Food Oils and Fats: Chemistry and Technology

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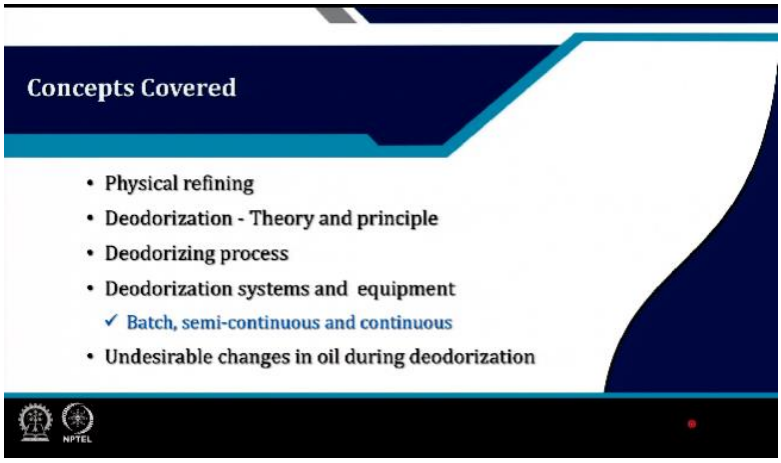
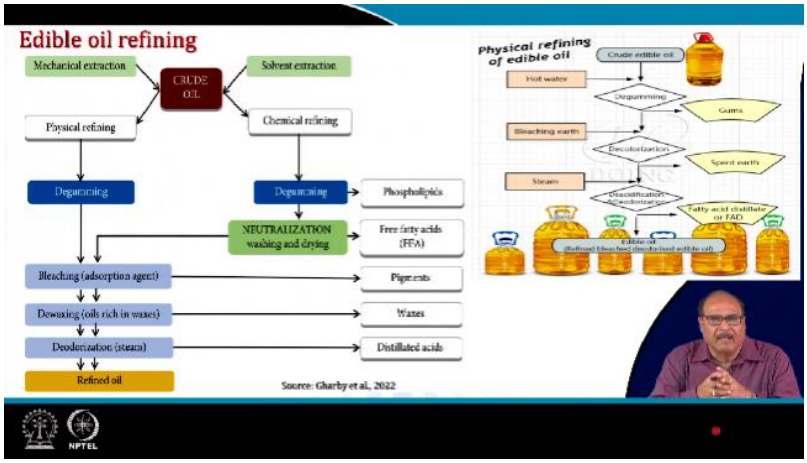
Module 06: Edible Oils Refining

Lecture 30: Physical Refining and Deodorization

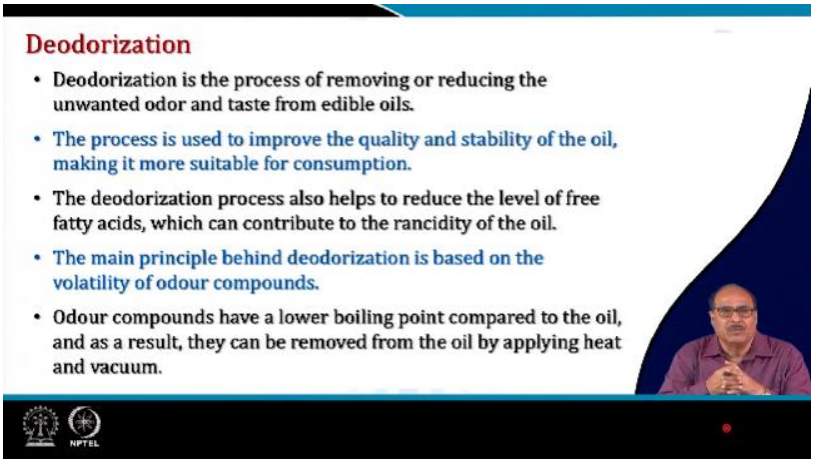
Hello everyone, Namaskar. Now, we are in lecture 30 that is the last lecture of module 6. In this lecture in the next half an hour or so, we will talk about physical refining and deodorization.



The topics which are included in this lecture include what is physical refining, the deodorization theory and principles, the deodorization process, various systems and equipment for deodorization may be batch, semi-continuous and continuous are also covered and then undesirable changes in oil during deodorization process.

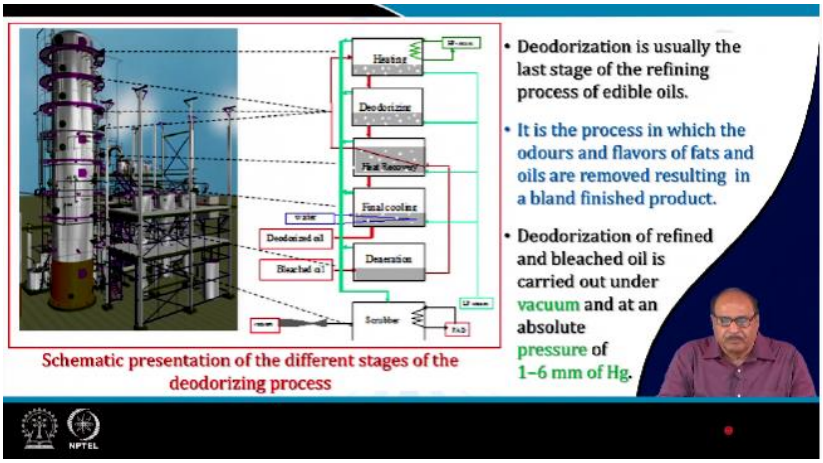


There are chemical refining and physical refining in the oil refining process, we will concentrate mainly on the physical refining which is a removal of impurities from the oil, particularly free fatty acids by physical means. So, it involve the steps usually steps of degumming and that bleaching etc. and then deacidification. The chemical refining is done using caustic solution sodium hydroxide or potassium hydroxide, but in the case of physical refining deacidification is done by steam distillation. So, that is you can say the deodorization and deacidification both are done in this case by that steam process by heat treatment. So, that is what is the physical refining. So, it steps include degumming, decolorization that is bleaching and then deacidification and deodorization together.

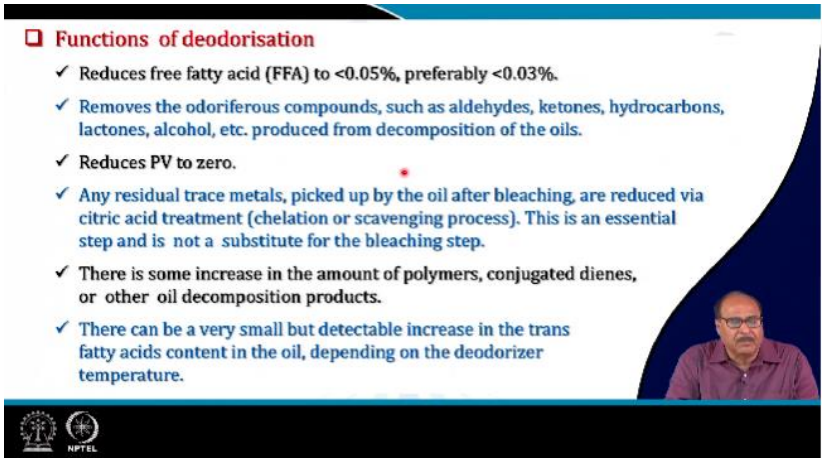


So, deodorization is the process of removing or reducing the unwanted order and taste from edible oils. The process is used to improve the quality and stability of the oil making it more suitable for human consumption. The deodorization process also helps to reduce the level of free fatty acid that whatever the fatty acids are not removed in the earlier processes they are removed here in deodorization process and they obviously, can contribute to the shelf life of the oil that is if the fatty acids free fatty acids are less then there will be less problem of rancidity in the oil. The main principle behind deodorization is based on the volatility of the other compound as I told you it is basically the distillation this compound are volatized and

then they are condensed and collected. Other compound have a lower boiling point compared to the oil and as a result they can be removed from the oil by applying heat and vacuum.

