Post-Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

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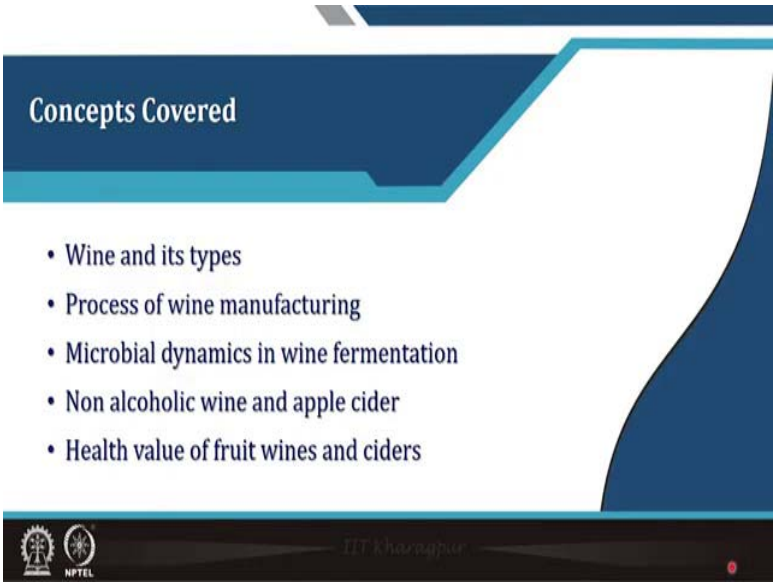
Lecture 47

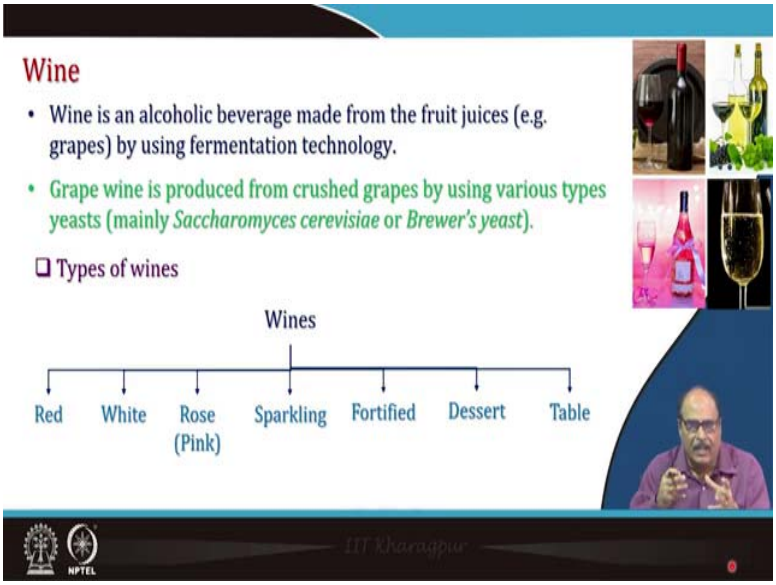
Fruit Wines and Ciders

Concepts covered



Hello everybody, Namaskar. Today in this lecture we will discuss about fruit wines and ciders. We will study what is wine, what are different types of wines, process for the manufacturing of wine and also the microbial dynamics in wine fermentation. We will also discuss non-alcoholic wine and apple cider and finally the health value of fruit wines and ciders.

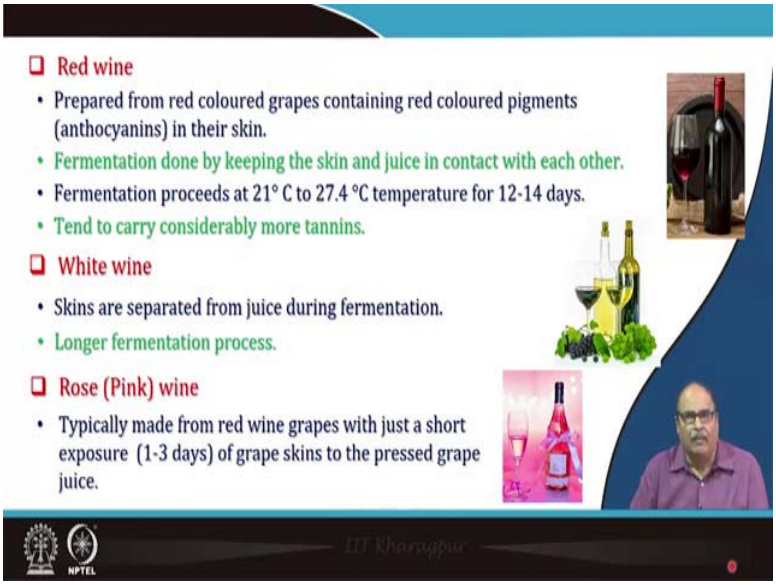
Wine



You know that in the earlier lecture we discussed about various aspects of fermentation technology, fermenters, etc. So this wine is basically an alcoholic beverage which is made from fruit juices using the fermentation technology and mostly the grape is used for production of wine in fact this wine "w i n e" is considered to be a product of wine that is the "v i n e" vine.

Grape wine is produced from crushed grapes by using various types of yeasts and mainly the *Saccharomyces cerevisiae* are more commonly known as Brewer's yeast is used in this fermentation. Different types of wines which are available in the market include red wines, white, rose or pink wines and sparkling wine, fortified wine, dessert wines or table vines.

Red Wine



The red wine is prepared from obviously the red coloured grapes. Outer skin of the red coloured grapes contains various pigments, red pigments which are mainly anthocyanins. So, this skin is used in the juice during the fermentation technology. The fermentation is done by keeping the skin and juice in contact with each other.

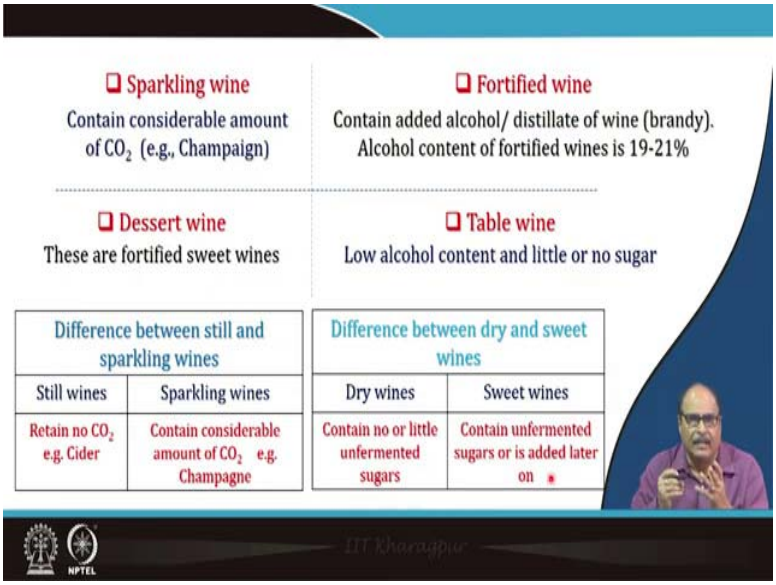
Fermentation proceeds at around 21 to 27 degree Celsius temperature for about 12 to 14 days and they tend to carry considerable amount of tannins. These red wines have more amount of tannins. White wines: even the green coloured grapes can be used to prepare the white wines, but even red coloured wines are also used to prepare white wines.

And in this case before the juice is subjected to fermentation the skins are separated beforehand, because the coloured component is there in the skins, so the skins are removed and then the juice without skin is subjected to the fermentation process. It takes longer fermentation time.

Rose or pink wine, as you can see in the figure here, looks very delicate. It is typically made from the red wine grapes. For some time the skin is allowed to remain in the juice during the fermentation process, may be for one to three days and then skins are separated initially maybe even before the fermentation has started.

So, in the extraction the juice and skins are allowed to be there and this facilitates the extraction of part of the colouring pigments into the juice. And then this fermentation process goes there. So, accordingly red wine, white wine or rose wines are produced by the industry.

