Food Oils and Fats: Chemistry & Technology
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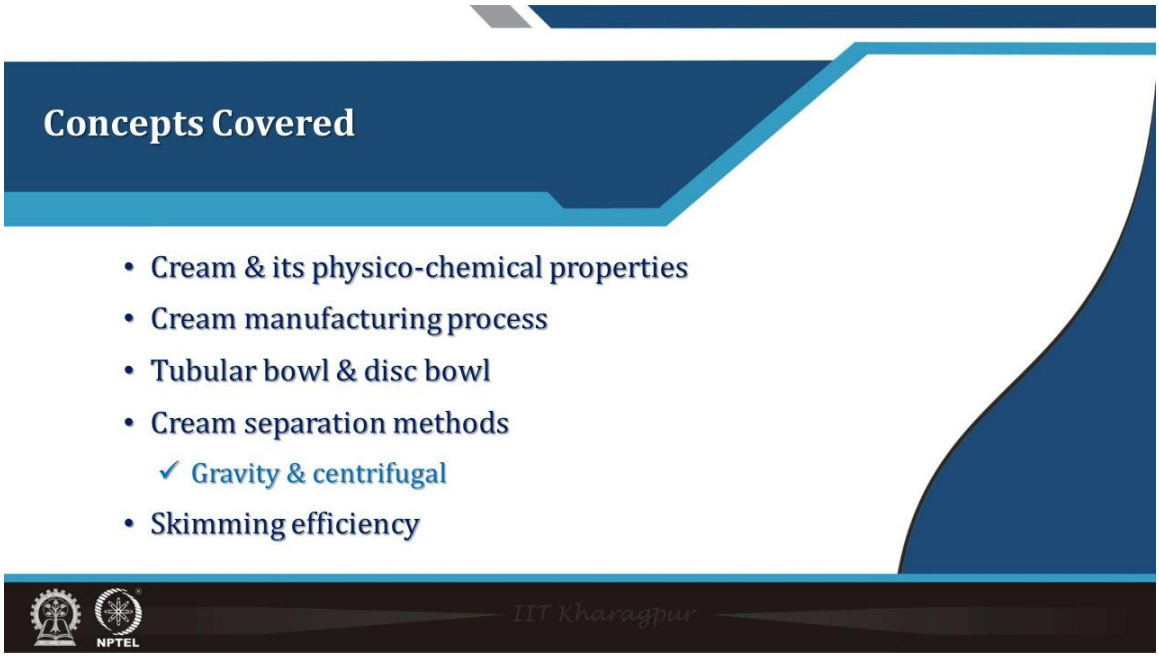
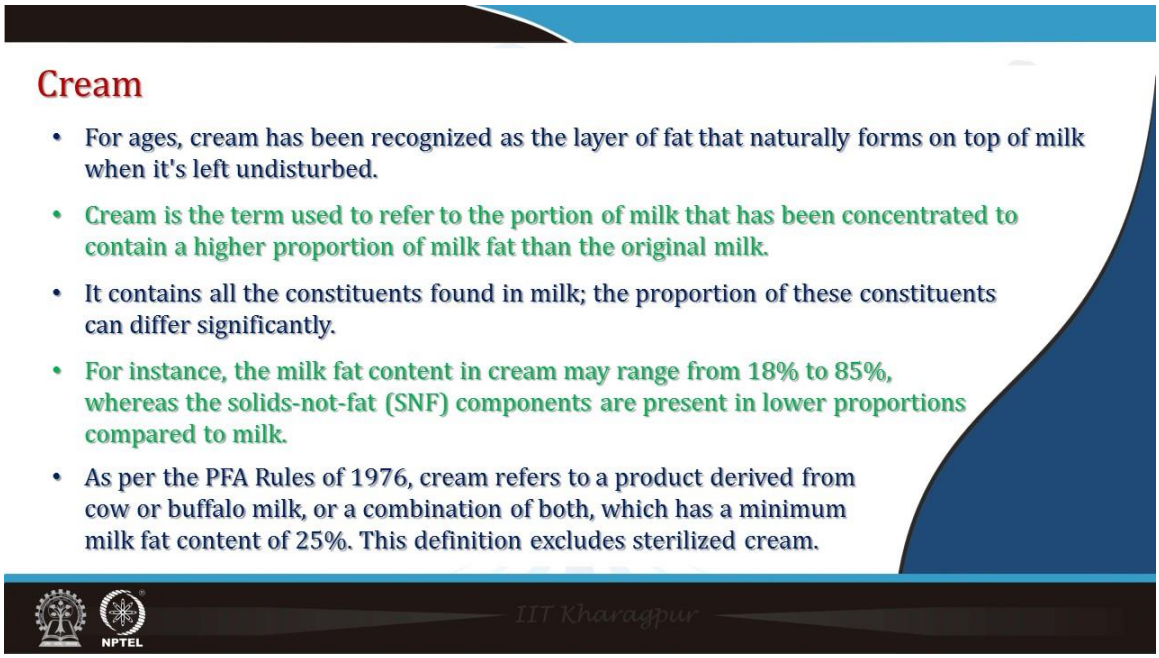
Module 8 : Animal & Dairy Fats
Lecture 38: Dairy Cream

Hello everyone, namaskar. Now in this lecture that is lecture 38, we will talk about Dairy Cream.