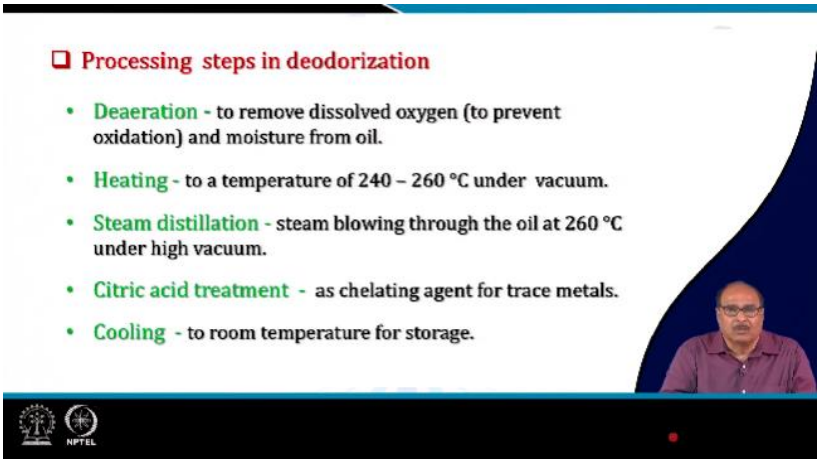


So, in this slide I have given you just a schematic representation of the different stages of the deodorization process. You can see that here in that there is a heating of the oil then deodorization, heat recovery, final cooling then deaeration and finally, the schemes are scrubbed off. So, in the whole refining step, deodorization is the last step of the refining process. It is the process in which the odors and flavors of fats and oils are removed resulting in a bland finished product. In fact, a properly deodorized oil should be bland in taste even experienced testers also should not be able to tell the source of the oil if it is properly deodorized because it will not contain any fatty acids, odors etc are totally removed. This deodorization of refined and bleached oil is carried out under vacuum and at an absolute pressure of 1 to 6 mm of Hg.

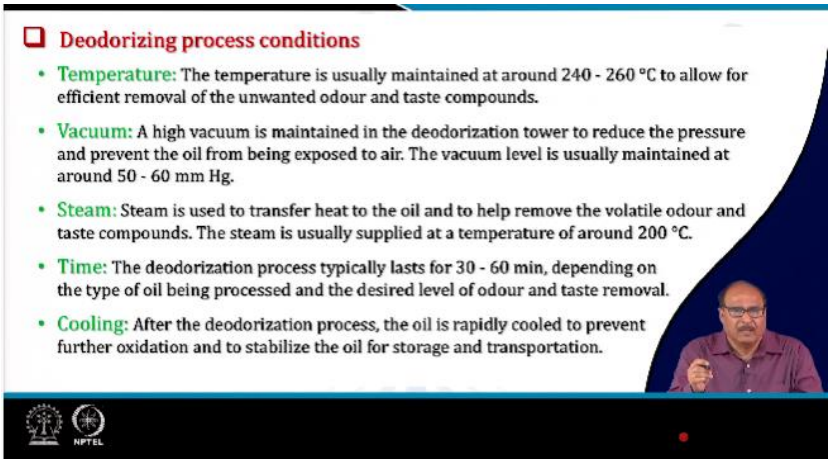


So, in the functions of deodorization, it reduces the free fatty acids to brings it to less than 0.05 percent and preferably it should be lower than 0.03 or 0. 02 percent. Deodorization process removes the odoriferous compounds such as aldehydes, ketones, hydrocarbons, lactones, alcohol etc which are generally produced from the decomposition of the oil. Also the deodorization process reduces the peroxide value of the oil to zero removes any such

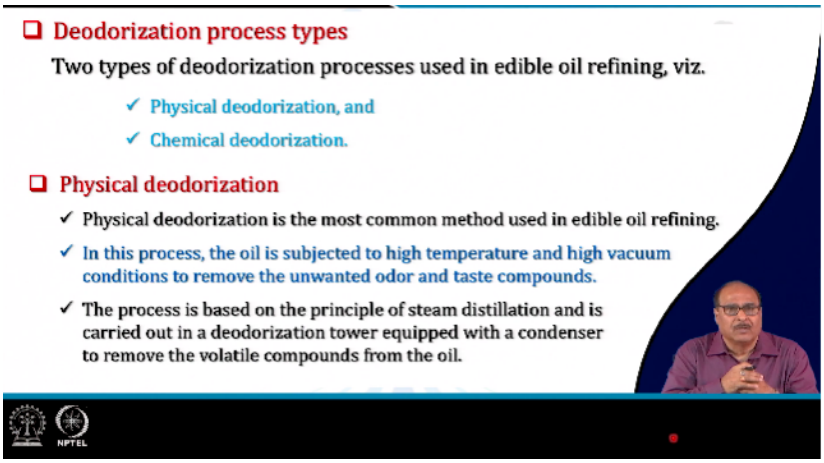
peroxide etc which are formed. Any residual trace metals picked up by the oil after bleaching. There will be some metal uptake if any. They are reduced by a citric acid treatment that is in the end of the deodorization process that is a compulsory about 0. 01 to 0.05 percent that there are regulations the limit is provided that the citric acid solution is added into the deodorization vessel in the last and this citric acid it chelates the metal ions. This is the essential step and it is not a substitute for the bleaching step this chelating is mainly for the metals otherwise if it is not done and if some metal ions are present they may cause oxidation of the fatty acid and whole process of refining may be defeated. There is some increase in the amount of polymers conjugated diner or other oil decomposition products, but a detectable increase in the trans fatty acids content in the oil depending upon the deodorization temperature. So, because you are giving a heat treatment. So, there are chances and there do occur some trans fatty acids are part, but the conditions in the process are control in such a way so as to minimize the trans fatty formation.



