Course on Industrial Biotechnology
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Lecture 29
Module 6
Brewing Industry

Welcome back to my course that Industrial Biotechnology. In the last two lectures I covered the ethanol fermentation process now I am going to discuss the brewing industry and brewing industry that deals with the beer making industry largely used throughout the world so we will give some detailed information on that.

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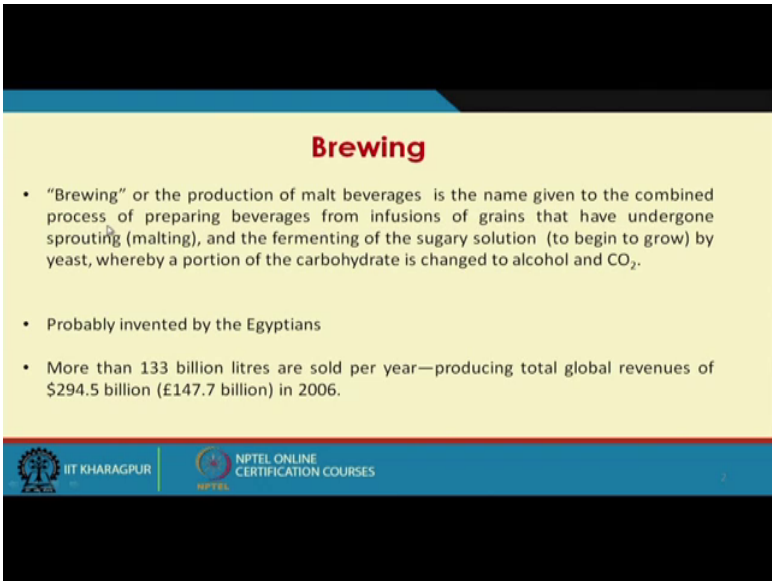

Now if you look at brewing, brewing is the product of malt beverage is the name given by the combined process of preparing the beverage from infusion of grains that have undergone sprouting what you call malting and the fermenting the sugary solution to begin to grow to by yeast, whereby a portion of carbohydrate is changed to alcohol and carbon-di-oxide, that means what happens in case of brewing industry that we use some kind of grain because we use mostly the barley grains.

And these barley grains undergoes some kind of malting process and during the malting process it produces hydrolytic enzymes and after that this is used this is dry then we make it powder and then we make it dough. Dough means with the help of water we make a semi solid mixture and keep at different temperature for hydrolysis of starch and the proteins and then then we get the soluble glucose.

This soluble glucose when used by the yeast cells it produce the alcohol. Now probably this has been invented by the Egyptians and more than 130 billions litres of beer sold per year producing total global revenue of 294.5 million that is dollar in 2006 this is a little old figure but now it has been increased to a great extent.

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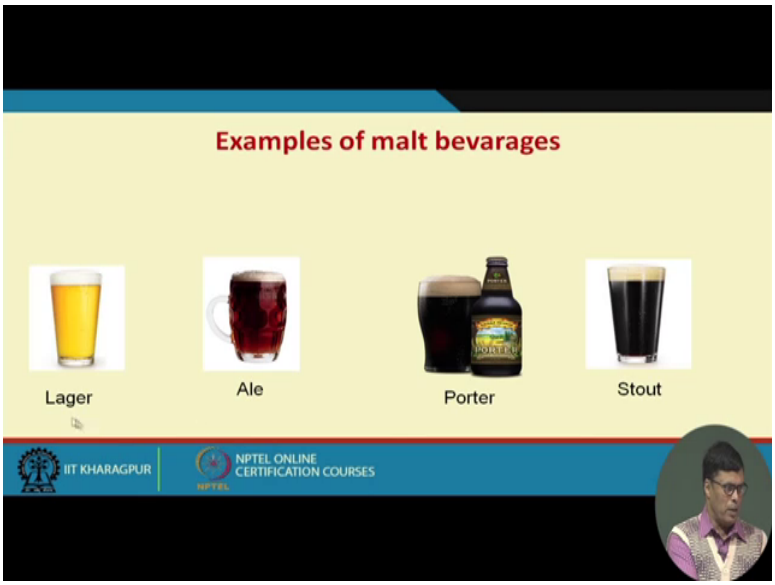

Now there are different examples of malt beverages that is available in the market the mostly we have four different malt beverage. One is called lager another is ale lager is largely used in India then we have ale little darker colour and porter is more darker you can see and there is a stout. So different types of beer has been marketed and mostly throughout the world we have this two type of beer mostly used by the people one is called lager another we call ale beer.