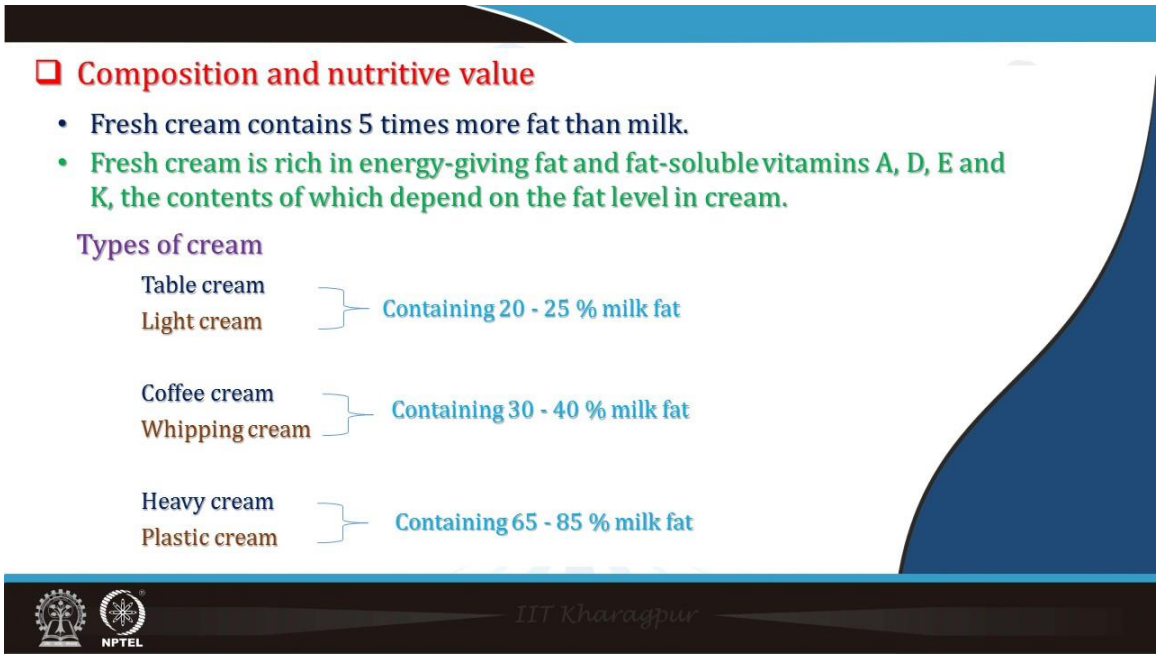
We will discuss what is cream, its physicochemical properties, then cream manufacturing process, where tubular bowl and disk bowl for cream making, cream separation methods both gravity method and centrifugal separation method and also we will talk about skimming efficiency.



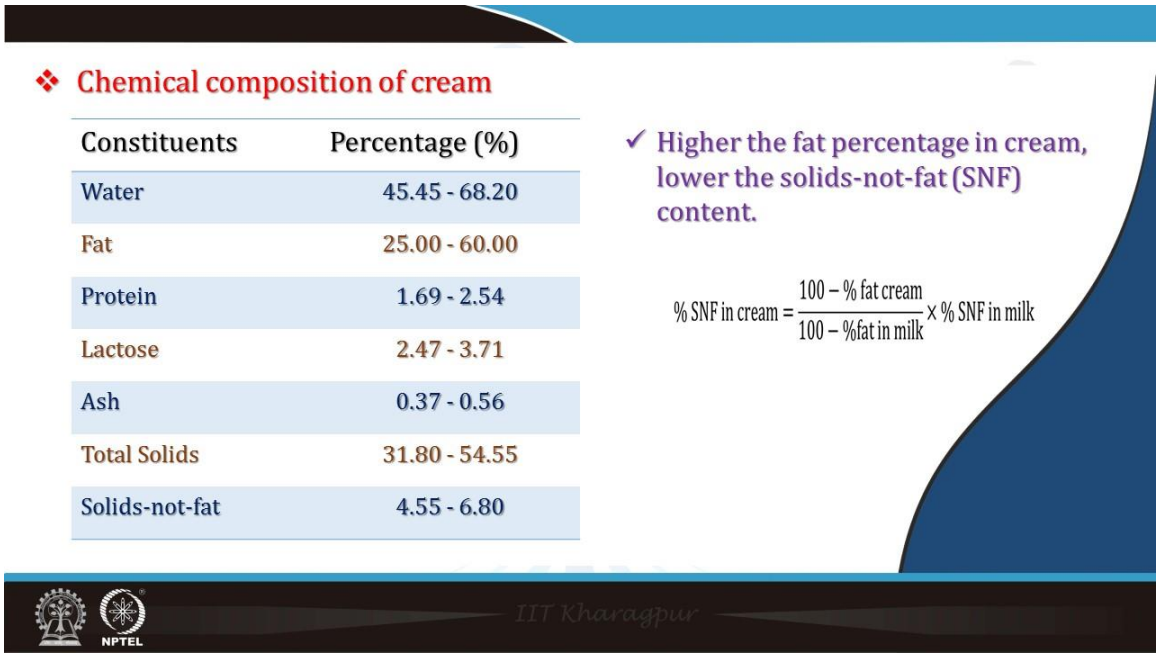
So, let us see what is a cream. For ages, cream has been recognized as the layer of fat that naturally forms on the top of milk when it is left undisturbed for some time.

Cream is the term used to refer to the portion of the milk that has been concentrated to contain a high proportion of milk fat than the original milk.

It contains all the constituents found in the milk. The proportions of these constituents, however, can differ significantly from that of the milk. For instance, the milk fat content in the cream may range from 18% to as high as 85%, whereas the solid nuts fat, popularly known as SNF components are present in lower proportions compared to the milk. As per the PFA rules of 1976, in India, cream refers to a product derived from cow or buffalo milk or a combination of both which has a minimum milk fat content of around 25%. This definition excludes sterilized creams.