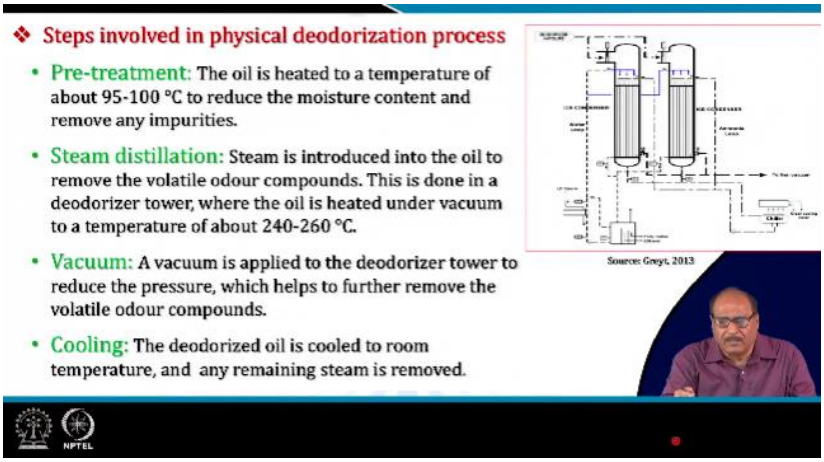
So, the processing steps which are involved in the deodorization process include deaeration. It is basically to remove the dissolved oxygen from the oil. So, to which the removal of oxygen obviously, prevents the oil from oxidation and also the moistures etc are removed in this process. Then the after deaeration oil is heated to a temperature of about 240 to 260°C under vacuum and this causes the evaporation of the fatty acids and other compounds etc. After heating the steam distillation that blowing the steam through the oil at 260°C once the oil has been previously heated. So, steam is blown and this steam causes the evaporation of free fatty acid and then separately it is condensed and this steams free fatty acids are distilled ok. And then as I told you towards the last stage is the citric acid treatment that is it is used as a chelating agent because you see under such a high temperature there may be some metals the corrosion etc although the all the piping and other containers of material is used with high acid resistance and fatty acid they should be with resistant the fatty acid vapors. So, material of construction should be that, but still there might be some chances that there are some metals etc which are used in the preparation of equipment manufacture of equipment they may get some into oil. So, that is chelated by using citric acid then final step is the cooling of the deodorized oil to room temperature.



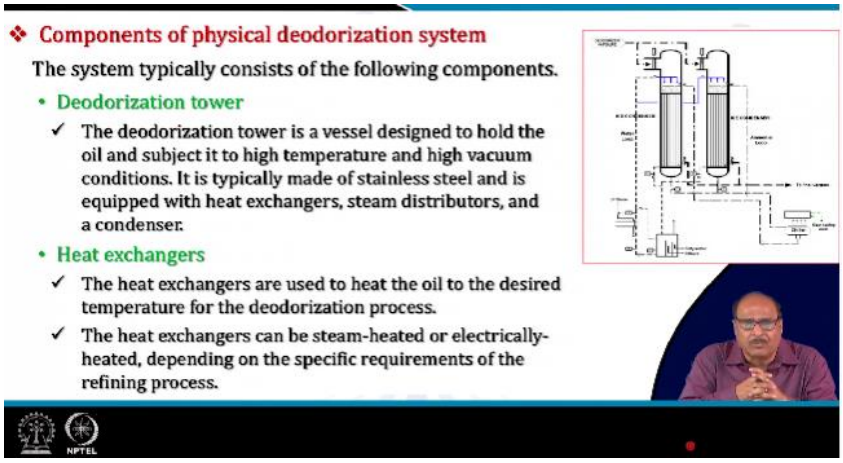
So, in the deodorization process conditions, temperature is usually maintained at around 240 to 260°C to allow the efficient removal of unwanted order and taste compound. Then a high vacuum is maintained in the deodorization tower to reduce the pressure and prevent the oil from being exposed to air. The vacuum level is usually maintained at around 50 to 60 mmHg. Then steam it is used to transfer the heat to the oil and to remove the volatile order and taste compounds. The steam is usually supplied at a temperature of around 200°C or more. Then time of the deodorization process that is sufficient time need to be given for the distillation of the fatty acid and other odorous compounds. So, it usually that is a 30 to 60 minutes depending upon the type of oil being processed and the desired level of order and taste that is required to be removed. Then cooling after the deodorization process the oil is rapidly cooled to prevent further oxidation and to stabilize the oil for storage and transportation.



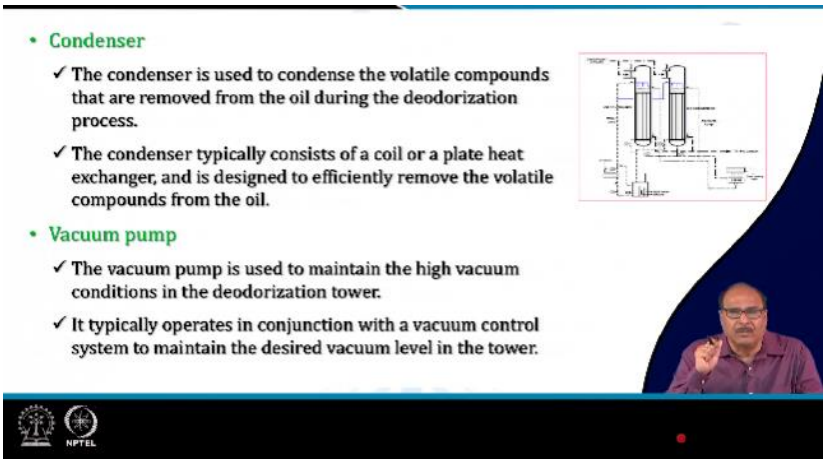
There are two types of deodorization processes. They are physical deodorization and chemical deodorization. So, physical deodorization is the most common method used in edible oil refining. In this process the oil is subjected to high temperature and high vacuum conditions to remove the unwanted order and taste compound. The process is based on the principle of steam distillation and is carried out in a deodorization tower which is equipped with a condenser to remove the volatile compounds from the oil.



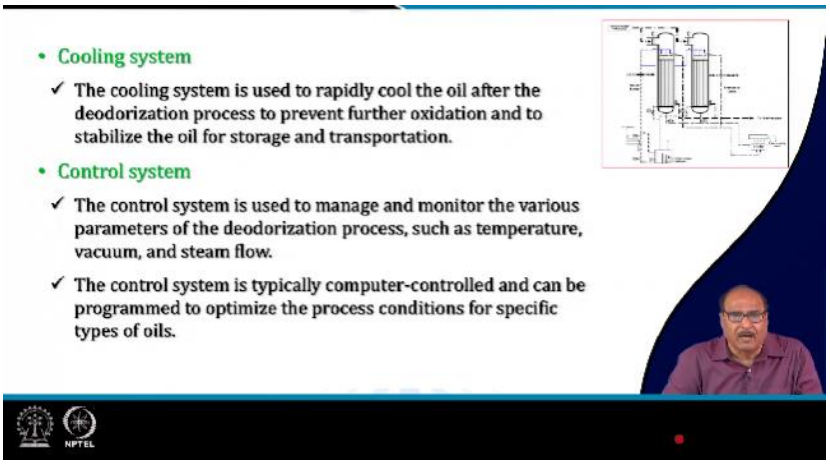
So, the steps involved in the physical deodorization process you can see the schematic of the deodorization setup. So, the oil is first preheated to a temperature of around 95 to 100°C to reduce its moisture content and remove any impurities from it. Then steam is introduced into the oil to remove the volatile order compounds this is done in a deodorization tower where the oil is heated under vacuum to a temperature of around 240 to 260°C. And then vacuum is maintained and cooling is done.



