**Food Oils and Fats: Chemistry & Technology**
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**Module 8 : Animal & Dairy Fats**
**Lecture 39: Butter**


Hello everybody, Namaste. Now, in this 39th lecture today, in the next half an hour, we will talk about another very very common and important derived that is butter.

## Concepts Covered


- Butter & its composition
- Classification of butter
- Butter manufacturing process
- Churns: Batch & Continuous
- Butter yield calculations
- Packaging of butter



We will discuss today what is butter and what is its composition, then different types of butter or classification of butter, butter manufacturing process, how what are the different churns, may be batch churn and continuous churn, then butter yield calculations and finally, I will also tell you something important about packaging of butter.

## Butter

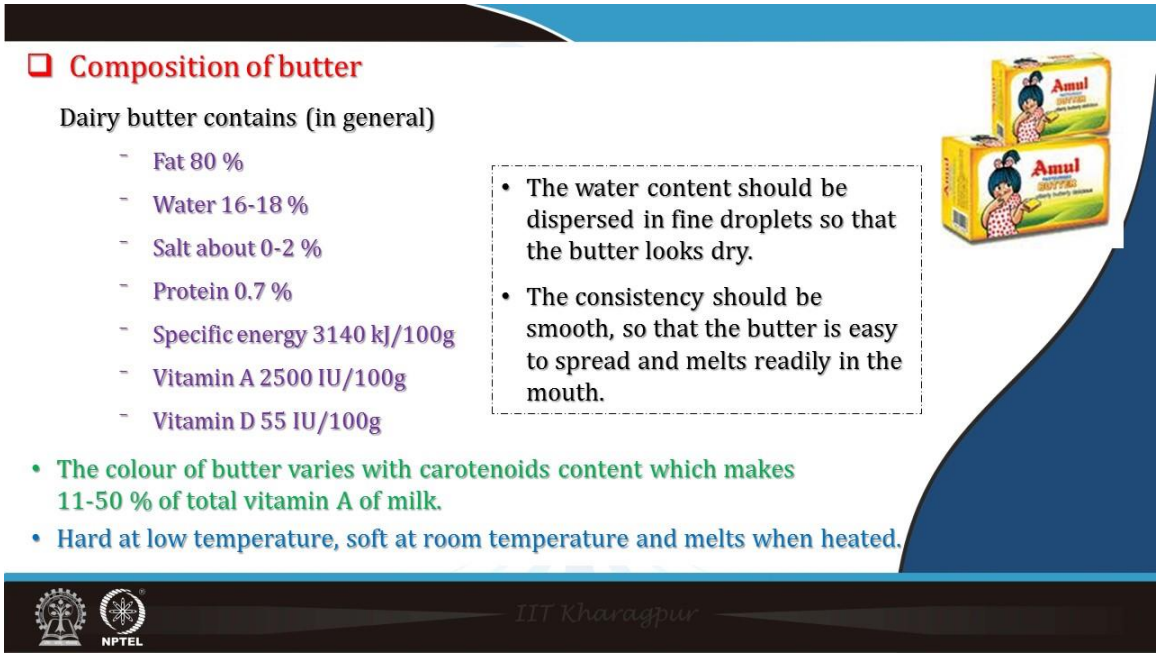
- A water-in-oil emulsion, comprised of > 80% milk fat, but also containing water in the form of tiny droplets, perhaps some milk SNF.
- Usually divided in two categories
  - ✓ Sweet cream butter
  - ✓ Cultured or sour cream butter made from bacteriologically soured cream
- Until well into the 19th century, butter was still made from cream that had been allowed to sour naturally.

Manual butter churner



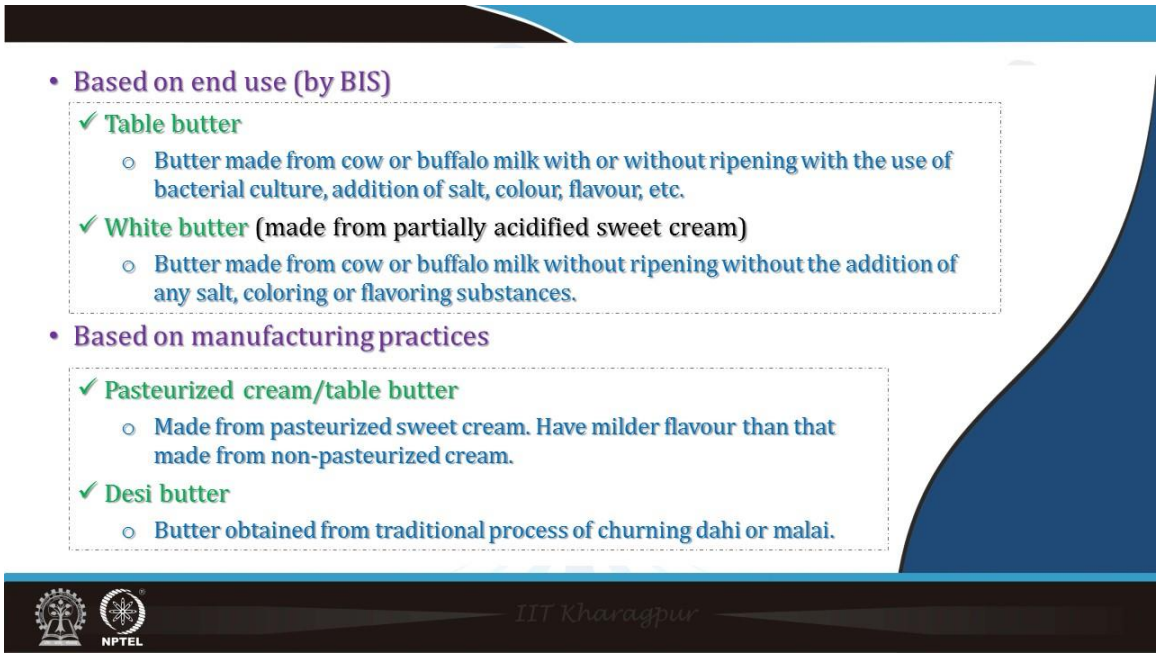
So, let us see what is a butter is. Butter is a water in oil emulsion which is comprised of more than 80 percent milk fat, but also contains water in the form of tiny

particles or tiny droplets. Perhaps some of the solids not fats also are present there. Usually butter is divided into two categories sweet cream butter or cultured or sour cream butter made from the bacteriologically soured cream. Until well into the 19th century, butter was still made from cream that had been allowed to sour naturally.



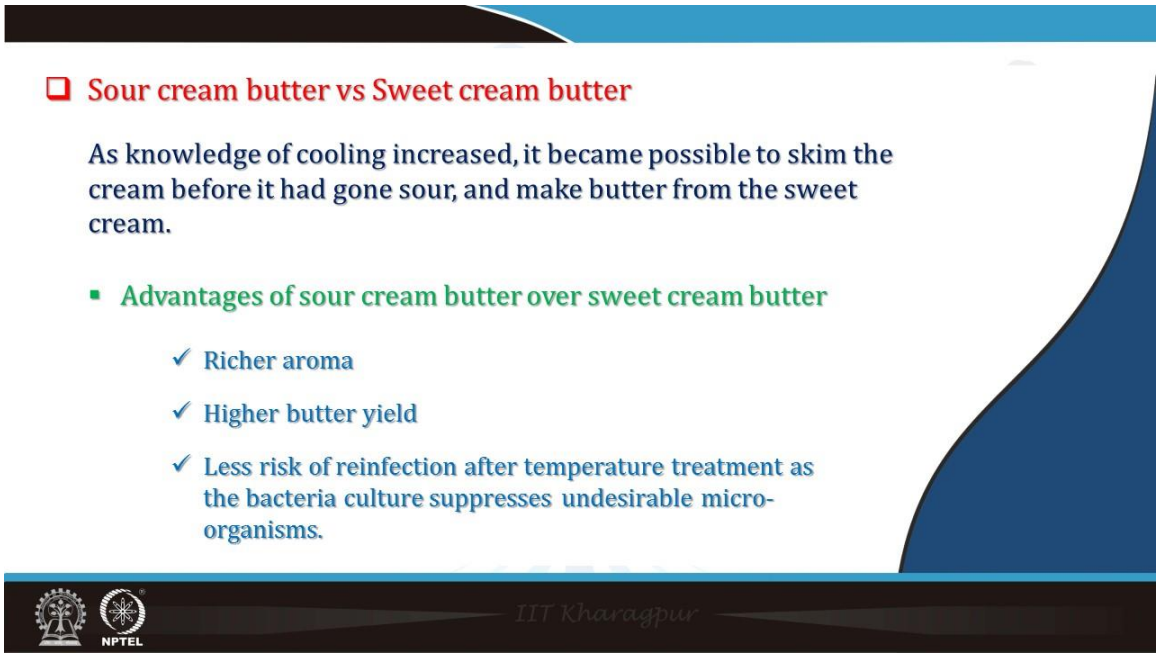

As far as the composition of the butter is concerned, it in general contains 80 percent milk fat, 16 to 18 percent water, about 0 to 2 percent salt, 0.7 percent protein. Specific energy of butter is 3140 kiloJoule per 100 gram, its vitamin A content is 2500 international unit per 100 gram and vitamin D content is 55 international unit per 100 gram. The color of butter varies with carotenoid content which makes around 11 to 50 percent of the total vitamin A of the milk. Hard butter is hard at low temperature, soft at room temperature and it melts when heated. The water content that is present into the butter, it should be properly dispersed in fine droplets so that the butter looks dry. The consistency should be smooth so that the butter is easy to spread and melts readily in the mouth.


