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

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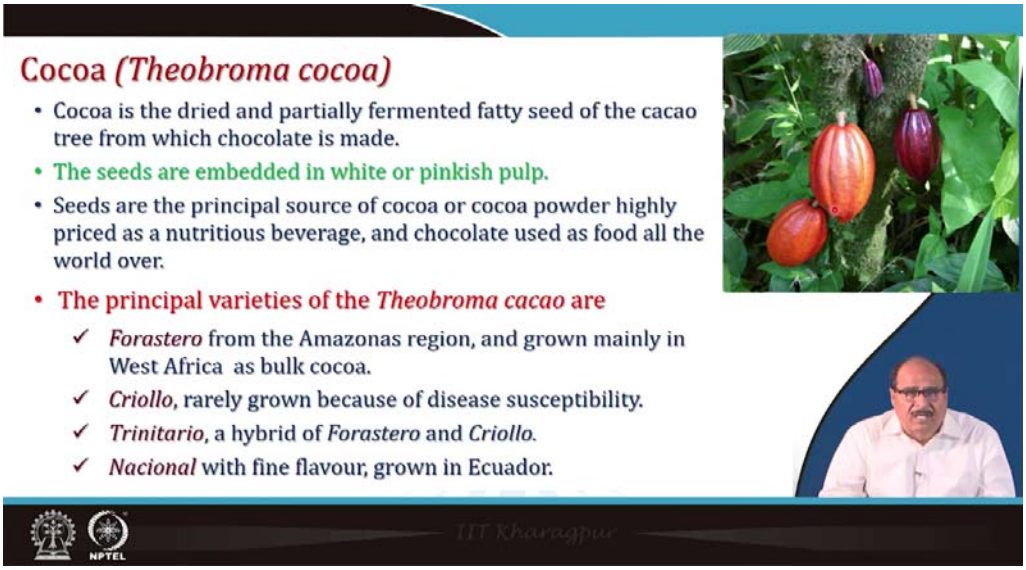
Lecture 38

Cocoa and Chocolate Technology

Hello everybody, in this lecture, we will study cocoa and chocolate technology.

The various aspects of the cocoa bean, cocoa pod, post-harvest treatment of cocoa, processing of cocoa, chocolate and its type and chocolate manufacturing technology, these topics and sub-topics will be covered in today's lecture.



Cocoa (Theobroma cocoa)

So, let us see cocoa, what cocoa is. Its botanical name is *Theobroma cocoa*. You can see the cocoa pod in this tree, it is a long tree, like a jackfruit, etc. These are cocoa flowers which further converted into pods. They grow on the main trunk or either on the main branches of the tree.

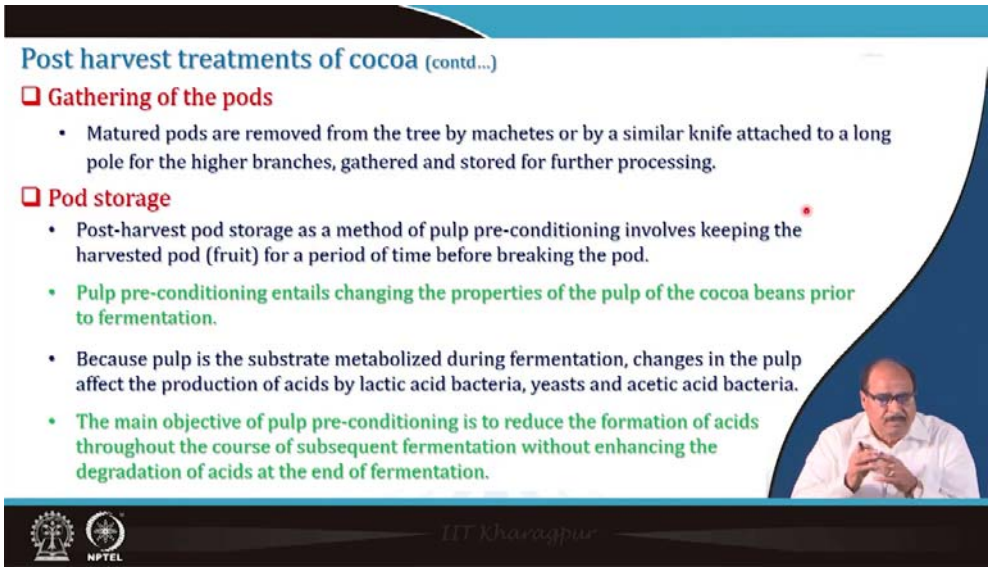
So, cocoa is actually the dried and partially fermented fatty seed of the cacao tree from which the chocolate is made. Inside this pod, there are about 22 to 50 beans arranged in a thick leathery rind inside that pod. These seeds which are there, inside, are embedded in white or pinkish pulp. The seeds are the principal source of cocoa or cocoa powder, which are highly priced as a nutritious beverage and chocolate. They are used as food all world over.

The principal variety of *Theobroma cocoa* are *Forastero* from the Amazon's regions and grown mainly in West Africa as bulk cocoa, *Criollo* is rarely grown because of disease susceptibility, *Trinitario* is a hybrid of *Forastero* and *Criollo*, and *Nacional* with the fine flavour, it grows in Ecuador.

Post-harvest treatment of cocoa

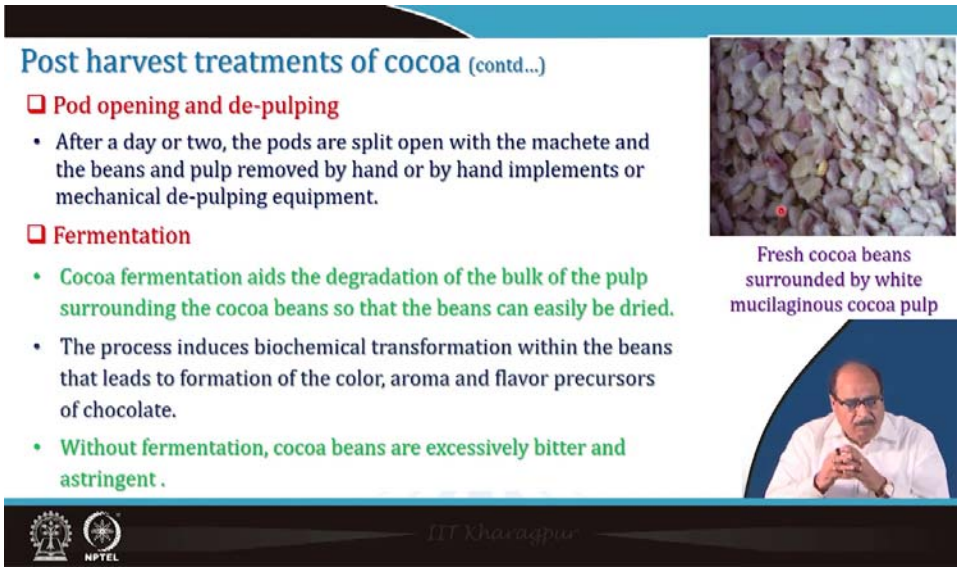
Raw cocoa beans have an astringent unpleasant taste and they have to be taken through the various post-harvest treatments of fermentation, drying and roasting to attain the characteristic cocoa taste, colour and flavour. It is similar to that of the coffee beans seen earlier, in the last class we discussed and studied. So, here also these cocoa beans or seeds, have an unpleasant taste.

So, various post-harvest treatments are done to cocoa in order to develop the characteristic colour and flavour. The major post-harvest operations and treatment of the cocoa pods are number one, gathering the cocoa pod, then the pod is storage as a means of pulp preconditioning, opening or pod breaking, then fermentation of the beans, drying of the fermented bean, sorting, packing and storage. So, these are the post-harvest statement of the cocoa pod and obtaining the beans from the cocoa.



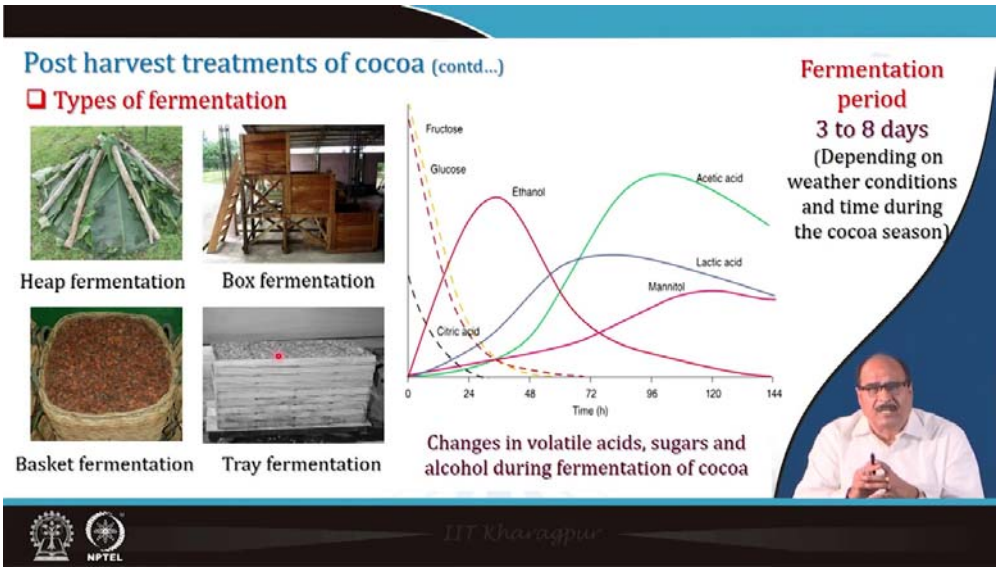
The mature parts are removed from the tree by machetes or by a similar knife attached to a long pole or the higher branches gathered and stored for further processing. Post-harvest pod storage as a method of pulp pre-conditioning involves keeping the harvested pod, i.e. the fruit which you have seen in the last slide in the figure, it is kept for a period of time before being broken.

