

Food Oils and Fats: Chemistry & Technology
Professor H N Mishra
Agricultural and Food Engineering Department
Indian Institute of Technology Kharagpur
Module 5 : Solvent Extraction of Edible Oils
Lecture 24 : Miscella Distillation and Meal Desolventization



NPTEL ONLINE CERTIFICATION COURSES

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Module 5 : Solvent Extraction of Edible Oils

Lecture 24 : Miscella Distillation and Meal Desolventization

Concepts Covered

- Post extraction processes
- Oil recovery from miscella – principles & methods
 - ✓ Distillation, evaporation, membrane filtration, absorption
- Meal desolventization
 - ✓ Desolventing, toasting, drying, cooling
 - ✓ Meal desolventizer-toaster



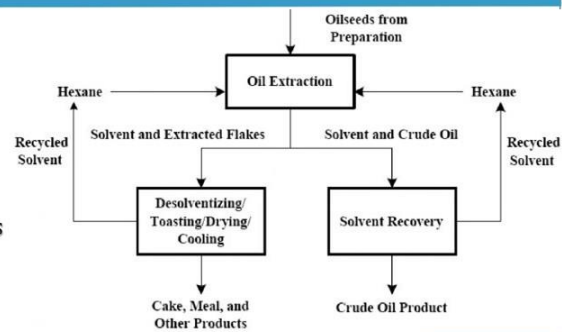
IIT Kharagpur

Hello everybody. Namaskar. Now, in the 24th lecture of the course today, we shall discuss miscella distillation and meal desolventization. In this lecture, we will discuss the post-extraction processes. In the last classes, earlier class, we discussed solvent extraction technology and the various types of extractors. Once the oil is extracted by the

solvent extraction process, it needs to be further processed that is because the solvent has a certain quantity of oil mixed with it which is the miscella. So, we need to recover oil from the miscella. So, in today's lecture, we will discuss about post extraction processes, oil recovery from miscella, what are the principles and various methods of oil recovery like distillation, evaporation, membrane filtration, absorption, and etcetera. And then another important aspect like we get miscella, we also get the de-oiled cake, de-oiled oil seed material that is normally called meal and this meal also has around 25 to 35 percent solvent in it. So, the meal desolventization is another crucial aspect. So, we will discuss the desolventization techniques, toasting, drying, cooling, and finally, the meal desolventizer toaster which is the latest development in the technology.

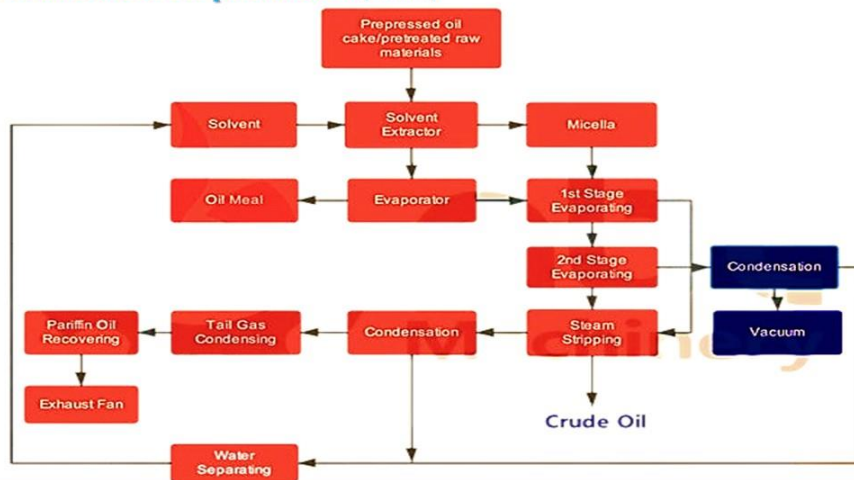
Post extraction processes

- The basic process in oil extraction is to immerse oil flakes (or pre-pressed cakes) in selected solvents, dissolve oil in solvents (composing mixed oil), then separate the mixed oil from solid residues (meal), evaporate and strip the mixed oil according to different boiling points, so that the solvent vaporizes and oil separates, thus obtaining oil (extracted crude oil).
- The solvent vapour is recycled after condensation and cooling.
- The meal also contains a certain amount of solvent.
- After desolventization, the meal can be dried. The solvent vapour volatilized during desolventization and drying is recovered by condensation and cooling.



So, you see the post-extraction process as I told you after the oil extractions, we get miscella and we get that meal and both they have the solvent. So, the solvent needs to recover from this. So, the basic process of the oil extraction is to in the earlier class, we discussed immersing oil flakes or pretest cakes in selected solvents. These solvents dissolve oil into it, which is miscella, and then miscella is obtained and cake is obtained which also has the solvent. So, the solvent vapors are collected or distilled, the miscella is distilled and that solvent is vaporized and then solvent vapors are recycled after condensation and cooling. And the meal as I told it also contains around 25 to 35 percent solvent. So, after desolventization, the meal can be dried, and it is a very good food protein, it contains protein and other components. So, the desolventization process should be conducted in such a way that the eating qualities of the proteins remain intact. The solvent vapors volatilized during this desolventization process and drying is recovered by condensation and cooling.

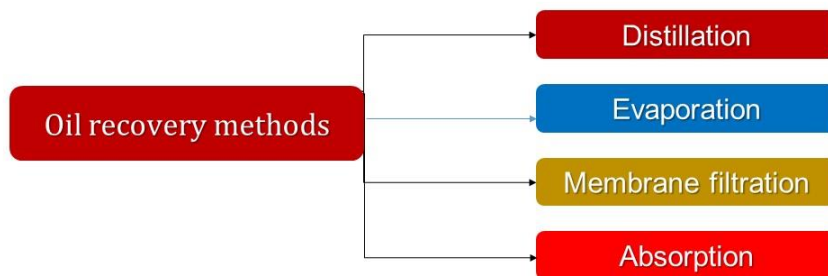
Post extraction processes (Contd...)



So, here again, in this figure, I have shown the different stages in the industry which is used for the desolventization of the meal as well as the distillation of the miscella.

Oil recovery from miscella

- Recovery of oil in miscella is an important step to obtain crude oil.
- The main focus is to remove the solvent from the miscella and to use the solvent for another oil extraction.
- There are various methods to perform the oil recovery from miscella.