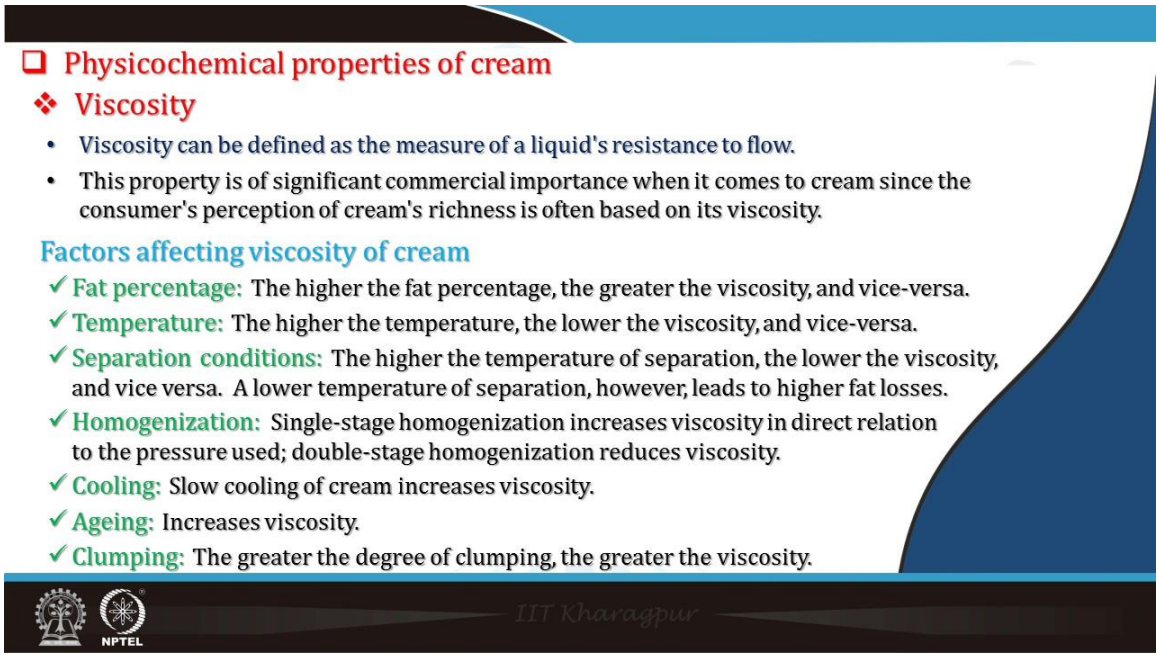
As far as the composition and nutritive value of the cream is concerned, fresh cream contains 5 times more fat than milk. Fresh cream is rich in energy giving fat and fat soluble vitamins that is A, D, E and K and the contents of which may be depend upon the fat level of in the cream that is the content of vitamins may vary with the variations in the fat levels in the cream. Different types of creams on the basis of their fat content like table cream and light cream are those cream which contain fat that is milk fat in the range of 20 to 25%. The cream containing milk fat in the range of 30 to 40% are categorized as coffee cream or whipping cream. Those creams which have fat content in the higher proportion like 65 to 85% of the milk fat are called heavy cream or plastic cream.



The chemical constituents of the cream composition normally it contains around 45 to 68% water, its 25 to 60% fat, may be 1.6 to 2.5% protein, it may contain 2.4 to 3.7% lactose about 0.3 to 0.56% as its total solids content may vary from 31.8 to 54.5% and solids non-fat fat may be 4.5 to 6.8%. However, the higher the fat percentage in the cream, lower will be the solids non-fat content. If you have high fat content, SNF content will be low. There is a formula to find out the percent SNF in cream can be calculated. That is the 100 minus percent fat in the cream divided by 100 minus percent fat in the milk multiplied by percent solids non-fat in the milk.

$$\%\ \text{SNF in cream} = \frac{100 - \%\ \text{fat cream}}{100 - \%\text{fat in milk}} \times \%\ \text{SNF in milk}$$

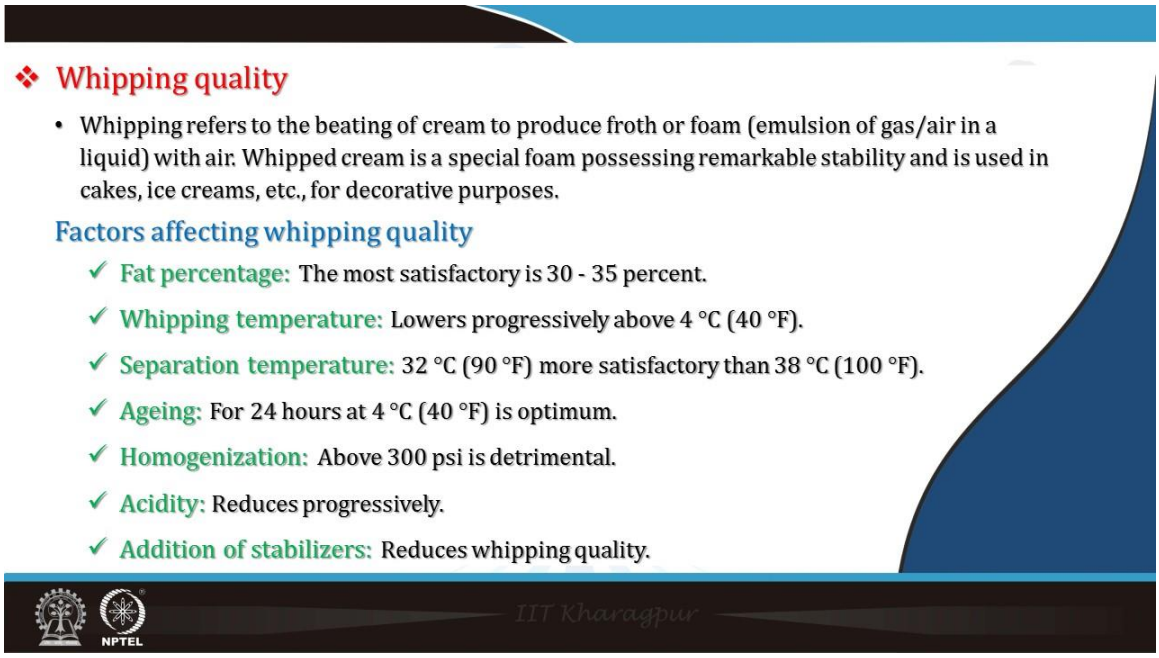
Using this formula, one can calculate how much will be the percentage SNF in the cream.