The pulp preconditioning entails changing the properties of the pulp of the cocoa beans prior to fermentation. Because the pulp is the substrates metabolized during fermentation, changes in the pulp affect the production of acids by lactic acid bacteria, yeasts or even acetic acid bacteria. The main objective of pulp pre-preconditioning is to reduce the formation of acid throughout the course and subsequent fermentation without enhancing the degradation of acids at the end of the fermentation process.



After that, the cocoa pods are opened and they are de-pulped i.e. after a day or two the pods are split open with the help of a machete and the beans and pulps are removed either by hand or by hand implements or even mechanical de-pulping equipment. The cocoa fermentation, that is the beans which are obtained, they are next subjected to the fermentation. The fermentation aids the degradation of the bulk of the pulp surrounding the cocoa bean so that the bean can easily be dried.

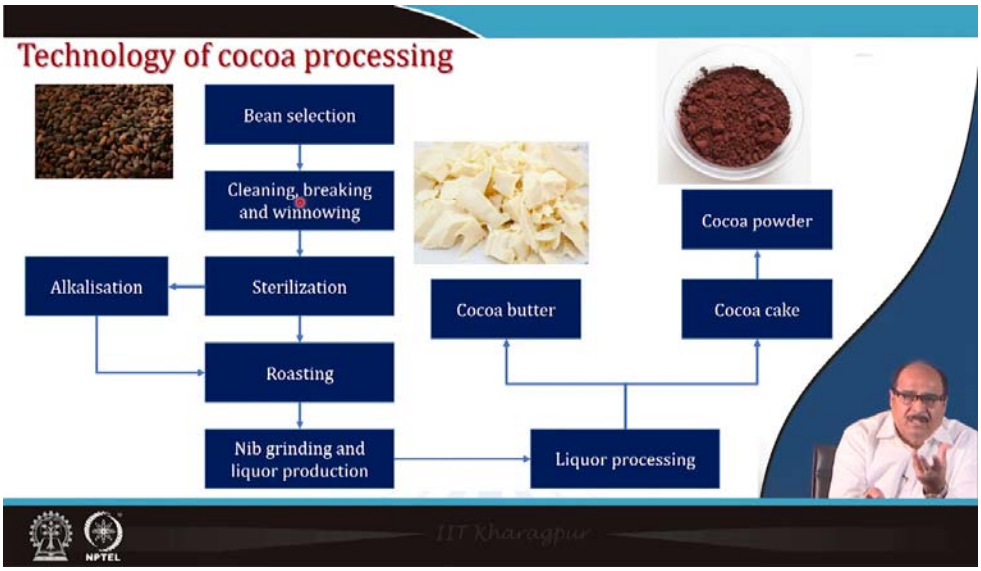
The process of fermentation induces biochemical transformations within the bean that lead to the formation of colour, aroma and flavour precursor of the chocolate, not actual compound but, their precursors are developed. Without fermentation, cocoa beans are excessively bitter and they will be astringent in taste.



Different types of fermentation are used i.e. heap fermentation, you can see in the pictures, the cocoa beans are just collected in a heap and they are covered with the banana and other leaves and then heat inside respiration, it facilitates the fermentation. Box fermentation is in the shade, they are kept, the cover in a box. Others are basket fermentation or tray fermentation. So, different types of fermentation, basically storing and keeping the beans or pods for some time. Maybe depending upon the weather conditions and time during the cocoa season, the period of the growing season, may take about 3 to 8 days for the completion of the fermentation process. You see that during the fermentation process, as I told you that is in the figure, the various volatile acids, sugar, alcohols, etc., are produced in the beans and act as a precursor of the flavouring and colouring compounds.

After the fermentation, the next important operation is drying. Here, they are dried either by shade drying or in an open environment, solar drying. These are spread on some sort of raised platform, as you can see here in the figure, the moisture content of the bean is reduced to a level of 5 to 8 percent. Because this is considered to be the appropriate level for storage of cocoa for a couple of months, prior to marketing and processing.

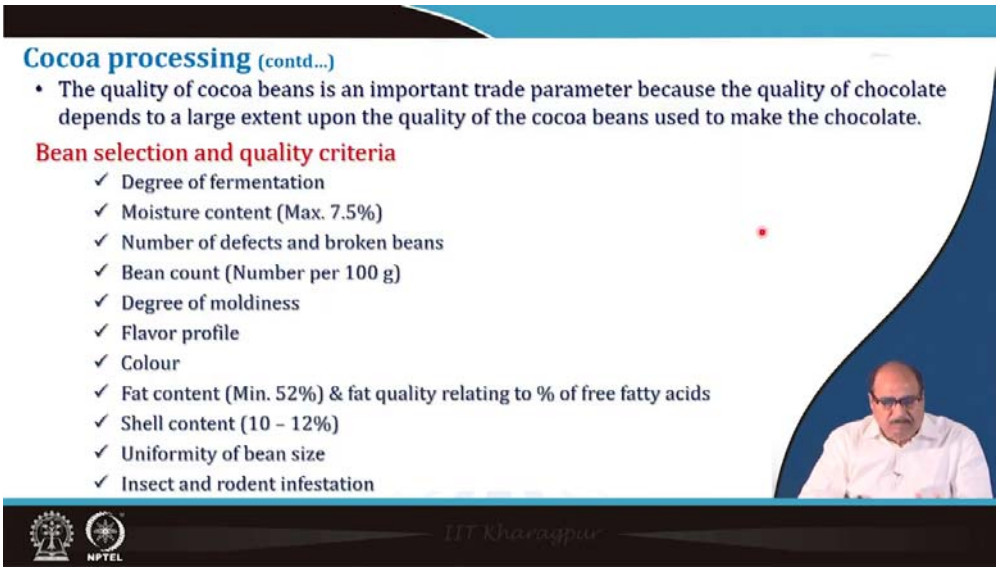
If the moisture content is above 8 percent, there will be the risk of mold development within the beans. If the moisture content is below 5 percent, the beans will become very brittle. So, 5 to 8 percent is the average moisture content. The drying of the bean continues the chemical changes that occur during fermentation, and it improves flavour development. It reduces the bitterness and astringency and develops the chocolate brown colour as well as well-fermented cocoa beans are obtained. So, dried cocoa beans after fermentation, you see that from the pod, these are the pics.



Technology of cocoa processing

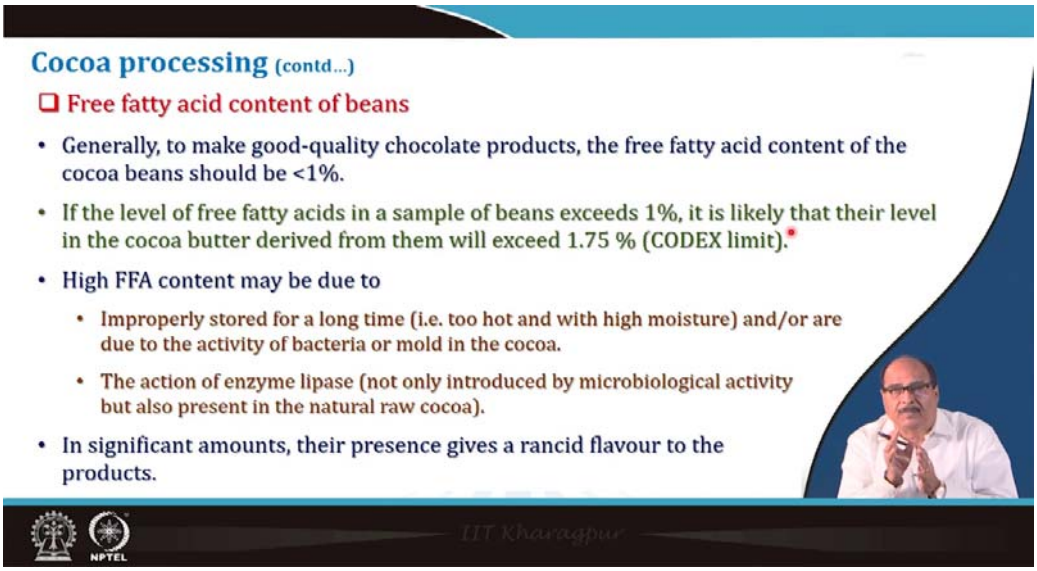
The beans are taken, cleaned, and then broken and winnowed. After winnowing that hulls are blown away, then the nibs or cotyledons are obtained. These cotyledons are valuable or priced sources of chocolate or cocoa powder, may be directly sterilized, roasted or may be subjected to alkalization treatment and Dutching process followed by roasting. After roasting, the nib is ground and liquor production in the trade is known as chocolate liquor or bitter chocolate. This chocolate liquor is further processed or pressed and the cocoa butter and cake are obtained. The cocoa cake is further pulverized into a fine powder and used for making the beverage.

You can see here, these are the two major products after processing of the cocoa bean, one is the cocoa butter, which is a very valuable ingredient in various confectionery, ice cream and other products, I will tell a little later about its characteristics and then, cocoa powder which is a priced item for making various beverages. This is used for beverage making.