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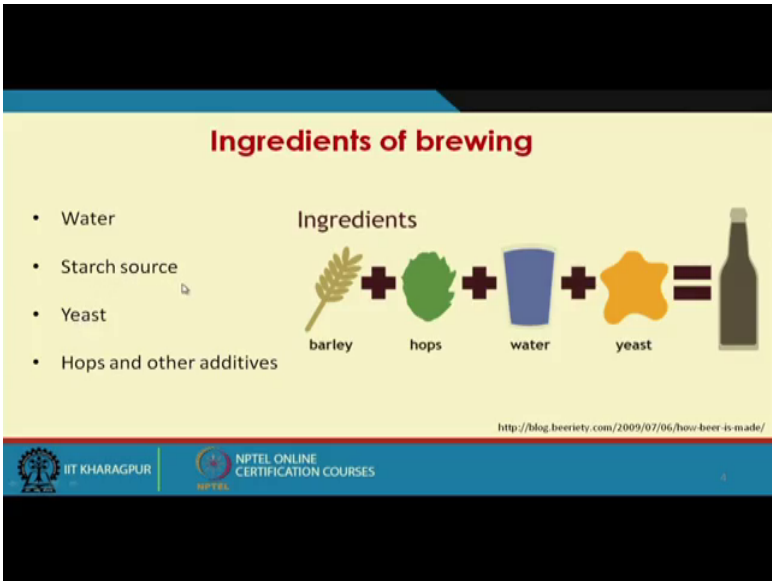

Now question comes what are the ingredients that required for the beer producing industries one is water then starch source, yeast and hops and other additives.

Now here I want to stress among all the alcoholic beverages the beer is considered as the energy drink and why it is energetic drink the reason is that the it contain not only alcohol but it contains significant amount of proteins. So that is that is why because no other drinks contain that much of proteins this protein comes from the barley grains. So this is that is why it is called the energetic drink.

Now if you look at this the ingredients that is used in the beer making industry that starch is we have starch source and starch source might be the barley grains as such maybe we use some malt agent malt agent is nothing but maybe rice, rice starch wheat starch that is used as a malty as a as a source of starchy material, and why it is used? This is used for diluting the colour you have seen that colour of the beer is different we suppose we want light colour beer then we shall have to use some malt agent then yeast we use for the fermentation hopes this is very important ingredients as the beer industry brewing industry is concerned because it gives the typical flavour and aroma of the of the beer, so we have this is barley grains then hops waters and yeast this gives the a beer.

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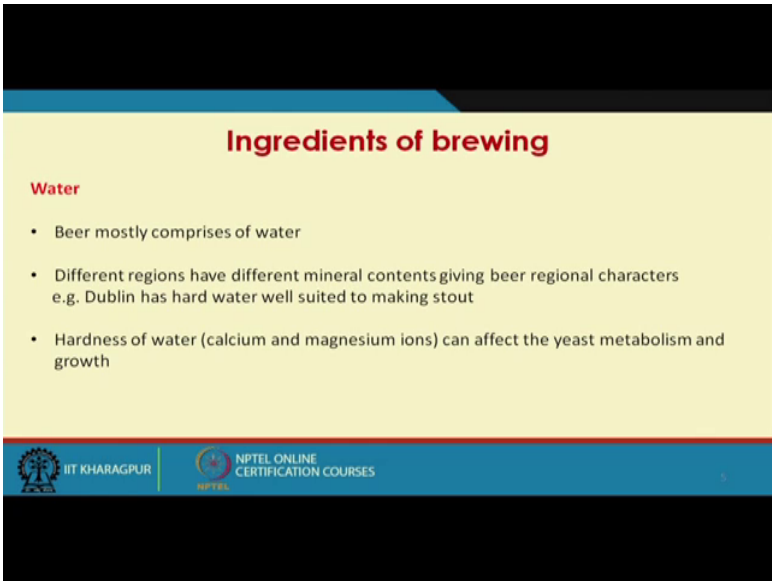

Now question what should be the here there is the very important issue that we have what should be the quality of water in the brewing industry, not only in brewing industry what should be the quality of water in different fermentation industries.