Physicochemical properties of the cream, number one is viscosity. It is a very important property. It can be defined as the measure of the liquid's resistance to flow and this property is of significant commercial importance. When it comes to cream, since the consumer's perception of cream's richness is often based on its viscosity.

The factors which influence the viscosity of cream include the fat percentage. The higher the fat percentage, the greater will be the viscosity and vice versa. Similarly, if the temperature is high, the viscosity will be lower and vice versa. When separation conditions, higher the temperature of separation, the lower will be the viscosity and vice versa. In lower temperature of separation, however, leads to higher fat losses.

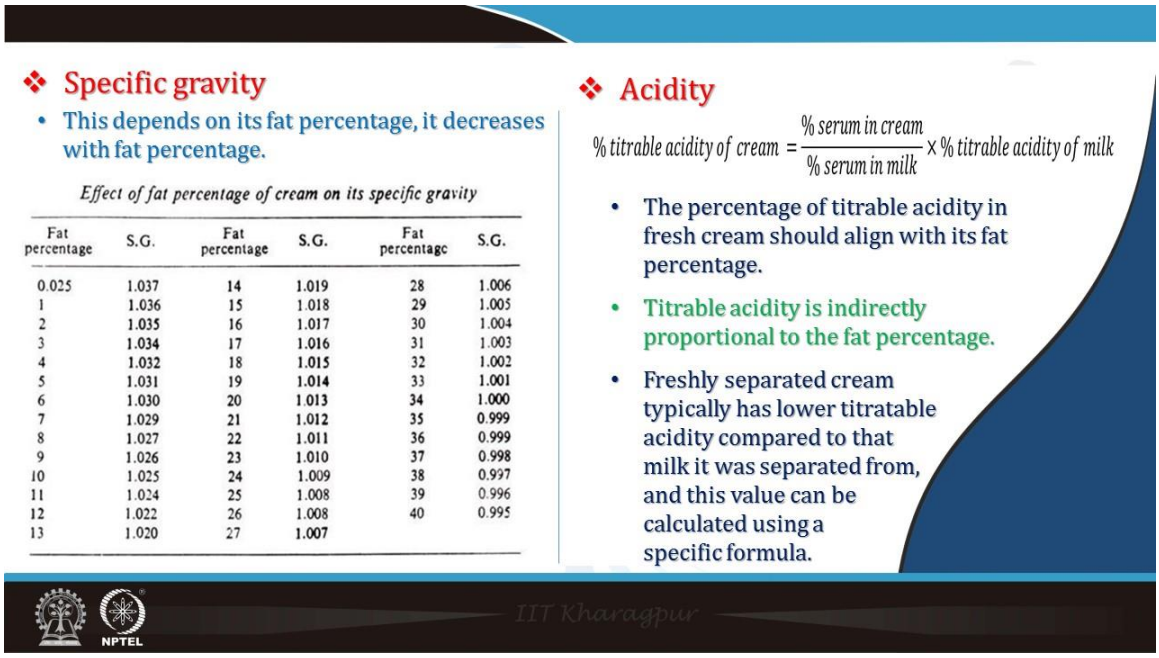
Then homogenization, single stage homogenization increases viscosity in direct relation to the pressure used. Double stage homogenization reduces the viscosity. Aging, slow cooling of cream increases its viscosity. Aging obviously will increase the viscosity and clumping, greater the degree of clumping, the greater will be the viscosity. So, these are the factors which influence the viscosity.



Similarly, whipping quality. Whipping refers to the beating of cream to produce fourth or half of the emulsion of gas and air in a liquid. That is the whipping. In many dairy industry, bakery industry, many such industries, whipping is done basically by the whipping process. Air is incorporated into the liquid.

Similarly, the air is incorporated in the cream and this makes many times that is whipped. The cream is a special form possessing remarkable stability and it is used in cakes, in ice-cream making etcetera for decorative purposes. So, the factors which influence the whipping quality of the cream include fat percentage and the most satisfactory fat content as far as the whipping is concerned is 30 to 35 percent fat. Then whipping temperature lowers progressively above 4 degree Celsius. The separation temperature is 32 degree Celsius more satisfactory than 38 degree Celsius.

Aging for 24 hours at 4 degree Celsius is considered optimum for whipping. Homogenization above 300 psi becomes detrimental to whipping. Gravity reduces progressively and addition of stabilizers reduces the whipping quality.