First, we will take up oil recovery from miscella. Recovery of oil is an important step to obtain crude oil as I told you and it is our effort that the oil should be triglyceride and should be as free as possible from any impurities that the last traces of the solvent should be removed from the miscella. There are various methods that are used for recovery of solvents and those may be distillation, evaporation, membrane filtration, and absorption. We will take up one-by-one these processes.

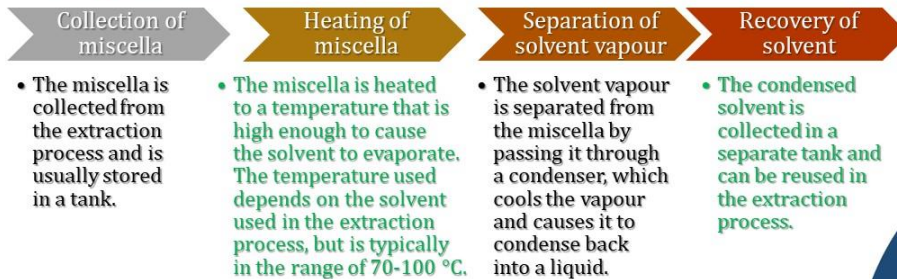
❖ Distillation

- Distillation is a common method used for separating the solvent from the miscella to obtain the oil in edible oil extraction processes. In this method, the miscella containing the solvent and the extracted oil is heated to a temperature where the solvent evaporates and can be collected separately.
- The distillation process typically involves the use of a distillation column or still, which is a tall vertical vessel with multiple trays or plates. The miscella is introduced into the top of the column and heated. The solvent, which has a lower boiling point than the oil, evaporates and rises up the column, where it is cooled and condensed into a liquid in a separate condenser unit. The condensed solvent is then collected and reused in the extraction process.
- The oil, which has a higher boiling point than the solvent, remains in the bottom of the column as a residue, and can be collected separately. This process may be repeated multiple times to increase the efficiency of the solvent recovery and oil extraction.
- One advantage of the distillation method is that it allows for efficient recovery of the solvent, which can be reused in the extraction process, reducing solvent waste and costs. However, the process may require high energy input and careful control of the distillation parameters, such as temperature and pressure, to prevent degradation or loss of the extracted oil.

Distillation is a common method used for separating the solvent from the miscella to obtain the oil in edible oil extraction processes. In this method, the miscella containing the solvent and the extracted oil is heated to a temperature where the solvent evaporates and can be collected separately. The distillation process typically involves the use of a distillation column or still, which is a tall vertical vessel with multiple trays or plates. The miscella is introduced into the top of the column and heated. The solvent, which has a lower boiling point than the oil, evaporates and rises up the column, where it is cooled and condensed into a liquid in a separate condenser unit. The condensed solvent is then collected and reused in the extraction process. The oil, which has a higher boiling point than the solvent, remains in the bottom of the column as a residue, and can be collected separately. This process may be repeated multiple times to increase the efficiency of the solvent recovery and oil extraction. One advantage of the distillation method is that it allows for efficient recovery of the solvent, which can be reused in the extraction process, reducing solvent waste and costs. However, the process may require high energy input and careful control of the distillation parameters, such as temperature and pressure, to prevent degradation or loss of the extracted oil.

❖ Evaporation

- The evaporation is another commonly used method to separate the solvent from the miscella in edible oil extraction processes.
- This method involves heating the miscella to a temperature that causes the solvent to evaporate, leaving behind the oil.



The next process is evaporation. It is a commonly used method to separate the solvent from the miscella in the edible oil extraction process. In this method, the miscella is heated to a temperature that causes the solvent to evaporate leaving behind the oil. It is also similar to the distillation method earlier discussed, but in the distillation, it is a compact unit where evaporation condensation etcetera is done in the same type of arrangement. But here in evaporation, the collection of the miscella that is from the extraction process is collected and kept in a storage tank. Then this miscella is heated to a temperature that is high enough to cause the solvent to evaporate which is the basic you heat and the solvent comes into the form of a vapor. The temperature used for the vaporization of the solvent depends upon the boiling point of the solvent, but it is generally in the range of 70 to 100 depending upon what type of solvent has been used for extraction of the oil. The third step is the separation of solvent vapor. This vapor is separated from the miscella by passing it through a condenser. There is a separate unit the vapors are redirected to a separate condenser unit where these vapors cool down and condense back into the liquid solvent. Finally, the solvent is recovered and collected in a tank and then it is sent to the further extraction process. The solvent can be reused.

❖ Membrane filtration

- Membrane filtration is a separation process that uses a semi-permeable membrane to separate components in a liquid.
- The process involves passing the miscella through a membrane with pores small enough to allow the oil to pass through but large enough to retain the solvent molecules.
- The membrane acts as a physical barrier that separates the oil and solvent, allowing the oil to pass through and the solvent to be retained.
- Membrane filtration has several advantages over traditional solvent removal methods like distillation or evaporation. One of the main advantages is that it operates at lower temperatures, which helps to preserve the quality of the extracted oil.
- Additionally, membrane filtration is a continuous process that does not require the use of additional solvents, which can reduce the environmental impact and cost of the extraction process.
- However, membrane filtration also has some limitations. The membrane can become clogged with impurities, leading to reduced efficiency and the need for frequent cleaning or replacement.

Another important technology for the recovery of the solvent from the miscella is membrane filtration. You know the membrane filtration in my earlier course I have discussed in another course that is novel technologies I have discussed about details of the membrane separation processes ok. Membrane filtration is a separation process that uses a semi-permeable membrane to separate components in a liquid. The process involves passing the miscella through a membrane with pores small enough to allow the oil to pass through but large enough to retain the solvent molecules. The membrane acts as a physical barrier that separates the oil and solvent, allowing the oil to pass through and the solvent to be retained. Membrane filtration has several advantages over traditional solvent removal methods like distillation or evaporation. One of the main advantages is that it operates at lower temperatures, which helps to preserve the quality of the extracted oil. Additionally, membrane filtration is a continuous process that does not require the use of additional solvents, which can reduce the environmental impact and cost of the extraction process. However, membrane filtration also has some limitations. The membrane can become clogged with impurities, leading to reduced efficiency and the need for frequent cleaning or replacement.