And whether we should go for distilled water or demineralized water or we should use the tap water or because this is because if we use the demineralized water naturally it will be costly and if we if we use the distilled water is more costly, if we use tap water it might be cheaper. Now what is the basis of using this water in the fermentation industry.

Now when we when we use any kind of water source first we should have some kind of analysis of the water where analysis on the basis of some it mostly contains some kind of minerals and we shall have to find out what are the minerals present in the in the particular this water and whether those minerals having some kind of effect on that fermentation process.

I can give a typical example particularly if you if you talk about the this that beer making industry that I told you that one important step is the saccharification of the starch. Now in the saccharification of starch alpha amylase plays very important role for the degradation of the starch to glucose. Now this alpha amylase it has been found in presence of calcium iron the thermostability of alpha amylase that increases to a great extent. So if your if your if your water contains some kind of calcium iron this is added advantage of that.

Similarly we shall have to find out the presence of some minerals whether it impart any kind of colour to the to the beer or it has some other effect on the beer. So if you find this is not

affecting the quality of the beer then we can go for using the tap water otherwise we shall have to thing for the using the demineralized water for a typical fermentation process. I can here if we take the example of the citric acid industry and citric acid industry we observe that iron and manganese iron that plays vital role that if those are present there the productivity of citric acid reduces drastically.

So there is the no that so the water the water should not contain any trace amount of iron and manganese. If it is present there then the productivity will decrease to a great extent. This is how we can determine the water quality of the fermentation industries.

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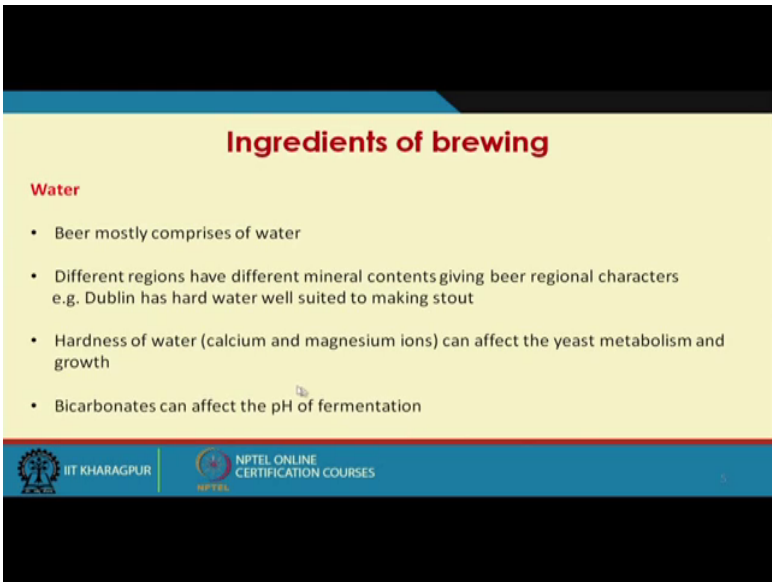

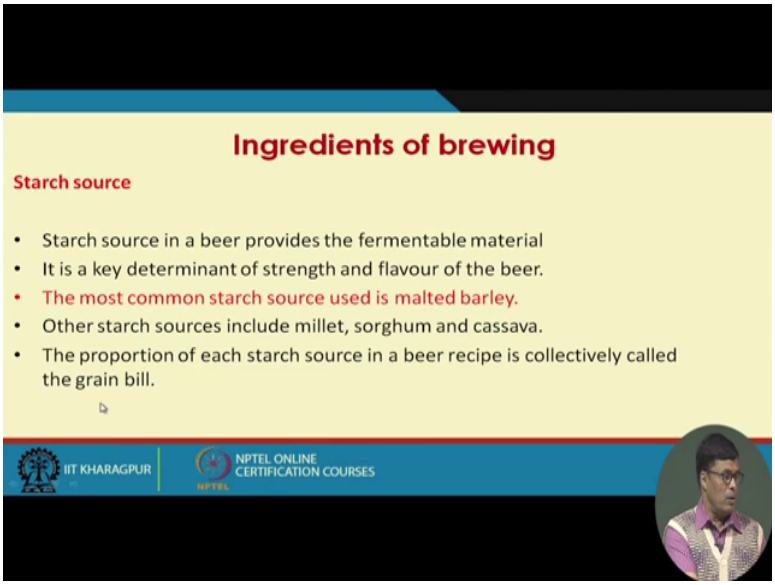

So here we have taken the example of Dublin as a hard water well suited for the making of stout because they have observed this contains some kind of minerals which is which is useful for this particular process.