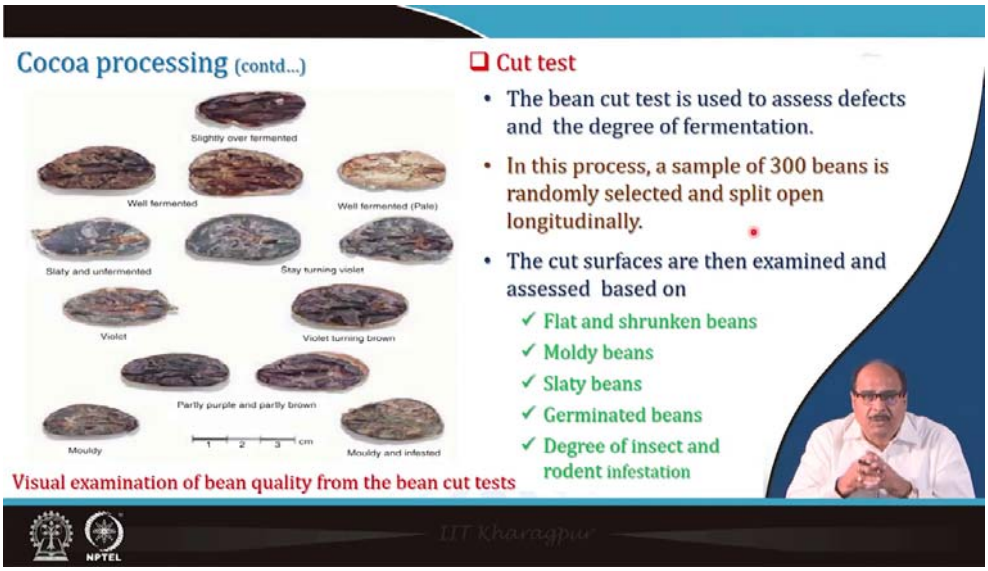
Cocoa processing

The quality of cocoa beans is an important trade parameter because the quality of chocolate depends to a large extent upon the quality of the cocoa beans used to make the chocolate. So, the bean selection and quality criteria may vary depending upon the local conditions. But in general, the degree of fermentation, the moisture content, as I told you maximum maybe 7.5 to 8 percent, a number of defects and broken beans, beans count, that in per 100 gram, how many beans are there, degree of moldiness, flavour profile, colour, fat content, i.e. minimum fat should be around 52 percent, etc. the fatty acid profile, free fatty acids content, cell content, uniformity of bean size, insect and rodent infestation, etc. These are the criteria for the selection of beans for chocolate manufacturing.



Fatty acid content of the beans.

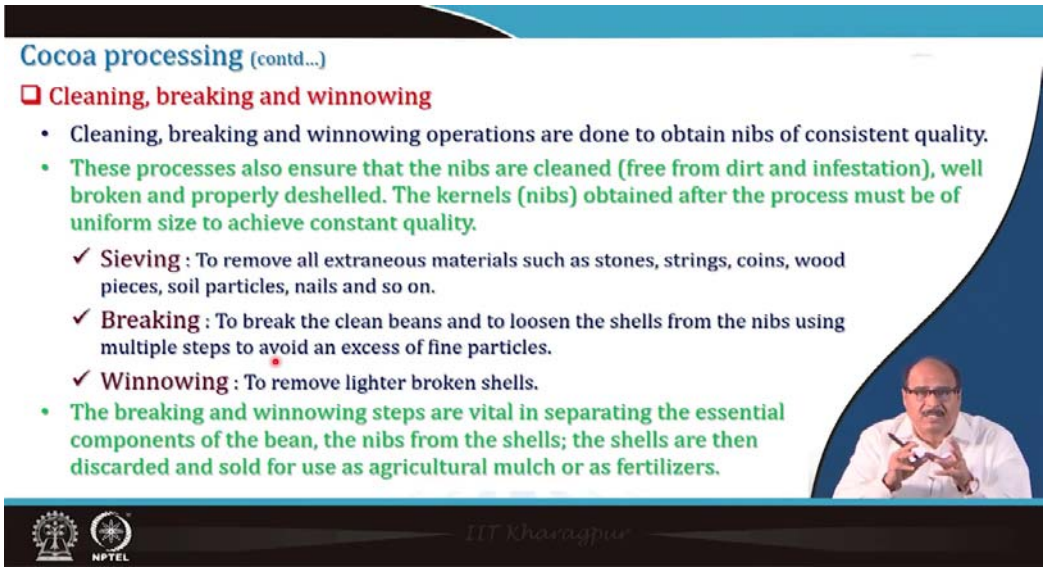
Generally, to make good quality chocolate products, the free fatty acid content of the cocoa beans should be less than 1 percent. If the level of FFA in a sample of the bean exceeds 1 percent, it is likely that the level in the cocoa butter derived from them will exceed 1.75 percent, which is the CODEX limit. High free fatty acid content may be due to improperly stored for a long time i.e. too hot and high moisture, high humid environment, and/or they are due to the activity of the bacteria or mold in the cocoa. Also, the action of enzyme-like lipase may cause the breaking of the triglyceride and the free fatty acids may be generated. So, if the free fatty acid is present in significant amounts, it may lead to the development of rancid flavour in the products. So, that should be avoided.



Cut test

It is basically the visual examination of the bean quality, which is being found from the cut test. The bean cut test is used to assess the defects and the degree of fermentation. In this process, a sample of about 300 beans is randomly selected and split open longitudinally.

The cut surfaces are then examined and assessed based on flat and shrunken beans, moldy beans, salty beans, germinated beans and degree of insect and rodent infestation. You can see here, the various type of visual expression, colour and other things are shown in the picture by the cut test.

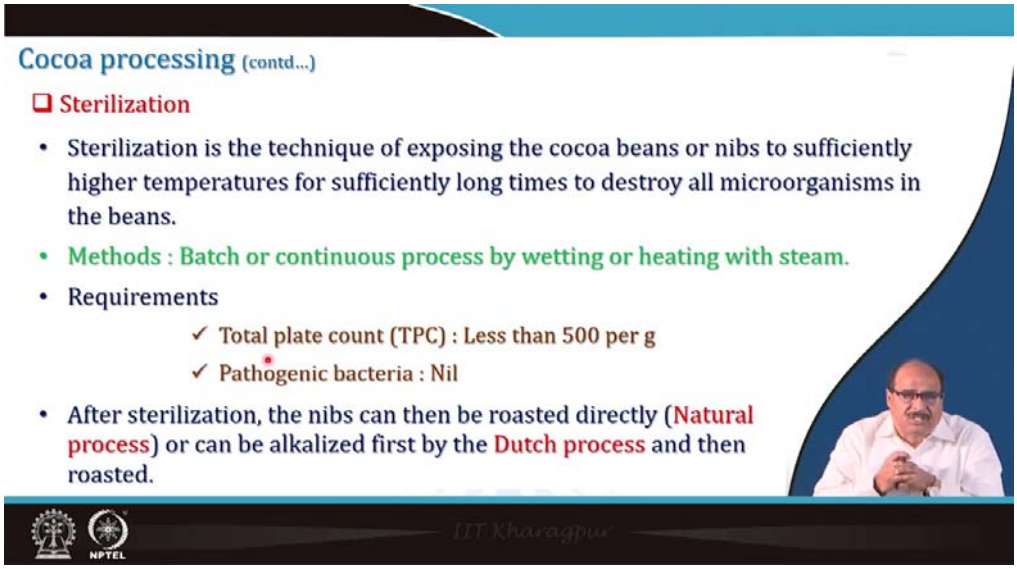


Cleaning, breaking and winnowing

Cleaning, breaking and winnowing operations are done to obtain the nib of consistent quality. These processes also ensure that the nibs are clean, well broken and properly de-shelled. The kernels which are are cotyledons which are known as nibs, they are obtained after the process and must be of uniform size to achieve consistent quality in the final product.

Basically, the sieving, breaking and winnowing are the three major unit operations here. The sieving is done to remove all extraneous matters such as stones, strings, coins, wood, pieces, particles, nails and so on. Then, it is broken, i.e. it is to break the clean beans and loosen the shell from the nibs using multiple steps to avoid the access of fine particles. Finally, winnowing is done to remove the lighter broken cells or even the hulls, etc. After winnowing we get the cotyledons which are nib.

The breaking and winnowing steps are vital in separating the essential components of the bean that is the nib from the shell. The shells are then discarded and are sold for use as agricultural mulch or as a fertilizer and the nibs are taken for further processing into chocolate and other valuable products.

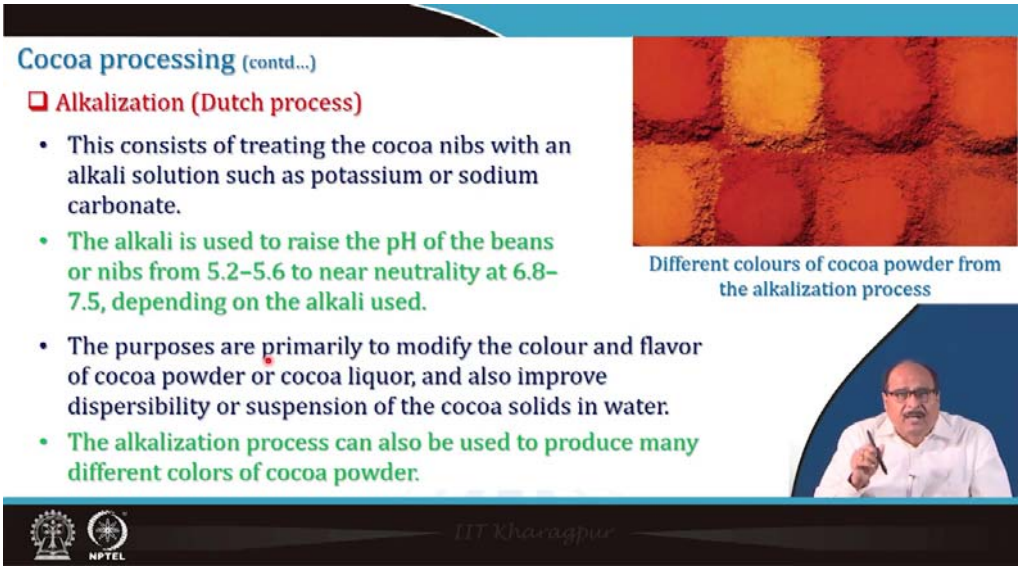


Sterilization

These nips, once obtained, are subjected to the sterilization process, we have discussed earlier in lectures, sterilization is the technique of exposing the beans in this case or nibs to a sufficiently

high temperature for a sufficiently long time or desired time to destroy all microorganisms in the beans, either by batch or continuous process by wetting or heating steam with steams.