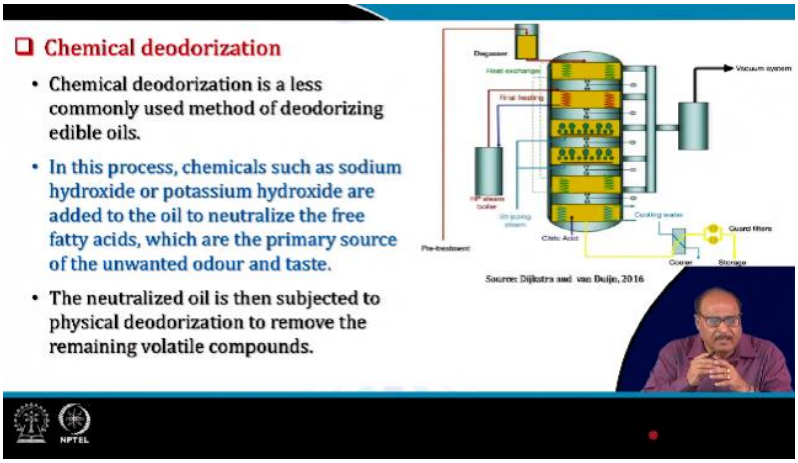
So, the components of a physical deodorization system include the deodorization tower. The deodorization tower is a vessel designed to hold the oil and subject it to high temperature and high vacuum condition. And accordingly the material of construction of deodorization tower is very important as I told you it must withstand the fatty acid vapor. It is typically made of stainless steel and is equipped with heat exchangers, steam distributors and a condenser. Heat exchangers are used obviously, to heat the oil to the desired temperature for the deodorization process. The heat exchangers can be steam heated or they can be electrically heated depending on the specific requirement of the refining process.



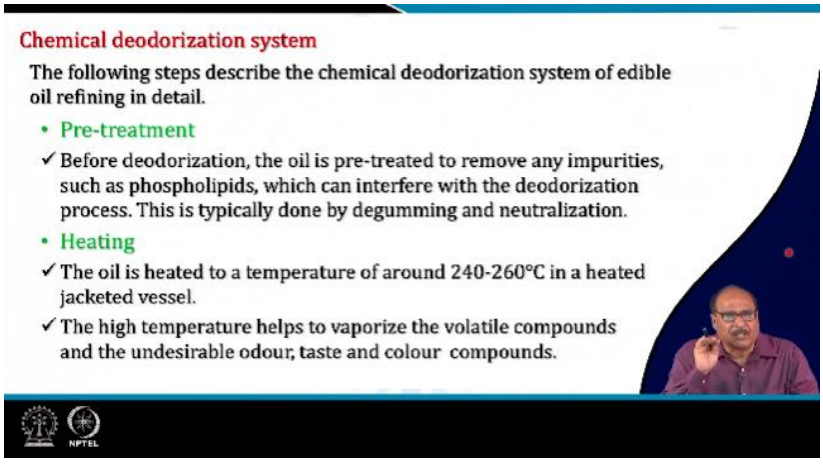
Then the deodorization setup is equipped with a condenser which is used to condense the volatile compounds that are removed from the oil during deodorization process particularly fatty acid vapors. And the condenser typically consists of a coil or a plate heat exchanger and is designed to efficiently remove the volatile compounds from the oil. Vacuum pump is used to maintain the high vacuum condition in the deodorization tower. It is typically operates in conjunction with a vacuum control system to maintain the desired vacuum level in the tower.



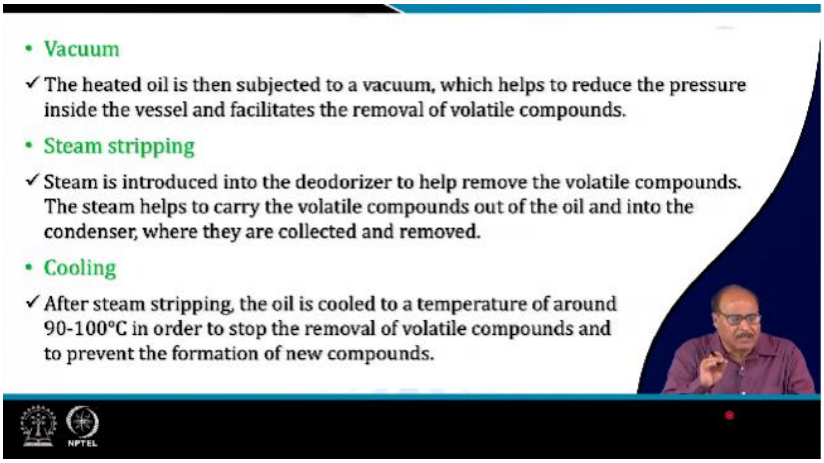
Then there is a cooling system which is used to rapidly cool down the oil after the deodorization process to prevent further oxidation and to stabilize the oil for storage and transport. Then a whole setup is provided which is a properly controlled proper control system that is used to manage and monitor the various parameters of deodorization process such as temperature, vacuum, steam flow etc so as to maintain the quality and to have a better efficiency process efficiency. The control system is typically computer control and can be programmed to optimize the process conditions for specific types of oils.



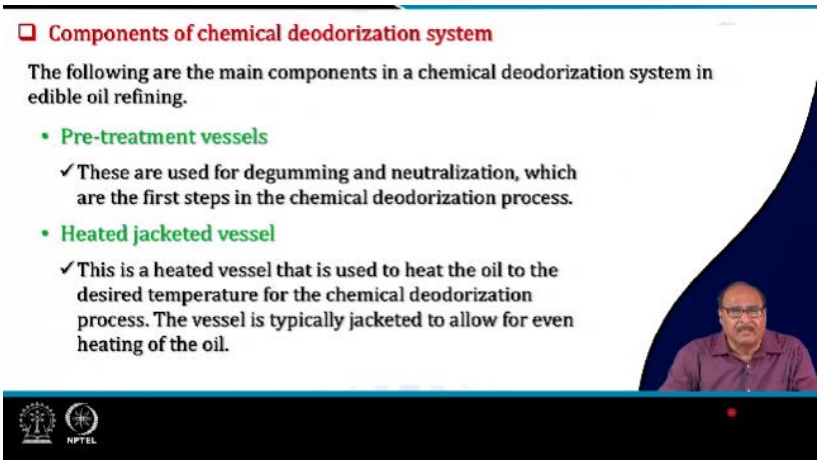
Chemical deodorization is a less commonly used method of deodorization of edible oil. In this process, chemicals such as sodium hydroxide or potassium hydroxide are added to the oil to neutralize the free fatty acids which are the primary source of the unwanted odors and taste. So, basically you can say in other words it is a chemical deodorization also some sort of chemical refining and neutralization process. So, the neutralized oil is then subjected to physical deodorization to remove the remaining volatile compounds. So, that is what in the neutralization and then deodorization that you can say a chemical deodorization process. Then the equipment setup is similar here again it is give acid there is a degasser is provided this is pre-treatment from the oil then oil is subjected from the top. There are prior heat exchangers provided for final heating. Then it is there for the distillation setup the vacuum system is provided then finally, citric acid system that is addition of citric acid in the last stage and then you goes to the cooling and transportation etc.