The hardness of water calcium and magnesium can affect the yeast metabolism growth that also you have to work out. Biocarbonates can affect the pH of the fermentation. The starch source we have beer provide the fermentable material it is key determinant of strength and flavour of the beer, the most common starch source used the malted barley and other starch source the millets, sorghum, cassava.

I told you that we use rice starch also wheat starch also we use the proportion of the yeast starch the beer recipe collectively called the grain bill.

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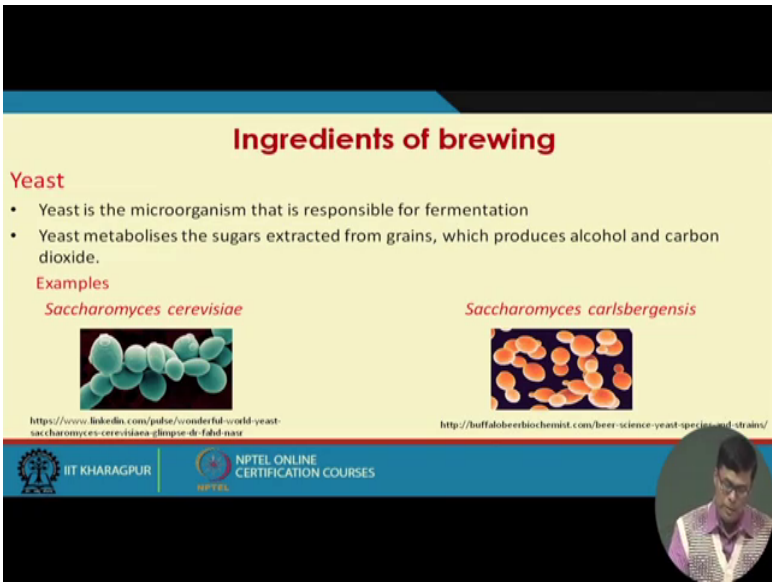

So this is this is different starch source we use now the ingredients of this one of the important ingredients that required in the beer brew industry is the yeast kind of yeast cell that is used and two type of yeast cells largely for the beer making industry one is called saccharomyces cerevisiae and you can see that you know the special characteristics of these yeast cells is the budding.

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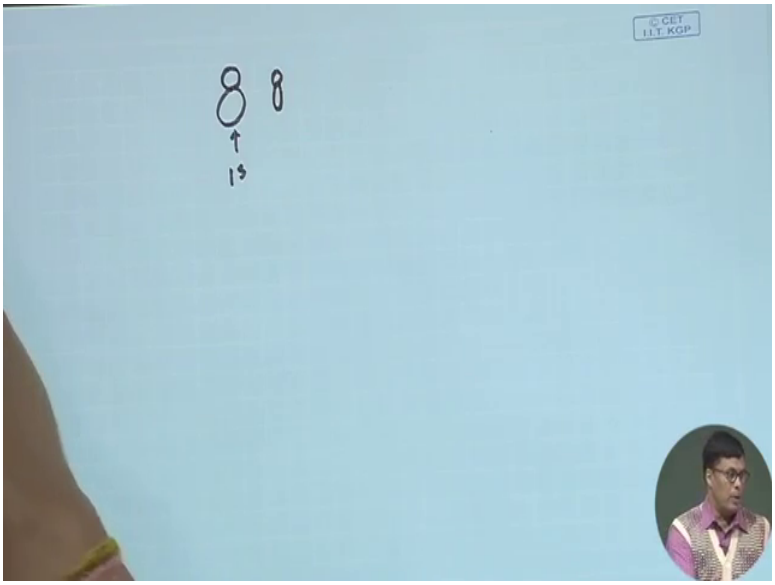

This is this is the organism and this is the budding and I can share my experience with the alcohol industry that you know the major contaminants of alcohol industry is that kind of contamination of wild yeast cells. Now if there is a this is we industry we usually use the industrial strain now if the wild strain that you can easily find out suppose there this is your suppose this is the industrial strain and this is the wild yeast.