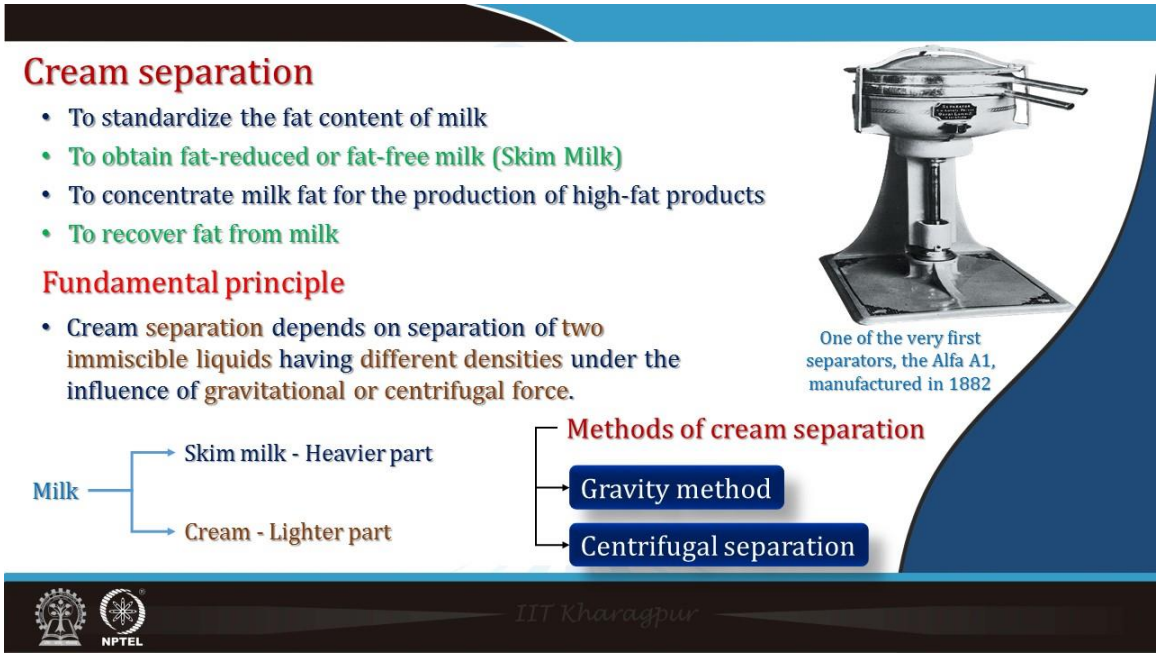


Specific gravity of the cream depends on its fat percentage. It decreases with the fat percentage decrease effect of fat percentage on cream and its specific gravity as you can see here.

$$\%\ titrable\ acidity\ of\ cream = \frac{\%\ serum\ in\ cream}{\%\ serum\ in\ milk} \times \%\ titrable\ acidity\ of\ milk$$

If the fat percentage is about 0.025, its specific gravity will be 1.037. So, if you increase the fat content like for example, at 10 percent fat content specific gravity of cream becomes 1.025. Further at 15 percent of the specific fat content specific gravity becomes 1.108, 25 percent it becomes 1.008. At 30 percent fat content specific gravity becomes 1.004 and 40 percent fat content in the cream, its specific gravity becomes 0.995 means that is the content of the fat if it is the less specific gravity will be more. More the fat content in the cream, specific gravity will be less. Similarly, percentage titratable acidity of cream that is it can be calculated using the formula that is percentage serum in cream divided by percentage serum in milk multiplied by percentage titratable acidity of milk. So, this gives percentage titratable acidity of cream. The percentage of titratable acidity in fresh cream should align with its fat percentage.

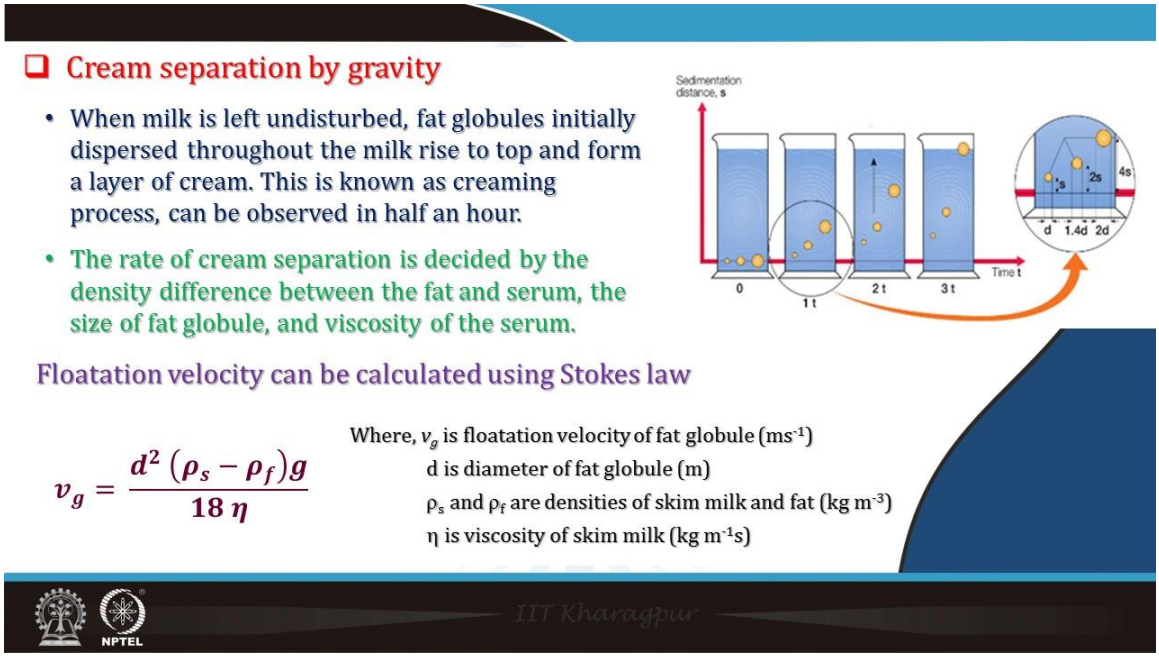
Titratable acidity is indirectly proportional to the fat percent. Freshly separated cream typically has lower titratable acidity compared to that of milk from which it was prepared from and this value can be calculated using the specific formula that is given above.



