tanks and steeped in warm water containing SO2 thus loosening the hulls from kernels will take place. Once the loosening of hulls from the kernels takes place you can do the attrition. Attrition is nothing but the rubbing kind of action. So, when you do this one you know they can be which break the gem away from the rest of the kernel easily by this attrition. That is possible when you do this step. That is the important difference compared to the other processes. Then what you do? The mixture whatever is there the germs and then kernel etc. you separate out. How you do separation? By running the mixture into a tank of water because of the density difference germs are you know floating because of their oil contents and then oil content density is low. They will be floating and then they should be skimmed off. So, then what you do? You further do the drying etc. washing the germs and then thoroughly drying etc. is required before taking them into the ordinary grinding and expelling operators as we have discussed for other oils productions.

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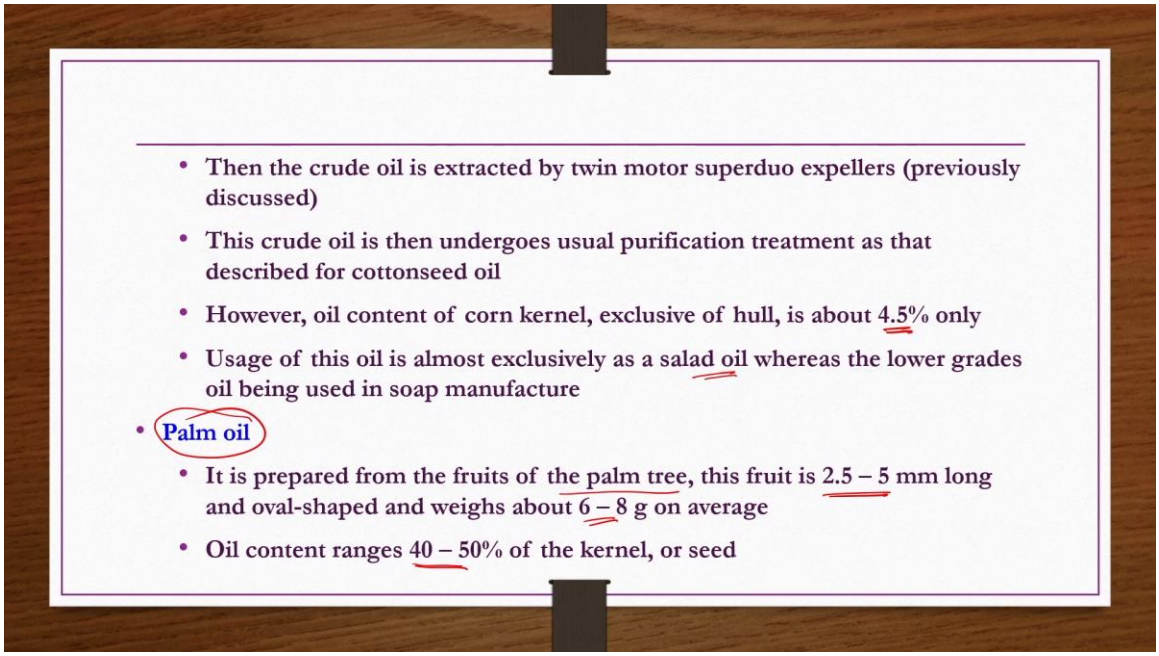

Then the crude oil is extracted by twin motor superduo-expellers as explained earlier. This crude oil is then undergoes usual purification treatment as that described for cottonseed oil. However, oil content of corn kernel exclusive of all is about 4.5 percent only. Usage of this oil is almost exclusively as a salad oil whereas the lower grades oil being used in soap manufacturing. Next is the palm oil. It is prepared from the fruits of the palm tree. This fruit is around 2.5 to 5 mm long and oval shaped. It weighs about 6 to 8 grams on average. Oil content ranges around 40 to 50 percent of the kernel or seed because in the fruits also some oil is there. So, in the palm oil not only from the fruit but also from the kernel and seed also you have to extract.