So if you do the micro microscopic study the morphological study under the microscope you can easily visualise that whether your strain is contaminated with that other wild microorganism that is undesirable. So that this is the budding is very important for the yeast this is how you can easily identify the presence of the yeast in this sample and saccharomyces carlbergensis that is used now saccharomyces cerevisiae is considered as the top fermenting yeast and saccharomyces carlbergensis used for the bottom fermenting yeast.

Now here because I told you two type of beer is largely in the market one is called ale beer and there is lager beer. So for ale beer production we use the saccharomyces cerevisiae and saccharomyces carlbergensis and for the sorry the ale beer we use saccharomyces cerevisiae and lager beer we use the saccharomyces carlbergensis.

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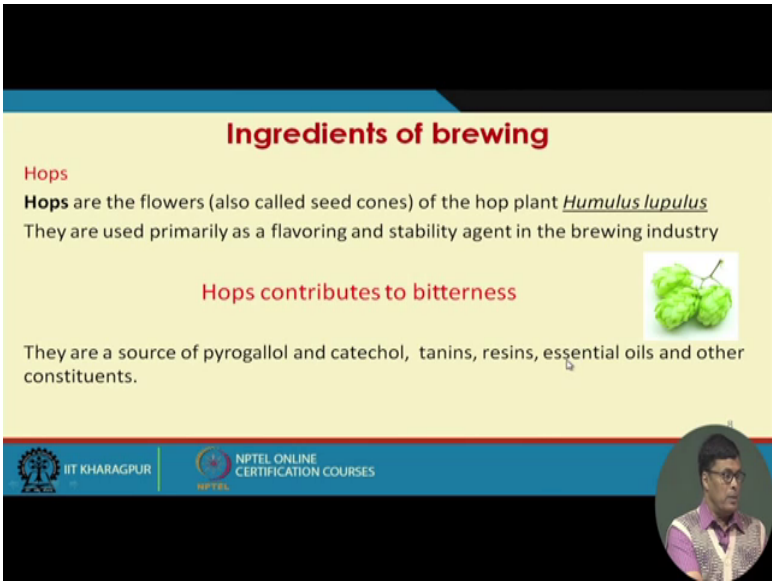

Now during this fermentation process I mentioned that one important ingredients is the hops. Hops are the flower they also called seed cones this the hop plant biologically it is called Humulus lupulus that is the name of the biological name of this and it looks like this. You can see how it looks this is usually available in the hilly places, they are used primarily as a flavouring and stability agent of the brewing industry. Hops contributes the beer I can tell you that three different ingredients mostly is has one is tannins, resin and the essential oils that contributes different properties to the beer.

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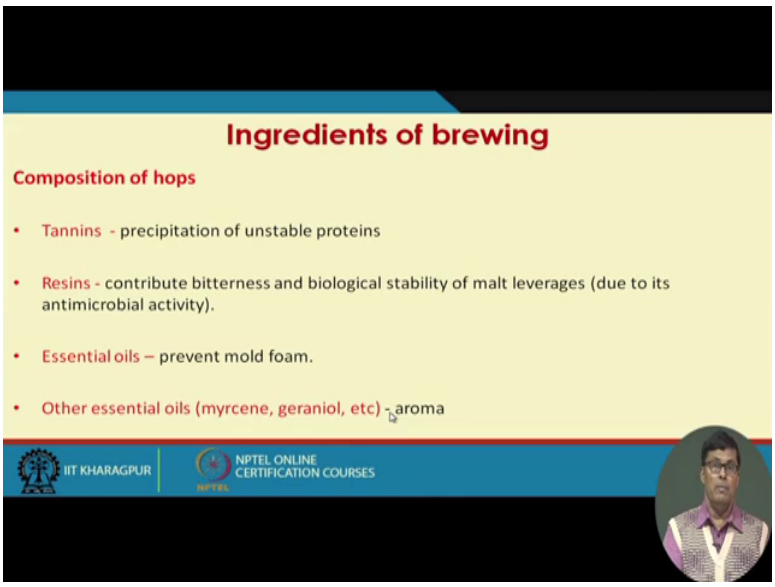

I can give the example that in case of in presence of tanning if you look at this tanning it causes the precipitation of the unstable protein because you know that in the brewing industry

one important factor is the chill proof beer, what is chill proof beer I already mentioned that that beer contains good amount of protein and protein as we know at high temperature and low temperature it precipitated out.