Different classification of the butter, there are various ways for classifying it and one is the based on the acidity of the cream and according to that that is the butter is classified in sweet cream butter that is the butter made from the non-acidified cream in which no bacterial culture has been added to enhance diacetyl content. It has a pH of around more than 6.4 and acidity does not exceed 0.2 percent. Then mildly acidified butter is made from partially acidified sweet cream, they have a pH in between 5.2 and 6.3. Then third category is the sour cream butter which is made from ripened cream and it has a pH less than or equal to 5.1 and acidity exceed 0.2. Then other classification of the butter is on the basis of its salt content that is the salted butter in which the salt is added to improve flavor and keeping quality of the butter. And then other category is unsalted butter where it is the butter which is primarily made to produce further ghee or butter oil. In this no salt is added that is unsalted butter.

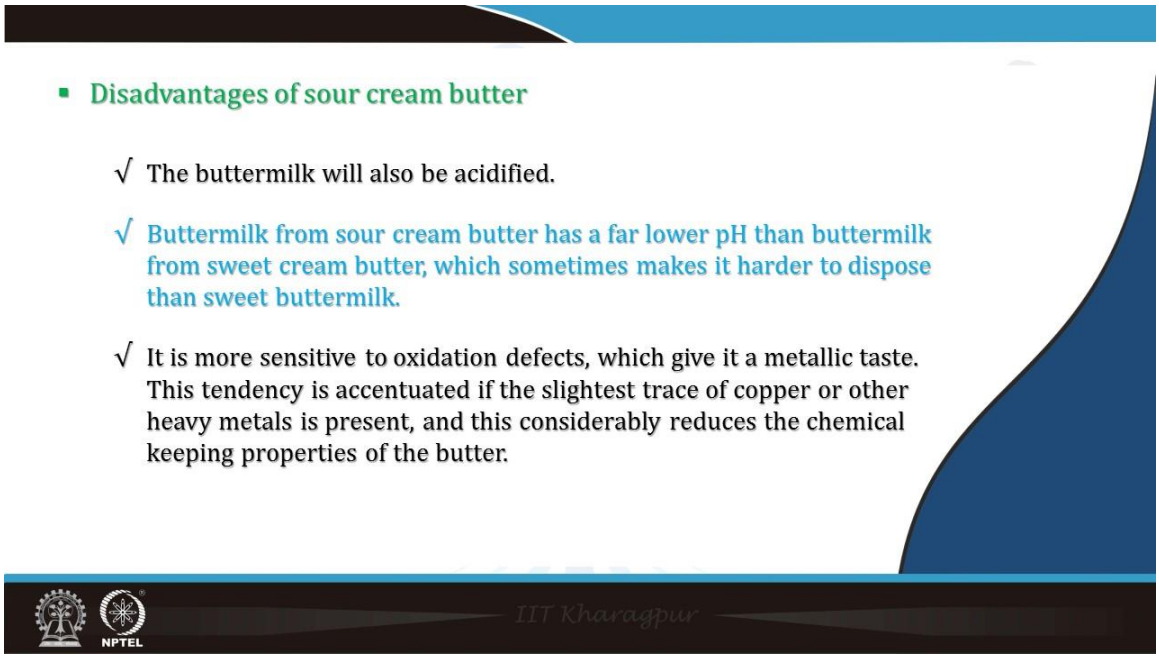



Then also the butter is classified on the basis of its consumption in daily use. As per the Bureau of Indian Standards, the butter is a table butter that is which is made from the cow or buffalo milk with or without ripening with the use of bacterial culture, addition of salt, color, flavor etcetera. So this is the definition of table butter as per the BIS. Classifying butter that is which is made from partially acidified sour cream, it is again made from cow or buffalo milk without ripening, without the ripening and without the addition of any salt coloring or flavoring substances.

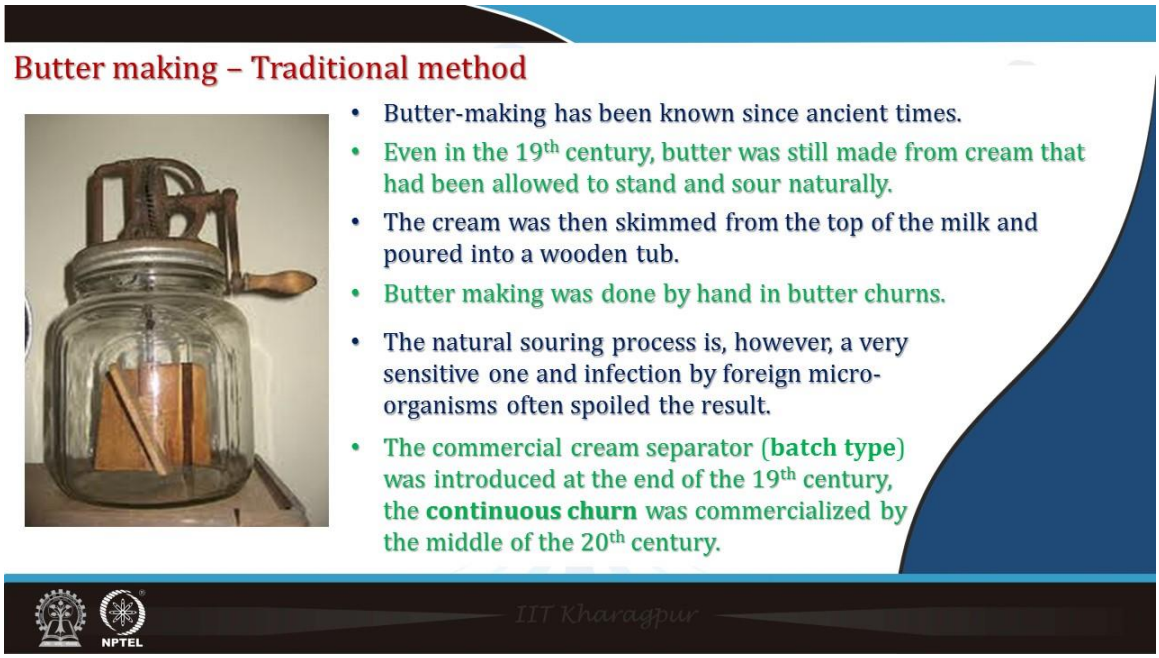
Then another way of classifying butter is the based on the manufacturing practices that is the pasteurized cream or table butter that is which is made from obviously as the name indicates that is pasteurized sweet cream. It has mild flavor than the that made from non-pasteurized cream. Then desi butter, desi butter is the one which is obtained from the traditional process of churning dahi or malai.



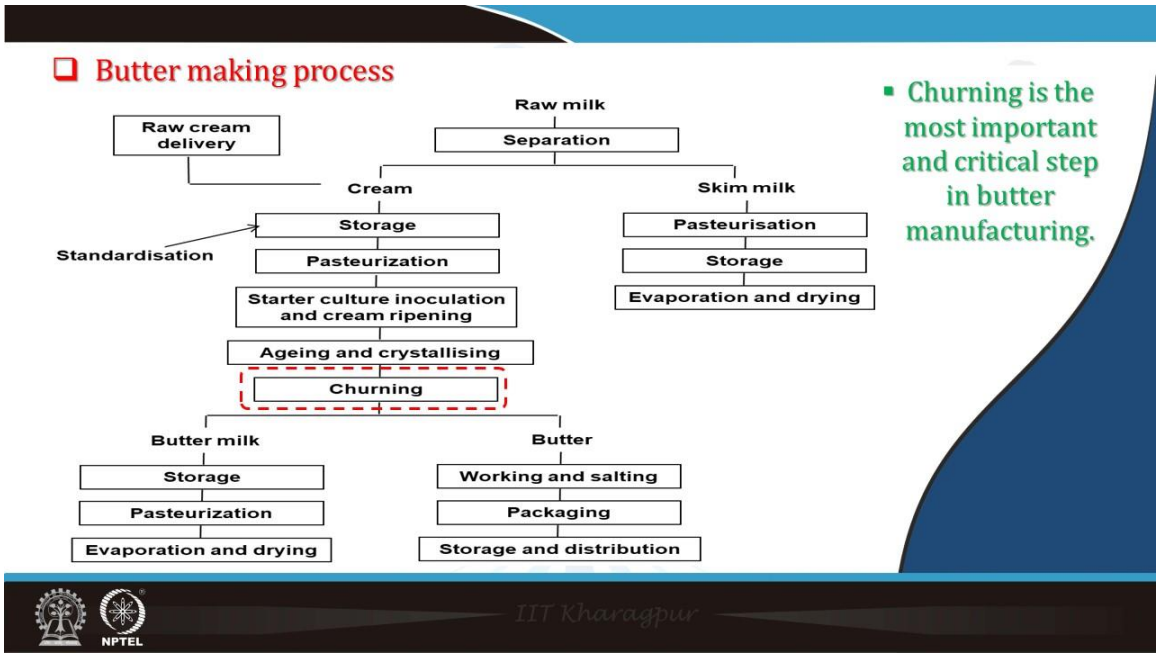

Then let us see what is the sour cream versus sweet cream butter. Based a knowledge of cooling increased, it becomes possible to skim the cream butter before it has gone sour and make the butter from the sweet cream. Advantage of sour cream butter over sweet cream butter includes that is it is a richer in aroma, it gives higher butter yield and there is a less risk of reinfection after temperature treatment as the bacteria culture suppresses undesirable microorganisms.