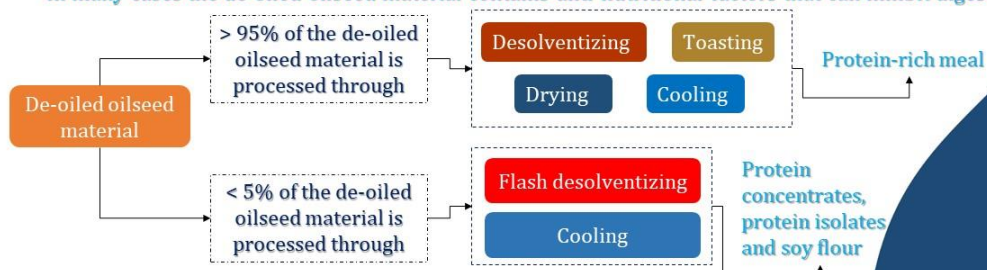
❖ Absorption

- Absorption is a process used to separate the solvent from the miscella to obtain the oil. It involves passing the miscella through a bed of absorbent material that selectively removes the solvent from the mixture. The absorbent material used is usually a porous solid or a liquid that has a high affinity for the solvent.
- The absorption process is typically carried out in a column or a packed bed. The miscella is introduced at the top of the column, and the absorbent material is packed in the column such that the miscella flows through it from top to bottom. As the miscella passes through the column, the solvent is selectively adsorbed by the absorbent material, while the oil remains unabsorbed and exits the column at the bottom.
- Once the solvent is absorbed by the absorbent material, it can be recovered by desorption.
- Desorption involves passing a desorbing agent through the column, which displaces the solvent from the absorbent material. The desorbed solvent can be recycled back to the extraction process.
- One of the main advantages of the absorption method is that it can be used to recover solvent from dilute solutions. Additionally, it can be operated continuously, which makes it suitable for large-scale operations. However, the absorption process may require high capital and operating costs, and the selection of the absorbent material can be critical to the efficiency of the process.

Another technique is absorption. Absorption is a process used to separate the solvent from the miscella to obtain the oil. It involves passing the miscella through a bed of absorbent material that selectively removes the solvent from the mixture. The absorbent material used is usually a porous solid or a liquid that has a high affinity for the solvent. The absorption process is typically carried out in a column or a packed bed. The miscella is introduced at the top of the column, and the absorbent material is packed in the column such that the miscella flows through it from top to bottom. As the miscella passes through the column, the solvent is selectively adsorbed by the absorbent material, while the oil remains unabsorbed and exits the column at the bottom. Once the solvent is absorbed by the absorbent material, it can be recovered by desorption. Desorption involves passing a desorbing agent through the column, which displaces the solvent from the absorbent material. The desorbed solvent can be recycled back to the extraction process. One of the main advantages of the absorption method is that it can be used to recover solvent from dilute solutions. Additionally, it can be operated continuously, which makes it suitable for large-scale operations. However, the absorption process may require high capital and operating costs, and the selection of the absorbent material can be critical to the efficiency of the process.

Meal desolventization

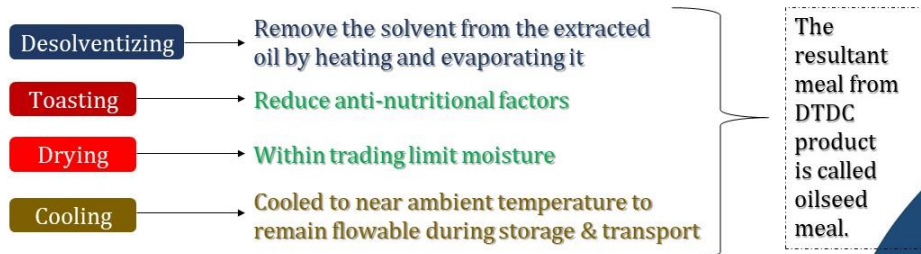
- After the solvent extraction process, the de-oiled oilseed material may be in the shape of flakes, cake particles or expanded pellet particles soaked with solvent.
- The de-oiled oilseed material typically contains 55 to 70 weight % dry solids, 25 to 35 weight % residual solvent, 5 to 10 weight % moisture and less than 1 weight % residual oil.
- The de-oiled oilseed material is normally at atmospheric pressure and 55 to 60°C temperature.
- In many cases the de-oiled oilseed material contains anti-nutritional factors that can inhibit digestion.



Now we will discuss meal desolventization. Once the micella is desolventized, we get the crude oil. Crude oil is sent for further processing, further refining, and utilization etcetera that we will take up separately in the next module. But here another aspect that I told you that is the de-oiled material that is meal, it is a good source of protein and it can be further processed for use in various food preparations, in various feed purposes, etcetera. So, it needs to be desolventized. So, after the desolventization, the de-oiled cake or meal can be obtained depending upon the process used in the shape of flake, cake particles, or expanded pellet particles that are soaked with the solvent. This meal typically contains about 55 to 70 weight percent dry solids, about 25 to 35 weight percent residual solvent, 5 to 10 weight percent moisture, and less than 1 weight percent residual oil. So, the de-oiled acid material is normally at atmospheric pressure and its temperature is around 55 to 60 degree Celsius. In many cases, the de-oiled acid material contains anti-nutritional factors, particularly in the case of soybean meal and other materials. So, these anti-nutritional factors can inhibit the digestion of the protein. So, during the desolventization process, this is also taken care of by proper toasting or roasting these anti-nutritional factors are also removed. So, the de-oiled acid materials I told you about over 95 percent of the de-oiled acid material is passed through various stages like desolventizing, drying, toasting and cooling or desolventizing, toasting, drying, and cooling and you get the protein-rich meal. And remaining 5 percent of the material is passed through flash desolventizing and cooling which finally gives protein concentrates, protein isolates, and soy flour. These flash desolventizing toasting cooling machines were recently developed especially for soybean meal desolventization.