Sparkling Wine

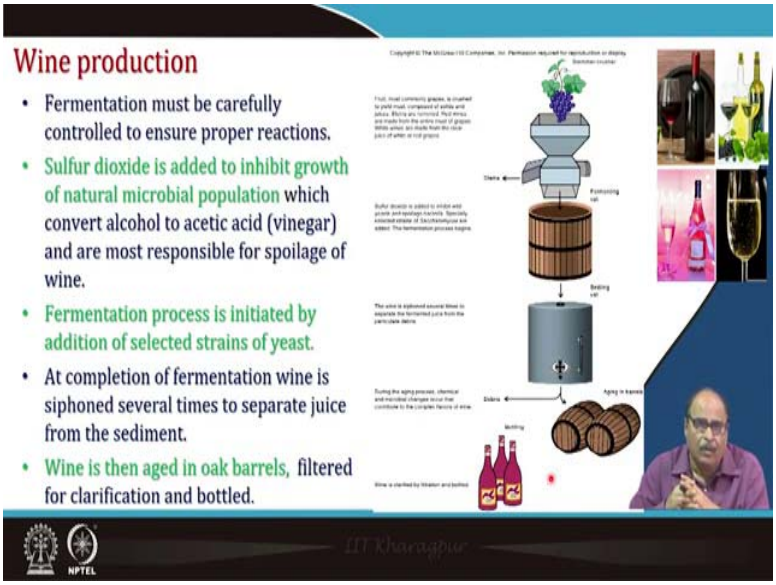


Sparkling wine, it contains considerable amount of carbon dioxide like champagne, etcetera. Dessert wines are those which are fortified sweet wines. Fortified vines contain added alcohol, they are also made by the distillation of wines like brandy. Brandy can be considered as a fortified vine. So, alcohol content in most of the fortified wines may be up to 19 to 21 percent.

Table wines have low alcohol content and there is no little or no added sugar. So, if you want to see the difference between still wine and sparkling wine: the still wines retain no carbon dioxide in them, for example, cider does not have carbon dioxide whereas the sparkling wine contains considerable amount of carbon dioxide.

Dry wines contain no or little unfermented sugar in it, whereas the sweet wines contain significant amount of unfermented sugars or even sometimes the sugar is added into the wine just before packaging, in order to give a sweet taste.

Wine Production



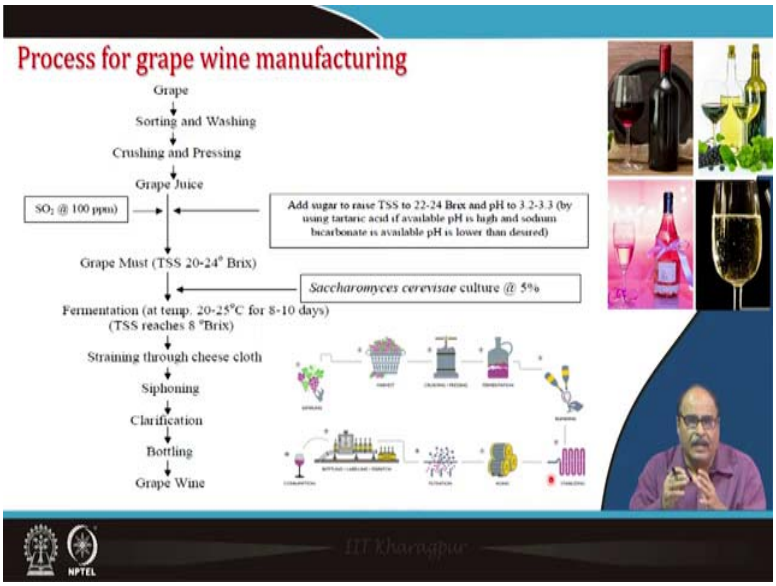
So, let us now discuss about the wine manufacturing technology. And before I go to the process details let me tell you that fermentation process is the heart of the wine production technology. So, the fermentation must be carefully controlled to ensure proper reactions that are desirable reactions.

Sulfur dioxide is added to inhibit the natural microbial population which convert alcohol to acetic acid, vinegar, etcetera and they are most responsible for the spoilage of the wine. Because there is a wine grapes when they are harvested from the crop prevailing the situation

in the field they are likely to be contaminated with various types of microorganism, even wild yeast and all those things.

So, these all should be properly taken care of by appropriate cleaning process. These unwanted microorganisms, wild yeast, etcetera should be removed. So, the fermentation process is initiated by the addition of selected strains of yeast as I told you *Saccharomyces cerevisiae*. And at completion of the fermentation wine is siphoned several times to separate juice from the sediment and then it is aged in oak barrels, filtered for clarification and finally bottled.

Process for grape wine manufacturing



So, as far as the exact process of wine making is concerned as I told you grapes are harvested at proper maturity, then it is sorted and washed, that is washing and cleaning is very important operation and sometimes this is added with some sanitizing agents, cleaning solution, washing solution. etc.

Then crushing and pressing, so with that you get the grape juice. In earlier classes we have discussed about what are the technology of crossing and expression and getting the various fruit juices. The same holds true here as well. So, now that juice is obtained, there are two important things. One is that it is treated with the sulphur dioxide at about 100 ppm, etcetera to suppress the growth of wild yeast, etcetera.

And we will see little later that it is in this is juice that amount of final alcohol content in the wine depends upon the initial content of sugar present in the juice. So, the next important step

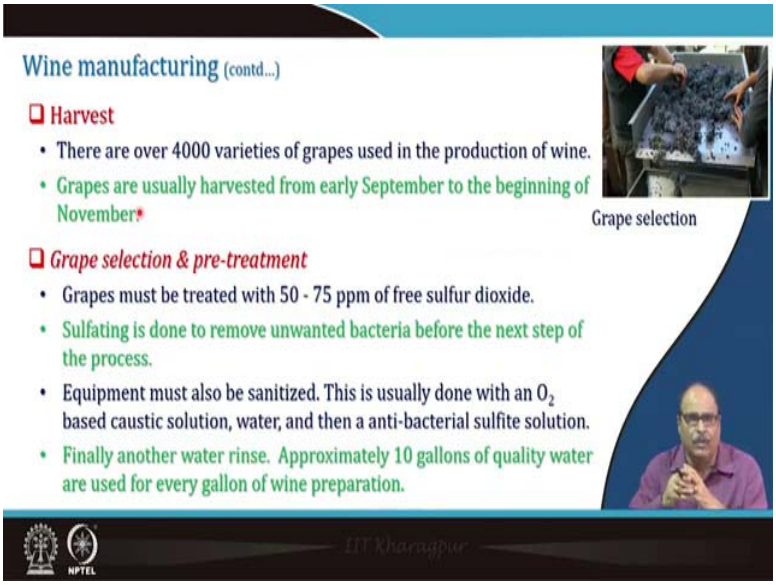
is, after the juice is extracted, is that the juice should be analyzed for its TSS (total soluble solids) content and it should be approximately in the range of around 20 to 24 percent and its pH is tested, so pH should be 3.2 to 3.3 in this range for optimum fermentation.

So, if there is a variation that is if the sugar, total sugar content is not in this range then maybe sugar may be added to increase the TSS levels or either by using tartaric acid or by using sodium bicarbonate, etcetera the pH should be adjusted suppose the pH is to be reduced or pH is to be raised accordingly that acid or some salt sodium bicarbonate or tartaric acid may be used.

So, important thing is that the juice is adjusted to its proper TSS and proper pH and then this adjusted juice is called grape must and this grape must which has around 20-24 degree brix is now then inoculated with the *Saccharomyces cerevisiae* yeast and then it is given the proper fermentation time. Maybe in general this yeas has optimum temperature for its better activity, best activity is around 20 to 25 degree Celsius.

So, this fermentation period may last accordingly for about 8 to 10 days and the TSS reaches to 80 degree brix in the final fermented juice. Then finally, siphoning, clarification, bottling and you get the grape wine. So, we will take up one by one these steps.