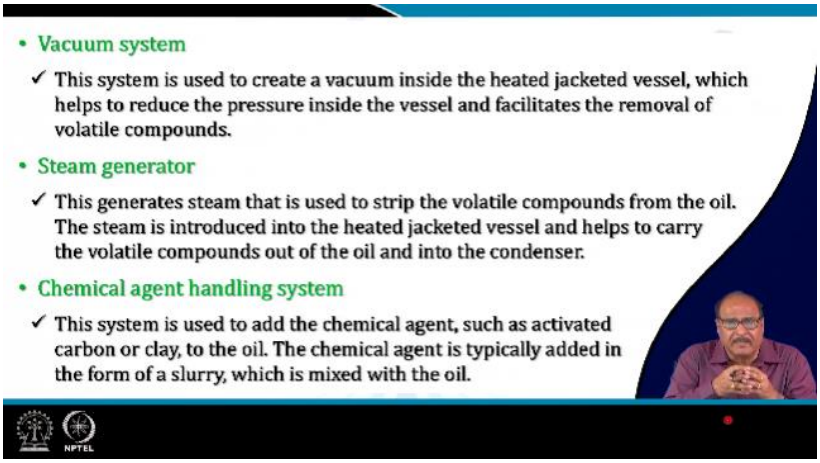
In chemical deodorization system, there are the steps which are used again like pre-treatment before deodorization the oil is pre-treated to remove any impurities such as phospholipids which can interfere with the deodorization process and this is typically done by degumming and neutralization as we discussed earlier. Then oil is heated to temperature of around 240 to 260°C in jacketed vessel and the high temperature helps to vaporize the volatile compounds. And to remove the undesirable colour, flavour, taste, etc.



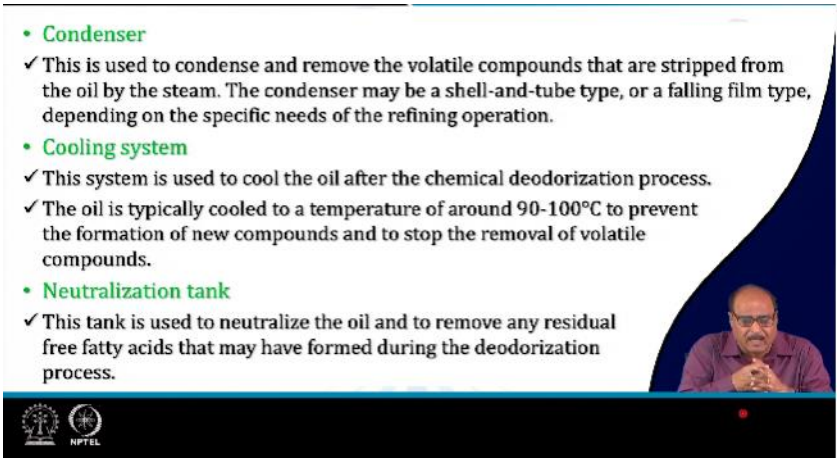
Then vacuum is an oil is a subjected to a vacuum which helps to reduce the pressure inside the vessel to facilitate the removal of volatile compounds and then finally, steam stripping is done. Steam is introduced into the deodorizer to remove the volatile compounds. Steam helps to carry the volatile compounds out of the oil and into the condenser where they are collected and removed. Then cooling the after steam stripping the oil is cooled to a temperature of around 90 to 100°C in order to stop the removal of the volatile compounds and to prevent the formation of new compounds. And then it is further cooled to the room temperature.



The components of a chemical deodorization system are pretreatment vessel these are used for degumming and neutralization which are the first step of chemical deodorization process. Then there is a heat jacketed vessel like in the physical deodorization system here also it is there. And the heated vessel is that is used to heat the oil to the desired temperature for chemical deodorization process and vessel is typically jacketed to allow for even heating of the oil. So, in this vessel there is an arrangement also where this alkali is to be added.

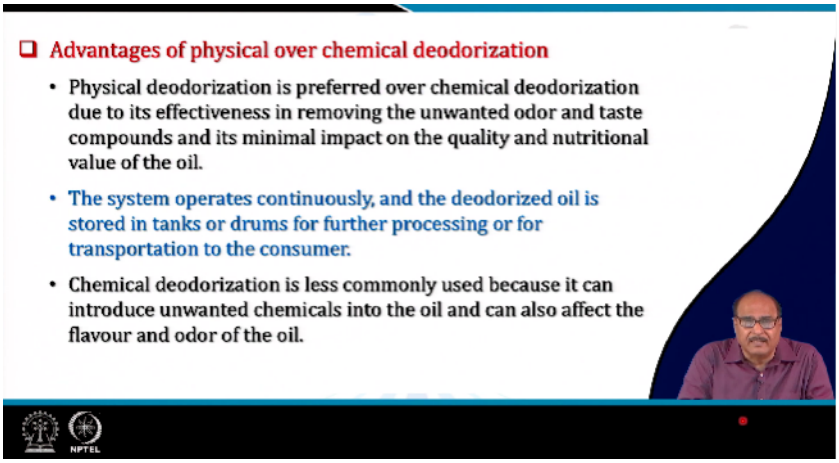


The vacuum system is to create the desired vacuum inside the heated jacketed vessel, which helps to reduces the pressure inside the vessel and facilitates the removal of volatile compounds. Then steam generator is used to generate the steam which is used to strip the volatile compounds from the oil. The steam is introduced into the heated jacketed vessel and helps to carry the volatile compounds out of the condenser. Then chemical agent handling system, this system is used to add the chemical agent such as activated carbon or clay to the oil for removing of some colors like what we do in the bleaching. Then chemical agent is typically added in the form of a slurry which is mixed with the oil. So, in the same setup all these process that is the removal of the degumming, neutralization, bleaching etcetera is done in the same.

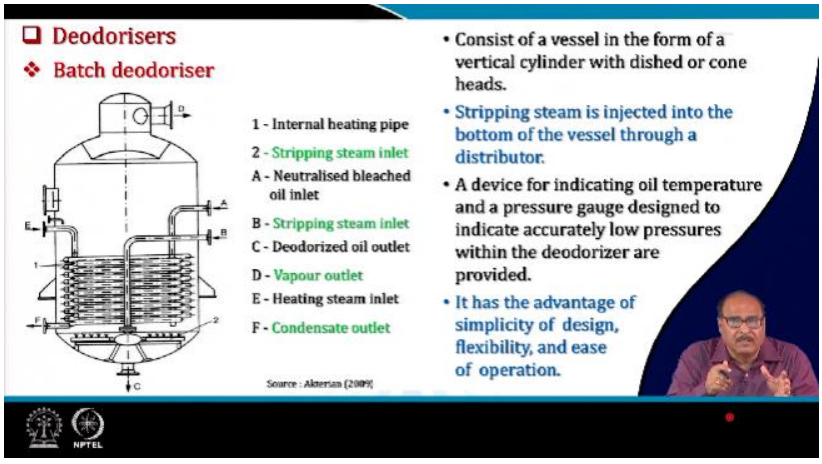


Then condenser, cooling system and neutralization tank. The condenser is obviously, to remove the volatile compounds that are stripped from the oil by the steam. The condenser may be a shell and tube type or falling film type depending on the specific need of the refining process. Cooling system is a there to reduce the temperature of the oil to around 90 to 100°C in first stage and then finally, to the room temperature. Neutralization tank is used to neutralize the oil and to remove any residual free fatty acid that may have formed during the deodorization process itself because you are subjecting the oil to such a high temperature. So,

this can also cause some breakage of the yeast and linkage some free fatty acids etc might do for. So, that are also removed in the neutralization tank.