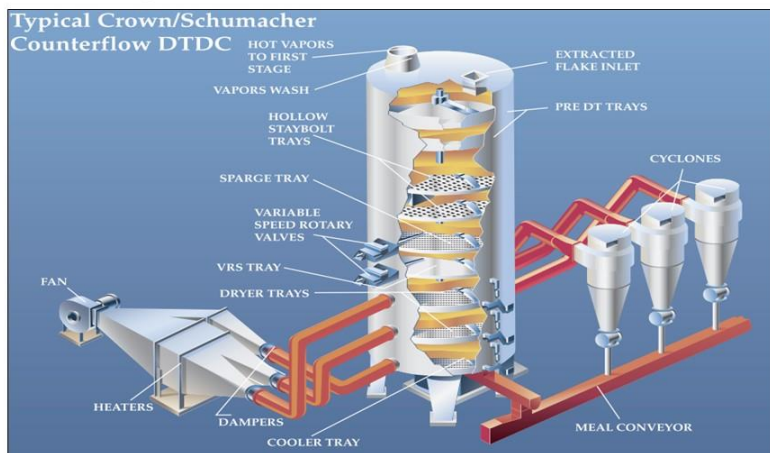
❑ Desolventizing, toasting, drying and cooling (DTDC) process

- In the DTDC process, the solvent is removed from the de-oiled oilseed material and recovered for re-use.



The steps here are desolventizing, toasting, drying, and cooling as you saw in the last slide. So, you can say as DTDC process. So, in the DTDC process, the solvent is removed from the de-oiled seed material and recovered for reuse. So, in desolventizing, you remove the solvent from the extracted oil by heating and evaporating it. Toasting reduces the anti-nutritional factors, drying brings the material within the trading limits of moisture, and cooling is done to bring down the temperature of the material or temperature of the meal to near to the ambient temperature to remain flowable during storage and transport. These are the resultant meal from the DTDC product, which is called oilseed meal and is a good protein source that can be used for food formulation.

❑ DTDC system



- The desolventizing, toasting, drying and cooling processes can be accomplished in a single vessel referred to as a DTDC.

So, this is the DTDC system that desolventizing, toasting, drying, and cooling processes can be accomplished in a single vessel. In this setup as you see it has an arrangement for passing that from the top that extracted flake inlet is there, then it has various trays like pre-DT trays, hollow spray-bolt trays, sparge trays, variable speed rotary trays, and then VRS trays, dryer tray, and etcetera. These are the different trays which are provided in the system. The system also has cyclones and there is a meal conveyor system from the cyclone the things are removed for separation and it is provided with a cooling tray, heaters, etcetera. So, these are the components of the typical DTDC system.

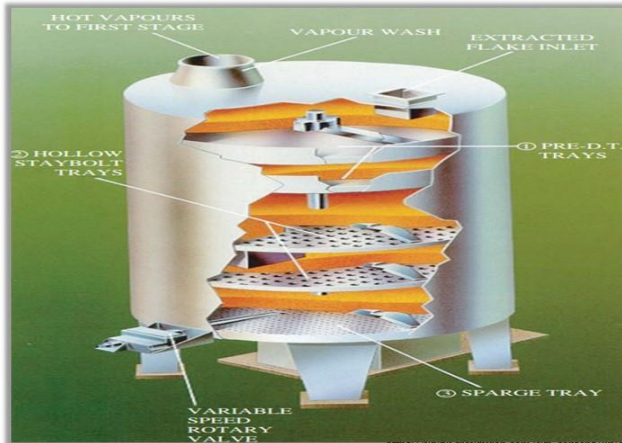
❑ Flash desolventizing and cooling process

- The solvent is removed very quickly from the de-oiled oilseed material and recovered for re-use without moisture addition to protect the integrity of the proteins.
- The de-oiled oilseed material is then cooled to near ambient temperature. The resultant flash desolventized and cooled product is commonly referred to as flash desolventized material or white flakes.



In the flash desolventizing and cooling process, the solvent is removed very quickly from the de-oiled oilseed material and recovered for reuse without moisture absorption to protect the integrity of the proteins. The de-oiled oilseed meal is then cooled to near ambient temperature and the resultant flash-desolventized and cooled product is commonly referred to as flash-desolventized material or white flakes and this is the system for the flash desolventizing and cooling process.

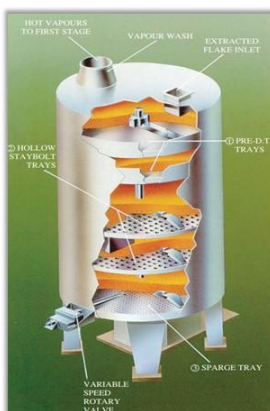
❑ Desolventizer - toaster (DT)



- More commonly, the desolventizing and toasting processes are combined in one vessel, referred to as a DT, and the drying and cooling processes are combined in a separate vessel referred to as a DC.

Now, let us take into detail the processes. First is the desolventizer toaster in the DTDC equipment setup which we showed you earlier. The top of the unit is the desolventizer toaster and then the bottom is the cooler and dryer. It is used for the desolventizing and toasting process and is combined in one vessel called desolventizer toaster and the drying and cooling process are combined in a separate vessel referred to as DC. So, DT and DC are these two important, and in the whole setup that is the first T, then DC, and the required arrangement.

❑ Desolventizing and toasting (DT) process

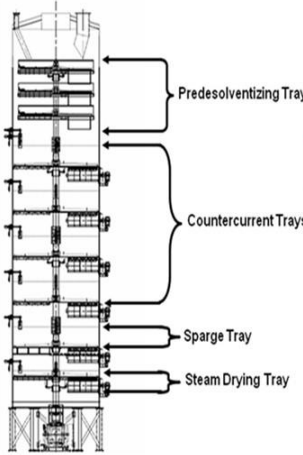


- After the prepared material has had its oil extracted in the solvent extractor, it is conveyed to the meal desolventiser toaster, commonly referred to as the DT.
- The material entering the DT is typically at the extractor temperature of 60 °C, and contains 25-35% by weight solvent.
- The primary purpose of the DT is to remove the solvent from the meal fraction so that the solvent can be recovered.
- DTs are vertical, cylindrical vessels with a multitude of horizontal trays.
- The extracted material enters at the top and is supported by the tray. The material is mixed above each tray, and conveyed downward from tray to tray, by agitating sweeps anchored to a central rotating shaft.
- The heat for increasing meal temperature and evaporating the solvent is supplied by steam, introduced directly and indirectly into the meal via the trays.

https://www.crowniron.com/wp-content/uploads/2018/01/Crown_DT_Brochure.pdf

After the prepared material has had its oil extracted in the solvent extractor, it is conveyed to the meal desolventiser toaster, commonly referred to as the DT. The material entering the DT is typically at the extractor temperature of 60 °C and contains 25–35% by weight solvent. The primary purpose of the DT is to remove the solvent from the meal fraction so that the solvent can be recovered. DTs are vertical, cylindrical vessels with a multitude of horizontal trays. The extracted material enters at the top and is supported by the tray. The material is mixed above each tray, and conveyed downward from tray to tray, by agitating sweeps anchored to a central rotating shaft. The heat for increasing meal temperature and evaporating the solvent is supplied by steam, introduced directly and indirectly into the meal via the trays.