Wine manufacturing (contd…)



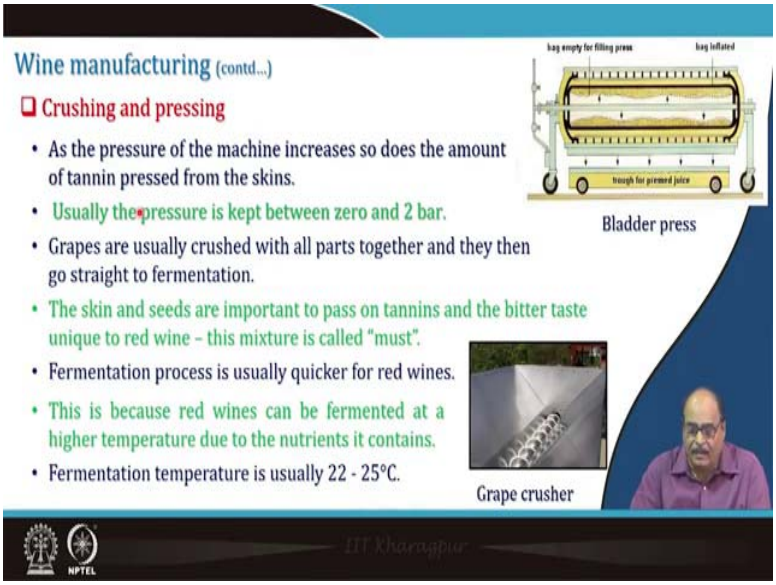
Now harvest: I told you that there are about 4000 variety grapes used in the production of wines and then the important thing is that the grapes are harvested generally from early

September to beginning of the November in India, but the important thing is that they should be harvested at proper maturity time.

And in fact, proper variety of the grapes should be taken because variety and time of harvesting will influence the sugar and acidity levels in the juice. In fact, in the industry there is a practice of vintage dating of the wine by providing the data that is from which season, from which place, which year that the grape was used for making the wine.

Then come grape selection and pre-treatment. As I told you grape-must must be treated with about 50 to 75 ppm of free sulphur dioxide. Sulfating is done to remove unwanted bacteria before the next step of the process. Equipment also must be properly sanitized and this is usually done with the oxygen base caustic solution, water and then an antibacterial sulphide solution. Finally, another water rinse is done. Approximately 10 gallons of good quality water is required or it is used for making 1 gallon of wine preparation.

Wine manufacturing (contd….)

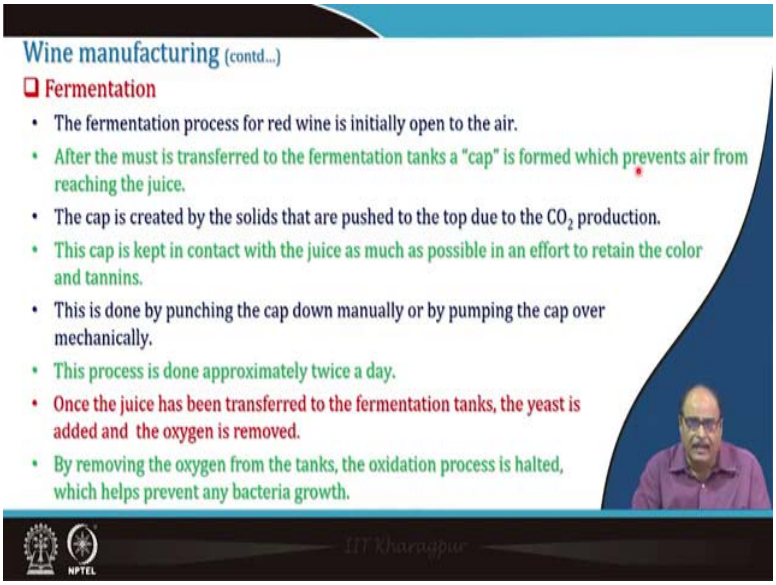


Then crushing and pressing: In the crushing process, as the pressure of the machine increases, so does the amount of tannins pressed from the skins. Usually the pressure is kept between 0 and 2 bar.

Grapes are usually crushed with all parts together and then they go straight to the fermentation, of course before that they are analysed. The skin and the seeds are important to pass to tannin and the bitter taste unique to red wines and the mixture is called must as I told you. Fermentation process is usually quicker for red wines and this is because red wines can

be fermented at a higher temperature due to nutrient it contains. Fermentation temperature is usually around 20 to 25 degree Celsius.

Wine manufacturing (contd…)



The fermentation process: In the earlier class we discussed the details of the fermentation technology, even the fermenters: what are the various components in the fermenters, so all those are applicable here. And the fermentation process for red wine is initially open to the air. After the must is transferred to the fermentation tanks a “cap” is formed which prevents air from the reaching to the juice.

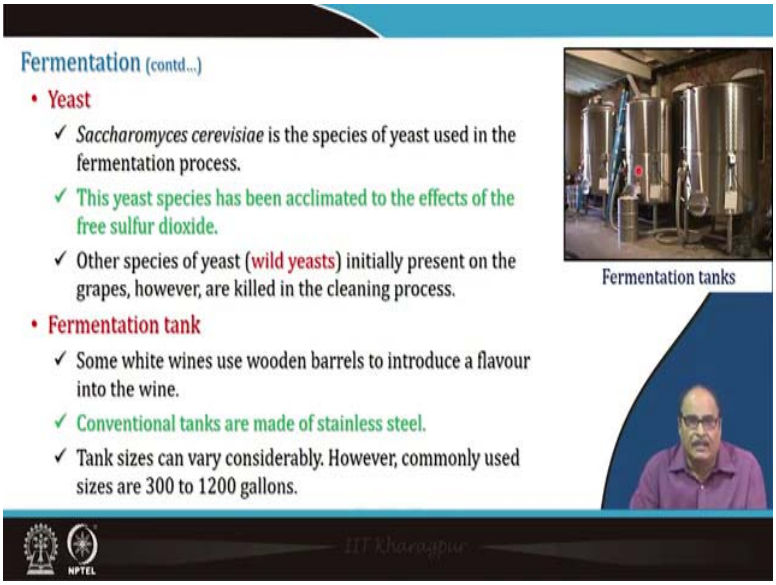
And this air is basically required initially before the yeast is added for proper extraction of the colouring components from the skin to the juice. And these skins will normally float on the cap which is surface of the liquid. And in big fermenters particularly this becomes a problem.

So, what is done? As I told you a cap is created by solids and then they are pushed on the top due to carbon dioxide production inside when the fermentation has taken place and gas is produced. So, this cap is kept in contact with the juice as much as possible in an effort to retain the colour and tannins.

So, this is done by punching the cap down manually or by pumping the cap over mechanically that is in larger fermenters from the bottom. There are arrangements provided so that the liquid is taken and then it is recirculated so in the process the cap should always be properly inserted in the juice to facilitate proper extraction, particularly in the making of red wine.

And once the juice has been transferred to the fermentation tank, the yeast is added and then oxygen is removed. Because the oxygen is removed this fermentation process is anaerobic fermentation and by removing the oxygen from the tank the oxidation process is halted which prevents any bacterial growth and facilitates the normal fermentation reaction.

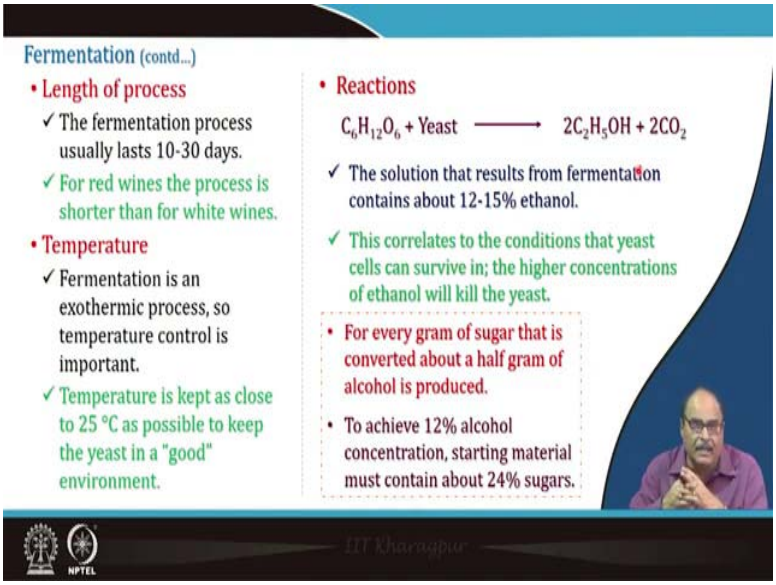
Fermentation (contd….)



Saccharomyces cerevisiae is the species of the yeast that is used in the fermentation process. This yeast species has been acclimatized to the effect of the free sulphur dioxide which has been added into the juice. Other species of the yeast which are known commonly wild yeast which might be initially present in the grapes they are killed in the cleaning process.

The fermentation tank: some wines use wooden barrels to introduce a flavour into the wine. Conventional tanks are made of stainless steel. Tank sizes can vary considerably. However, commonly used sizes are about 300 to 1200 gallons.