So usually beer served under chill conditions now in the chill conditions if the protein precipitated out then what will happen the beer will be will look hazy that is undesirable. So it should be perfectly clear to make it perfectly clear what you have to do you have to you have to precipitate out the bigger protein molecules because smaller protein molecules may not be precipitated at low temperature but bigger protein molecules will precipitate out at the low temperature. So you have to separate out so tannin when because one process that you know we boil the liquid with hops and during the boiling process that you know tannin mix with the protein and it will precipitated out the protein molecule. So this is the role of tannin and in case of resin is very because one typical characteristics of the beer that it has the bitterness in the beer and this bitterness of the beer why it is there it's the presence of the resin because it contributes bitterness and biological stability of malt beverage because this is also has the anti-microbial property.

So reason that is the bitterness of the beer that come from the resin. Another is the essential oil this is prevent the mold mold form but is main effect of this essential oil is the aroma because aroma because beer has a typical flavour and this flavour comes from this essential oil. So hops contribute a typical flavour and typical taste in the beer, so hop is very important ingredient in the beer making industries.

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The major steps involved in the beer making industry is the malting, first is the is the malting of barley grains, now what do you mean by malting of barley grains? Malting of barley grains means barley grains what you do we soak it for overnight or two days to wet the barley grains and after that we drain the water and take the wetted barley grains out and put it in a humidified room under anaerobic condition and then that germination of the barley grains take place you will find kind of suit formations in the barley grains.

And then then this that during this process the during germination process different hydrolytic enzymes that produce inside the barley grains when these are mostly the amylases and the proteases and this is very well. So malted food actually that is usually recommended for the for the patient as well as for the for the school children particularly during the examination all the children are under tension.

So doctor usually prescribe that you know malted food the reason is that this since it has the hydrolytic enzyme this is easy for digestion, so because during this tension that you know that our system does not secrete the enzymes as per the requirements. So you might be having the digestion problem and that is why it is prescribed that for the patients as well as for the for the school children during examination this malted food.

So malting malting is a process through which we can produce this hydrolytic enzymes. The second is the mashing process mashing process is after malting process we dry these barley grains when we dry these barley grains and barley grains contents good amount of starch and protein also during this malting process is produced hydrolytic enzymes. So when we dry it what will happen this hydrolytic enzymes will mix with starch and protein molecules this will mix with that.

And then then we make a dough because we mix with water and at different temperatures sacchrification and that degradation of protein of that will photolysis will take place and during this degrading process we get the soluble sugar soluble protein that we can get in the liquid forms. So this is the mashing process that of the solubilisation of the insoluble material to soluble material. Then another step we what you call the boiling with hops I told you hops give the typical characteristics of the beer so boiling of the hop is very important step of the beer making industries.

Then we have fermentation process after this we cool this material and what we call wort and this wort we take it in the fermentation process where in presence of yeast cell we produce

the alcohol and this then it passes through the maturation process now this is very interesting that why what is the importance of the maturation process maturation process because we have ethanol in this system we have produced ethanol but if you look at our Embden Mayer pathway the we will find that in the metabolic pathway lot of acid formations are there.

And these acid might be present very low level in the in the beer and due to presence of this acid it gives some kind of hops flavour so maturation is very important the reason is that if you if you keep it for some time then it will the alcohol and acid will get the opportunity to combine with each other and form the esters as soon as the ester formation is there then harsh flavour that will go and sweet flavour will develop. So maturation process is very important very important steps for the both for the beer industry and the wine making industry.

This this is very important and their we preferred we it produces some esters the ethanol a part of the ethanol combined with a part of acid to form the ester and you might be knowing that the esters are responsible for developing different flavours. So this is what is actually happening during the maturation process. Now finishing operation means after that you know the beer can be used for the two type of beer we have one is that we shall have to long time long time consumption and short time consumption.

So we have if we have immediate demand in the market then what we use that we add some kind of preservative in it and we do the carbonization and we put it in the marketed either in the form of can or in a bottle or in the barrels. So wherever is a you do it another and assign it in the market.

But when you long time consumption that we it is passes through the pasteurization process, pasteurization I told you is the process through which we kill the germs because you know so that is the pasteurization process is used for the long time use of the beer because if we beer can be used for the longer period of time we go or pasteurization process.