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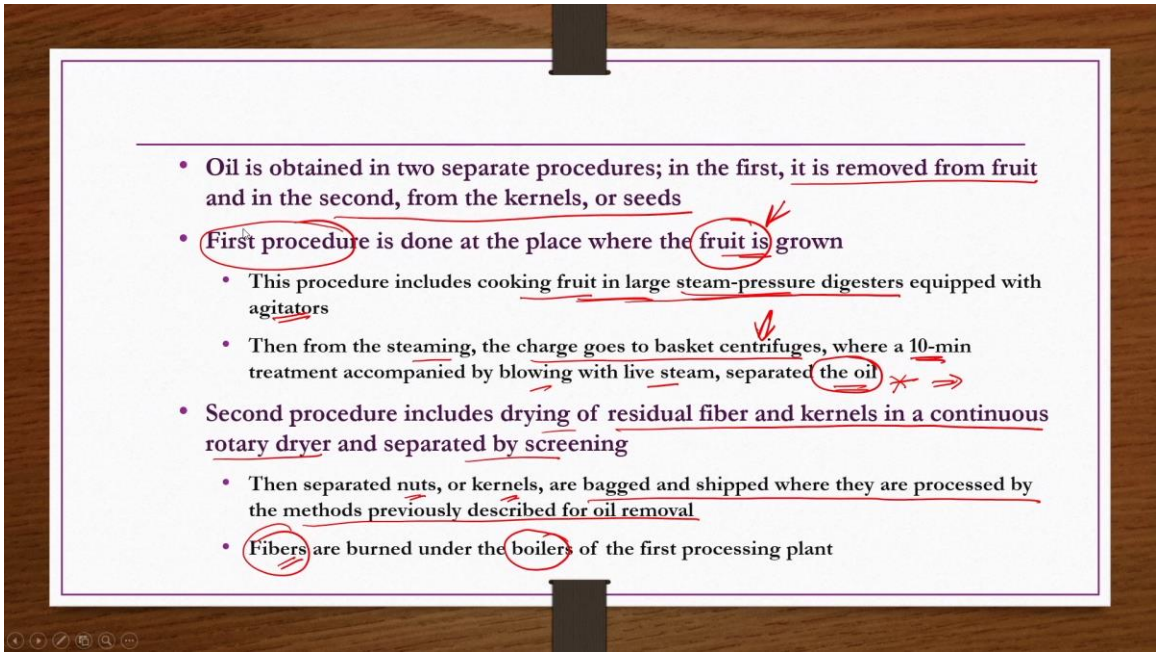

Oil is obtained in two separate processes. In the first oil is removed from the fruit and in the second it is removed from the kernels or seeds. How it is done? The first procedure is done at the place where the fruit is grown because of the same reasons as in the case of coconut oil production. Rather taking coconut you make them as copra at the plant site at the tree's location and then do the other subsequent process. Same thing is done is here also but the process is slightly different. What you do here? Here it includes the cooking fruit in large steam pressure digesters equipped with agitators. Then whatever the mixture is there wet meal is there that you do the centrifugation. Then from the steaming the charge goes to the basket centrifuges where 10 minutes treatment accompanied by blowing with live steam separates the oil. So that is the first step from the fruit how you get and then you preferably you do it at the plant location at the locations where the palm trees are present. Second procedure includes drying of residual fiber and kernels in a continuous rotary dryer and separated by screening. Then separated nuts or kernels are bagged and shipped where they are processed by the methods previously described for oil removal whether it is mechanical method or solvent extraction method. In the first method you try to do where the plants are growing that because you are getting them from the fruits. From the fruits what you do? Fruits you are doing the digestion or cooking of the fruit you are doing using the steam high pressure steam digesters. Whatever the wet meal is coming out from the digester that you do the centrifugation. When you do the centrifugation the oil separates out as a lighter phase heavier phase whatever cake is there that is separated out and then taken as a product. This oil you can directly take to the further processing of hydrogenation etc if required. Second step because in the palm oil it is not only the fruit but also hulls and then seeds are also used

to get the oil. So here what you do? You do the drying of residual fiber and kernel in a continuous rotary dryer and separated by screening and after that conventional mechanical or solvent extraction methods may be adopted based on the economic conditions. Fibers whatever are there they are usually taken as a solid fuel to the boilers of the first processing plant where from the fruit you are taking you know oil. From the fruit you are trying to get extraction whatever the first step is there for that purpose these fibers are used as a solid fuel for the boilers used for the first pressure that is extraction of oil from the fruits. So that is all about the extraction of vegetable oils.