Fermentation (contd…)



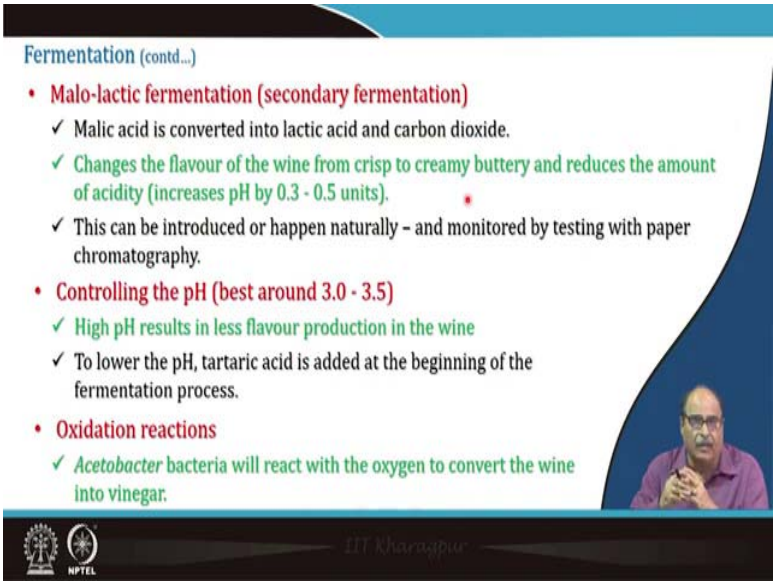
The length of the fermentation process may be about 10 days to 30 days depending upon the temperature and other conditions in the reactor. For red wines the process is shorter than that for the white wines. And the temperature of the fermentation process, maintenance of proper temperature is very important because this reaction as you see that glucose or sugar is oxidized by the yeast to ethanol and carbon dioxide; it also releases lot of heat energy.

So, this fermentation is exothermic process, so temperature control is very important. Temperature is kept as close as possible to 25 to keep the yeast in a good environment to give the proper condition for the proper growth environment. So, the solution that results from fermentation finally contains around 12 to 15 percent ethanol.

You have seen the earlier that the sugar level TSS level is about 22 to 24 percent, so normally it should give in general around 12 percent ethanol depending upon the sugar content. The maximum alcohol content in the wine may be about maximum you can say 15 percent because if ethanol content goes more than fifteen percent its concentration becomes inhibitory to the yeast and yeast will die as yeast cannot survive in an environment which has more than 15 percent alcohol.

So, another important thing for every gram of sugar that is converted about a half a gram of alcohol is produced and therefore to reach, to achieve about 12 percent alcohol concentration in the wine, the starting material (the juice) must contain about 24 percent of the sugars.

Fermentation (contd…)

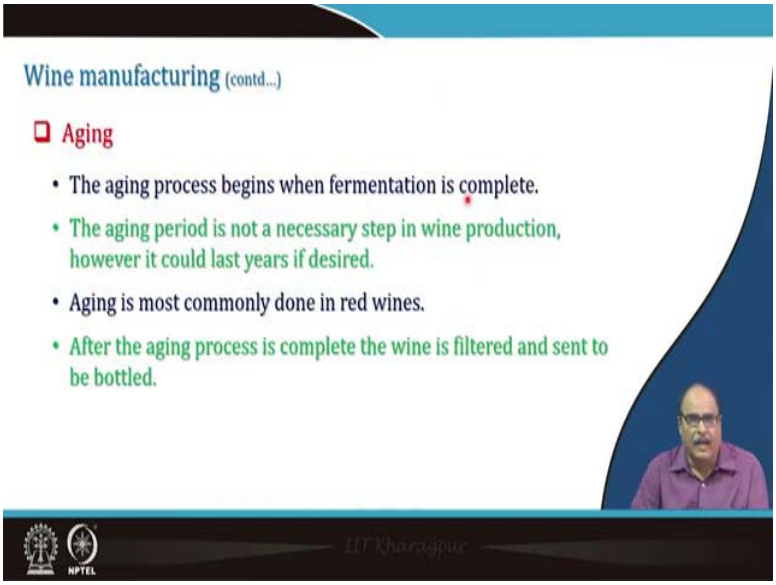


Malo-lactic fermentation is a secondary fermentation which usually take place in the wine. In this, malic acid is converted into lactic acid and carbon dioxide. It changes the flavour of the wine from crisp to creamy buttery and also it reduces the amount of acidity, that is increases the pH by a factor of 0.3 to 0.5 units. And this can be introduced or it can happen naturally and monitored by testing with the paper chromatography, etcetera or such other standard protocols.

So, controlling the pH of the fermenting juice around pH 3 is best. High pH will result in less flavour production in the wine. To lower the pH, tartaric acid is added at the beginning of the fermentation process as required but either by addition or depending upon what is the initial pH of the juice that is either suitable acid or tart salt should be added but the pH should be brought in this range.

The oxidation process: *acetobacter* bacteria will react with the oxygen to convert the wine into vinegar and that should be stopped that is why oxygen supply is stopped once the wine is produced.

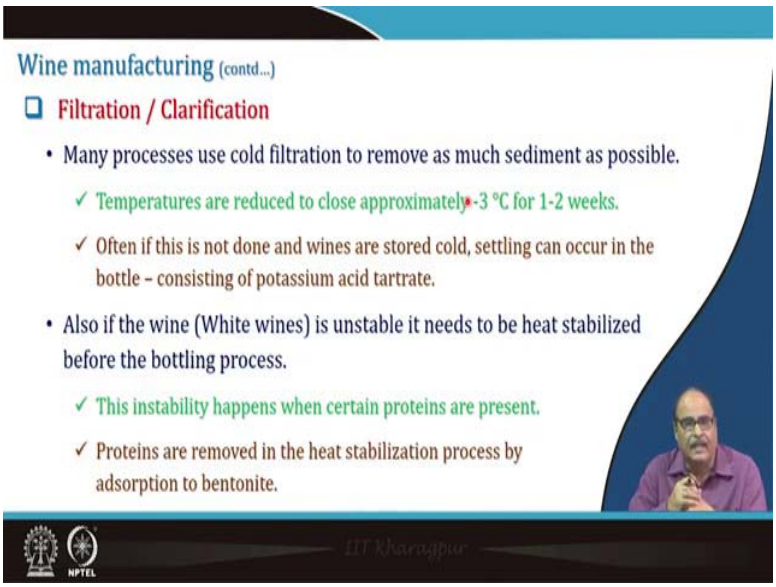
Wine manufacturing (contd…)



Then after the fermentation next step is aging. Aging process begins after the fermentation is complete. Aging period is not necessary step in wine production. However, it could last for several years if desired. Aging is most commonly done in red wines. After the aging process is complete, the wine is filtered and sent to be bottled.

So, in fact, during aging, the ripening of wine takes place that is the mellowing because this tannins, etcetera they are bitter tasting compound so during the aging process the flavour and even the texture, colour, etc. improve and the wine is said to be mellowed.

Wine manufacturing (contd…)

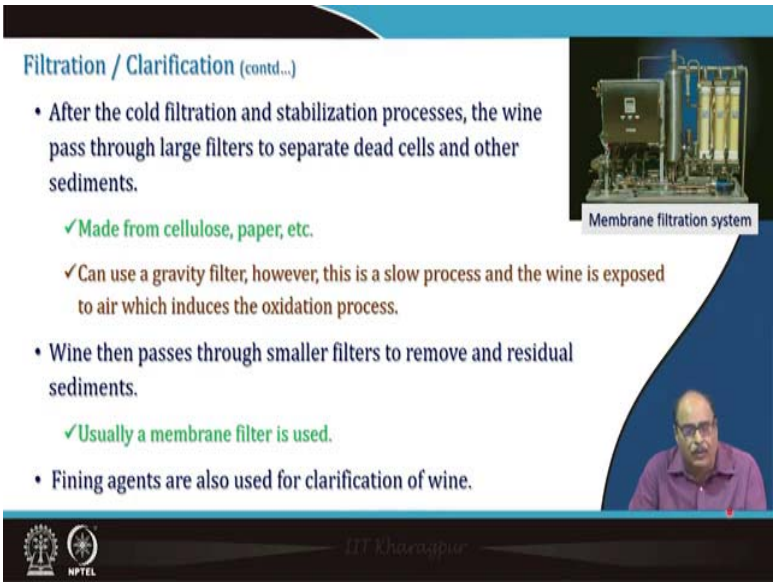


Then filtration or clarification: Many processes use cold filtration to remove as much sediment as possible because during the aging also some of the fine particle, which might

have come from the filter, they get settled so the temperature are reduced to close approximately to -3 degree Celsius for 1 to 2 weeks and this also results in the settling of the finally suspended particles.