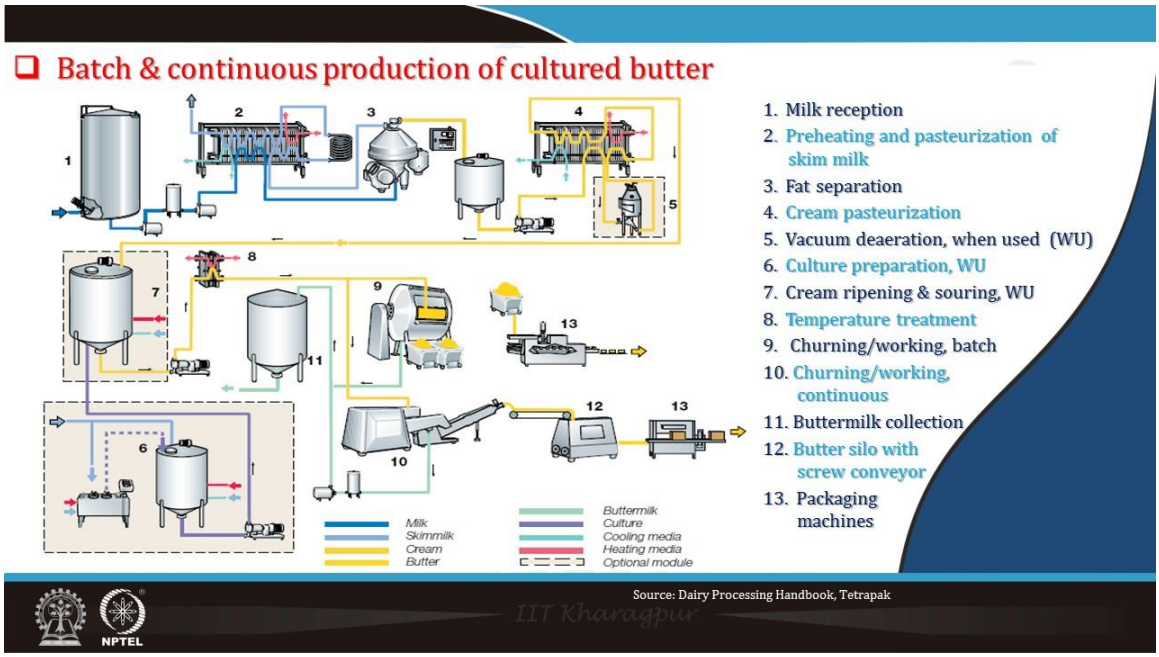
However, this disadvantages of the sweet cream or sour cream butter are the butter milk will also be acidified here and the butter milk which is obtained, it has a far lower pH than butter milk normal butter milk which is one made from sweet cream. This sometimes make it harder to dispose than the sweet butter milk. It has more sense it is more sensitive to oxidation defects which give a metallic taste. This tendency is a accentuated if the slightest trace of copper or other heavy metals is present and this considerably reduces the chemical keeping properties of the butter.



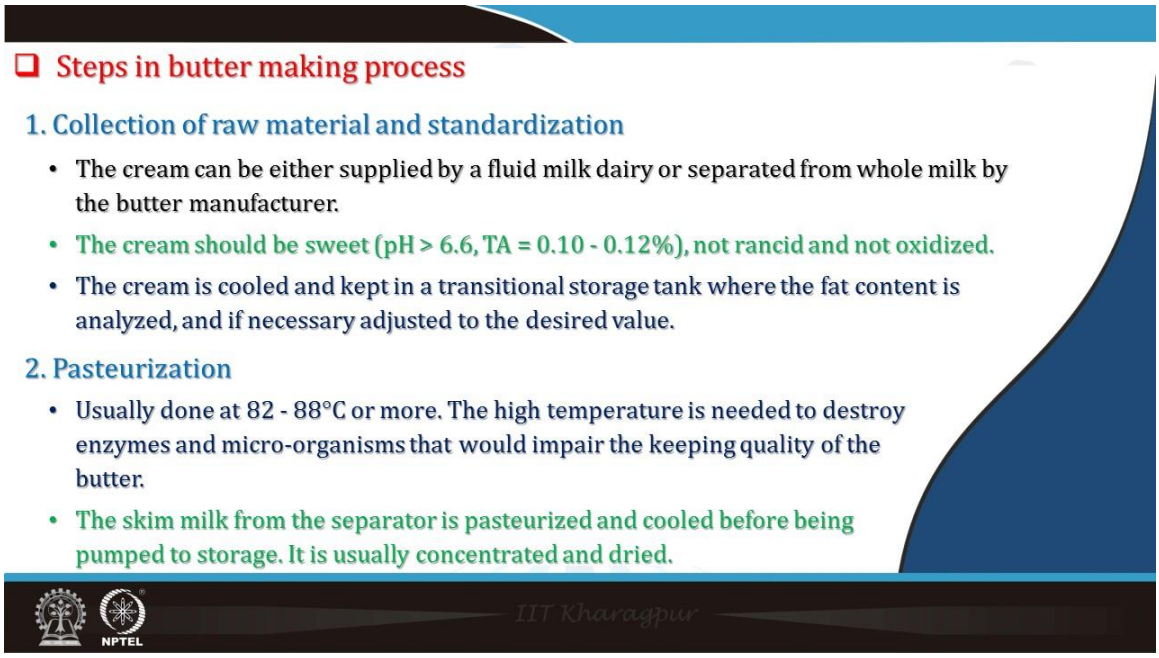

Now, let us understand how butter is made. Traditional method for making butter has been used or it has been made since ancient time even in our homes. Even in the 19th century butter was still made from cream that had not been allowed to stand and sour naturally. The cream was skimmed from the top of the milk and poured into a wooden tub as you can see here in the figure. The butter baking was done by the hand in butter churns. The natural souring process is however a very sensitive one and infection by foreign microorganism then often spoiled the results. So, the commercial cream separator that is batch type was introduced at the end of the 19th century and continuous churns were commercialized in the middle of the 20th century. Now, these commercial separator of the cream from the milk that is centrifugal separator and continuous churns are being used by the extensively by the industry for manufacturing butter.