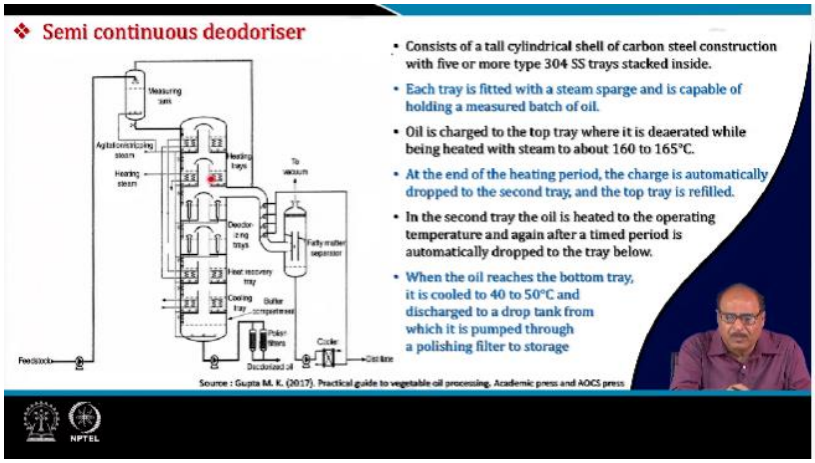


So, the advantages of physical deodorization over chemical deodorization process that is physical deodorization is preferred over chemical deodorization due to its effectiveness in removing the unwanted odour and taste compound and its minimal impact on the quality and nutritional value of the oil. The system operates continuously and the deodorized oil is stored in tanks or drums for further processing or for transportation to the consumer. Chemical deodorization is less commonly used because it can introduce unwanted chemicals into the oil and can also affect the flavour and order of the oil.

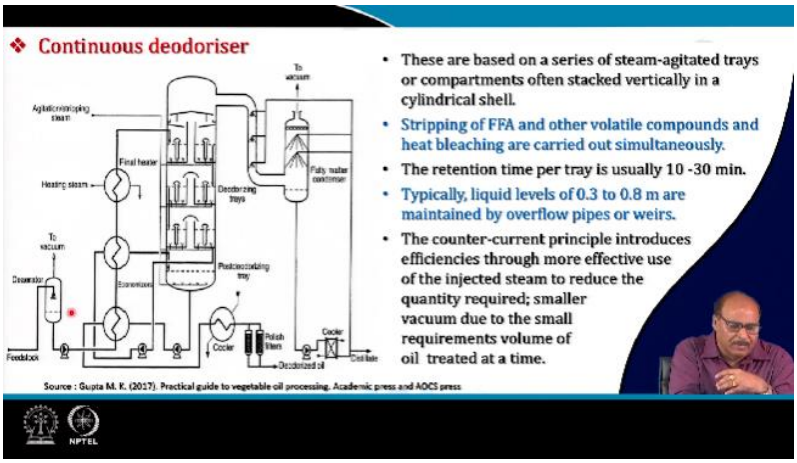


The batch deodorizer, it is a vessel in the form of a vertical cylinder with dished or cone heads and then it has arrangement that is you see for internal heating pipe that is the air are provided and then the number 2 is the stripping strip inlet port system. Then this from this A is for the neutralized bleached oil inlet, B is for stripping strip steam inlet and from this point C the deodorized oil goes out and this went for outlet went for the vapour. Then here that is heating E point is that heating steam inlet and F is the condensate outlet. So, all these arrangements are provided in the same vessel. So, stripping steam is injected into the bottom of the vessel through a distributor, a device for indicating oil temperature and a pressure

gauge etc designed to indicate accurately low pressures within the deodorizers are also provided. And it has the advantage of simplicity of design flexibility and ease of operation.

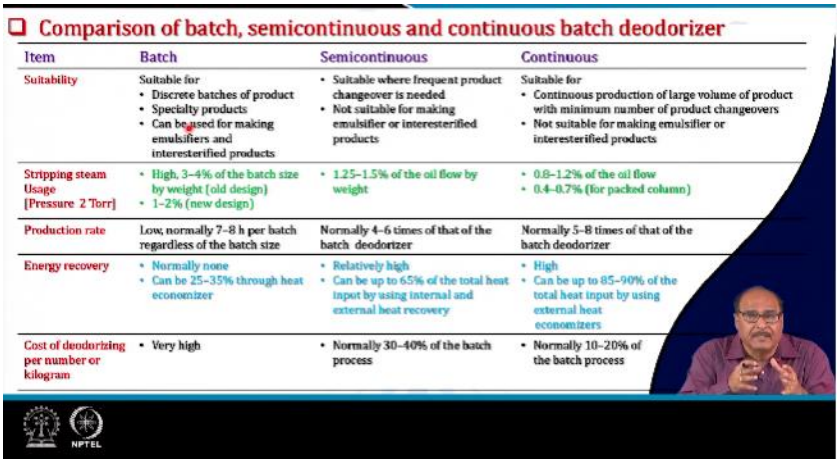


Semi continuous deodorizer it consists of a cylindrical shell of carbon steel construction with 5 or more SS 304 trays stacked one above the other that you can see as here in this vessel. Each tray is fitted with a steam sparge and is capable of holding a measured batch of oil. Oil is charged to the top tray where it is deaerated while being heated with steam to around 160 to 165°C in the top tray. Then at the end of the heating period the charge is automatically dropped to the second tray and the top tray is filled with the fresh oil. Then in the second tray the oil is heated to the operating temperature and again after a time period it is automatically dropped to the third plate. And the oil from the first plate is dropped to the second plate, first plate again fresh oil comes. So, in this way the process continues. When the oil reaches to the bottom tray finally, it is cooled to around 40 to 50°C and discharged to a drop tank from which it is pumped to a polishing filter and taken out to the storage. So, this is a semi-continuous operation.

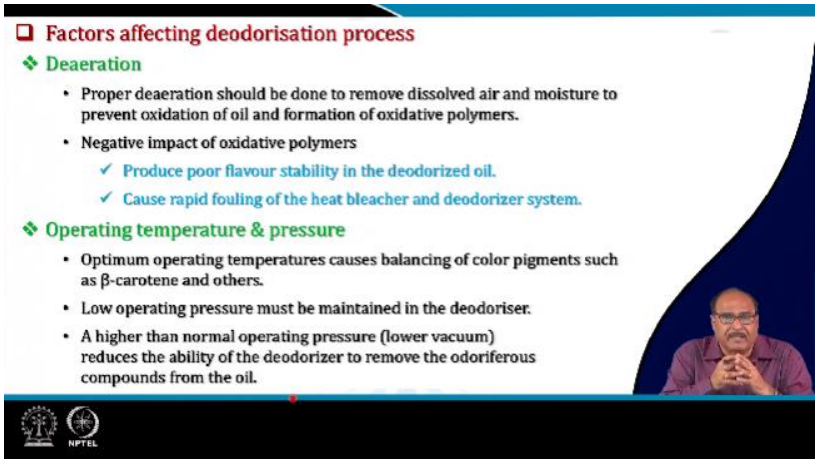


Then continuous operation again similar to that, but here the arrangement for oil inlet into the tops and then outlet is done in continuously and these are based on a series of steam agitated trays which are provided inside the vessel or compartments of a stirred vertically in