DT process (Contd...)



- The trays of the DT are designed with an upper plate, lower plate, and structural members between designed to hold pressurized steam.
- **The DT has four different types of trays; pre-desolventizing trays, countercurrent trays, a sparge tray, and a steam drying tray.**

Predesolventizing trays

- The predesolventizing trays have as their sole purpose the provision of conductive heat transfer through their upper surface to the solvent-laden material supported above.
- **The steam is typically held at 10.5 kg/cm² pressure within predesolventizing trays, providing a surface temp. of 185°C.**
- The steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the solvent-laden meal layer above.

http://www.crowdfunder.com/wp-content/uploads/2016/01/Crowd_DT_Brochure.pdf

So, you can see here the complete DT process. The trays of the DT are designed with an upper plate, lower plate, and structural members between designed to hold pressurized steam. The DT has four different types of trays; pre-desolventizing trays, countercurrent trays, a sparge tray, and a steam drying tray, and the arrangement of trays are shown here in this schematic diagram. So, let us see what the functions of individual trays are. The predesolventizing trays have as their sole purpose the provision of conductive heat transfer through their upper surface to the solvent-laden material supported above. The steam is typically held at 10.5 kg/cm² pressure within predesolventizing trays, providing a surface temperature of 185°C. The steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the solvent-laden meal layer above.

Continued....

- A DT may have as many as seven predesolventising trays, or as few as one. The predesolventising trays are located in the upper portion of the DT and must allow ascending vapours from below to pass around them to the vapour exit at the top of the DT.
- Some manufacturers design disc-shaped trays, providing space for the ascending vapours to pass between the outside perimeter of the tray and the shell wall, while others design donut-shaped trays, providing space for ascending vapours to pass between the inside perimeter of the tray and the central shaft.
- As an alternative to a large number of predesolventising trays, the upper section of the DT is often expanded in diameter so as to enable fewer, larger-diameter trays.

Countercurrent trays

Purpose of
countercurrent
trays

- to provide conductive heat transfer through their upper surface in order to warm wet material supported above.
- to provide convective heat transfer through their lower surface in order to superheat direct steam swirling below.
- to provide apertures to allow direct steam to evenly ascend up through the tray and into the meal supported above.

A DT may have as many as seven predesolventising trays, or as few as one. The predesolventising trays are located in the upper portion of the DT and must allow ascending vapors from below to pass around them to the vapor exit at the top of the DT. Some manufacturers design disc-shaped trays, providing space for the ascending vapors to pass between the outside perimeter of the tray and the shell wall, while others design donut-shaped trays, providing space for ascending vapors to pass between the inside perimeter of the tray and the central shaft. As an alternative to a large number of predesolventising trays, the upper section of the DT is often expanded in diameter so as to enable fewer, larger-diameter trays.

Then next comes the counter-current trays. The purpose of counter-current trays is to provide conductive heat transfer through their upper surfaces in order to warm the wet material supported above. Another purpose is to provide conductive heat transfer through their lower surfaces in order to superheat direct streams swirling below. Also, these counter current trays provide apertures to allow the direct stream to evenly ascend up through the trays and into the meal supported above.

- The steam is typically held at 10.5 kg/cm² pressure within the countercurrent trays, providing a surface temperature of 185°C.
- Steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the meal layer above and transferred into the direct steam swirling below.
- A DT will have from one to four countercurrent trays.
- The number of countercurrent trays is selected to achieve a target residence time of the meal contacting stripping steam, typically 25 to 30 min for soybean meal and 60 to 90 min for rapeseed meal.
- The countercurrent trays are located directly under pre-desolventizing trays in center of DT. The apertures in trays must allow direct steam swirling below to pass through tray and into the meal supported above.
- There are three designs of countercurrent trays with differing apertures for allowing the ascending direct steam to pass through. Greater open area in the countercurrent trays allows for more uniform steam distribution and has been the trend in modern DT design.
- The original countercurrent tray design used hollow stay-bolts as apertures and generally had 1 to 2% open area for the vapours to ascend upward. A later design used hollow stay-pipes capped by a perforated plate, with generally 2 to 4% open area for vapours to ascend upward. The latest design uses hollow stay-pipes capped with stainless steel slotted screens, with generally 7 to 10% open area for the vapours to ascend upward.

The steam is typically held at 10.5 kg/cm² pressure within the countercurrent trays, providing a surface temperature of 185°C. Steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the meal layer above and transferred into the direct steam swirling below. A DT will have from one to four countercurrent trays. The number of countercurrent trays is selected to achieve a target residence time of the meal contacting stripping steam, typically 25 to 30 min for soybean meal and 60 to 90 min for rapeseed meal. The countercurrent trays are located directly under pre-desolventizing trays in center of DT. The apertures in trays must allow direct steam swirling below to pass through tray and into the meal supported above. There are three designs of countercurrent trays with differing apertures for allowing the ascending direct steam to pass through. Greater open area in the countercurrent trays allows for more uniform steam distribution and has been the trend in modern DT design. The original countercurrent tray design used hollow stay-bolts as apertures and generally had 1 to 2% open area for the vapors to ascend upward. A later design used hollow stay-pipes capped by a perforated plate, with generally 2 to 4% open area for vapors to ascend upward. The latest design uses hollow stay-pipes capped with stainless steel slotted screens, with generally 7 to 10% open area for the vapors to ascend upward. The steam is typically held at in this case also at 10.5 kg per centimeter square pressure within the counter-current trays providing a surface temperature of about 185 degrees Celsius. Steam condenses within the trays provides it is providing it is a latent heat to maintain about a 185-degree Celsius tray surface temperature and allow heat to be conducted into the meal layer above and transferred into the direct steam below.