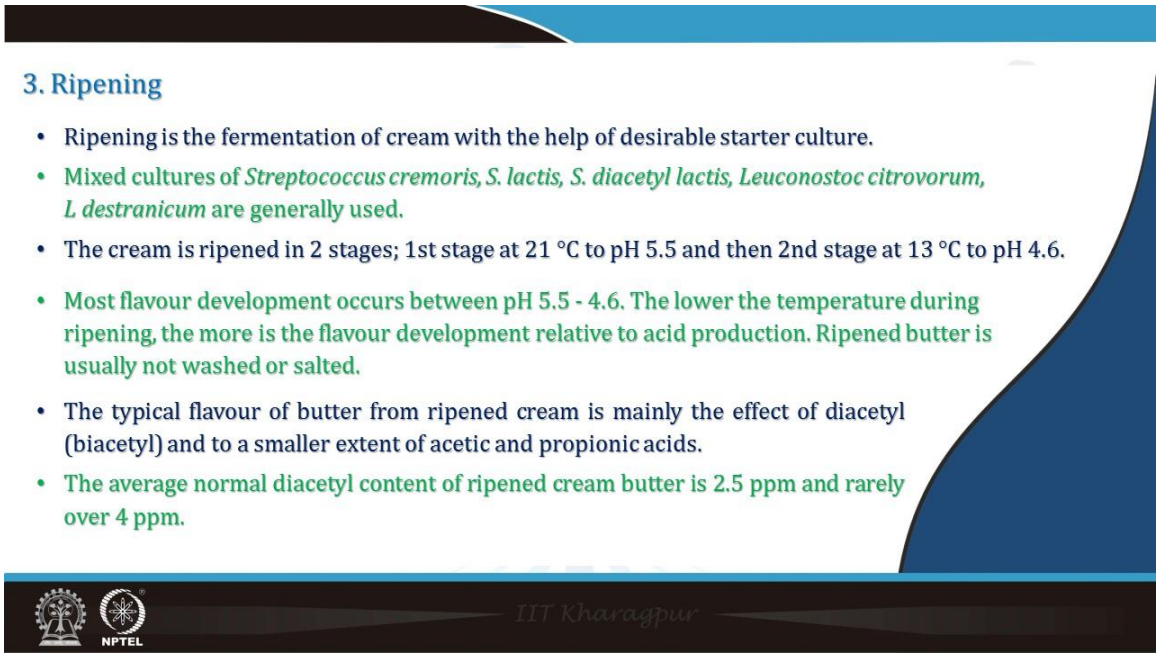

So, the butter manufacturing process here flow sheet you can understand that is the raw cream and this from the milk cream is separated in we discussed this separation of the cream in the earlier class. So, you have the cream and then skim milk after the cream separation you get. Skim milk may be pasteurized, stored or dried into making for making skim milk powder. Then the cream is a standardized and pasteurized and after that sometime even in the industry the structure culture inoculation is done and the cream is allowed to ripen or even it is a it is not a standard nature natural sweet cream then directly it is. So, after the for making sour cream that is aging and crystallizing is allowed then finally, the churning is done and after churning that is the butter gets separated, fat gets separated from this you get buttermilk and the butter and then it is finally, worked and salted packaged and stored and distributed this is the butter making process in general. So, here you can say in the butter making the most important process operation is the churning it is a critical step in the butter manufacturing process and the characteristics quality property etcetera of this will depend on how the churning has been done.



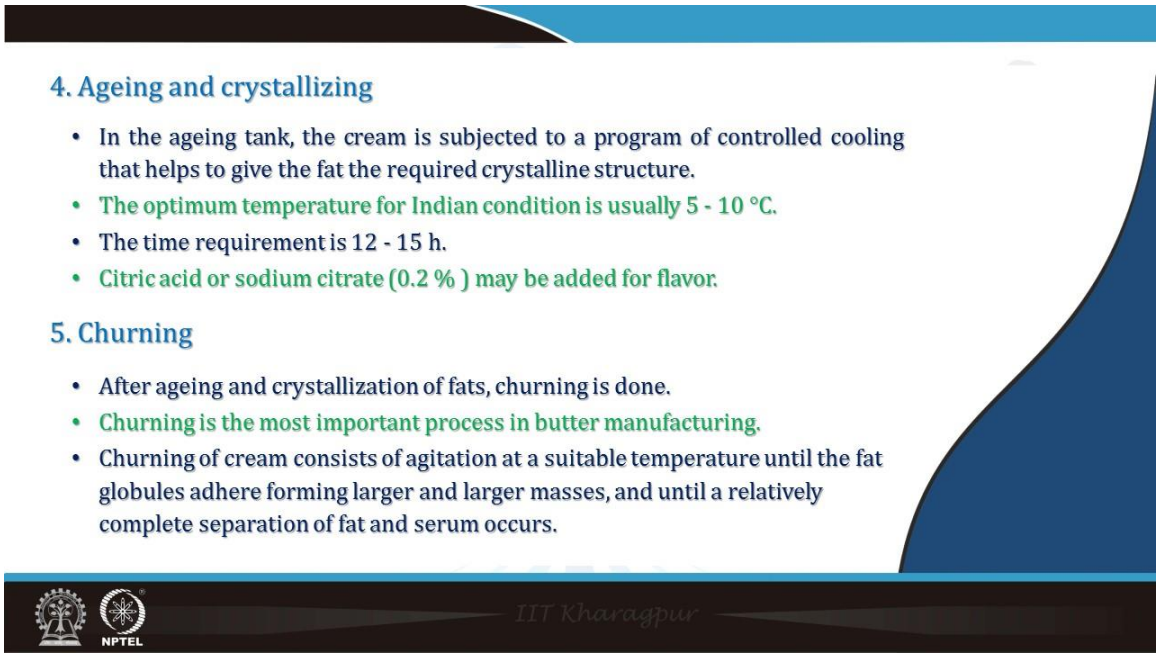

So, this is a batch and continuous production of cultured butter that is schematic it has given and all the equipment etcetera also shown that is the there is a milk reception unit after this it milk is sent to the preheating and pasteurization then finally, cream separation is done and then or the cream is sent to the next setup that is the cream pasteurizer and from there it comes to the vacuum deaeration when used and then finally, culture room it goes to the culture preparation cream ripening and souring then there is a some sort of a where it is treated temperature treatment then finally, it comes to the stage that is the churning or working batch here these are the churn that this is a pasteurized and cultured cream is put into the churn churn operates etcetera and then it butter milk is collected separately and butter is sent to the working section etcetera even this yellow line red line and deep blue light blue etcetera all these lines. So, in the process that is whether the milk is flowing skim milk is flowing cream or butter that is where from it is the flow diagram.




So, the steps in it that is I tell the first thing is the collection of raw material and its standardization the cream it can be either supplied by a fluid dairy or separated from whole milk by butter milk manufacturer the cream is then it should be sweet, pH should be 6.6, saturated table acidity may be 0.1 to 0.12 and it is not rancid and not oxidized the cream is cooled and kept in a transitional storage tank where the fat content is analyzed and if necessary it is adjusted to the desired value. Then the pasteurization as I told you it is usually done to at 82 to 88 degree Celsius and the high temperature is needed to destroy enzymes and microorganisms that would impair the keeping quality of the butter. The skim milk from the separator is pasteurized and cooled before being pumped to the storage it is usually the concentrated and dried into skim milk powder.

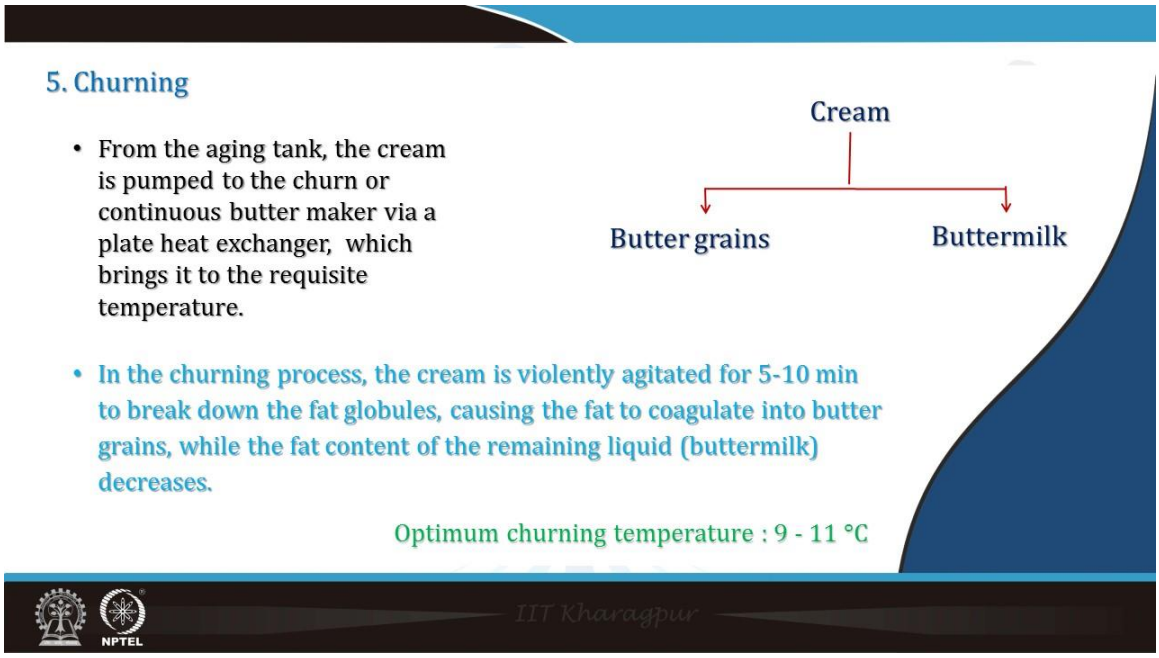



Then ripening is the important step for making sweet cream sour cream butter the ripening fermentation of the cream with the help of desirable starter culture that is mixed culture of normally *Streptococcus cremoris*, *Streptococcus lactis*, *S. lactis*, *Leuconostoc citrovorum* or *Leuconostoc destranicum* etcetera are generally used. The cream is ripened in two stages in the first stage at 21 degree Celsius it is ripened to pH 5.5 and then in the second stage the pH is brought down to as low as 4.6 percent the temperature is maintained at 30 degree Celsius. And the most of flavor development occurs between pH 5.5 to 4.6. The lower the temperature during ripening the more is the flavor development relative to the acid production and ripened butter is usually not washed or salted. The typical butter flavor from the ripened cream is mainly the effect of diacetyl and to a smaller extent of acetic acid and propionic acid that is formed during the fermentation process during the ripening process. And the average normal diacetyl content of the ripened cream butter is 2.5 ppm and rarely over 4 ppm.