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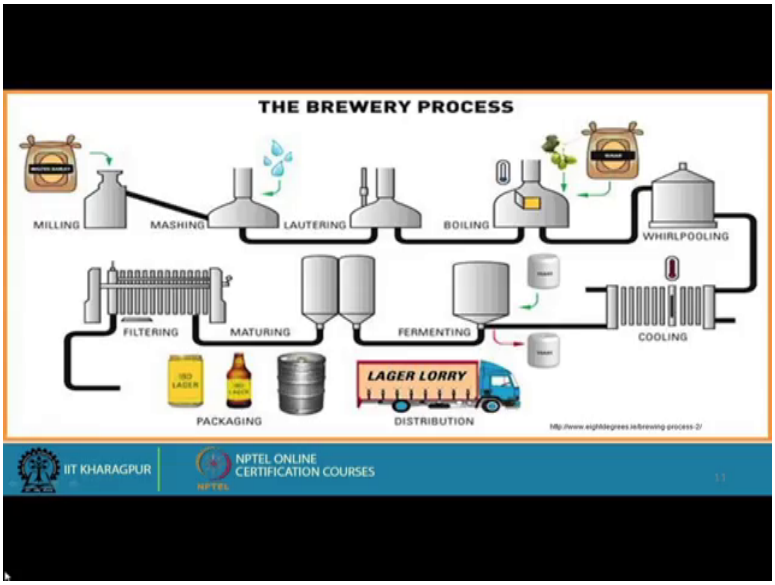

Now this is the kind of flow that is process flow diagram of this process and I told you this is the first is the malting process where germination of the barley grains take place after germination of barley grains we dry it and we passes through the milling machine, what is the purpose of the milling machine? To make it powder form and after making it powder we take it we passes through the mashing what I told you in the mashing that that you know we mix it water and this is mashing is usually take place at different temperature at lower temperature the photolysis takes place and high temperature sacchrification take place.

So we have two type of mashing process we have infusion and decoction that I shall discuss in the later and then that main purpose that insoluble material will be solubilized here and then we take the semi-solid mixture in this here where there is lauter, lautering process lautering process is nothing but here we have the stainless steel perforated disc and there we press together and when we press then soluble material that soluble material comes out and the insoluble material remain that until insoluble material can be used as a good fodder and the soluble material we take it out and here in the we take it in the kettle.

In this kettle that we adjust the sugar concentration as per our alcohol requirement in the beer because I told you beer contains the alcohol concentration of the beer varies from 4 to may be 8 per cent, so as per we have already seen in the stoichiometry that one gram glucose approximately produce 0.5 gram of ethanol.

So if we want to produce 4 per cent ethanol concentration in the fermentation broth we shall have to use 8 per cent sugar. So 8 per cent sugar we have to use so if after this after this

process if you find the sugar concentration here is less than 8 per cent then we have to adjust by the sugar concentration by adding some syrup here. So if you want high sugar concentration you have to use more syrup. Then you add here this what you call hops that and boil it and during the boiling process I told you the tannin, resin and the essential oil they participate in the reaction and keep the typical favour and then we cool it down.

And then we polish it we filter it out and then we cool it down and take it in the fermenter and we have told you two type of yeast cells are used one is saccharomyces cerevisiae, saccharomyces carlbergensis as well because if we use the lager beer we use the saccharomyces carlbergensis here and then we pass it through the maturation process. Maturation process is nothing but is the storage vessel at low temperature we keep it for longer period of time just to show that you know a free acid and alcohol they form the ester and harshness of the beer can be removed.

Then we can filter it off and not only this during maturing process also we add some kind of proteolytic enzyme purposefully. Why we add some proteolytic enzymes to degrade the bigger protein molecule in the small protein molecule so that we can have the chill proof beer so we can add that and then we pass it through the filtering system to remove the suspended material then we package it either in the form of can or in the bottles or in the in the barrels.