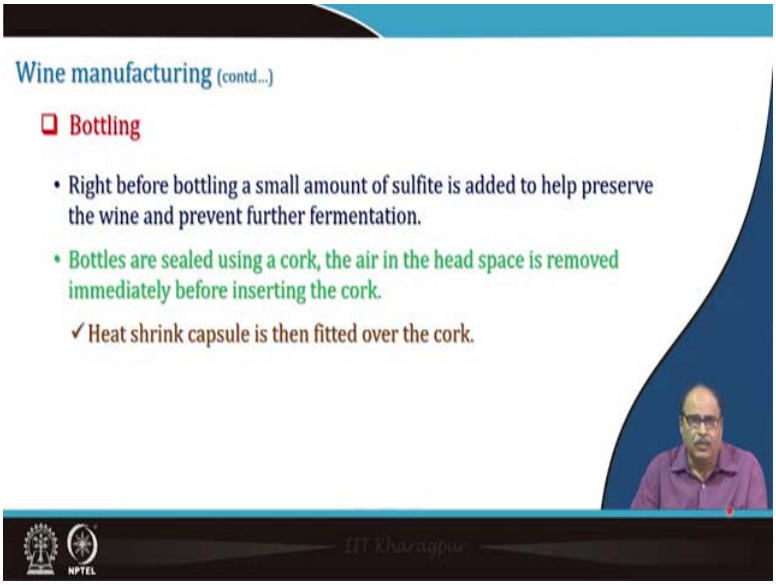
And often if it is not done and wines are stored cold, settling can occur in the bottle consisting of potassium acid tartrate. Also white wines are unstable; it needs to be stabilized before the bottling process and this instability of the wine happens when certain proteins are present into the fermented juice. Proteins are removed in the heat stabilization process by adsorption to bentonite.

Filtration / Clarification (contd….)



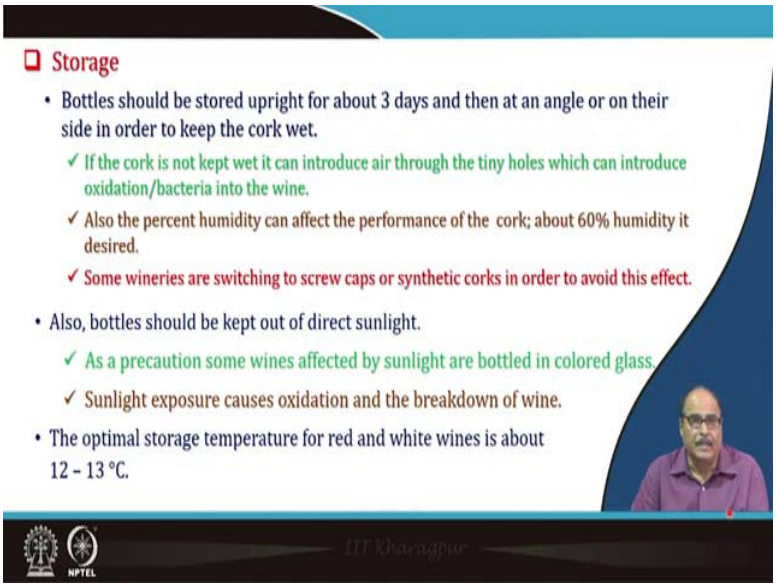
After the cold filtration and stabilization process, the wine passes through large filters to separate dead cells and other sediments. These filters may be made of cellulose or paper; they can use a gravity filter, however, this is slow process and the wine is exposed to air which induces the oxidation process. So, gravity filters generally are avoided. So, wines pass through smaller filters to remove the residual sediments; usually they use the membrane filtration process. And sometimes fining agents are also used for clarification purposes.

Wine manufacturing (contd….)



Then bottling, right before the bottling a small amount of sulphide is added to help preserve the wine and prevent further fermentation. Bottles are sealed using a cork. The air in the head space of the bottle is removed immediately before inserting the cork and heat sink capsule is then fitted over the cork.

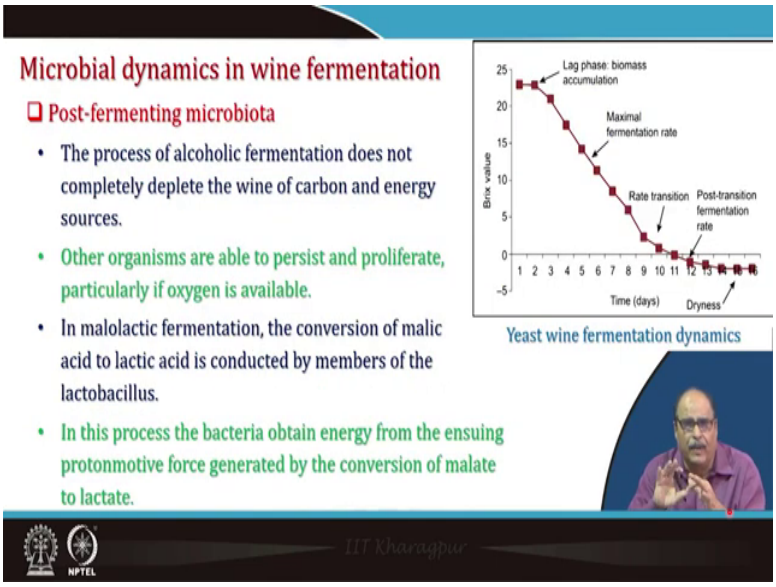
Storage



During the storage, care should be taken that bottles are stored upright for about 3 days and then at an angle or on their side in order to keep the cork wet. If the cork is not kept wet it can introduce air through the tiny holes which can introduce oxidation process. It can also allow some bacteria to go into the wine and contaminate the wine and initiate spoilage reactions.

Also the percent humidity can affect the performance of the cork. About 60 percent humidity is desired. Some wineries are now switching to screw caps or synthetic corks in order to avoid this effect. So, the bottles should be kept out of the direct sunlight as a precaution. Some wines affected by sunlight are bottled in coloured glass bottles. Sunlight exposure causes oxidation and breakdown of the wine. The optimum storage temperature for red wine and white wine is about 12 to 13 degree Celsius.

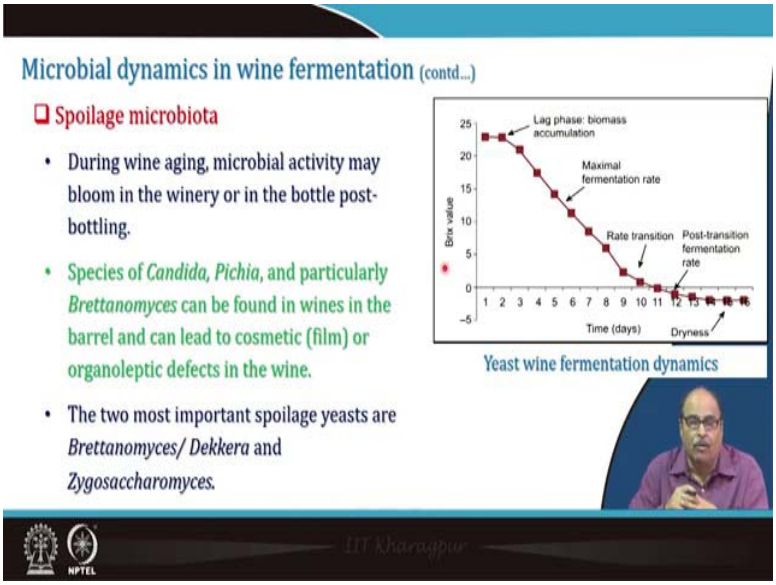
Microbial dynamics in wine fermentation



Then let us discuss some of the microbial dynamics in wine fermentation like particularly post fermenting microbiota. You can see here the figure: the time after fermentation and brix value. The process of alcoholic fermentation does not completely deplete the wine of carbon and energy sources, because in the wine there will be carbon source, energy source, so if the microorganism is present there then it will grow and multiply, see other organisms are able to persist and proliferate particularly if oxygen is available.