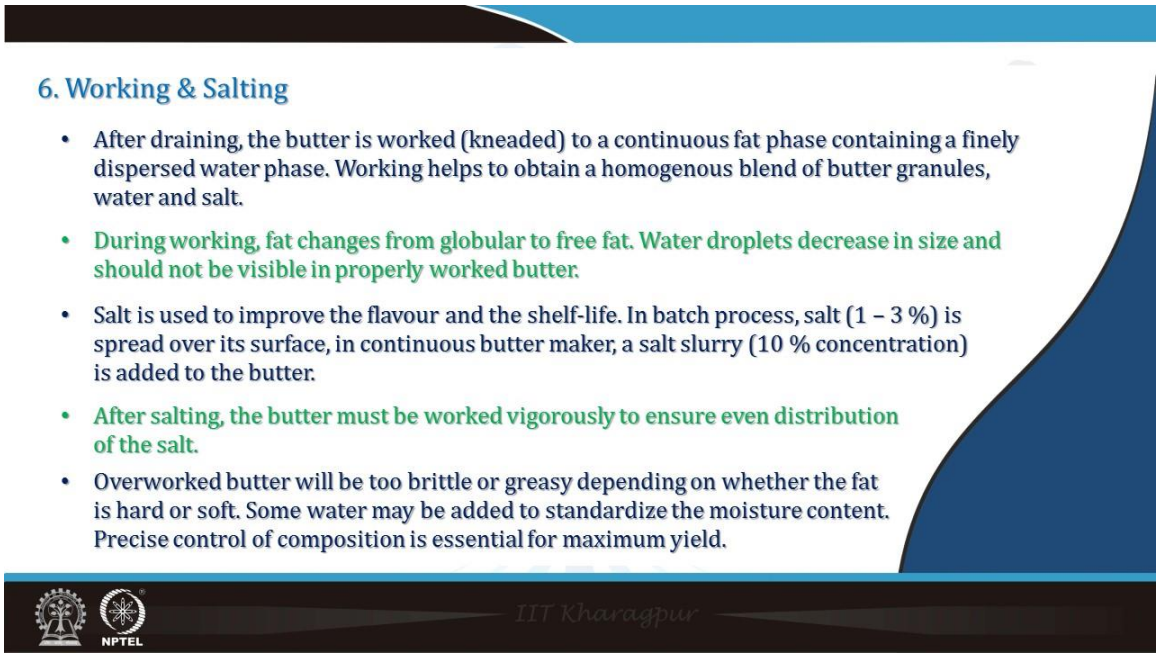



Then aging and crystallization in the aging tank the cream is subjected to a program of controlled cooling that helps to give the fat the required crystallization crystalline structure. The optimum temperature of the Indian condition butter is usually 5 to 10 degree Celsius and the time required for aging is 12 to 15 hours. Then citric acids or sodium citrate at the rate of 0.2 percent may be added for flavor. Then finally, comes the important step churning that is after the aging and the crystallization of fat churning is done. Churning is most important process as I told you.

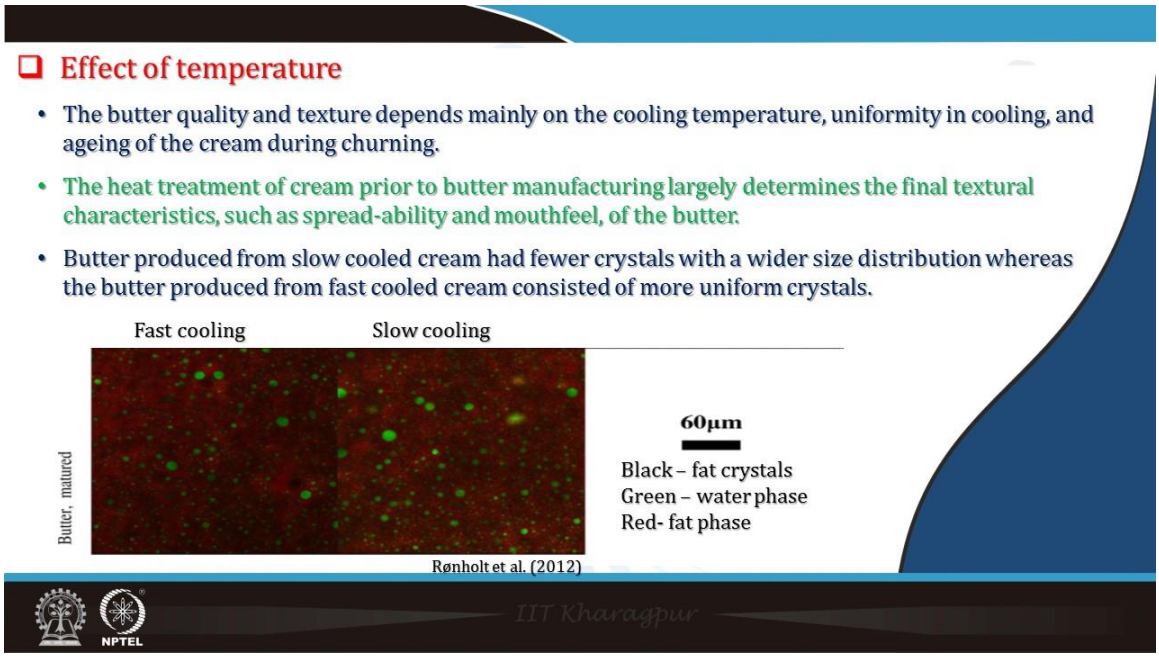
The churning of cream consists of agitation at a suitable temperature until the fat globules adhere forming larger and larger masses and until a relatively complete separation of the fat from the serum fat and serum occurs.



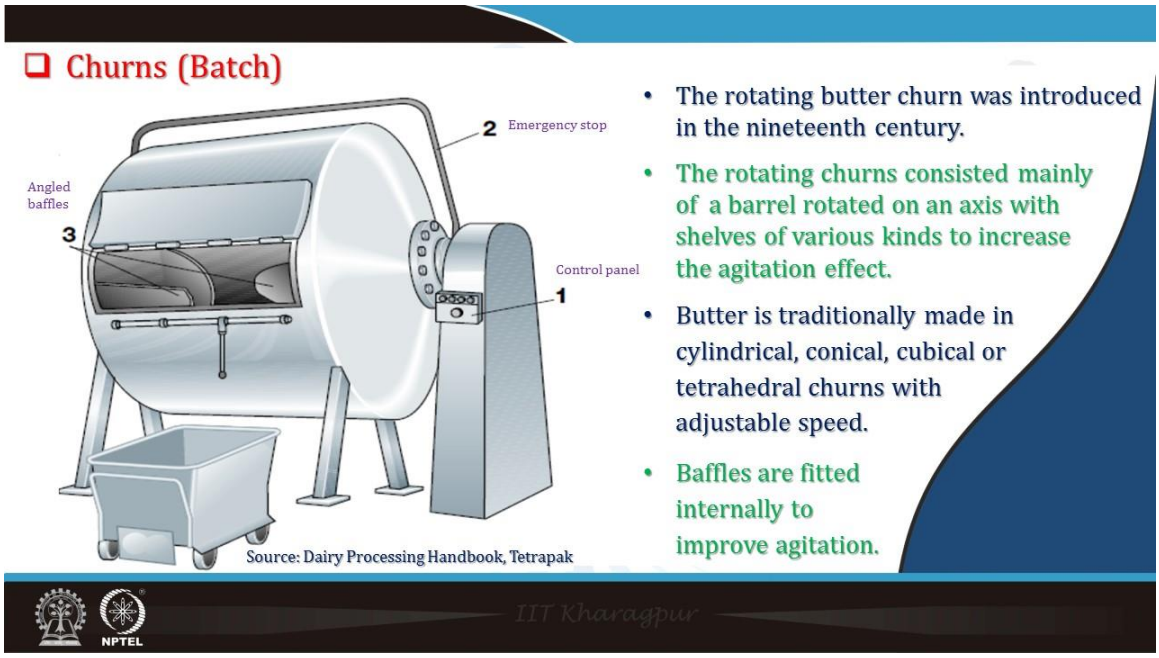

The churning that it may be from the aging tank the cream is pumped to the churn that there are continuous butter making by a plate heat exchanger which belongs to the requisite temperature. In the churning process the cream is violently agitated for 5 to 10 minutes to break down the fat globules causing the fat to coagulate into butter grains while the fat content of the remaining liquid butter milk decreases. So optimum temperature of the churning may be 9 to 11 degree Celsius. So basically in the churning process the butter grains and buttermilks are separated.