Then now let us talk about the fat separation or cream separation. The cream is separated from milk for various purposes like for standardization of the fat content in the milk to obtain fat reduced or fat free milk that is skin milk to concentrate milk fat for the production of high fat products or to recover fat from milk for the making butter for making ghee and so on. So, the fundamental principle if you talk about the cream separation, it depends on the separation of two immiscible liquids having different densities under the influence of gravitational or separation forces.

That is here you have one is the water and with the solid not fat is there and the fat is there containing cream. So, these basically are the two immiscible liquids and they have the different density and accordingly under the gravitational force or by applying centrifugal force they are separated. So, the milk you have a skim milk is a heavier part and the cream is the lighter part. So, there are two methods of separation that is one is the gravity methods and other is the centrifugal separation that is they get separated because there is a gradient they are different in their density. So, obviously they will be

separated and this picture here they are one of the very first separator the alpha-a1 charge manufacture in 1882.



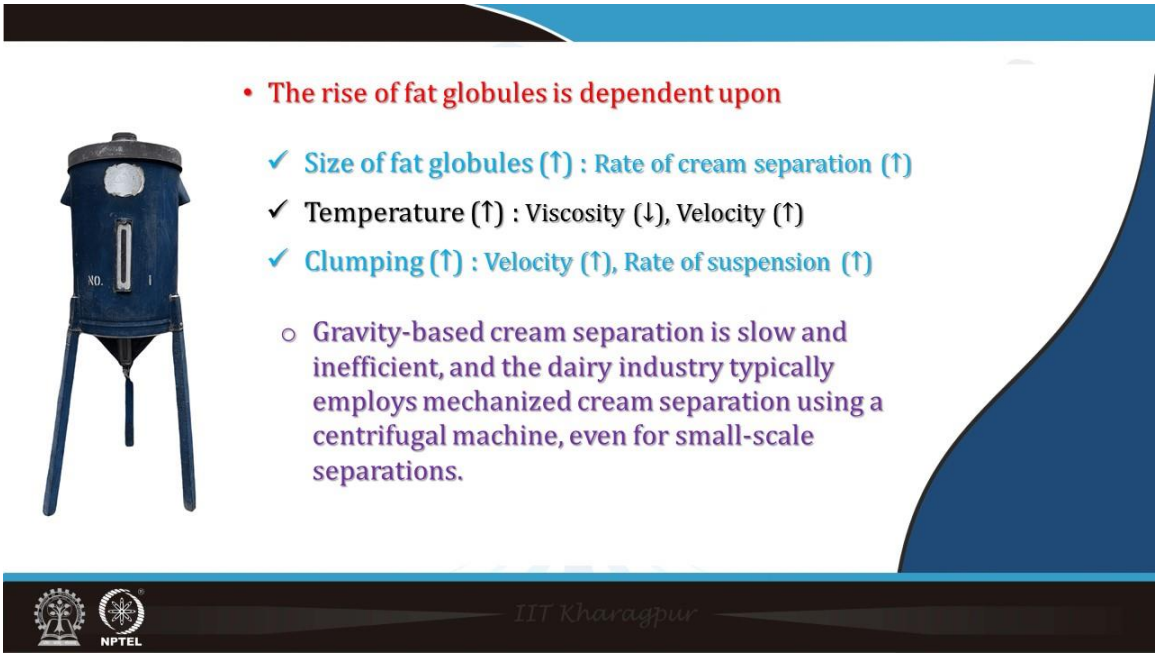
So, let us talk about cream separation by gravity method in the figure here. You see that where settle any liquid and in the liquid there are separate solids and they are having various densities. You keep undisturbed obviously that the material that is when there is the low density material it will go on the top and high density material will settle in the water that is simply by the gravitational force. So, when the milk is left undisturbed fat globules because they are of low density which were initially dispersed throughout the milk they will rise to the top and form a layer of cream and this is known as creaming process and can be observed in half an hour or so. If you just leave milk undisturbed for half an hour you can see that the formation of its top layer in the cream layer.

$$v_g = \frac{d^2(\rho_s - \rho_f)g}{18\eta}$$

The rate of cream separation is decided by the different density difference between the fat and the serum as I told you. The size of the fat globule and viscosity of

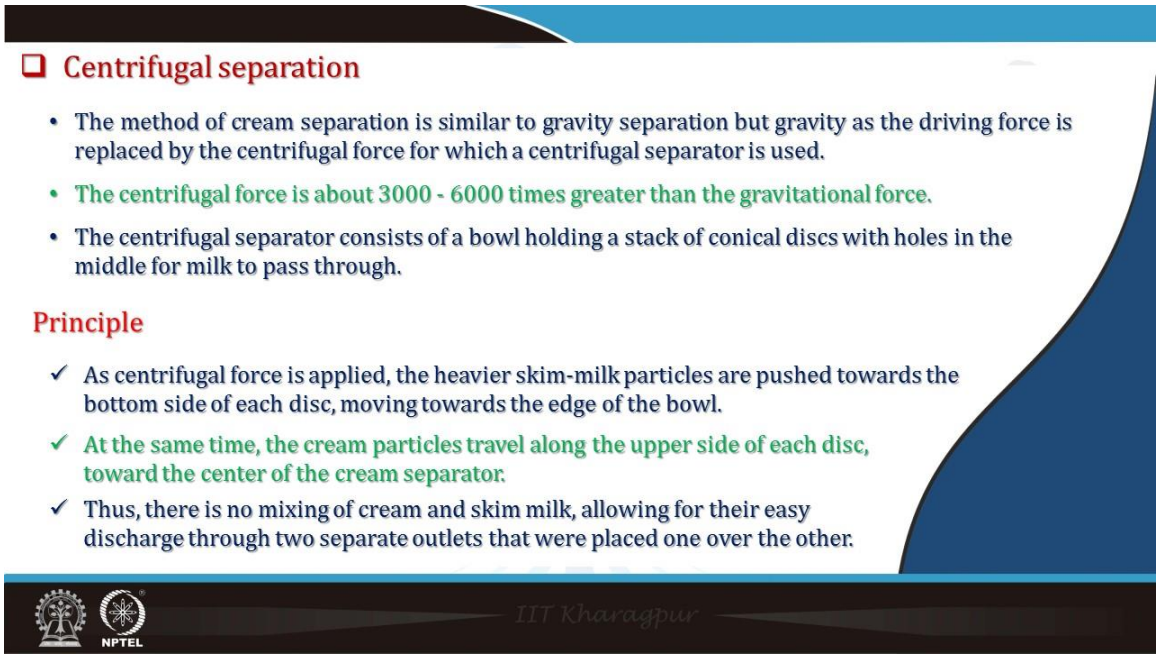
the serum if the size of the fat globule becomes less then the separation will be difficult. That is what if you take normal milk and homogenized milk and in the homogenized milk where the size of the fat globule is reduced you get almost nil depending upon the efficiency of the homogenization process are very difficult separation. But in the whole milk because the fat globule size is more they come to the top. So the flotation velocity can be calculated using the Stokes law that is Vg is equal to d-square rho s minus rho r whole thing multiplied by g divided by 18 η where Vg is the floatation velocity of the fat globule in m s meter per second.