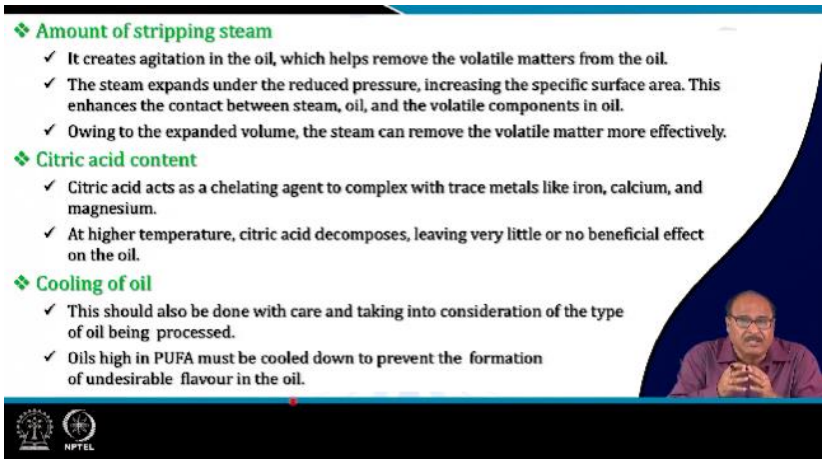
a cylindrical cell. Steeping of free fatty acids and other volatile compounds and bleaching are carried out simultaneously here in this setup. The retention time per tray is usually 10 to 30 minutes typically, liquid levels of 0.3 to 0.8 meter are maintained by overflow pipes or wires, and the counter-current principles introduces efficiency through more effective use of the jacketed steam to introduce or to reduce the quantity required and a smaller vacuum due to the small requirements or volume of oil-treated at a time. So, this is a continuous process.



So, let me give you here a comparison between the batch semi-continuous and continuous system of reauthorization. So, first is the suitability of the process for various. So, the batch system is suitable for discrete batches of the product or specialty products and it can be used for making emulsifier and inter-esterified products whereas, the semi continuous system is more suitable for the products where frequent product change over is needed. It is not suitable for making emulsifier or inter esterified products. Continuous system is suitable for continuous production of large volume of product with minimum number of product changeovers. Also it is not suitable for making emulsifier or inter esterified products. Then steaming strip usage that is pressure is generally 2 Torr. So, in the batch system it is a steam stripping usage is high around 3 to 4 percent of the batch size by weight in old design and 1 to 2 percent in new design and in the semi continuous it is a 1.25 to 1. 5 percent of oil flow by weight in continuous 0.8 to 1.2 percent of the oil flow and then 0.4 to 0.7 percent per packed column. Then production rate in the batch system is usually low normally say 7 to 8 hour per batch regardless of the batch size. Then in a semi continuous it is 4 to 5 times of that of the batch deodorizer and in continuous process you can have normally 5 to 8 times of that of the batch deodorizer process. Energy recovery in batch process is normally none and can be about 25 to 30 percent through heat economizer if it is provided into the system. In semi-continuous process, energy recovery is relatively high and it can be up to 65 percent of the total heat input by using internal and external heat recovery system. But in the continuous process, it is further again very high. It can be as high as 85 to 90 percent of the total heat input by using external heat economizers. Cost of deodorizer per number or per kilogram in batch process is very high. In semi continuous process normally 30 to 40 percent of the batch process and in continuous process, it is further reduced.

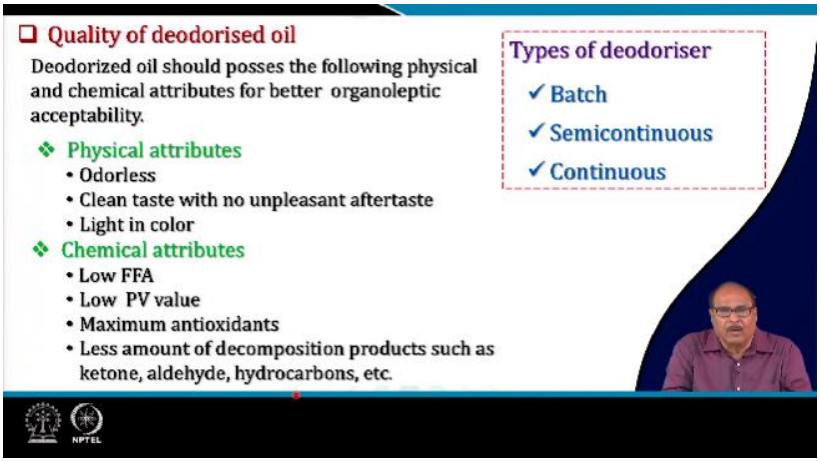


Now, let us see the factors that affect the deodorisation process. Number 1 deaeration. So, proper deaeration should be done to remove dissolved air and moisture to prevent oxidation of the oil and formation of oxidative polymers. And the negative impact of oxidative polymers and this will reduce poor flavor stability in the deodorized oil, this will produce poor flavor stability. And this oxidative polymers can cause rapid fouling of the heat bleachers and deodorizer system. Then operating temperature and pressure are important that optimum operating temperature causes balancing of color pigments and the beta-carotene and others. Low operating pressure must be maintained in the deodorizer, a higher than the normal operating pressure that is the lower vacuum. Low vacuum reduces the ability of the deodorizer to remove the odoriferous compounds from the oil. So, that proper temperature and pressures will be maintained.

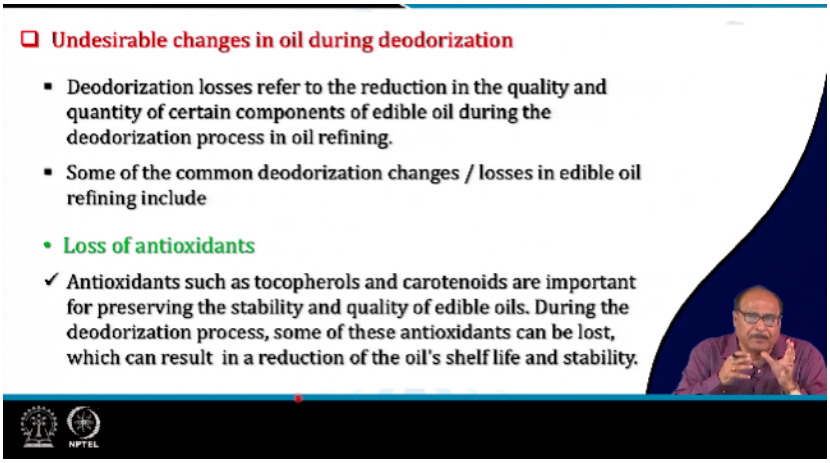


Then amount of the stripping stream increases agitation in the oil which helps remove the volatile matter from the oil. The stream expands under the reduced pressure increasing the specific surface area. This enhances the contact between the steam, oil and the volatile components of the oil owing to the expanded volume. The steam can remove the volatile matters more effectively. Citric acid content is used as a chelating agent to complex the trace metals like iron, calcium, magnesium etc. At higher temperature, the citric acid decomposes very little or no beneficial effect of the oil. So, the citric acid quantity also is important. Then