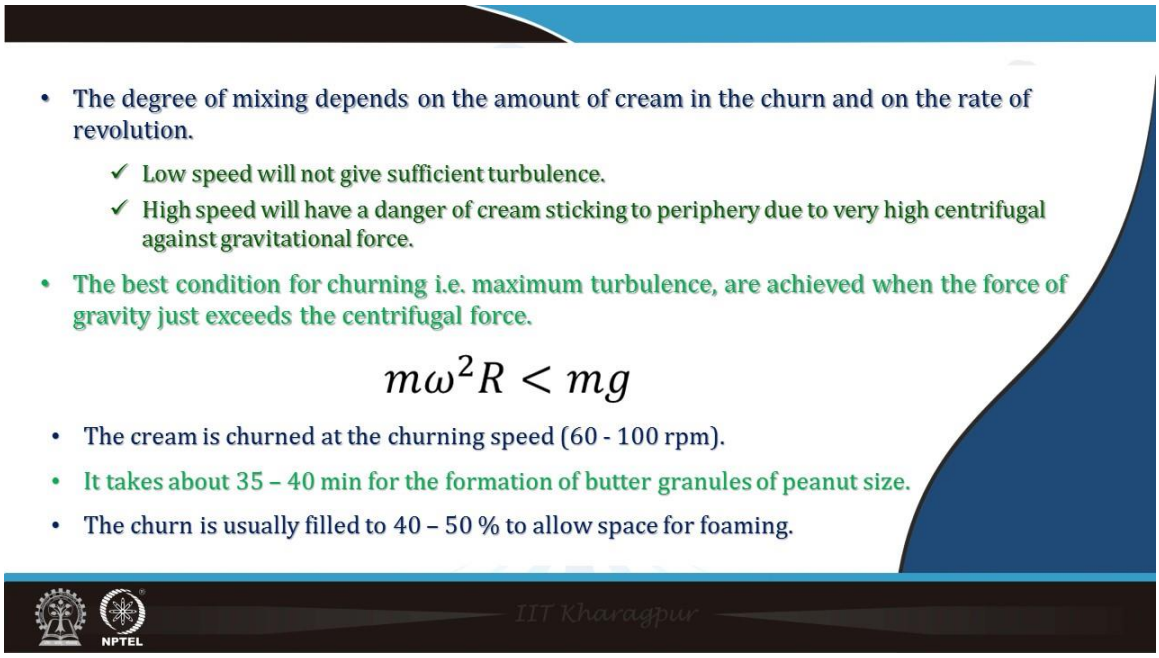

Then finally, it comes to the after it is churned the working and salting. After draining the butter is worked out that is kneaded to continuous fat phase containing a finally, dispersed water phase that is the fat granules which are obtained from the churn they are needed properly they are worked on it. And during this working that it gives a homogeneous blend of butter granules and also water and salt etcetera are added into it some water the fine dry and dainty dry food they are homogeneously mixed into it. During working fat changes from globular to free fat water droplet decreases in size and should not be visible in properly worked butter. Salt is used to improve the flavor and shelf-life in batch process about 1 to 3 percent salt is spread over its surface in continuous butter making process a salt slurry of even 10 percent concentration is added to the butter. So after salting the butter must be worked vigorously to ensure even distribution of the salt. Overworked butter will be too brittle or greasy depending on the weather the fat is hard or soft. Some water may be added to standardize the moisture content precise control of the composition is essential for maximum yield.




So here you see the effect of temperature that is the quality of the butter and the texture of the butter which is finally obtained it mainly and the depends on the mainly and the cooling temperature uniformity in cooling and aging of the cream during churning. The heat treatment of the cream prior to butter manufacturing largely determines the final textural characteristics such as spreadability mouthfeel etcetera of the butter. The butter produced from slow cooled cream had fewer crystals with a wider size distribution whereas, the butter which is made from fast cooled cream as you can see here in the picture it had a it consisted of a more uniform crystal. So normally the 60 micron size it in the figure here it is slow cooling and fast cooling methods is there is black, white is the first crystal fat crystals, green is the water phase and red is the fat phase.

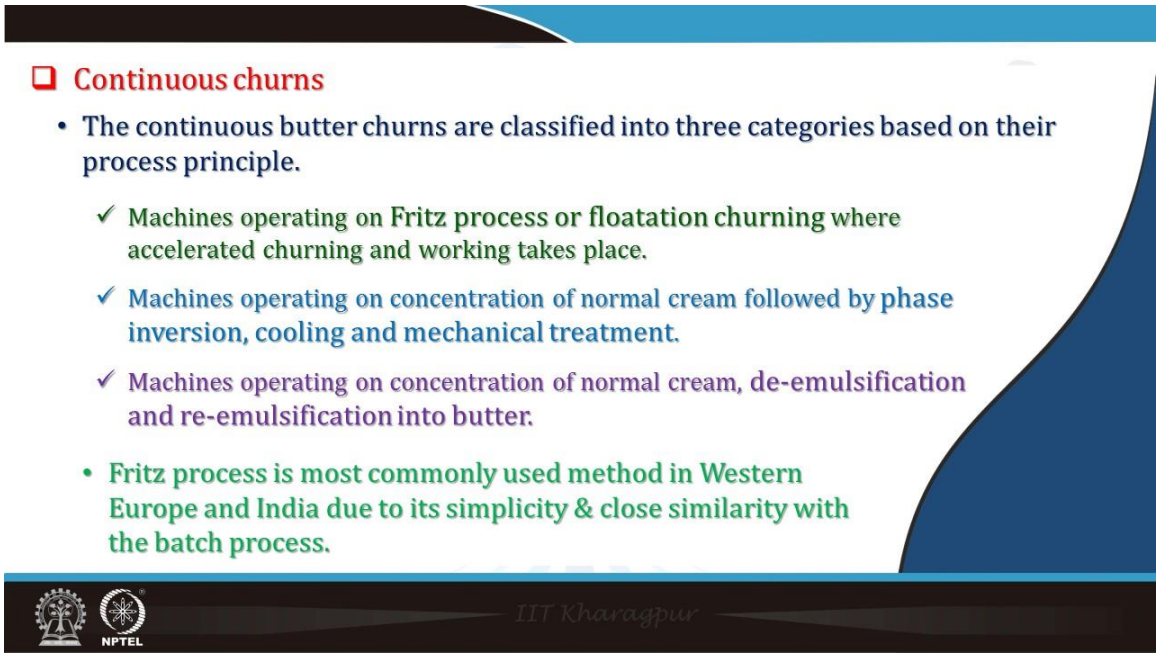



Then the churn you can see that is here in the actually main equipment used for the churning of the cream for making the butter you can see in the figure. This rotating butter churn is introduced in the 19th century. The rotating churn consisted mainly of a barrel which rotates on an axis with the shelves on various kinds to increase the agitation effect here it is there basically it is churn. So butter is traditionally made in cylindrical, conical, cubical or tetrahedral churns with adjustable speed. Baffles are fitted internally to improve the agitation.



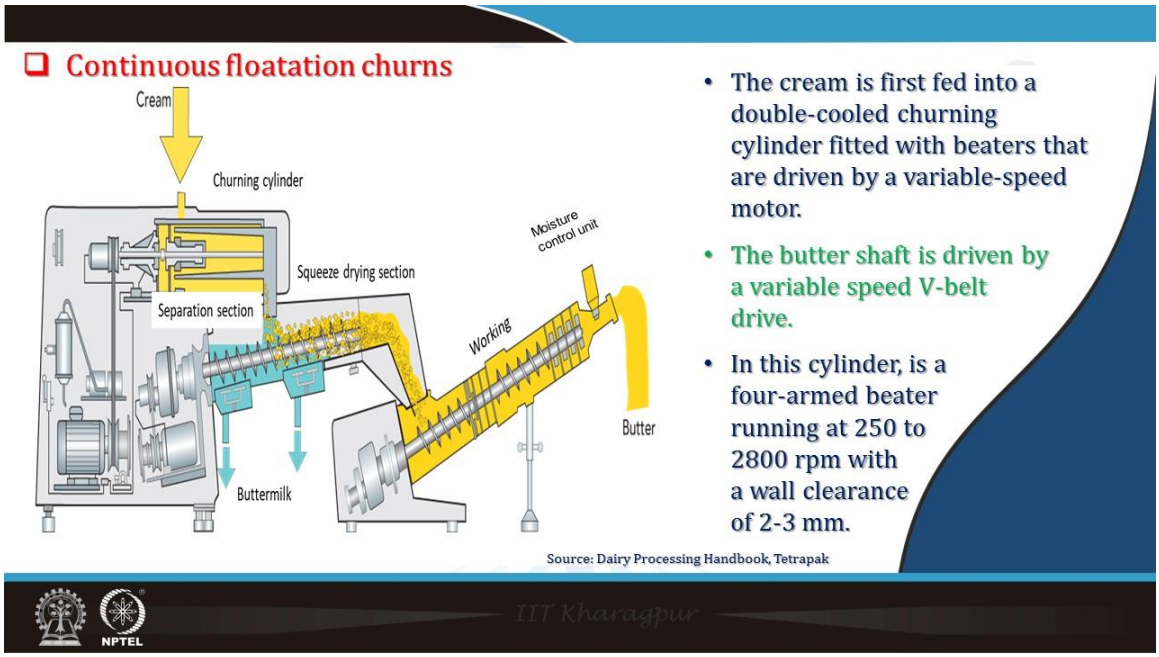

The degree of mixing depends on the amount of cream in the churn and on the area of revolution. Low speed will not give sufficient turbulence, high speed will have a danger of cream is sticking to the periphery due to very high centrifugal against gravitational force. So the best condition for churning that is maximum turbulence are achieved when the force of gravity just exceeds the centrifugal force and that can be found out by m omega square r that is this is less than mg. The cream is churned at the churning speed of 60 to 100 rpm. It takes about 35 to 40 minute for the formation of the butter granules of peanut size. The churn is usually fitted to 40 to 50 percent to allow space for forming.

$$m\omega^2 R < mg$$




Then there are also continuous churn which are used in the industry. These are classified into three categories based on their process principle that is the machines operating on Fritz process of or flotation churning where accelerated churning and working takes place. Then machines other continuous churn of the machines operating on the concentration of normal cream followed by phase inversion, cooling and mechanical treatment.