Sparge tray

- The DT sparge tray has the dual purpose of providing a uniform means of introducing direct steam into the meal layer, and providing conductive heat transfer through its upper surface to the wet material supported above.
- The direct steam introduced through the sparge tray provides approximately 75% of the total heat required for desolventizing and heating the meal in the DT.
- The sparge tray is typically designed with a plurality of apertures across its entire upper surface to evenly introduce direct steam into the meal.
- The size and quantity of apertures is calculated based upon the anticipated direct steam flow rate to provide a pressure drop of 0.35 to 0.70 bar.
- The direct steam supply is 10 barg pressure saturated steam (185°C) and after passing through a flow control valve, its quality changes to 0.35 - 0.70 bar pressure superheated steam (150-160°C).
- Therefore, the upper surface of the sparge tray is maintained at approximately 155°C.

The DT sparge tray has the dual purpose of providing a uniform means of introducing direct steam into the meal layer, and providing conductive heat transfer through its upper surface to the wet material supported above. The direct steam introduced through the sparge tray provides approximately 75% of the total heat required for desolventizing and heating the meal in the DT. The sparge tray is typically designed with a plurality of apertures across its entire upper surface to evenly introduce direct steam into the meal. The size and quantity of apertures is calculated based upon the anticipated direct steam flow rate to provide a pressure drop of 0.35 to 0.70 bar. The direct steam supply is 10 barg pressure saturated steam (185°C) and after passing through a flow control valve, its quality changes to 0.35 - 0.70 bar pressure superheated steam (150-160°C). Therefore, the upper surface of the sparge tray is maintained at approximately 155°C.

□ Functioning of desolventizing and toasting (DT) system

▪ Predesolventising trays

Solvent-laden meal enters the DT at a temperature of 60°C and contains 25–35% by weight solvent.

The solvent-laden meal is stirred across the surface of the predesolventising trays by the rotating sweeps.

- ✓ A shallow layer of 150–300 mm meal depth is held above each tray.
- ✓ Meal temperature is increased to approximately 68°C.
- ✓ Approximately 10–25% of the solvent is evaporated on the predesolventising trays.

▪ Countercurrent tray

Material exits the predesolventising trays of the DT and falls on to the top countercurrent tray.

Since most of the heat is transferred into the meal layer by condensation of direct steam, a deep layer of 1000–1200 mm meal depth is held above the tray.

- ✓ The solvent-laden meal is stirred above the top countercurrent tray by the rotating sweeps.
- ✓ The direct steam passes from below up through apertures in the countercurrent tray.

Most critical tray of the DT

Finally, that is to summarize the functioning of the desolventizing and toasting that is the DT system, in the pre-desolventizing trays solvent laden meal enters the DT at a temperature of 60 degrees Celsius and contains 25 to 35 percent weight solvent. The solvent-laden meal is then stirred across the surface of the pre-desolventizing trays by rotating sweeps. A shallow layer of around 150 to 300 mm meal depth is held above each tray. Meal temperature is increased to approximately 68 degrees Celsius. Approximately 10 to 25 percent of the solvent is evaporated on the pre-desolventizing trays. Then in the counter current trays material exits the pre-desolventizing trays of the DT and falls onto the top of the counter current tray. Since most of the heat is transferred into the meal layer by condensation of direct steam, a deep layer of 1000 to 1200 mm meal depth is held above the tray. The solvent-laden meal is stirred above the top counter current tray by the rotating sweeps. The direct steam passes from below up through apertures in the counter current trays.

Continued....

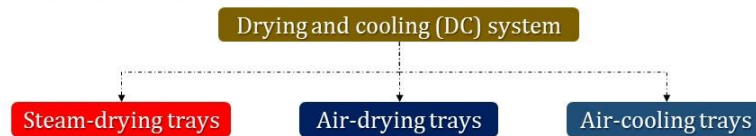
- As the direct steam penetrates the upper meal layer, it reaches the solvent-laden meal and condenses, providing direct latent heat to evaporate the solvent, which exits the meal layer as vapour.
- The condensation of steam causes the meal exiting the tray to be wet, typically in the range of 17–21% moisture.
- Once the wet meal exits the top countercurrent tray, it has had over 99% of its solvent removed.
- On the remaining countercurrent trays and the sparge tray, the meal is typically held in a 1000 mm-deep layer, in order to provide residence time to allow solvent stripping and toasting.
- The wet meal is stirred above each tray by rotating sweeps. The final desolventising takes place as the ascending steam passing through the meal slowly strips out the final traces of residual solvent, down to 100–500 ppm.
- The meal temperature increases from 100 to 105–110°C and the meal moisture decreases approximately 1% before the meal discharges from the sparge tray.
- The meal colour darkens slightly, providing the meal with a toasted colour.

For soybeans, antinutritional factors like trypsin inhibitors & urease are reduced on these trays by maintaining meal moisture and temperature elevated for a period of time.

As the direct steam penetrates the upper meal layer, it reaches the solvent-laden meal and condenses, providing direct latent heat to evaporate the solvent, which exits the meal layer as vapor. The condensation of steam causes the meal exiting the tray to be wet, typically in the range of 17–21% moisture. Once the wet meal exits the top countercurrent tray, it has had over 99% of its solvent removed. On the remaining countercurrent trays and the sparge tray, the meal is typically held in a 1000 mm-deep layer, in order to provide residence time to allow solvent stripping and toasting. The wet meal is stirred above each tray by rotating sweeps. The final desolventising takes place as the ascending steam passing through the meal slowly strips out the final traces of residual solvent, down to 100–500 ppm. The meal temperature increases from 100 to 105–110°C and the meal moisture decreases approximately 1% before the meal discharges from the sparge tray. The meal color darkens slightly, providing the meal with a toasted color. For soybeans, anti-nutritional factors like trypsin inhibitors & urease are reduced on these trays by maintaining meal moisture and temperature elevated for a period of time.

❑ Drying and cooling (DC) process

- After the solvent-laden material is desolventised, it is conveyed to the DC.
- The material entering the DC is typically at the DT exit temperature of 108°C, and contains 18–20% moisture (for soybeans).
- The primary purposes of the DC are to reduce the moisture in the meal to within trading rule limits and to lower the meal temperature prior to storage.
- DCs are vertical, cylindrical vessels with a multitude of horizontal trays.
- The desolventised material enters at the top and is supported by the tray.
- The material is mixed above each tray and conveyed downward from tray to tray by agitating sweeps anchored to a central rotating shaft.