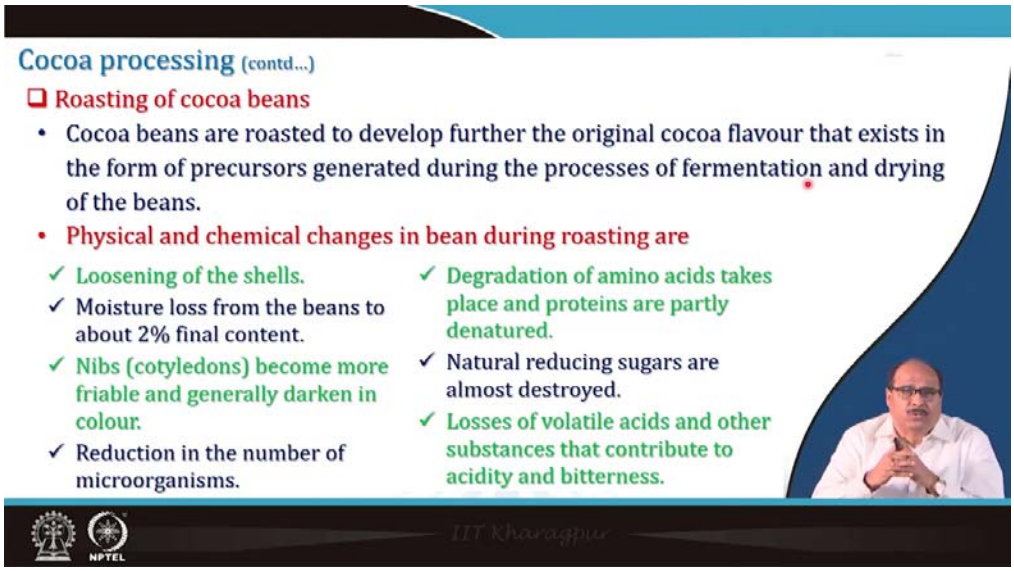
The requirement after the sterilization process is that the nibs should contain a total plate count of less than 500 CFU per gram and it should contain nil pathogenic bacteria. After sterilization, the nibs can then be roasted directly using either a natural process or can be alkalized first by the Dutch process and then roasted.



Alkalization

Alkalization is a Dutch process because this process was developed in Holland so it is known as the Dutch process. This consists of treating the cocoa nibs with an alkali solution such as potassium or sodium carbonate. The alkali is used to raise the pH of the beans or the nibs from about 5.2 to 5.6 to near neutrality, that is 6.8 to 7.5 depending upon the strength of the alkali and the nature of the alkali used.

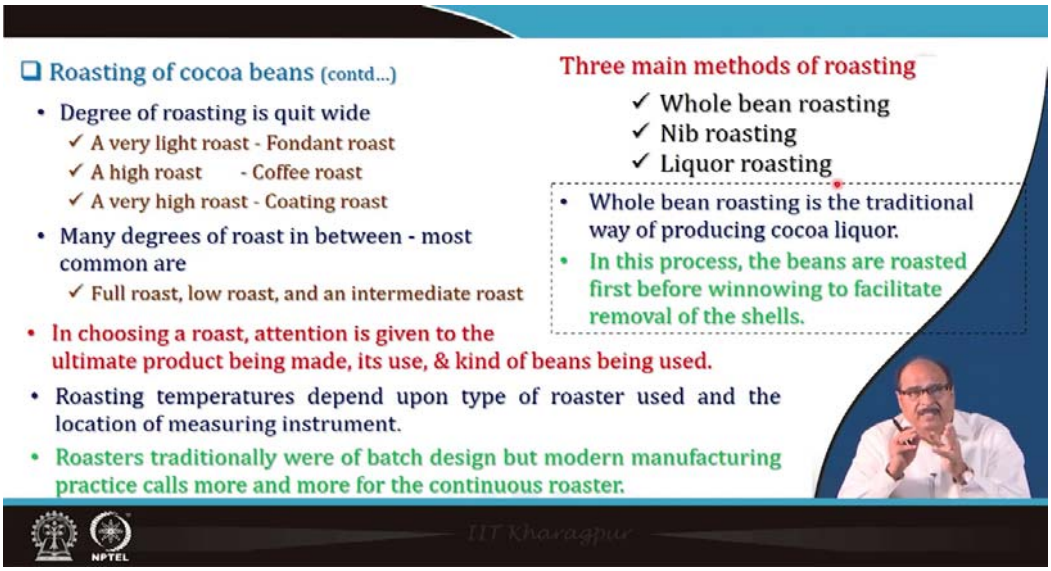
The purpose of this Dutching process is primarily to modify the colour and flavour of cocoa powder or cocoa liquor and also to improve the dispersibility or suspension of the cocoa solids in water and also remove the free fatty acids present in the bean powder or the liquor. The alkalization process can also be used to produce many different colours of cocoa powder. You can see here in the picture that the different colours of cocoa powder, are produced from the alkalization process.



Roasting of cocoa beans

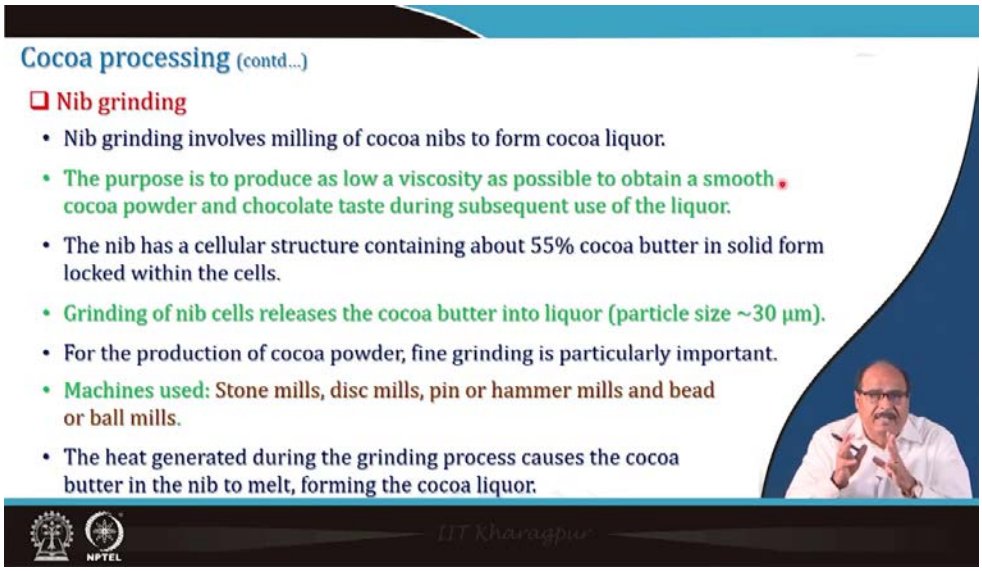
Then the important operation is the roasting of the cocoa beans. The similar roasting which we studied in the last lecture in coffee processing. Similarly, here also, the cocoa beans are roasted to develop further the original cocoa flavour that exists in the form of precursors generated during the process of fermentation and drying of the beans.

During roasting various physical and chemical changes take place. It loosens the shell, moisture loses from beans to about 2 percent final content, nibs or cotyledons become more friable and generally darken in colour, there is a reduction in the number of microorganisms, degradation of amino acid takes place and proteins are partly denatured, natural reducing sugars are almost destroyed. There is a loss of volatile acids and other substances that contribute to acidity and bitterness development.



The degree of roasting may vary. In fact, a very light roast may be a fondant roast, a high roast is coffee roast or a very light roast is quoting roast. Many degrees of roast in between, most commonly used are full roast, low roast and intermediate roast. If the type of roasting is sometimes secret of the manufacturing company to have their branded flavour and branded product. So, obviously, in choosing a roast, the degree of roast, attention is given to the ultimate product being made, its use, and the kind of beans being used.

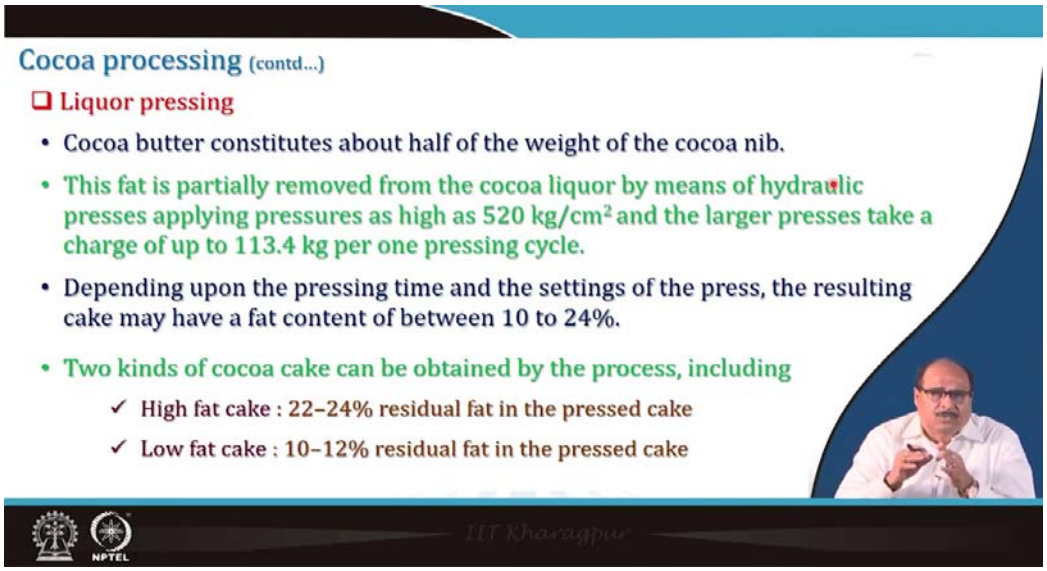
Roasting parameters depend upon the type of roaster used and the location of the measuring instrument, i.e. the temperature measuring instrument put in the roaster. Roasters traditionally were of batch design but modern manufacturing practices call more and more for the continuous roaster. There are three main methods of roasting, i.e. whole bean roasting, nib roasting or even liquor roasting also. Whole bean roasting is the traditional way of producing cocoa liquor. In this process, the beans are roasted first before winnowing to facilitate the removal of the shells.