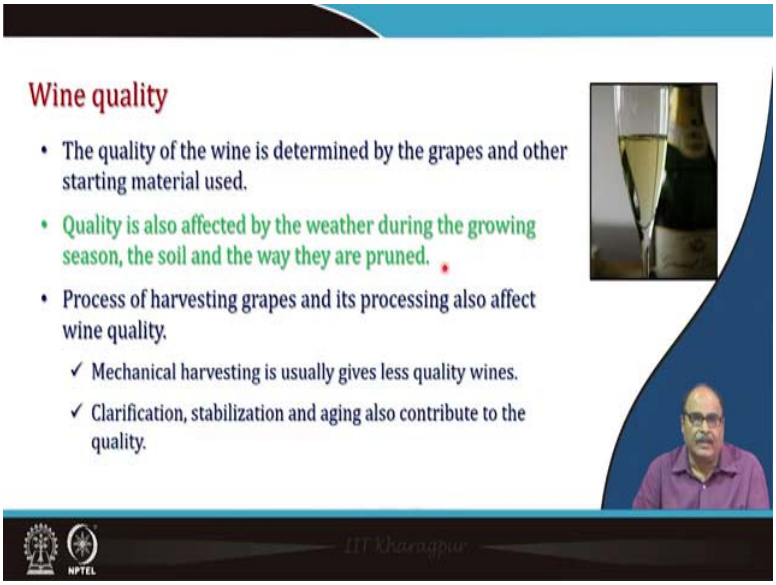
So, in malolactic fermentation, you have seen earlier the conversion of malic acid to lactic acid also is conducted by the members of the lactobacillus. In this process the bacteria obtain energy from ensuing proton motive force generated by the conversion of malate to lactate.

Microbial dynamics in wine fermentation (contd…)



Also the spoilage microbiota may grow if they are not properly controlled during the cleaning process. During the wine aging microbial activity may bloom in the winery or in the bottle post bottling. Species of *Candida*, *Pichia* and particularly *Brettanomyces* can be found in the wines in the barrel and can lead to cosmetic or organoleptic defects in the wine. The two most important spoilage yeasts are *Brettanomyces* / *Dekkera* and *Zygosaccharomyces*, so these should be taken care properly.

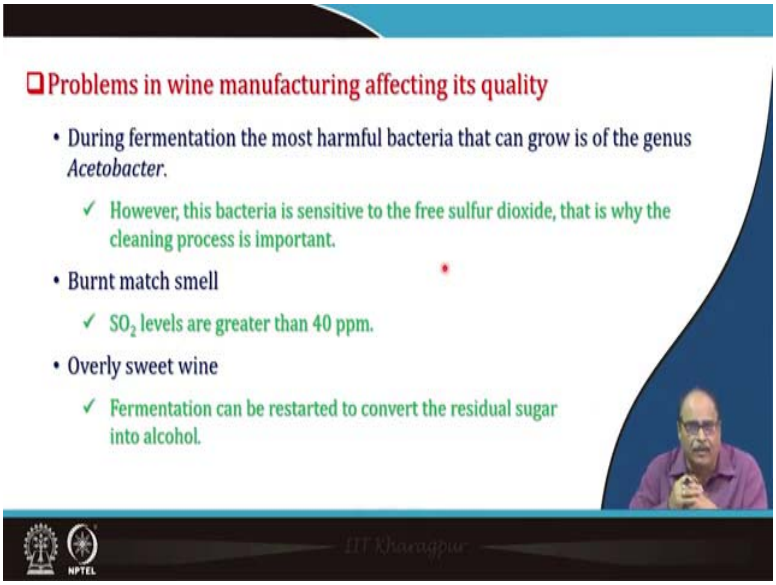
Wine quality



Then wine quality: quality of the wine is determined by the grapes and other starting material. As I told you, initially, quality is also affected by weather during the growing season, the soil and the way the grapes are pruned. The process of harvesting grape and its processing also

affects the wine quality like mechanical harvesting usually gives less quality wines. Clarification, stabilization and aging processes also contribute to the wine quality.

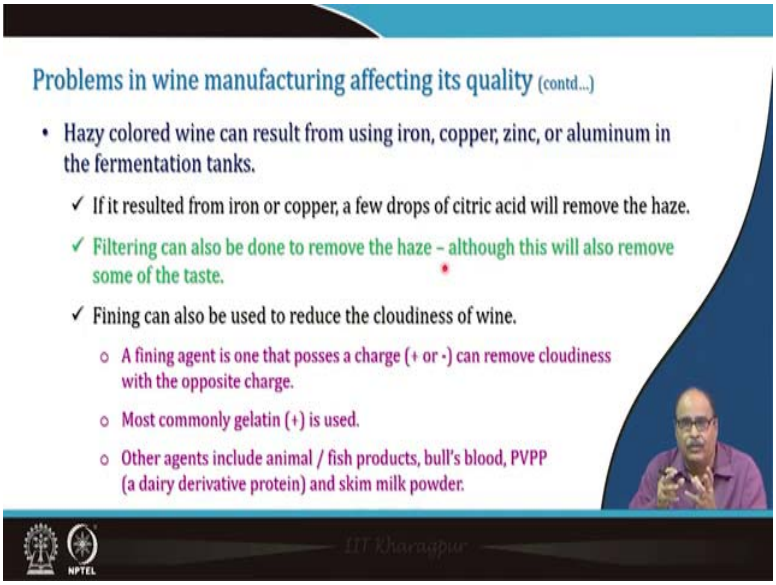
Problems in wine manufacturing affecting its quality



Now, we will discuss little problems in wine manufacturing affecting its quality. During fermentation, the most harmful bacteria that can grow is the genus *acetobacter*. However, this bacterium is sensitive to the free sulphur dioxide that is why the cleaning process is very important. So, if *acetobacter* is available, it will convert wine into alcohol, so care should be taken.

There may be burnt match-smell, that is the sulphur dioxide labels if they are very high (more than 40 ppm) then it may affect adversely the smell or flavour of the wine. Overly sweet wine: the fermentation can be restarted to convert the residual sugar into alcohol, if the sugar content is high and fermented sugar in the wine then it may give sweet taste.

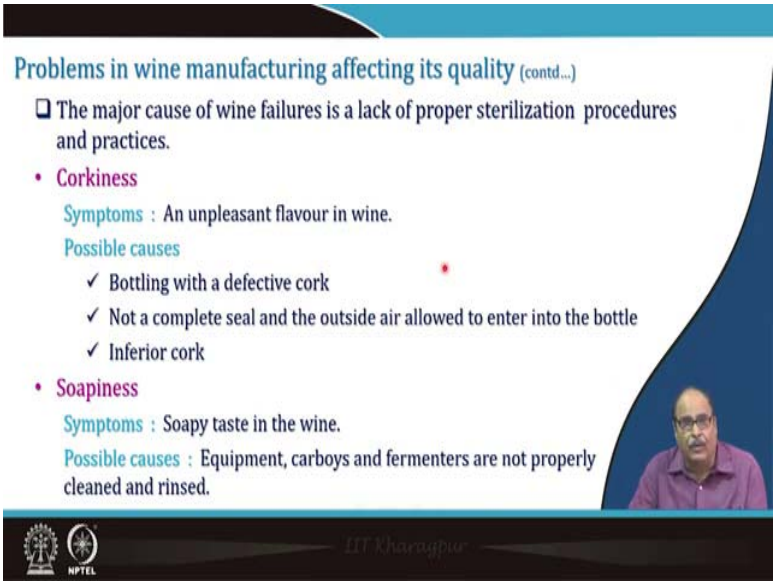
Problems in wine manufacturing affecting its quality (contd….)



Hazy coloured wine can result from using iron, copper, zinc or aluminium in the fermentation tanks that is if the fermentation tank material is this. So, if it is resulted from the iron or copper, a few drops of citric acid will remove the haze. Filtering can also be done to remove haze although this will also remove some of the taste.

Fining agents can also be used to reduce the cloudiness of wine that is a fining agent is one that possesses a charge, may be positive or negative, and it can remove cloudiness with the opposite charge. Most commonly used fining agent is gelatin. Other agents include animal or fish products, bull's blood, PVPP, which is a dairy protein derivative, skim milk powder and so on.