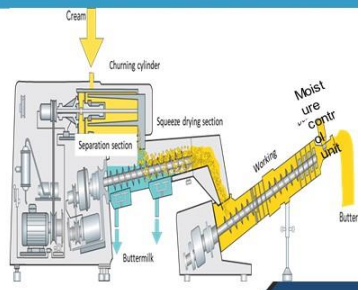
Also the other categories of the continuous churn are the machine operating on concentration of normal cream, de-emulsification and re-emulsification into butter. Batch process is most commonly used in western Europe and India due to its simplicity and close similarity with the batch process.




So, here you see it shows the continuous production of that flotation of the churn continuous churn. So, after churning the butter granules are coming that is the drying section and working unit is done that is yellow portion is coming cream and then part line. So, the cream is first as you can see in the figure is first fed into a double cooling churn cylinder fitted with the beaters that are driven by a variable speed motor.

The butter shaft is driven by a variable speed V-belt drive. In this cylinder is a four armed beater churning at 250 to 2800 rpm with a walled clearance of around 2 to 3 mm.

- The speed can be varied as required.
- The pockets in the churning cylinder impart extra turbulence to the film of cream thereby enhancing the butter making action and improving the yield.
- Rapid conversion takes place in the cylinder and, when finished, the butter grains and buttermilk pass on to a separation section also called the first working section, where the butter is separated from the buttermilk.
- The first washing of the butter grains takes place en-route with recirculated chilled buttermilk.
- The separation section is equipped with a screw that initiates the working of the butter while conveying it to the next stage.

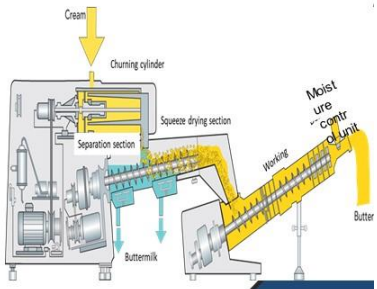





The speed can be varied as required. The pockets in the churning cylinder impart extra turbulence to the film of cream thereby enhancing the butter making action and improve the yield. Rapid conversion takes place in the cylinder in and finished the grain butter grains and butter milk pass on to a separation section and called the first working section that is first working section is coming here where basically the butter is separated from the butter milk.

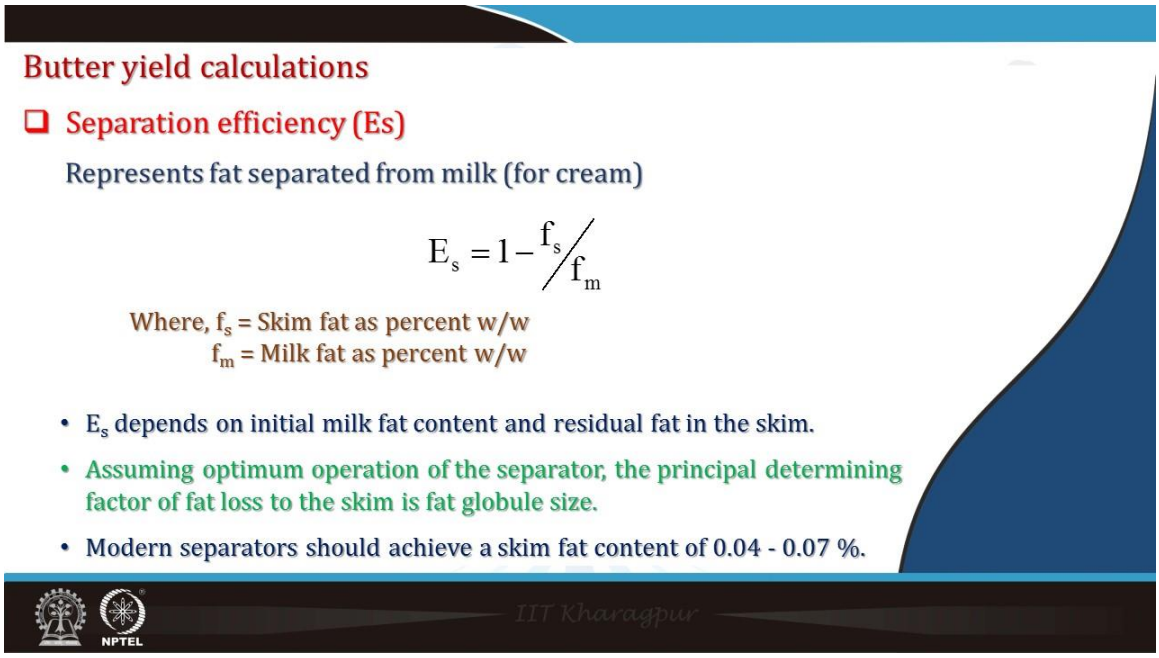
The first washing of the butter grains takes place en route with recirculated chilled butter milk. The separation section is equipped with a screw that initiate the working of the butter while conveying it to the next stage.

- As it leaves the separation section the butter passes through a conical channel and a perforated plate, the squeeze-drying section where any remaining buttermilk is removed.
- The butter grains then proceed to the second working section.
- Each working section has a separate motor that can operate independently at different speeds.
- Salt, color, and moisture corrections may be checked.
- Transmitters for moisture content, salt content, density and temperature can be fitted in the outlet from the machine.
- The discharged butter is transmitted for further packaging.






As it leaves the separation section the butter passes through a conical channel and is on a perforated plate and then it goes to the squeeze drying section ok where any remaining butter milk is removed from it. The butter grains then proceed to the second working section and each working section has a separate motor that can operate independently at different speeds. Salt, colour and moisture corrections may be checked. The water content can be fitted in the outlet from the machines and the discharge butter is transferred for further packaging.

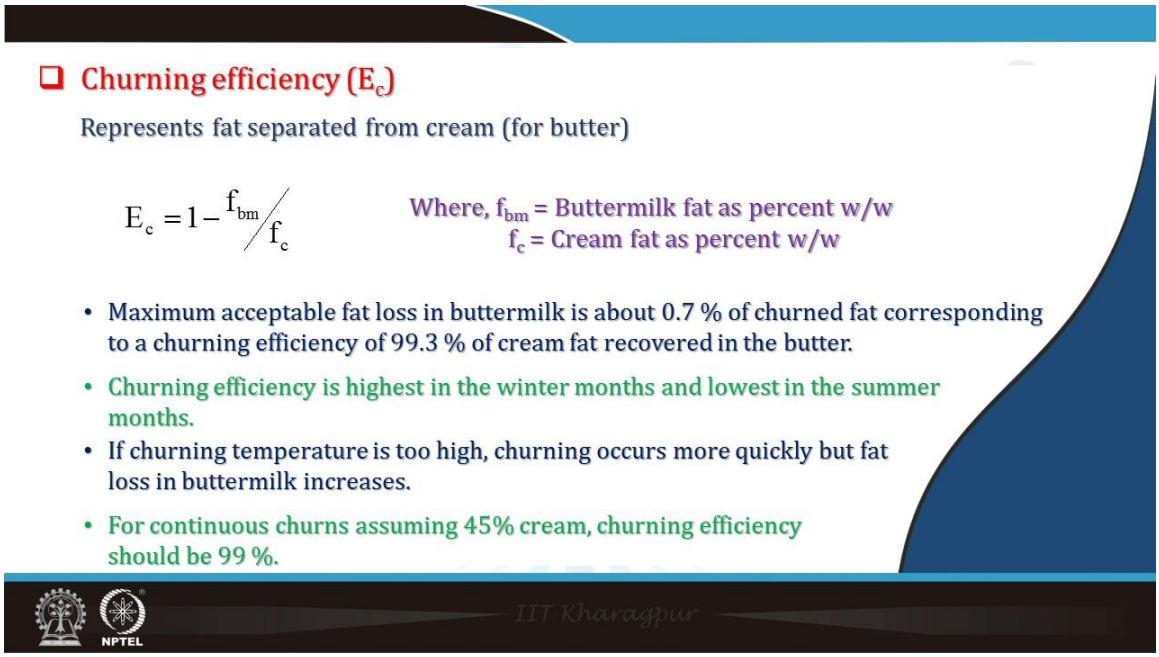



Then we can calculate the butter yield. There are separate various methods provided. One is the separation efficiency $E_S$. It represents the fat separated from milk for cream.