Nib grinding

After roasting, the next important operation is the nib grinding. Nib grinding involves milling the cocoa nibs to form cocoa liquor or bitter chocolate or bitter cocoa mass. The purpose here is to produce as low a viscosity as possible to obtain a smooth cocoa powder and chocolate taste during subsequent use of the liquor.

The nibs have a cellular structure containing about approximately 55 percent cocoa butter in solid form, which is locked within the cells. Grinding of the nib releases the cocoa butter into liquor, i.e. final particle size may be up to 30 microns or so. For the production of cocoa powder, fine grinding is particularly important. Machines which are used for nib grinding may be stone mills, disc mills, pin or hammer mills or bead or ball mills, etc. So, when the cocoa nibs are put there, as they contain a very high amount, 55 percent cocoa butter, the heat generated during the grinding process causes the cocoa butter to melt which gives a cocoa liquor. That is, the melted cocoa fat carries with it the solid particles and finally, we get either cocoa mass or chocolate liquor or bitter chocolate, etc.

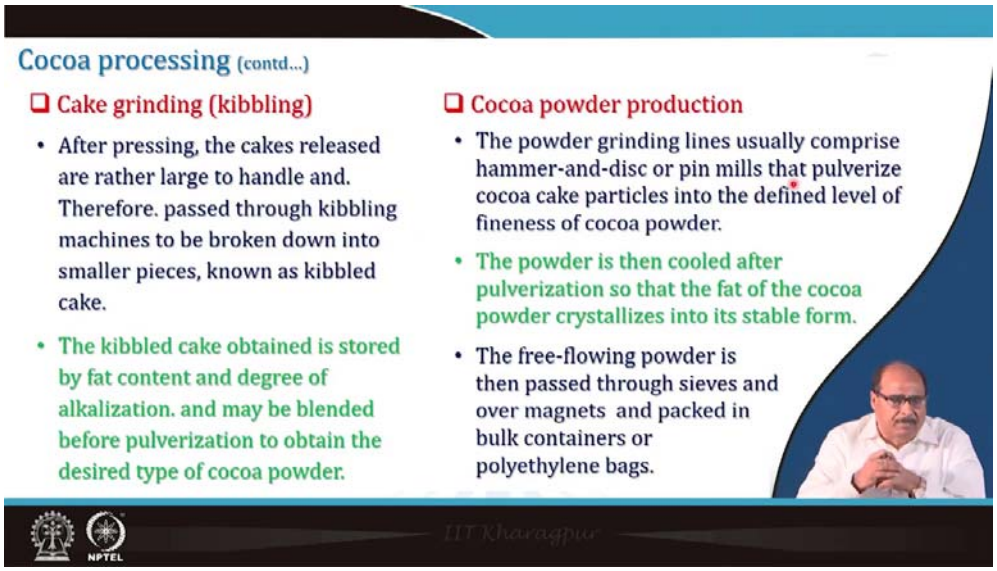


Liquor pressing

These liquors are the next, as you know that they contain around 50 to 55 percent high valuable fat, it will be wasted if this whole batch is used for chocolate manufacturing or beverage. In order to make the cocoa powder for the beverage industry, this liquor is pressed, and a high-fat cake is made out of 20 to 24 percent residual fat in the fresh cake or low fat cake of 10 to 12 percent residual fat in the fresh cake.

This fat is partially removed from the cocoa liquor by means of hydraulic pressing, applying the pressure as high as 520 kg per centimetre square and the larger presses take a charge up to 113.4 kg per one pressing cycle. Because initially just by the simple application of pressure the butter is removed. But as the quantity of fat lowers down, one has to give more and more amount of pressure to remove the remaining quantity of fat, and this high pressure or temperature is developed, also excessively high heat, and that adversely affected the chocolate qualities as well as the cake, their powder quality.

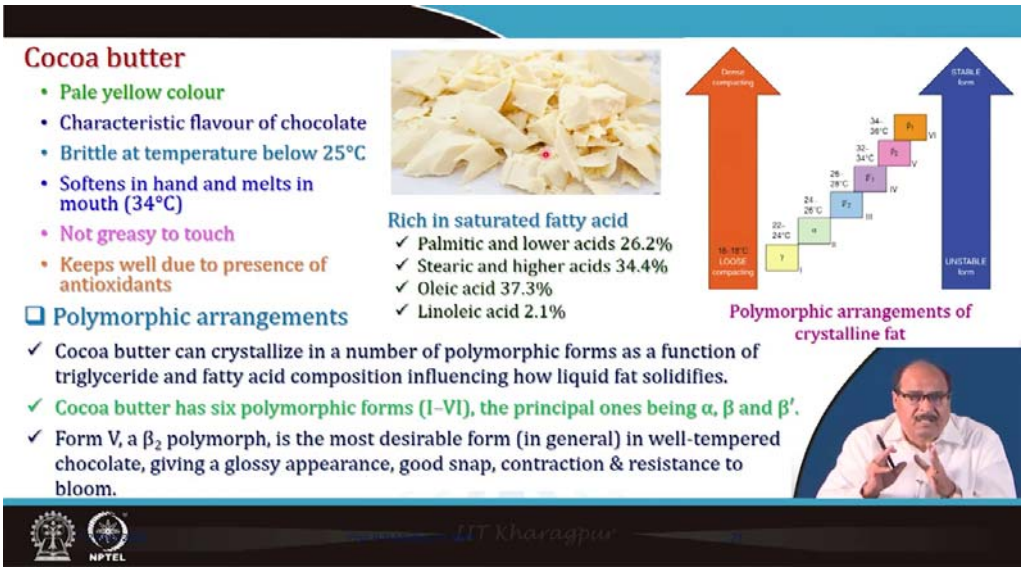
So, in fact, it becomes very economically unviable to lower the fat content in cocoa to less than 12 percent. Accordingly, there are regulations made for the industry in BIS regulations, it should be brought down to around 15 percent to 20 percent, high fat cake or low fat cake. Depending upon the pressing time and the setting of the press the result in a cake may have a fat content between 10 to 24 percent. This is the limit, 20-25 percent and more or above that, is separated, and cocoa butter is obtained.



Cake grinding

After the pressing, cake grinding or kibbling or the cocoa powder production, are the two major operations, for powder making because this powder is used for making beverages. After pressing the cake is released from a large handle, and therefore, it is passed through kibbling machines to be broken down into smaller pieces which are known as kibbled cake. The kibbled cake obtain is stored by fat content and degree of alkalization and may be blended before pulverization to obtain the desired type of cocoa powder with proper solubility another characteristic.

The cocoa powder grinding lines usually comprises hammer and disk or pin mills that pulverize the cocoa cake particles kibbled cake particles into the defined levels of fineness of the cocoa powder. The powder is then cooled after pulverization so that the fat of the cocoa powder crystallizes into a stable form. The free-flowing powder is then passed through sieves over magnets and packaged in a bulk container and polyethene bags.



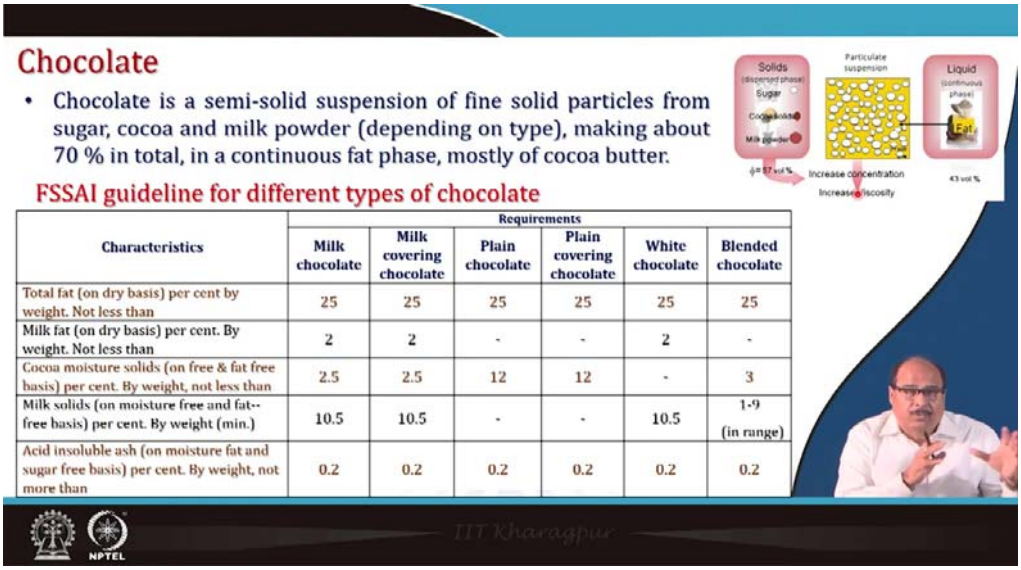
Cocoa butter

Cocoa butter is a very important product of the cocoa processing industry. You can see here, it is a pale-yellow colour material. It has a characteristic flavour of chocolate. It is brittle at a temperature below 25 degrees Celsius. It is soft in the hand and melts in the mouth. It is not greasy to the touch, it keeps well due to the presence of antioxidants in it. It is rich in saturated fatty acids about 26 percent is a palmitic and lower saturated fatty acid, about 34 percent is the stearic and higher acids, 37 percent oleic acid and about 2 percent linoleic acid. Because of its melting characteristics, it becomes a very important and common ingredient in confectionery products, ice creams and others.

But the polymorphic form arrangement of the cocoa butter is very important for deciding its usefulness in the various processes. As you can see here the different polymorphic arrangements of the crystalline fat. Butter can crystallize into a number of polymorphic forms as a function of triglyceride and fatty acid composition influencing how the liquid fat solidifies.