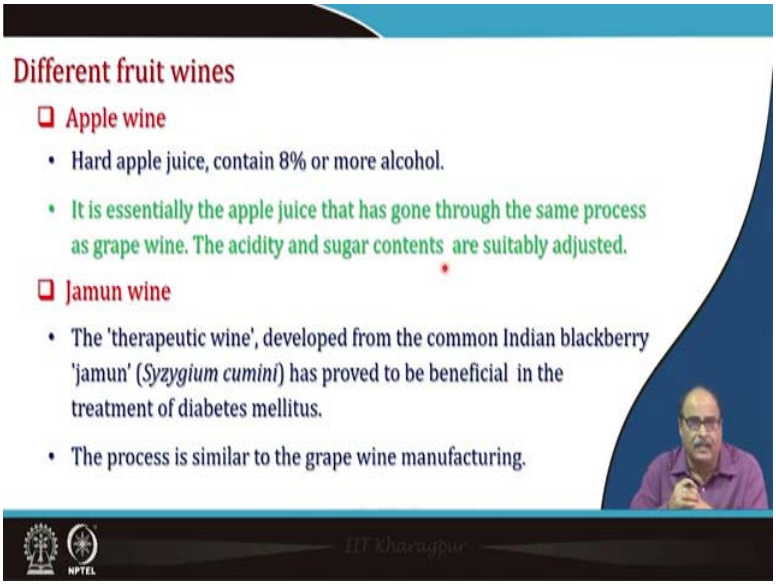
Problems in wine manufacturing affecting its quality (contd…)



The major cause of wine failure is lack of proper sterilization procedure and the practices. Corkiness, an unpleasant flavour in wine; its possible causes may be bottling with a defective cork; not a complete seal and the outside air allowed to enter into the bottle or inferior quality cork.

There may be soapiness: the soapy taste in the wine is developed. The possible causes for this might be equipment, carboys and fermenters are not properly cleaned and rinsed so the sterilization of the equipment should be properly done to ensure this.

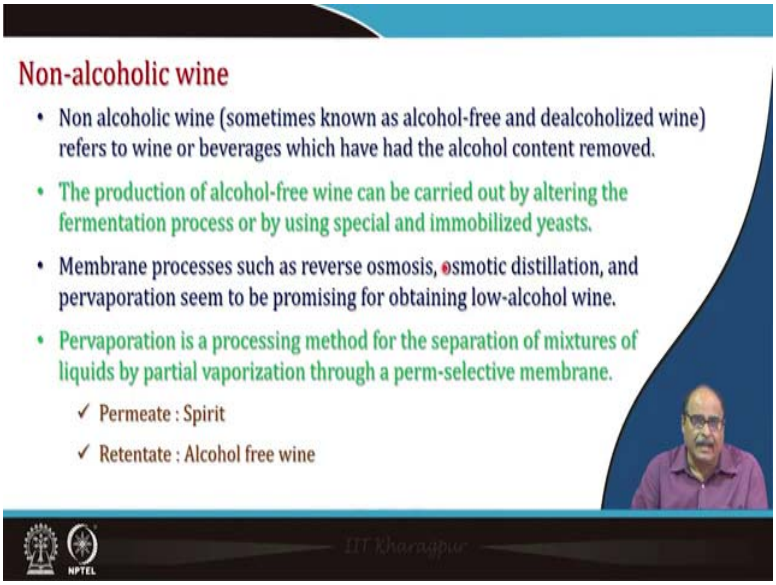
Different fruit wines



Then other fruit wines: different fruit wines like apple wines and jamun wine have been developed. Apple wines are hard apple juice but contain about 8 percent are more alcohol and it is essentially the grape apple juice that has gone through the same process as grape wine. The acidity and sugar content are suitably adjusted; the process parameters are also accordingly.

Then jamun wine also the therapeutic wine developed from the common Indian blackberry that is called jamun, it has proved to be beneficial in the treatment of diabetes mellitus and the process here also is similar to the grape wine manufacturing.

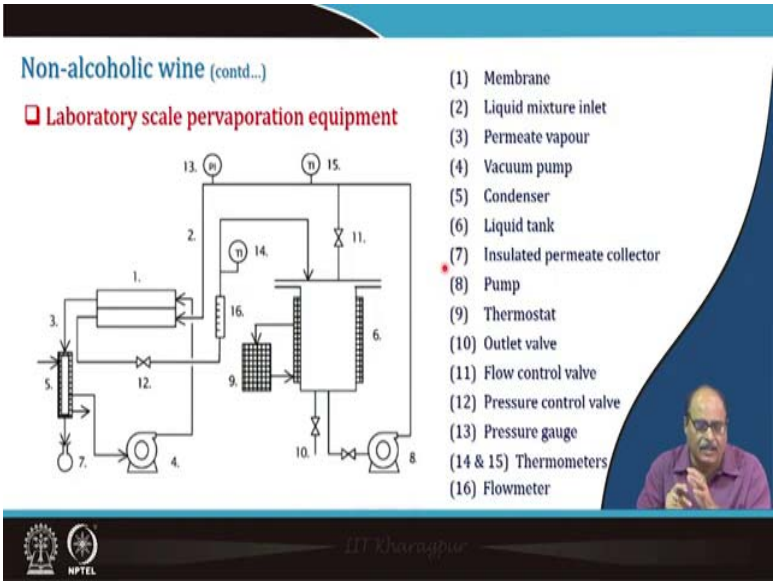
Non-alcoholic wine



Non-alcoholic wines like sometimes they are also known as alcohol free or dealcoholized wine. These refer to the wine or beverages which have had the alcohol content removed. The production of alcohol free wine can be carried out by altering the fermentation process or by using the immobilized yeast. Normally the membrane processes such as reverse osmosis, osmotic distillation and pervaporation seem to be promising for obtaining low alcohol wines.

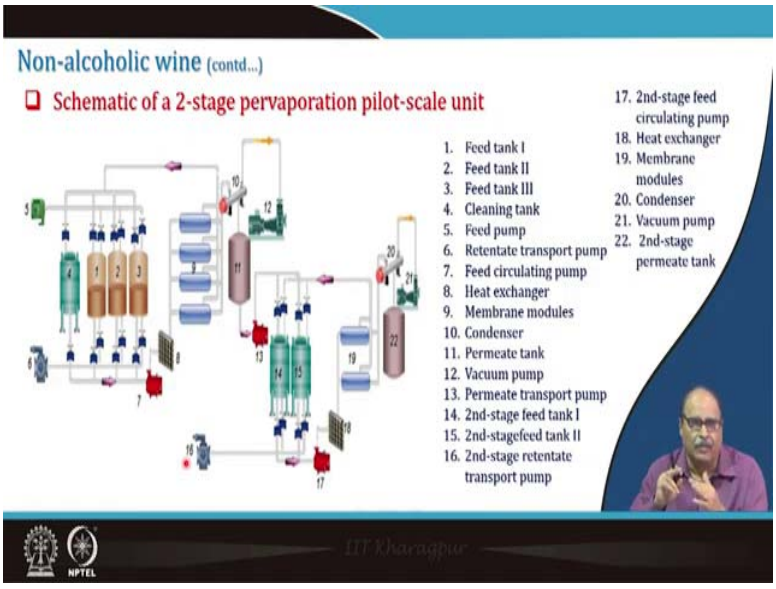
So, pervaporation is a processing method for the separation of mixtures of liquids by partial vaporization through a perm-selective membrane. Many industries are commercially using this pervaporation process for making alcohol free wines, removing the alcohol from the wine but the taste, it remains there. So, the permeate obtained after the process is spirit that is the alcohol and the retentate is the alcohol free wine.