$E_S$ is equal to 1 minus $f_S$ by $f_m$ where $f_S$ is the fat percentage in skim milk, skim fat percent w by w weight by weight and the $f_m$ is the milk fat at percent weight by weight. $E_S$ depends on the initial milk fat content and residual fat in the skim milk assuming optimum operation of the separator. The principle determining factor for fat loss to the skim milk is fat global size. Modern separators should achieve a skim fat content of about 0. 04 to 0.07 percent.

$$E_s = 1 - f_s / f_m$$

Where, $f_s$ = Skim fat as percent w/w ; $f_m$ = Milk fat as percent w/w

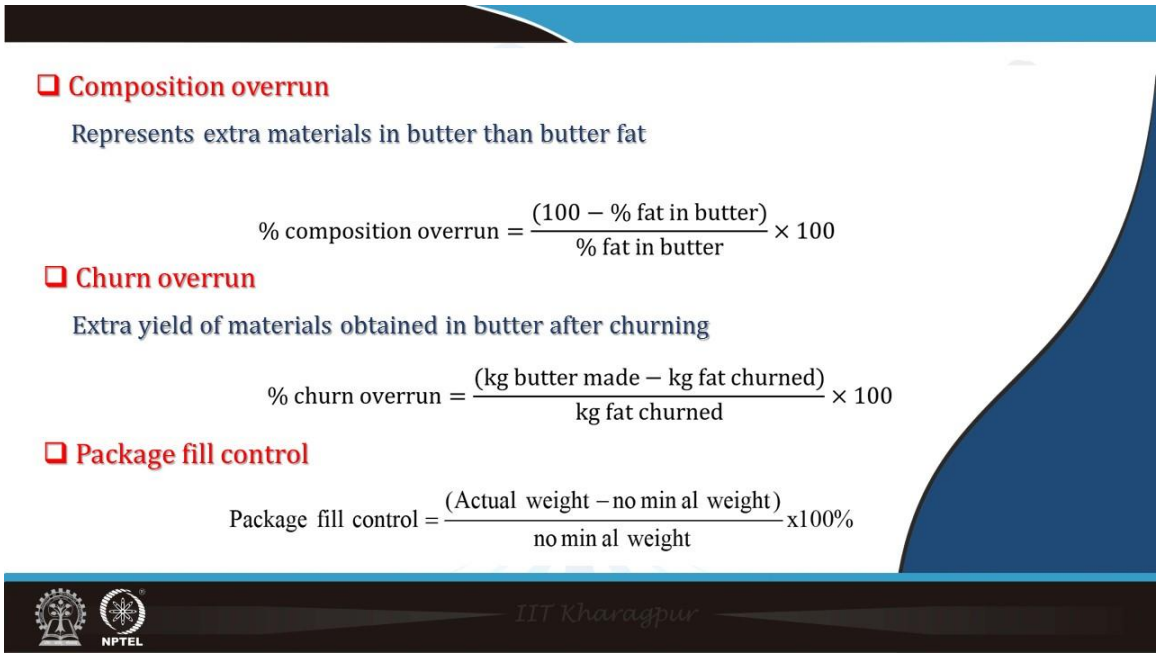



Then churning efficiency that which represents the fat separated from the cream for butter making is defined as $E_C$ is equal to 1 minus $F_{bm}$ by $F_C$ where $f_{bm}$ is the butter milk fat at percent weight by weight and $F_C$ is the cream fat at percent weight by weight. Maximum acceptable fat loss in butter milk is about 0.7 percent of the churned fat corresponding to a churning efficiency of around 99.3 percent of the cream fat recovered in the butter. Churning efficiency is highest in the winter method and lowest in the summer methods.

$$E_c = 1 - f_{bm}/f_c$$

Where, $f_{bm}$ = Buttermilk fat as percent w/w; $f_c$ = Cream fat as percent w/w

If the churning temperature is too high, churning occurs more quickly, but fat loss in the buttermilk increases. Fat for continuous churns assuming 45 percent cream churning efficiency should be 99 percent.




Then we can also calculate overrun that is a composition overrun which represents extra material in the butter the other than the fat the percent composition overrun is equal to 100 minus percent fat in butter divided by percent fat in butter multiplied by 100. So, it gives the overrun that overrun means that is what are the other ingredient other than the fat. Then churn overrun is the extra yield of material obtained in butter after churning.

Then percent churn overrun calculated by using kg of butter made minus kg of fat churn divided by kg of fat churn whole thing multiplied by 100. Then package fill control is a calculated from the actual weight minus nominal weight divided by nominal weight multiplied by 100. So, this gives package fill control ok.

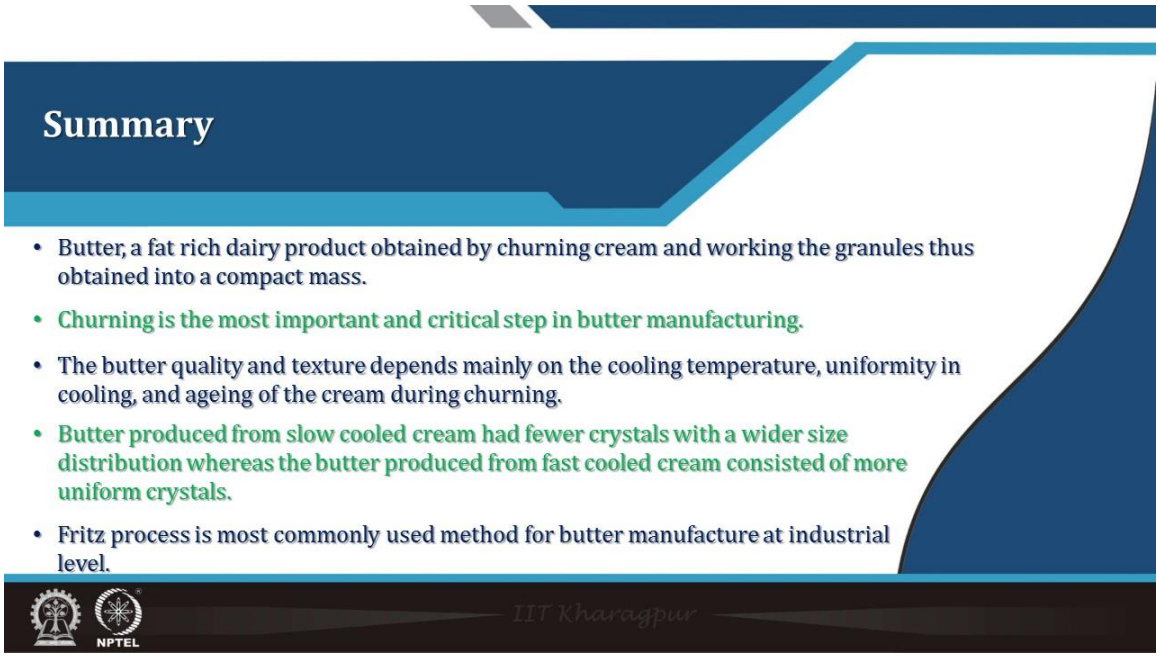
$$\% \text{ composition overrun} = \frac{(100 - \% \text{ fat in butter})}{\% \text{ fat in butter}} \times 100$$

$$\% \text{ churn overrun} = \frac{(\text{kg butter made} - \text{kg fat churned})}{\text{kg fat churned}} \times 100$$

$$\text{Package fill control} = \frac{(\text{Actual weight} - \text{no min al weight})}{\text{no min al weight}} \text{x} 100\%$$


Then finally, packaging of the butter obviously, there is a packaging should be done as soon as possible after the churning to reduce the chances of prime rose that is a color defect due to evaporation of the moisture from the surface of the butter ok. So, the packaging of butter is done to protect against contamination, prevent moisture evaporation loss of weight, to prevent off-flavor development, to prevent its oxidation and other related spoilage ok.

So, packaging material which is used for butter is normally a parchment paper that is called butter paper. It is wax coated papers, silicon or cardboard wax, that you could drum dried with food grade plastics, aluminum foil laminates or lacquered tin cans. The important thing is that the packaging material is used it should be impermeable to water vapors, it should be impermeable to oxygen and carbon dioxide gases etcetera. So, that there is a no surface evaporation from the moisture, there is a no oxidation etcetera of the fat which is a major process in the deteriorating the quality of the butter fat.




So, finally, I will summarize this lecture by saying that the butter a fat rich dairy product obtained by churning cream and working the granules is obtained into a compact mass. Churning is the most important and critical step in butter manufacturing. The butter quality and texture depends mainly on the cooling temperature, uniformity in cooling and aging of the cream during churning. Butter produced from slow cooled cream had fewer crystals with a wide range distribution whereas, the butter produced from fast cooled cream consists of more uniform crystals. Fritz process is most commonly used method for butter manufacture at industrial level.


These are the references that are used in preparation of this lecture.


Thank you very much for your patience here. Thank you.