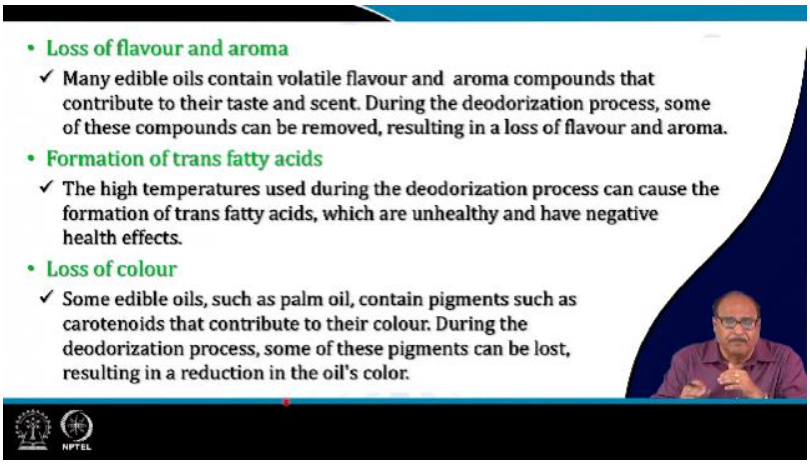
cooling of the oil this will also be done with care and taking into consideration of the type of oil being processed. Oil high in PUFA must be cooled down to prevent the formation of undesirable flavors in the oil.



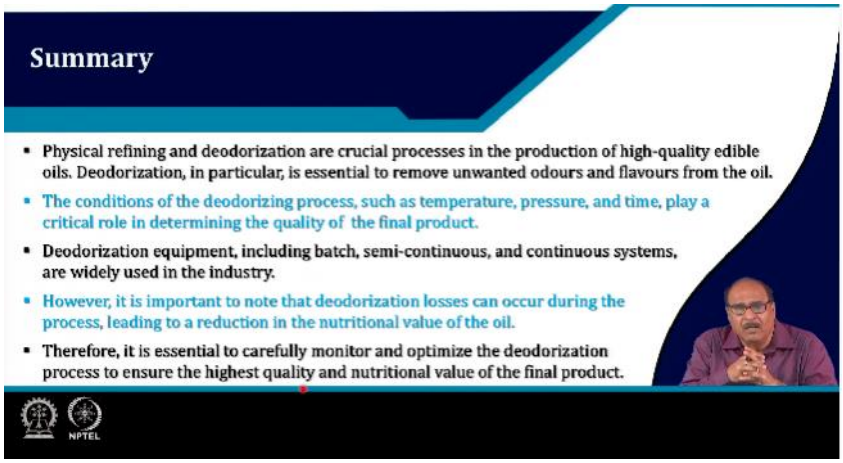
And the quality of the deodorizer oil obviously, it depends upon the type of the deodorizer and process which is used whether batch process, semi-continuous process or continuous process which we have seen also a comparison in the earlier slide. So, obviously, that the physical attributes of the oil that deodorizer oil accordingly the process objective is to get the better quality oil. So, the deodorizer oil must be analyzed properly and it should possess various physical and chemical attribute and to fit into the quality system that is physical attributes like it should be odorless, it should have clean taste with no unpleasant after taste and it should be light in color. Similarly, there should be low maybe point less than 0.02 percent FFA, low peroxide or no peroxide value, maximum antioxidant should be there and there should be less amount of decomposition products such as aldehyde, ketones, hydrocarbons etc. So, this should be the quality in the deodorizer oil and accordingly this should be maintained by maintaining the proper process parameters conditions in the deodorization.



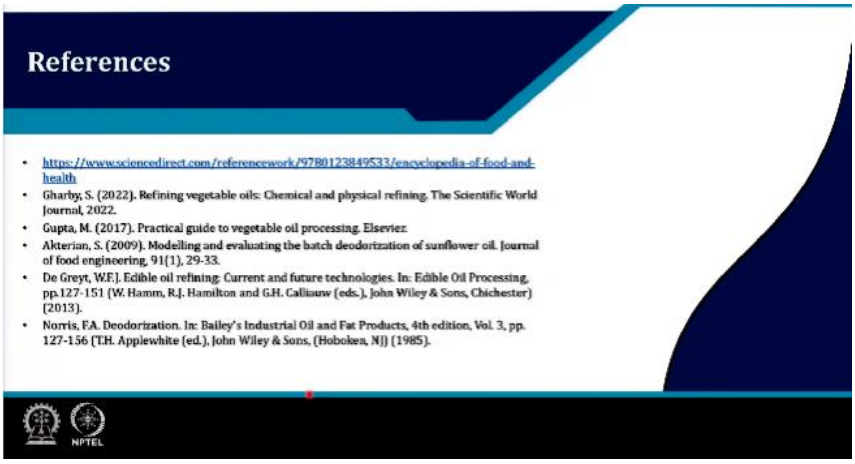
Some process parameters are not properly maintained, there may be even some undesirable changes because here you are treating the oil subjecting to oil so, such a high very high temperature. So, there it may result to the deodorisation losses and this losses in the deodorisation process refers to the reduction in the quality and quantity of certain compounds of edible oil during the deodorisation process in oil refining. Some of the common deodorisation changes or losses in the edible oil include number one most important loss of antioxidants that antioxidants such as tocopherols and carotenoids they are important for preserving the stability and quality of the edible oils and they are present in the naturally in the plant oils. So, during the deodorisation process some of these antioxidants can be lost if the process is not properly done and this can result in a reduction in the oil shelf life and stability as well.



There are certain oils where these flavor and aroma is liked by the consumers. They contribute to specific or characteristic taste and send to the product. So, during the deodorisation process some of these compounds are removed resulting in loss of flavor and aroma. Then one another very important aspect of this is the formation of trans fatty acid that is the high temperature used during the deodorisation process can cause the formation of trans fatty acids which are unhealthy and have negative health impacts. So, the process must take care that, it should result into as low as possible formation of trans fatty acid. Then loss of color some edible oils such as palm oil contain pigments such as carotenoids etc that contributes to their color and people like it consumers like it. So, during the deodorisation process some of these pigments also can be lost resulting in reduction in the oils color. So, the deodorisation process conditions should be maintained to overcome these problems.



So, finally, I will conclude this lecture by saying that as physical refining and deodorisation both these are crucial processes in the production of high quality food oils. Deodorisation in particular is essential to remove unwanted odors and flavors from the oil also it is used to remove the pre fatty acids. The conditions of deodorisation process such as temperature, pressure and time play a crucial role in determining the quality of the final product. Deodorisation equipment including batch, semi continuous and continuous systems are widely used in the country. However, it is important to note that the deodorisation losses can occur during the process leading to a reduction in nutritional value and quality of the oil and this must be taken care of by maintaining proper conditions or by optimizing using the optimized process parameters. So, it is essential to carefully monitor and optimize the deodorisation process parameters to ensure the highest quality and nutritional value of the final product.



So, these are the references used in this lecture with this. Thank you very much for your patience here. Thank you.