Non-alcoholic wine



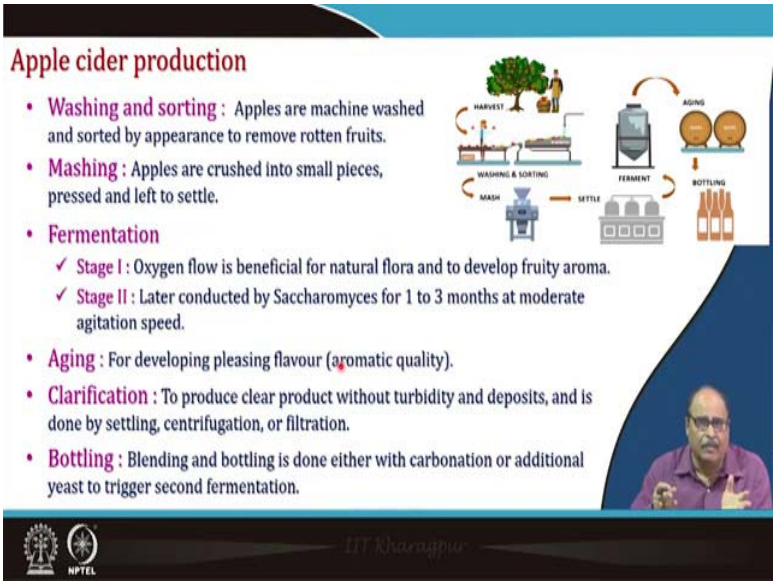
So, here actually it is a schematic of laboratory-scale pervaporation equipment. You can see that there is a membrane. The juice is continuously flown to the membrane and where the conditions are maintained the alcohol is collected separately and the permeate which is separated juice, alcohol free wine collected.

Non-alcoholic wine (contd….)



And this is also almost similar. It is a schematic of a 2 stage pervaporation pilot scale unit and in the one stage from feed tanks it is sent to the membrane and then again it was sent to the second stage membrane separation. So, this basically ensures better efficiency. All the components of this setup are listed here.

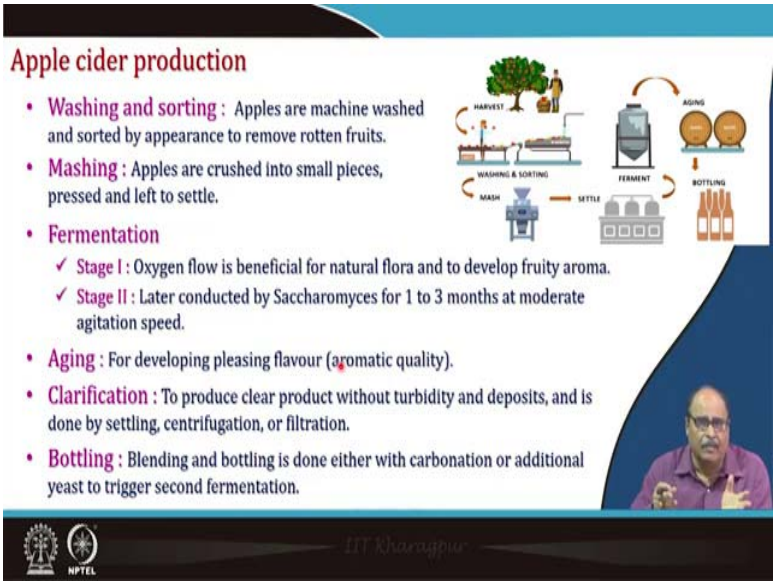
Apple cider production



And apple cider is an alcoholic drink made from fermented apple juice. Dry cider is fully fermented apple juice with little or no residual sugar. It is called as dry or hard cider as it contains an alcohol around 6 to 7 percent. Then sparkling cider contains considerable amount of CO2, 3.5 percent alcohol is there.

And champagne type cider is produced in a similar manner as that used in the preparation of champagne. Here also the microorganism is yeast that is *Saccharomyces cerevisiae*.

Apple cider production

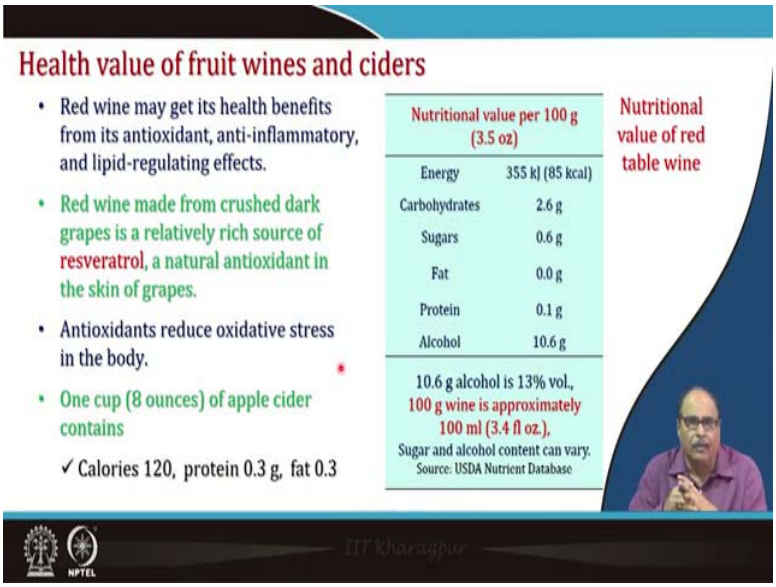


So, the process also is similar to that of wine production from grape. Apples are machine washed and sorted by for appearance to remove rotten fruits, then they are crushed into

smaller pieces, pressed to lift and settle; then juice is subjected to the fermentation process. In stage 1 oxygen flow is beneficial for natural flora to develop the fruity aroma.

And then it in the second stage it is conducted by the *Saccharomyces* for 1 to 3 months at a moderate agitation speed and finally aging, clarification and bottling process similar to that of the grape wine.

Health value of fruit wines and ciders

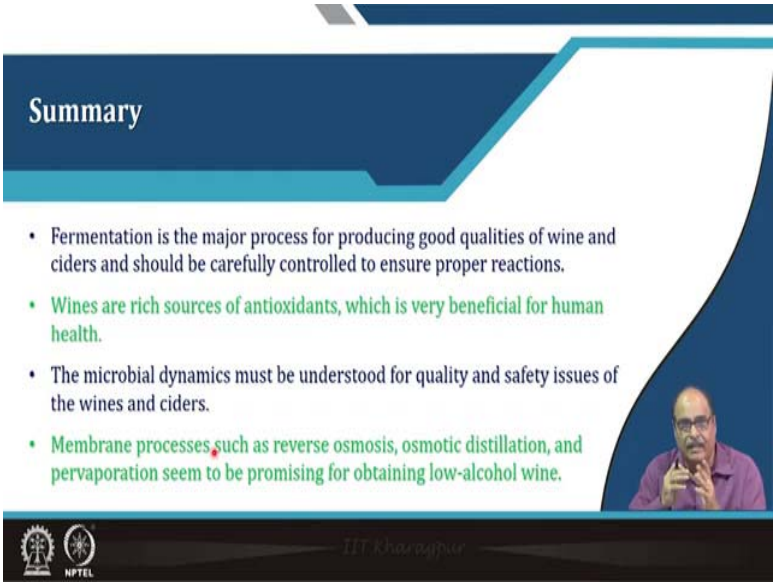


These red wines particularly may get their health benefits from their antioxidant, anti-inflammatory and lipid regulating effects that is the red wines made from crushed dark grape is relatively a rich source of resveratrol which is a natural antioxidant in the skin of the grapes.

And you know that antioxidants reduce the oxidative stress in the body, so these red wines are very health promoting. But it should be consumed in limit, if you take excessive then alcohol may also have undesirable effect but if it is taken in limit in a proper quantity, there is no better medicine than the red wine that is, see energy content in this, nutritional value per hundred gram of the wine are 3.5 ounces.

That is it contains around 85 kilo calorie heat energy, 2.6 gram carbohydrates, sugars 0.6, fat, protein are negligible but alcohol around 10.6. So, 100 gram wine is approximately 100 ml sugar and alcohol content can vary. Even apple cider one cup that is 8 ounces of apple cider contains around 120 calories and 0.3 gram fat and 0.3 gram protein.

Summary



So, finally I will summarize this lecture. The fermentation is a major process but for making good quality, healthy wines and this fermentation temperature receptors, fermentation process conditions should be properly controlled and the raw material should be proper quality, proper maturity, proper cleaning and sanitization processes should be done and obviously the wines are rich sources of antioxidant and other health promoting components they are very good for human health.

But very important is that microbial dynamics must be properly understood and all the steps should be taken. Proper steps should be taken during pre-processing, processing or post processing, bottling and storage to avoid unwanted reaction secondary fermentation, etc. If unwanted reactions happen or oxidation bacteria grow, they will adversely affect the quality of the wine.

Nowadays the trend is increasing to get the alcohol free wine, that is, people want to have the taste and flavour of the wine but just not the alcohol effect. So, for that the membrane processes such as reverse osmosis, pervaporation, etc. seem to be promising for obtaining low alcohol wine.

References

These are the references used in this lecture. Thank you very much for your patient hearing.