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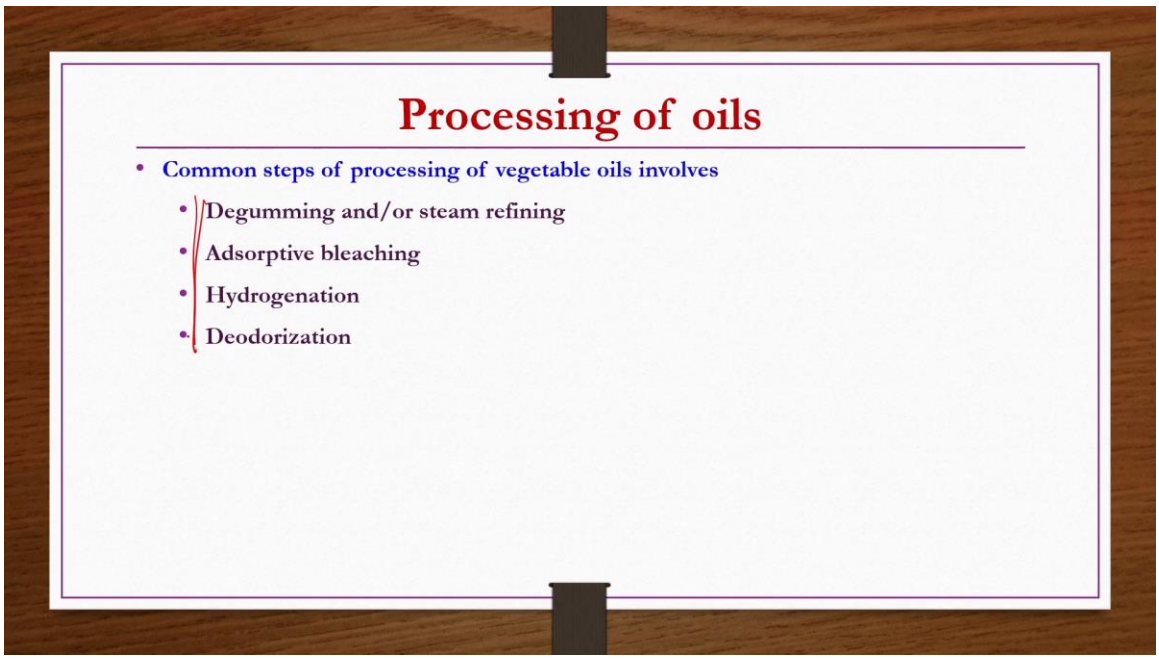

Next is the processing of oils. Now here in this lecture we will be seeing only the important steps of the processing oils whereas the details of each of the steps we will be discussing in the next lecture. If you see important steps of processing of oils or common steps of processing of vegetable oils include degumming and or steam refining, adsorptive bleaching, hydrogenation and deodorization. We stop our today's lecture here and then details of each of these steps we are going to discuss in the next lecture.

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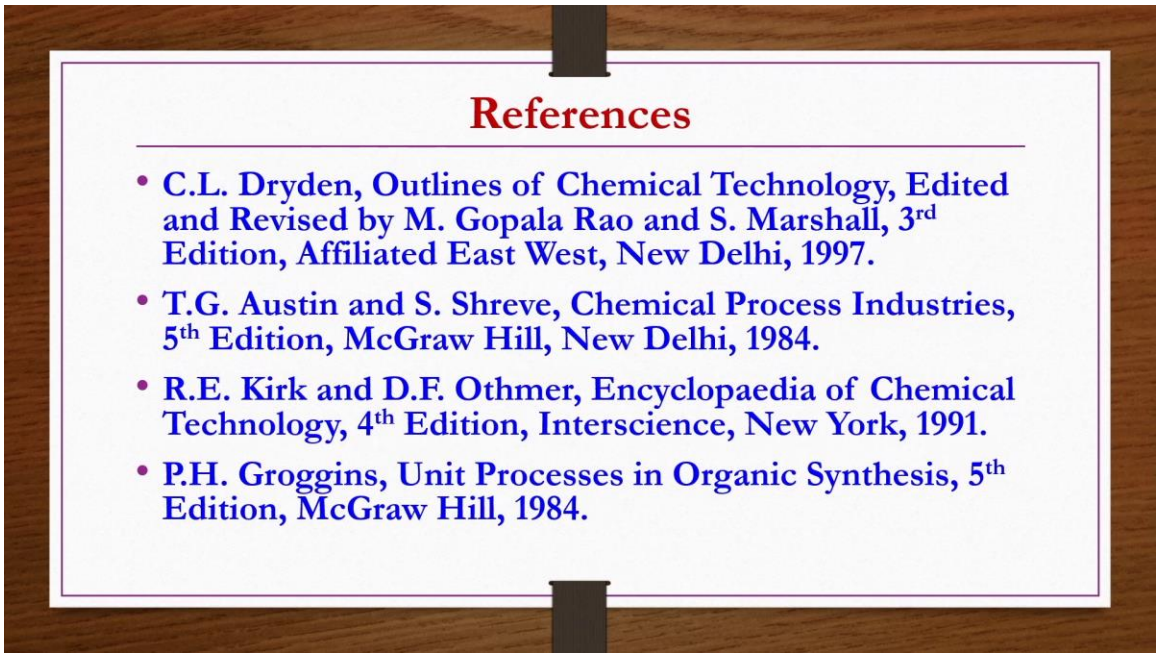

The references for today's lecture are provided here. Outlines of chemical technology by Dryden edited and revised by Gopala Rao and Marshall third edition. Chemical process industries by Austin and Shreve fifth edition. Encyclopedia of chemical technology Kirk and Othmer fourth edition. Unit processes in organic synthesis by Groggins fifth edition. Thank you.