You can see here, generally, six polymorphs are produced. These polyforms have 16 to 18 degrees Celsius. It is cocoa butter of loose compacity, and once it crystallizes, 20 to 24 degrees, first polyform gamma, then during 24 to 26-degree alpha, which can polyform, then beta 26 to 28 then fourth, fifth and finally, at around 30 to 34 degree, beta 1 polyform is obtained. This gamma polyform which is loose and other beta 1 is a very compact density. Accordingly, gamma 1 is the unstable form and the most stable form is polyform 6, which is the beta 1 form.

So, cocoa butter as you can see here has 6 poly farms, 1 to 6 and the principal 1 among these are alpha, beta and beta dash. The form 5 i.e. beta 2 polymorph is the most desirable form, in general, in well-tempered chocolate, giving a glossy appearance, good snap, contraction and registrants to bloom.



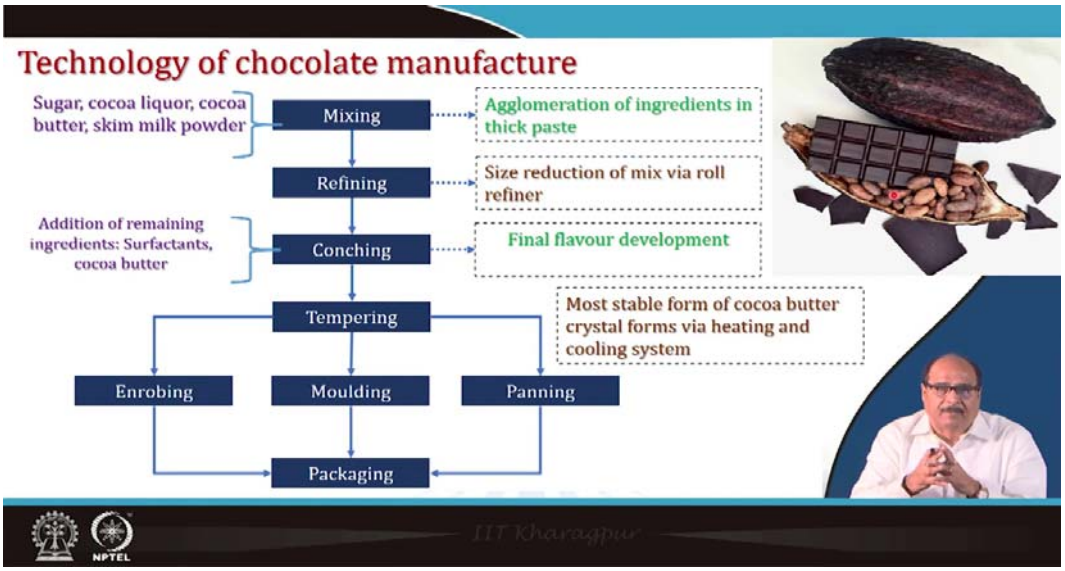
Characteristics	Requirements					
	Milk chocolate	Milk covering chocolate	Plain chocolate	Plain covering chocolate	White chocolate	Blended chocolate
Total fat (on dry basis) per cent by weight. Not less than	25	25	25	25	25	25
Milk fat (on dry basis) per cent. By weight. Not less than	2	2	-	-	2	-
Cocoa moisture solids (on free & fat free basis) per cent. By weight, not less than	2.5	2.5	12	12	-	3
Milk solids (on moisture free and fat--free basis) per cent. By weight (min.)	10.5	10.5	-	-	10.5	1-9 (in range)
Acid insoluble ash (on moisture fat and sugar free basis) per cent. By weight, not more than	0.2	0.2	0.2	0.2	0.2	0.2

Chocolate

We will now come to chocolate manufacturing. We have now cocoa powder, and we have got cocoa butter. Now, this butter is made for making chocolate. Chocolate is a semi-solid suspension of final solid particles from sugar, cocoa mass, cocoa butter and milk powder depending upon the type, making about 70 percent in total in a continuous fat phase of the cocoa butter.

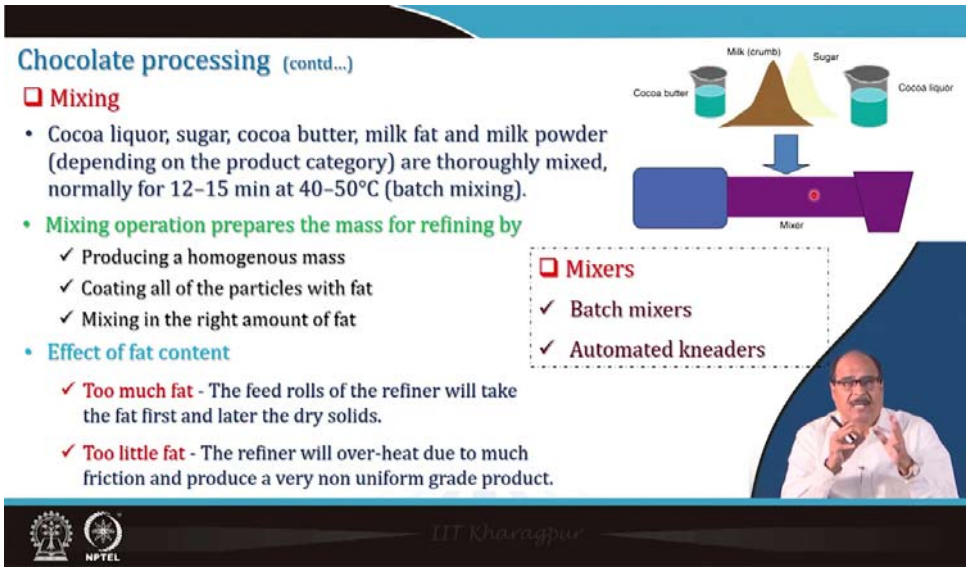
The FSSAI guidelines give for different types of chocolate like milk chocolate, milk covering chocolate, plain chocolate, plain covering chocolate, white chocolate, blended chocolate, depending upon the amount of total fat percent by weight or milk fat content or acid insoluble ash or milk solids, depending upon these various types of chocolates are made.

Accordingly, in all these chocolates, the total fat should not be cocoa butter or cocoa fat, should not be less than 25 percent. Other regulations are also there, for instance, in milk chocolate, around 10.5 percent minimum by weight, there should be milk solids and so on.



Technology for chocolate manufacture

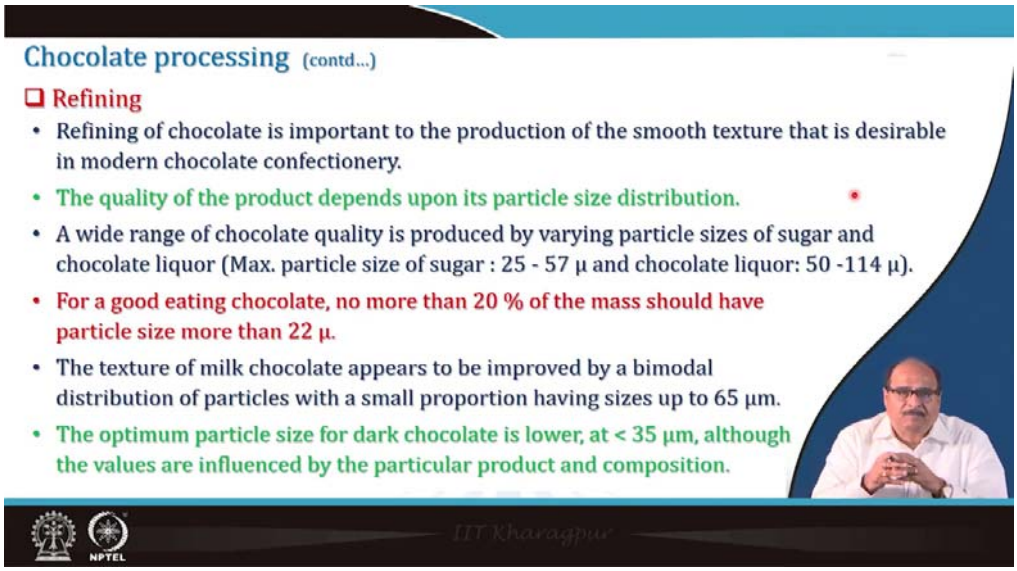
The process of chocolate manufacture or technology of chocolate manufacture includes the mixing of the ingredients like sugar, cocoa liquor, cocoa butter, skim milk powder, etc. After mixing, you get agglomeration of ingredients in a thick paste, a pliable thick mass is obtained at this stage and then this mass is sent for the refining where the size reduction of the mix via 2-roller refiner or 5-roller refiner. After refining, the conching is another process which helps the final flavour development process. Here, the addition of remaining ingredients like surfactant, and cocoa butter may be added and then the conched chocolate is finally tempered, enrobed, moulded or panned and finally packaged. The tempering, in fact, gives the most stable form of cocoa butter crystal via heating and cooling systems.



Mixing

Mixing is very important, all these ingredients i.e. cocoa liquor, sugar, cocoa butter, milk fat and milk powder, depending upon the product category are thoroughly mixed, normally around 12 to 15 minutes at 40 to 50 degrees Celsius in the batch mixing. The purpose and objective of the mixing are for producing a homogeneous mass which is coated properly with fat all particles of the solid particles are uniformly properly coated with cocoa fat, and also it helps the right mixing and right amount of fat.