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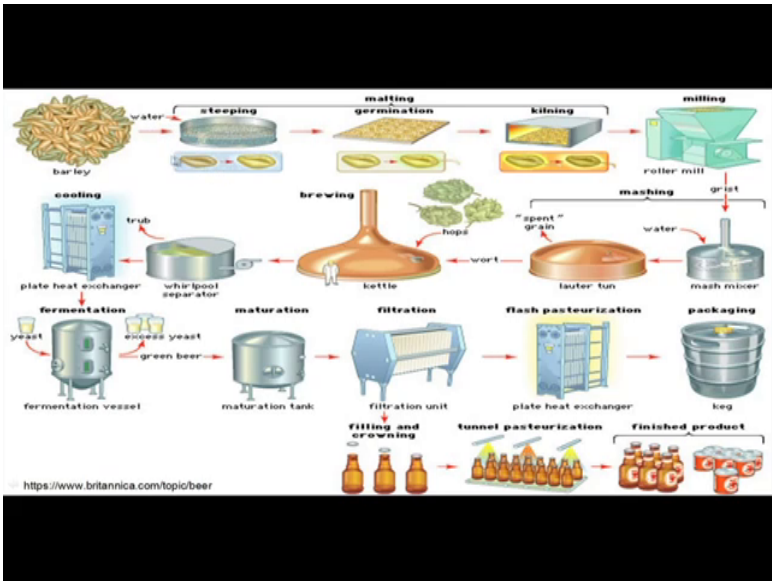

This we can do this then we load it in the in the truck and send it to the market. This is this is another schematic diagram of this process that how is this is in practise in the beer making industry, this is the barley grains you can see the barley grains it is similar to the wheat grains

only the difference is that it is little bit longer and little bit thinner and wheat grain is will be smaller and little bit thicker that you know that as compared to that and then as I as I told you first process is steeping, steeping means soaking you soak this when you soak with water then this is dry but when you soak this will be wetted.

This surface will be wetted then we put it keep it in a floor because where we maintain the humidity, humid conditions and we pass little bit of air and during this condition the sprouting takes place the you can see that kind of suit formation takes place here when the (())(25:26) that you know that the here in this (())(25:30) enzyme formation will take place and then after that we dry it we dry it stop this germination process.

And then then we pass it through the milling machine in this milling machine we convert this two the powder form and this powder then we take it to the max mixture, max mixture is nothing but I told you is mixed water and it have the semi-solid mixture and that different temperature proteolysis as well as saccharification both take place and the soluble material we take it the the total material we take it to the lauter tone where we have the perforated desk that where we press it and so that we soluble thing can be separated out from the insoluble thing, soluble thing we consider as a the spent grain it can be you can you can take it take it back and reuse this or it can be used as a good fodder.

Then then this this is we take it in a kettle in the kettle we take the hops this we boil this with hops so that resins, tannin and essential oil all that comes in the soluble forms then we have the separater here we take the insoluble material from the soluble material then we pass it through the heat exchanger to cool it down and then we take it in the fermenter we add some yeast here then then then form this we can we can pass it through we separate the yeast cells then we can maturation process in this maturation process is a kind of settling tank where we settle your clarification of the beer will take place your beer will be and that you know and not only that that acid and alcohol they will form the esters and whatever remaining that cells are there that can be separated with the help of this filtration unit. Again you pass through the plate heat exchanger then we do the carbonation process that is not showing here.

And then then we put it in the different containers we can bottle like this. So this gives you some preliminary ideas how the beer production takes place because I told you that beer we have four different steps, major steps involved in the beer making industry. One is called malting another is mashing, the hoping the fermentation then it also we have another

important step what the maturation process where the harshness of the beer will be removed and major steps involved in this beer making process is the malting and hoping process

Malting process is a barley grains we produce some kind of hydrolytic enzyme this hydrolytic enzyme helps for the degradation of the starchy and the and the protein to the soluble form and then in the hoping process it helps you to develop the typical aroma and typical taste of beer and then we get the we pass it through the fermentation process and maturation process and we get the carbonated this.

Now one typical thing I want to aspects of beer I want to mention that in case of though it is a carbonated beverage drinks when you when you open any beer bottle you will find lot of foam formation and this foam will remain in the in the bottle for quite some time, it will not subside so easily but if you if you look at any soft drinks bottles that also contain carbon-di-oxide as soon as you open this bottle you will find lot of (())(29:45) of carbon-di-oxide will take plane but that will immediately subside.

The reason for that is that I told you this foam formation is mainly due to the protein and the carbon-di-oxide present in the in the beer and this is the protein that helps you for the permanent foam that of the beer that is why the foam remain in the beer for quite some time. Thank you very much.