The fat globule larger the size they will have more fat. The diameter of the fat globule rho s and rho t are densities of skim milk and fat and η is the viscosity of the skim milk. So with this one can find out the flotation velocity how much time it will take for the cream to come on the top depending upon the size of the fat globules.



So obviously the size of the rise of the fat globule on the top and the formation of cream will depend upon the size of the fat globule that is higher the size of the fat globule and rate of the cream separation. More is the size of the fat globule higher will be the rate of cream separation it will come faster on the top.

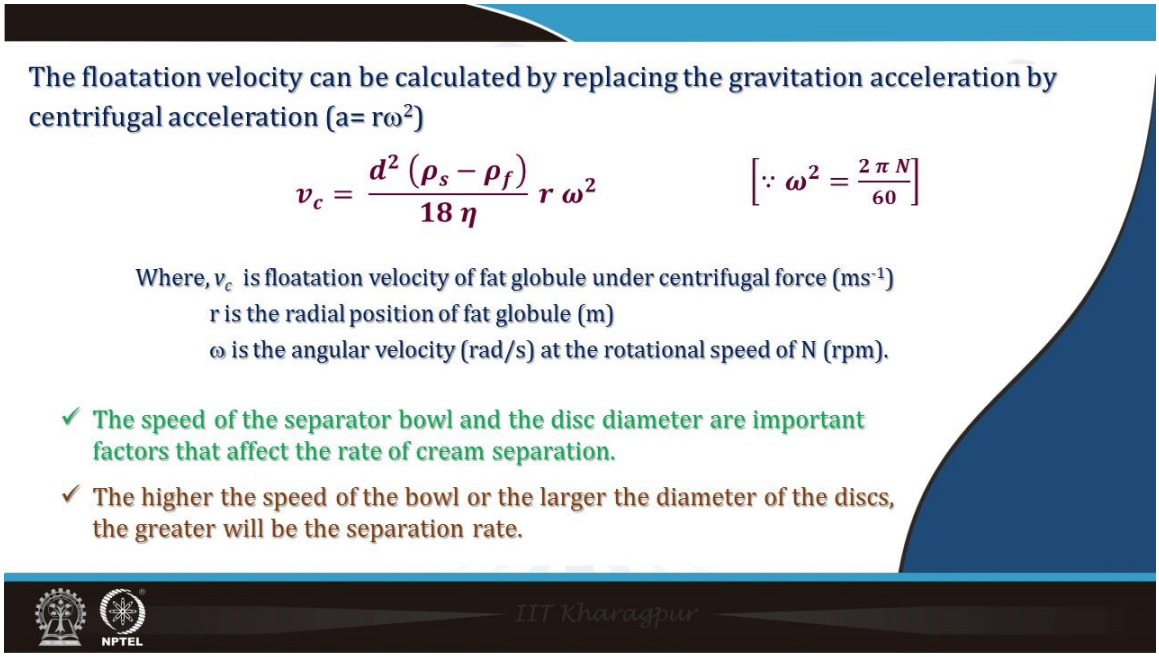
Similarly, temperature if temperature is more viscosity will be less and velocity will be more. Clumping is more viscosity will be more and rate of separation will be also more. So these are how that fat size of the flat globules temperature and clumping they influence the separation of cream or formation of cream. Gravity based cream separation is slow and inefficient and the dairy industry typically employs mechanized cream separation using a centrifugal machines even for small scale operations.



Centrifugal separation this method of cream separation is similar to the gravity separation, but here gravity as the driving force is replaced by the centrifugal force for which a centrifugal machine centrifuge is used.

The centrifugal force is about 3000 to 6000 times greater than the gravitational force. The centrifugal separator consists of a bowl holding a stack of conical discs with holes in the middle for milk to pass through. We will see little later the centrifugal separator construction and work principle. So the principle of centrifugal separation is as the centrifugal force is applied the heavier skim milk particles are pushed towards the bottom side of each disc moving towards the edge of the bowl. At the same time the cream particles travel along the upper side of each disc towards the center of the cream separator.

Thus there is no mixing of cream and skim milk allowing for the easy discharge through the two separate outlets that are placed one above the other.