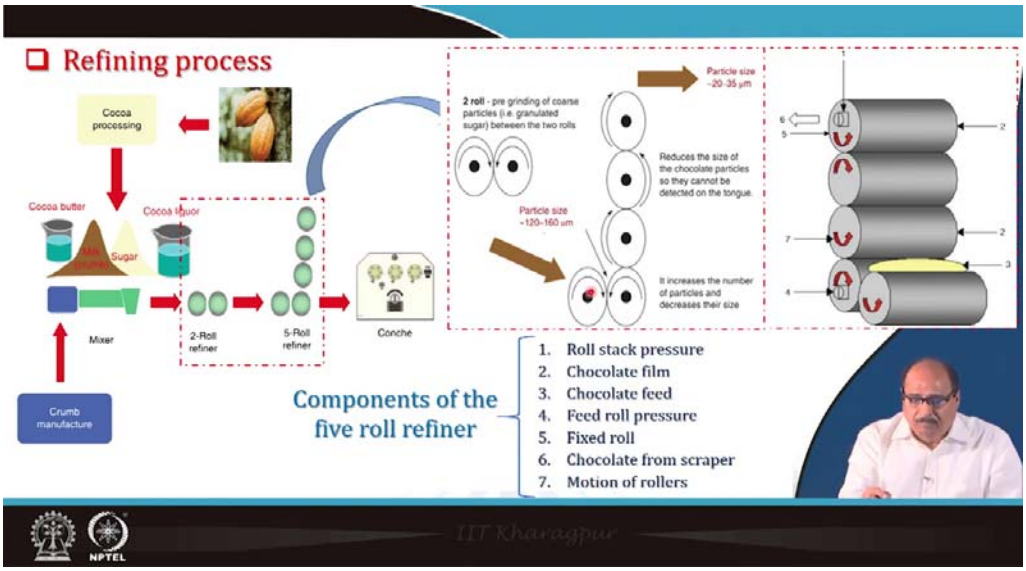
If there is too much fat, the feed roller of the refiner, which is the next process, will take the fat first and then later the dry solids. If there is too little fat, the refiner will overheat due to much friction and will produce a very non-uniform grade product. For the mixing, batch mixers can be used or even automated kneaders are also. By automatic metering of the ingredient, scaling and then properly mixing can be done. The purpose of the mixing is to produce a homogeneous, mass of uniform size.



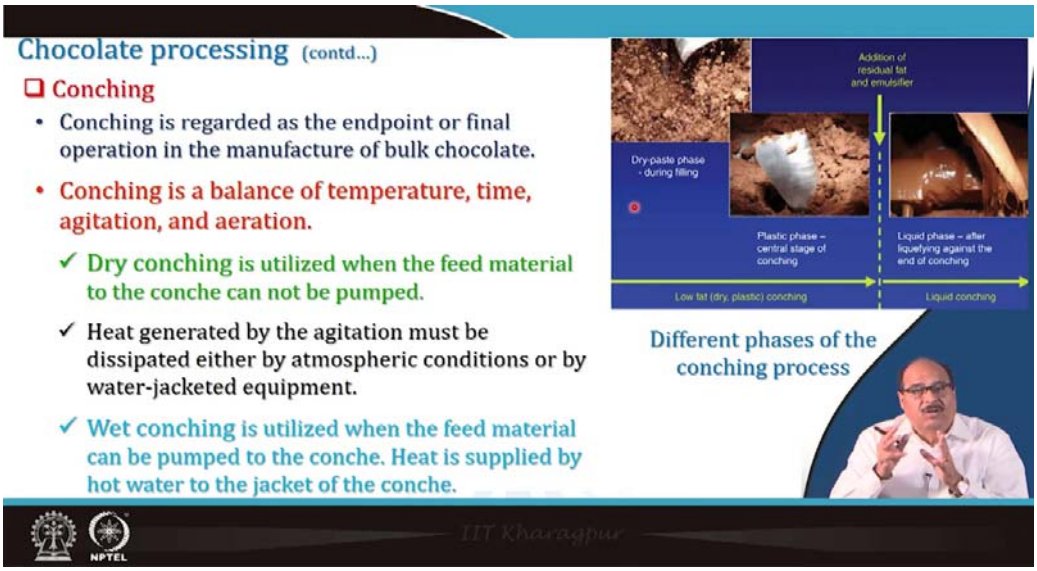
Refining

The next step is refining. Refining of chocolate is important to the products of smooth texture that is desirable in modern chocolate confectionery. The quality of the product depends upon the particle size distribution. A wide range of chocolate quality is produced by varying particle sizes of sugar and chocolate liquor. The maximum particle size of sugar may be around 25 to 57 microns and the chocolate liquor particle size may be in the range of somewhere 50 to 114 microns.

For good-eating chocolate, no more than 20 percent of the mass should have a particle size of more than 22 microns. The texture of the milk chocolate appears to be improved by a bimodal distribution of particles with a small proportion having sizes up to 65 microns. The optimum particle size for dark chocolate is lower, that is, at less than 35 microns, although, the values are influenced by the particular product and composition.



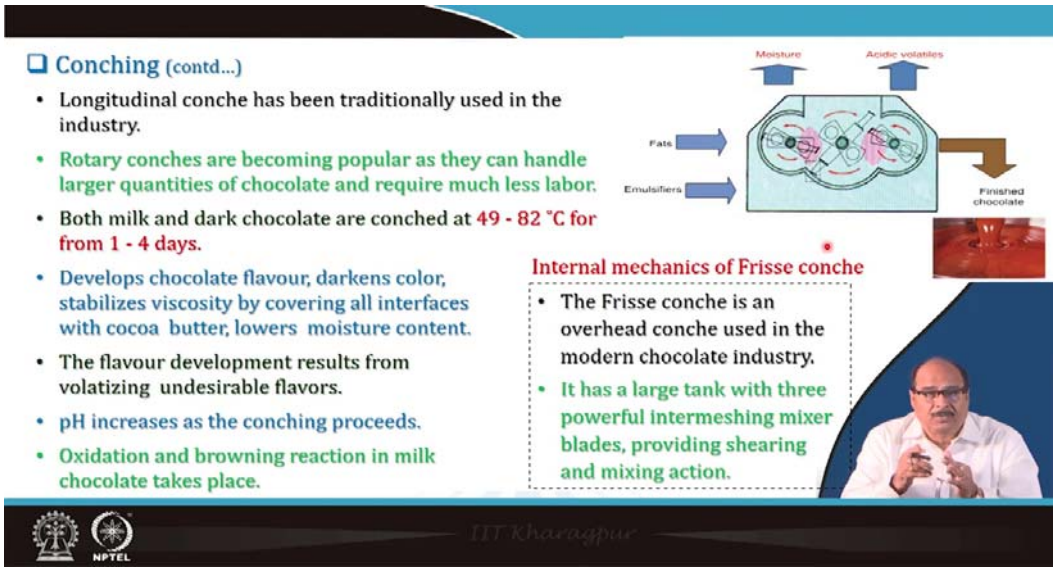
This is the refining process, you can see here, the 2-roller refiner. The material which is after mixing, is put into the 2-roller refiner and this 2-role refiner, it is pre-grinding, grinding of coarse particle, that is granulated sugar, between fine, between these two rollers, which are here and then they are pressed to the next roller. In the two rollers, it increases the number of particles and decreases their size. Then these rollers, that is, the next roller move at a larger speed than the previous roller. These wipe the material and carry it to the next roller. In fact, the clearance between these rollers has to be adjusted by the operator depending upon the size of the particles which is to be obtained finally. So, this second, third roller, fourth roller, etc. reduce the size of the chocolate particles. So, they cannot be detected even by the tongue. You get a completely homogeneous mass, it gives a smooth taste. Finally, the last roller is taken out, and the particle size may be 20 to 35 microns. The components of the different 5-roll refiners are shown here. It consists of roll stack pressure, chocolate film, chocolate feed, feeds roll pressure, fixed roll, chocolate from scraper and motion of the rollers. These are the various accessories that are provided in the refiner.



Conching

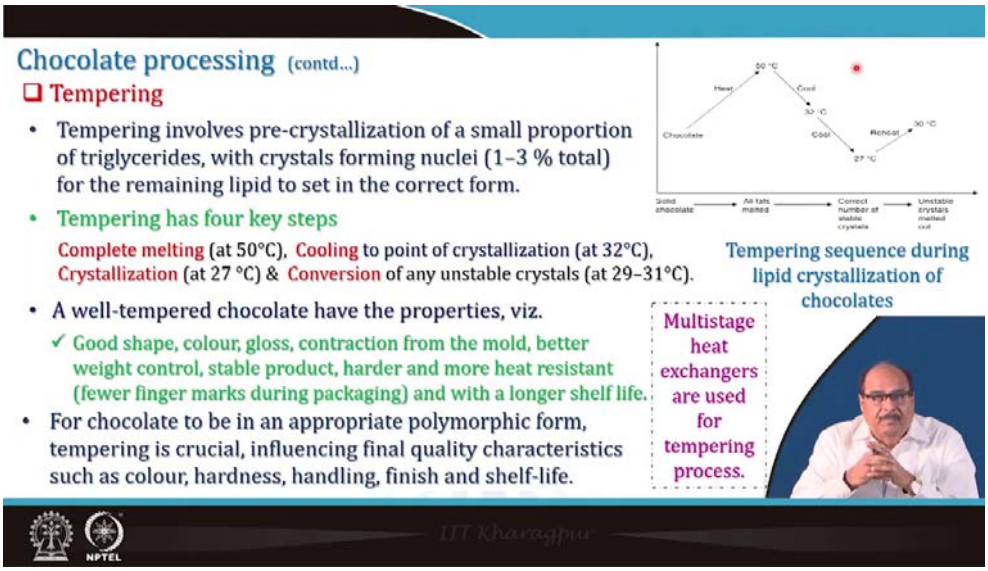
Conching is, a very important operation as you can see here in the figure. It is regarded as the endpoint or final operation in the manufacture of bulk chocolate making. Conching is basically a balance of the temperature, time, agitation and aeration. Dry conching is utilized when the feed material to the conch cannot be pumped.

The heat generated by the agitation must be dissipated either by atmospheric conditions or by water jacketing equipment. Wet conching is utilized when the feed material can be pumped to the conch, and in this case, heat is supplied by the hot water to the jacket to the conch. There are different phases, which you can see here in the conching process.