Then comes the drying and cooling process which is DC process. After the solvent-laden material is desolventised, it is conveyed to the DC. The material entering the DC is typically at the DT exit temperature of 108°C, and contains 18–20% moisture (for soybeans). The primary purposes of the DC are to reduce the moisture in the meal to within trading rule limits and to lower the meal temperature prior to storage. DCs are vertical, cylindrical vessels with a multitude of horizontal trays. The desolventised material enters at the top and is supported by the tray. The material is mixed above each tray and conveyed downward from tray to tray by agitating sweeps anchored to a central rotating shaft. So, a drying and cooling system, that is the DC system contains stream drying trays, air drying trays, and air cooling trays.

Steam-drying trays

- The steam-drying trays of the DC are designed with an upper plate, lower plate and structural members between them designed to hold pressurized steam.
- The steam-drying trays have the purpose of providing conductive heat transfer through their upper surface to wet meal supported above. The steam is typically held at 10.5 kg/cm² pressure within the steam-drying trays, providing a surface temperature of 185°C.
- Steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the wet meal layer above.
- A DC may have as many as five steam-drying trays, or as few as none.
- The water vapour evaporated from the meal can be compressed in an ejector and have its heat recovered within the solvent extraction plant.

The steam-drying trays of the DC are designed with an upper plate, lower plate and structural members between them designed to hold pressurized steam. The steam-drying trays have the purpose of providing conductive heat transfer through their upper surface to the wet meal supported above. The steam is typically held at 10.5 kg/cm² pressure within the steam-drying trays, providing a surface temperature of 185°C. Steam condenses within the trays, providing its latent heat to maintain the 185°C tray surface temperature and allowing heat to be conducted into the wet meal layer above. A DC may have as many as five steam-drying trays, or as few as none. The water vapour evaporated from the meal can be compressed in an ejector and have its heat recovered within the solvent extraction plant.

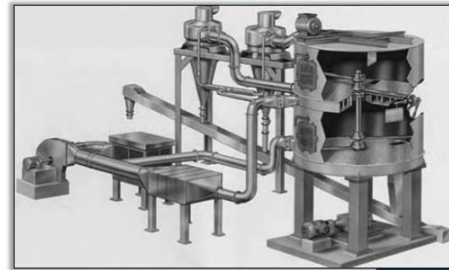
Air-drying trays

- The air-drying trays of the DC are designed with an upper plate, lower plate and structural members between them designed to hold low-pressure air.
- The air-drying trays are designed with a plurality of apertures across their entire upper surface in order to evenly introduce air into the meal.
- The air supplied to each air-drying tray is first filtered to remove dust and then pressurized using a centrifugal blower. The air for the dryer trays is passed through a steam-heated coil between the blower and the entrance to the trays. After the air enters the trays, it flows upward through the meal at a nominal velocity of 14–21 m/min, partially fluidizing the meal.
- The meal evaporatively cools and the released moisture is transferred to the ascending air. The warm, damp air exits the top of the meal layer and then moves through the sidewall of the DC to a cyclone collector in order to remove dust prior to discharge to atmosphere.

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Continued....

- The major source of heat for evaporation of the moisture in the meal is the high temperature of the meal exiting the DT or the DC steam-drying trays.
- When the meal drops in temperature from 108 to 38°C, the heat provided is adequate to reduce the meal moisture by 6.5%.
- For soybean meal, the trading rule moisture limit is 12.5%; therefore, if the incoming moisture from the DT, or the DC steam-drying trays, does not exceed 19%, the DC will typically require no additional evaporative heat source in order to dry the meal.
- If additional heat is required to evaporate moisture from the meal, the air entering the meal dryer trays can be heated up to 150°C prior to entering the air-drying trays.
- The heat source may be recovered flash steam, hot glycol–water solution (oil cooler) or fresh steam.



Meal dryer cooler
(Courtesy of Desmet Ballestra)

The major source of heat for the evaporation of the moisture in the meal is the high temperature of the meal exiting the DT or the DC steam-drying trays. When the meal drops in temperature from 108 to 38°C, the heat provided is adequate to reduce the meal moisture by 6.5%. For soybean meal, the trading rule moisture limit is 12.5%; therefore, if the incoming moisture from the DT, or the DC steam-drying trays, does not exceed 19%, the DC will typically require no additional evaporative heat source in order to dry the meal. If additional heat is required to evaporate moisture from the meal, the air entering the meal dryer trays can be heated up to 150°C prior to entering the air-drying trays. The heat source may be recovered flash steam, hot glycol–water solution (oil cooler), or fresh steam.

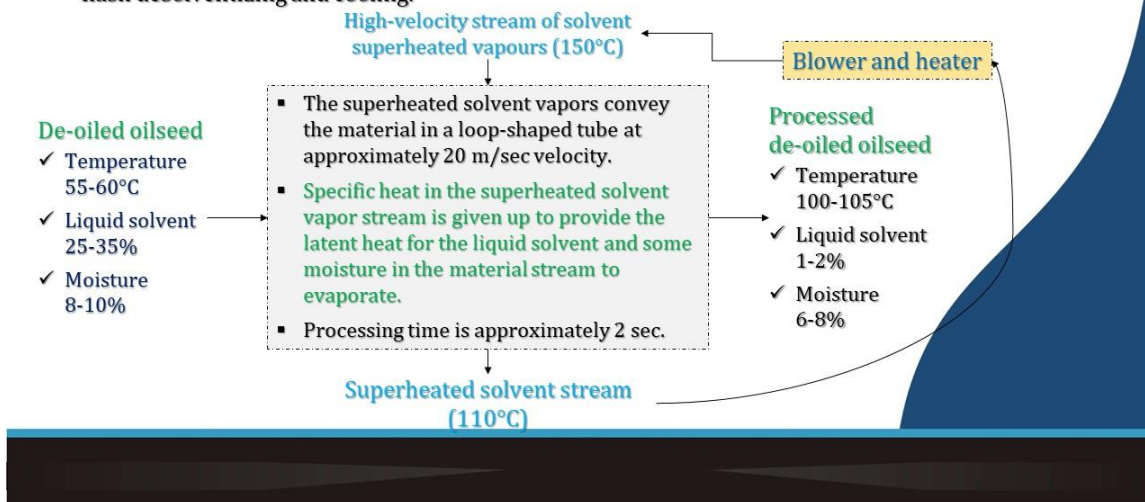
Air-cooling trays

- The construction and working of air-cooling trays is similar to the air-drying trays.
- Ambient air is heated by approximately 5 °C by the energy of the blower, before it blows into the air-cooling trays of the DC. The meal cools to within approximately 5 °C of the air temperature passing through the meal.
- Therefore, the temperature of the meal exiting the DC is typically cooled to within 10°C of ambient air. A suction blower fitted downstream of the DC can thus reduce exit meal temperatures by upto 5 °C by avoiding the heating energy of the upstream blower.
- The dry cool meal is conveyed from the DC outside the solvent extraction plant to allow size reduction and then on to meal storage.
- It is important to properly dry and cool the meal in order to prevent continued evaporative cooling in storage or transport, which will cause reduced flowability, solidification and bridging of the meal inside storage and transport vessels.