The longitudinal conches have been traditionally used in the industry but now rotary conches are becoming more popular as they can handle large quantities of chocolate and require much less labour. Both, the milk and dark chocolates are conched at around 49 to 82 degree Celsius for about 1 to 4 days. You can see here the internal mechanics for Frisse conche. It is a rotary conche, that is, Frisse's conche and overhead conche used in the modern chocolate industry. It had a large tank bigger tank with the three powerful interfacing mixer blades providing shearing and mixing action. So during conching, the chocolate flavour develops, its colour darkens, it stabilizes the viscosity by covering all interfaces with cocoa butter, and there is some lowering of moisture content.

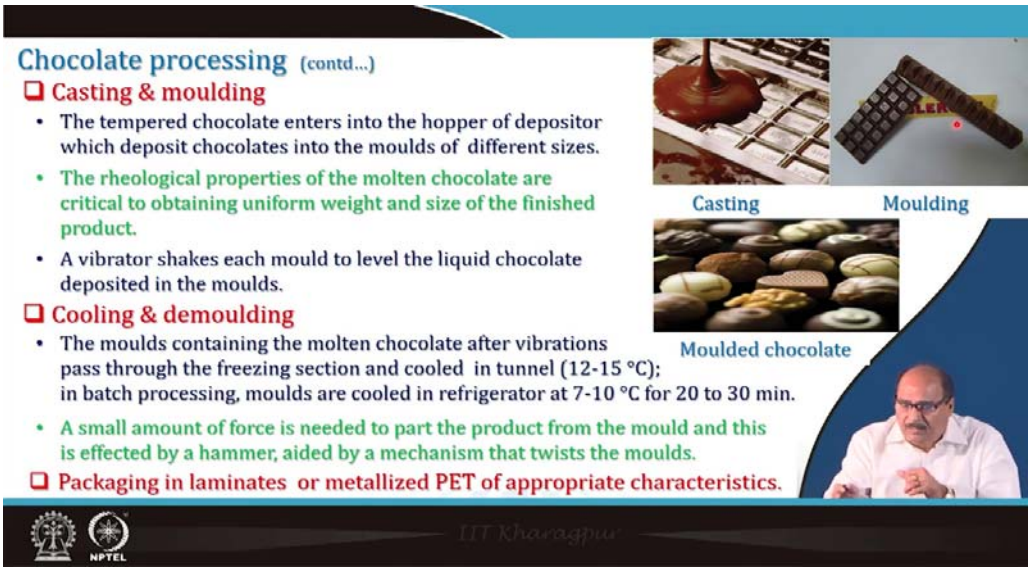
The flavour development results from mainly volatilizing the undesirable flavour as you can say, acidic material, etc. that they get volatile. Some moisture also goes out. pH increases as the conching proceeds, and oxidation and browning reactions in the milk-type chocolates also take place which adds to the colour and flavour.



Tempering

Finally, the tempering process, i.e. tempering involves pre-crystallization of a small portion of triglyceride with crystals forming nuclei maybe 1 to 3 percent total for the remaining lipid to set in the correct form. Tempering has four key steps, as you can see here in this figure. That is, the first is the complete melting at around 50 degrees Celsius, then cooling to the point of crystallization, the material is brought, its temperature to around 32 degrees Celsius. Then crystallisation occurs at a temperature of 27 degrees Celsius, and finally, conversion of any unstable crystals at 29 to 31 degrees Celsius. So, here in the figure, that is a tempering sequence during lipid crystallization of chocolates is shown. Solid chocolate then the temperature 50, all fats melted, then a correct number of stable crystals get at around 27 degrees Celsius, and finally, the temperature is a little bit raised, any unstable crystals are melted out.

A well-tempered chocolate has properties like it has a good shape, colour, gloss, and contraction from the mold. It has better weight control, is a stable product, is harder and more heat resistant, has fewer fine grades during packaging, and with a longer shelf-life. For chocolate to be an appropriate polymorphic form, tempering is crucial, influencing final quality characteristics such as colour, hardness, handling, finish and self-life. In fact, multistage heat exchangers are used for the tempering of chocolate.

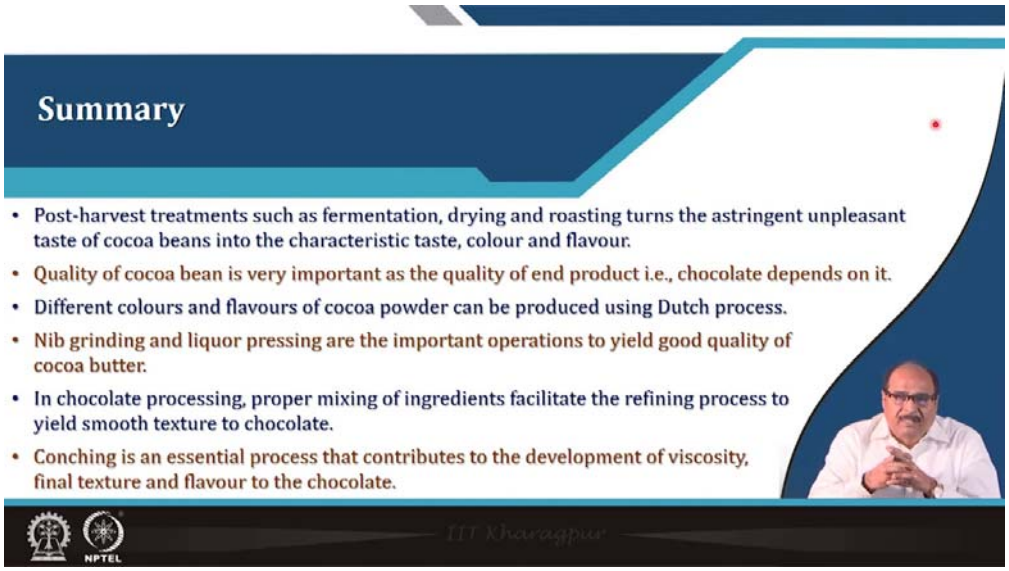


Casting and moulding

Finally, the casting and moulding, you can see here in the figure, casting & moulding and finally moulded chocolate that is giving the chocolate the desired shape. The tempered chocolate enters into the hopper of the depositor which deposits chocolates into the moulds of different sizes. The rheological properties of the molten chocolates are critical to obtaining uniform weight and size of the finished product. A vibrator shaker shakes each mould to the level of the liquid chocolate deposited in the mould.

Cooling and demoulding

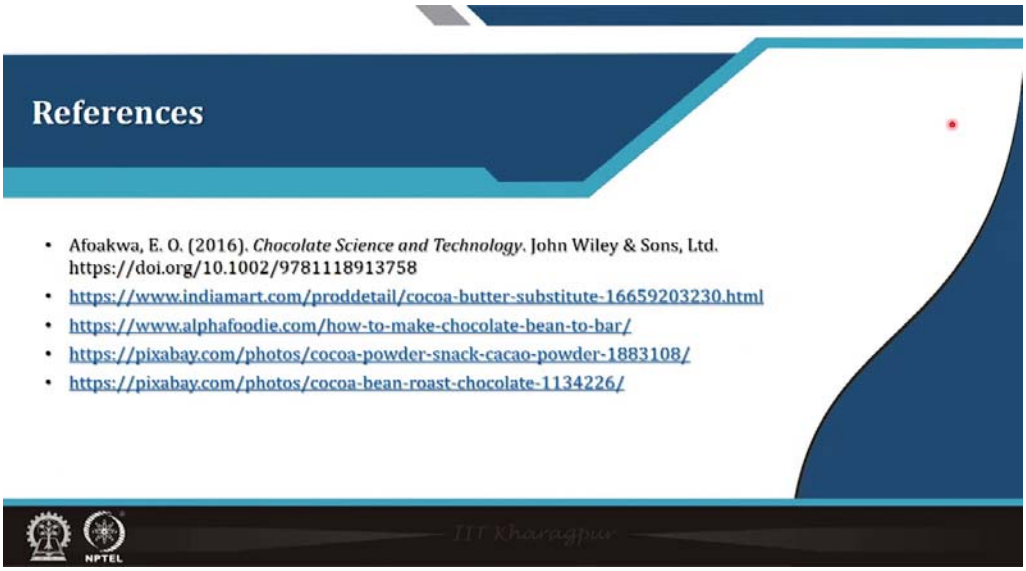
Then the moulds containing the molten chocolates after vibration, pass through the freezing section and are cooled in a tunnel freezer at around a temperature of 12 to 15 degrees Celsius. In the batch processing, the moulds are cooled in a refrigerator at around maybe maintained at around 7 to 10 degrees Celsius for 20 to 30 minutes. A small amount of force is needed to part the product from the mould, and this is affected by a hammer aided by a mechanism that twists the moulds. Finally, these products are again packaged in laminate or metallized polyester under control environment and the packaging materials should have proper characteristics, appropriate characteristics, particularly hygroscopicity, gas permeation or oxygen permeability, that is, they should be impermeable to all the light, gas, oxygen, etc. so that the colour and flavour and characteristics texture of the chocolate is maintained during packaging and the storage.



So finally, I will summarize this lecture, that as cocoa beans, once they are obtained from the trees, they are fermented, left open for some days, then after that they are split open, fermented and the unwanted seeds, pulps etc. are removed. The cocoa beans which are always, the main, in the industry, they store these cocoa beans and contain 10 to 12 percent moisture content.

These cocoa beans as desired, are further roasted and grinded and during the grinding, the heat produces, causing the melting of the butter or fat. Then melted fat carries with it, the solvent, to get the cocoa mass or bitter chocolate and this is pressed, butter is obtained and the cocoa powder is prepared.

The cocoa butter is mixed with the appropriate amount of milk sugars, milk solids, and other flavourings and other agents, and it is converted into chocolate. Chocolate manufacturing basically consists of three major operations like mixing, refining, and finally conching and tempering, and then properly tempered cocoa butter or chocolate is then moulded and packaged, given the desired shape and packaged.



So, these are the references which are used in this lecture. Finally, thank you for your patience in hearing.