The construction and working of air-cooling trays is similar to the air-drying trays. Ambient air is heated by approximately 5 °C by the energy of the blower before it blows into the air-cooling trays of the DC. The meal cools to within approximately 5 °C of the air temperature passing through the meal. Therefore, the temperature of the meal exiting the DC is typically cooled to within 10°C of ambient air. A suction blower fitted downstream of the DC can thus reduce exit meal temperatures by up to 5 °C by avoiding the heating energy of the upstream blower. The dry cool meal is conveyed from the DC outside the solvent extraction plant to allow size reduction and then on to meal storage. It is important to properly dry and cool the meal in order to prevent continued evaporative cooling in storage or transport, which will cause reduced flow ability, solidification, and bridging of the meal inside storage and transport vessels.

❑ Flash desolventizing and cooling process

- The alternative process path for de-oiled oilseed material leaving the solvent extraction process is flash desolventizing and cooling.



Then finally, the flash desolventization and cooling process which we discussed a little bit. The alternative process path for de-oiled oilseed material leaving the solvent extraction process is flash desolventizing and cooling. The de-oiled oil seed temperature is at 55 to 60 degrees Celsius, liquid solvent 25 to 35 percent, and moisture 8 to 10 percent. It is passed through here where the high-velocity stream of solvent-superheated vapors are at 150 degree Celsius. The superheated solvent vapors convey the material in a loop-shaped tube at approximately 20 m/sec velocity. Specific heat in the superheated solvent vapor stream is given up to provide the latent heat for the liquid solvent and some moisture in the material stream to evaporate. Processing time is approximately 2 sec. And the superheated solvent stream comes out at around 110 degrees Celsius. Finally, the de-oiled cake when it is processed comes out of the flash desolventization coolers its temperature is around 100 to 105 degrees Celsius, the liquid solvent may be less than 1 percent or so, and the moisture content will be 6 to 8 percent. The superheated solvent steam that comes out through the blower and heater is recycled.

Continued....

- The solvent level of 1 to 2% is too high to safely handle this flash desolventized material.
- Therefore, it is further conveyed into a flake stripper vessel and contacted with superheated steam to strip out the remaining solvent down to less than 2000 ppm remaining.
- The flake stripper vessel may be a vertical tray type vessel, or horizontal conveyor type vessel, or horizontal paddle mixer type vessel.
- To maintain the PDI of the meal as high as possible, none of the superheated steam can condense.
- Therefore, it is critical that this flake stripper vessel is traced with hot water and very well insulated.
- For protein isolates and specialty flour applications the desired PDI is as high as possible (85 to 90 PDI).
- In these cases, heated surfaces in the flake stripper are maintained at 90 to 100 °C. For protein concentrate applications, the desired PDI is commonly around 70 PDI.
- In this case moisture is sprayed into the flake stripper and/or the heated surfaces are operated at higher temperature.

The solvent level of 1 to 2% is too high to safely handle this flash-desolventized material. Therefore, it is further conveyed into a flake stripper vessel and contacted with superheated steam to strip out the remaining solvent down to less than 2000 ppm. The flake stripper vessel may be a vertical tray type vessel, or horizontal conveyor type vessel, or horizontal paddle mixer type vessel. To maintain the PDI of the meal as high as possible, none of the superheated steam can condense. Therefore, it is critical that this flake stripper vessel is traced with hot water and very well insulated. For protein isolates and specialty flour applications, the desired PDI is as high as possible (85 to 90 PDI). In these cases, heated surfaces in the flake stripper are maintained at 90 to 100 °C. For protein concentrate applications, the desired PDI is commonly around 70 PDI. In this case, moisture is sprayed into the flake stripper, and/or the heated surfaces are operated at higher temperatures.

Cooling process

- The temperature of the flash desolventized material exiting the flake stripper is typically 90 to 100°C. This temperature is reduced to within 10 to 20°C of ambient by passing air through the material.
- In small-capacity plants, this cooling is accomplished in a dilute phase pneumatic transport system, while in large-capacity plants, this is accomplished in a DC (as described earlier).
- The cool product is commonly referred to as white flakes. For white flakes going into specialty soy flour applications, the air used in the cooling process must be filtered through a biological filter to remove any bacteria.
- For white flakes going into a protein concentrates or protein isolates process, this is not critical as any bacteria will be eliminated downstream. For protein concentrates applications the integrity of the flake shape is important and fine material needs to be screened away.
- For specialty flour applications and protein isolates applications, maintaining the shape of the flash desolventized material is not important, as size reduction is a normal process step downstream.

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Summary

- Oil extraction process generates miscella and oil meal which can requires further processing.
- **Distillation, evaporation, membrane filtration and absorption are the oil recovery methods from miscella.**
- The desolventizing, toasting, drying and cooling (DTDC) process is used for removing the solvent from the de-oiled oilseed material and recovered for re-use.
- **Flash desolventizing and cooling process removed the solvent very quickly from the de-oiled oilseed material and recovered for re-use without moisture addition to protect the integrity of the proteins.**



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I will summarize this lecture by saying that the oil extraction process generates miscella and oil meal which can require further processing. Distillation, evaporation, membrane filtration, and absorption are the oil recovery methods from miscella. The desolventizing, toasting, drying, and cooling process is used for removing solvent from the de-oiled oil seed material that is a meal and recovered for reuse. The flash desolventizing and cooling process removed the solvent very quickly from the de-oiled oilseed material and recovered it for reuse without moisture addition to protecting the integrity of the proteins.

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And these are the references used in this lecture. Thank you very much for your patience hearing. Thank you.