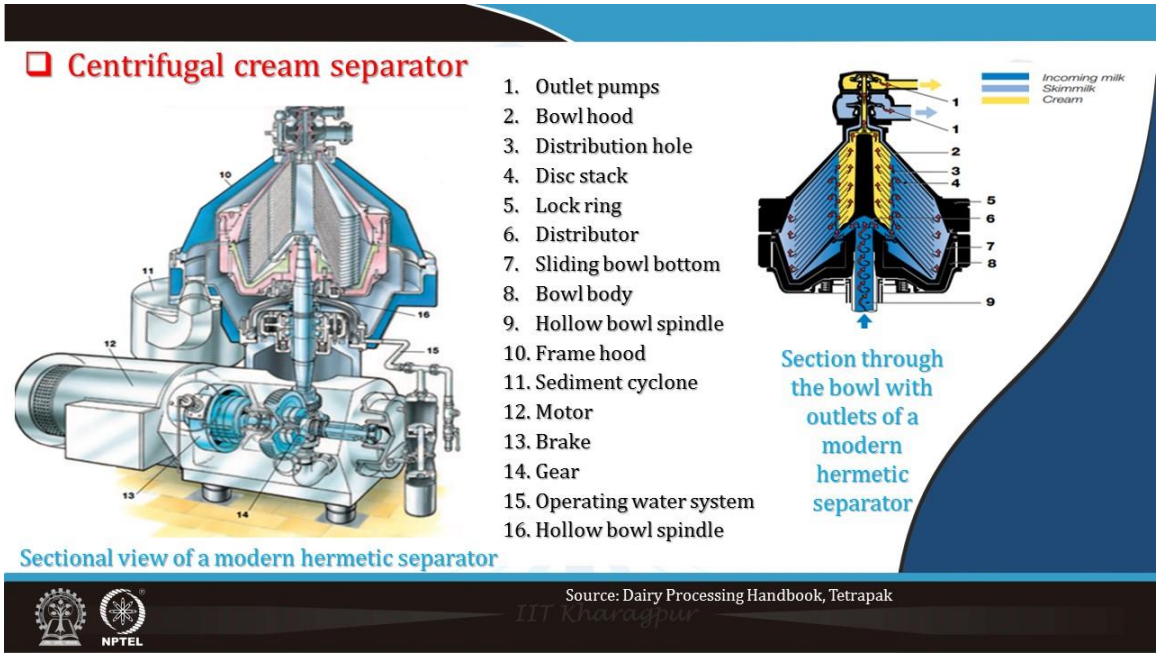


The flotation velocity in this case can be calculated by replacing the gravitational acceleration by centrifugal acceleration that is ‘a’ is equal to r omega-square. So the Vc in this case is equal to d square multiplied by that is Ps minus Pf divided by 18 η and here the ‘a’ is replaced by r omega square. Omega square is the 2 pi N by 60 where Vc is the flotation velocity of fat global under centrifugal force, r is the radial position of fat global and omega is the angular velocity at the rotational speed of N that is in rpm. The speed of the separator bowl and the disc diameter are two important factors that affect the rate of cream separation.

$$v_c = \frac{d^2(\rho_s - \rho_f)}{18\eta} r\omega^2$$

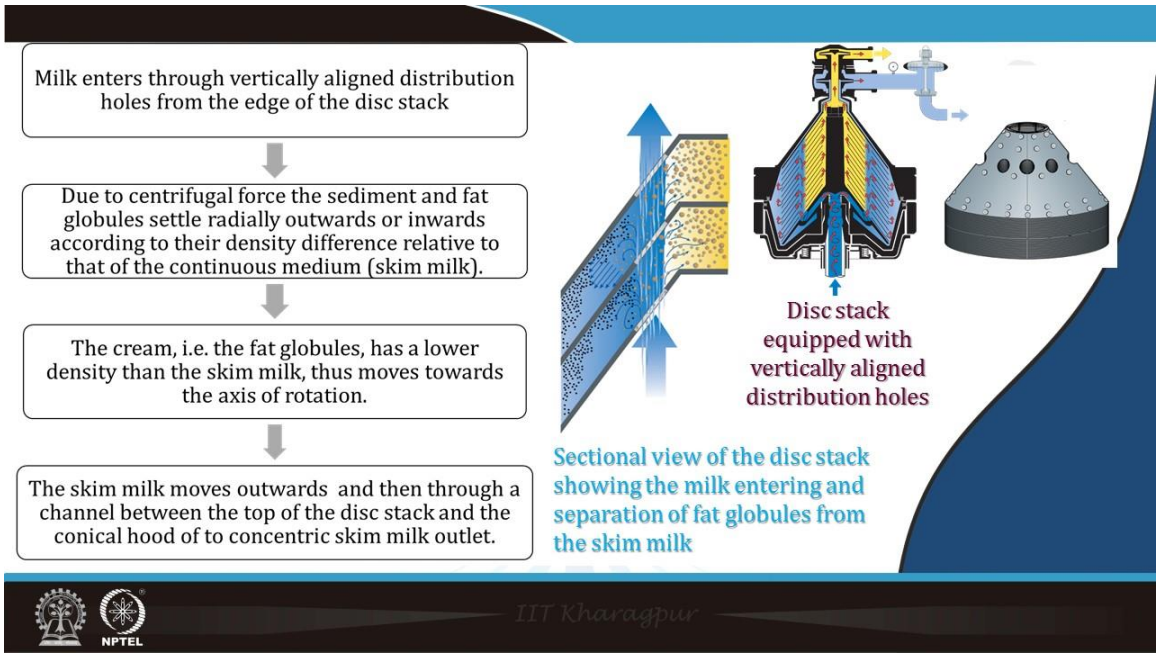
$$\left[\because \omega^2 = \frac{2\pi N}{60}\right]$$

The higher the speed of the bowl or the larger the diameter of the disc the greater will be the separation rate.



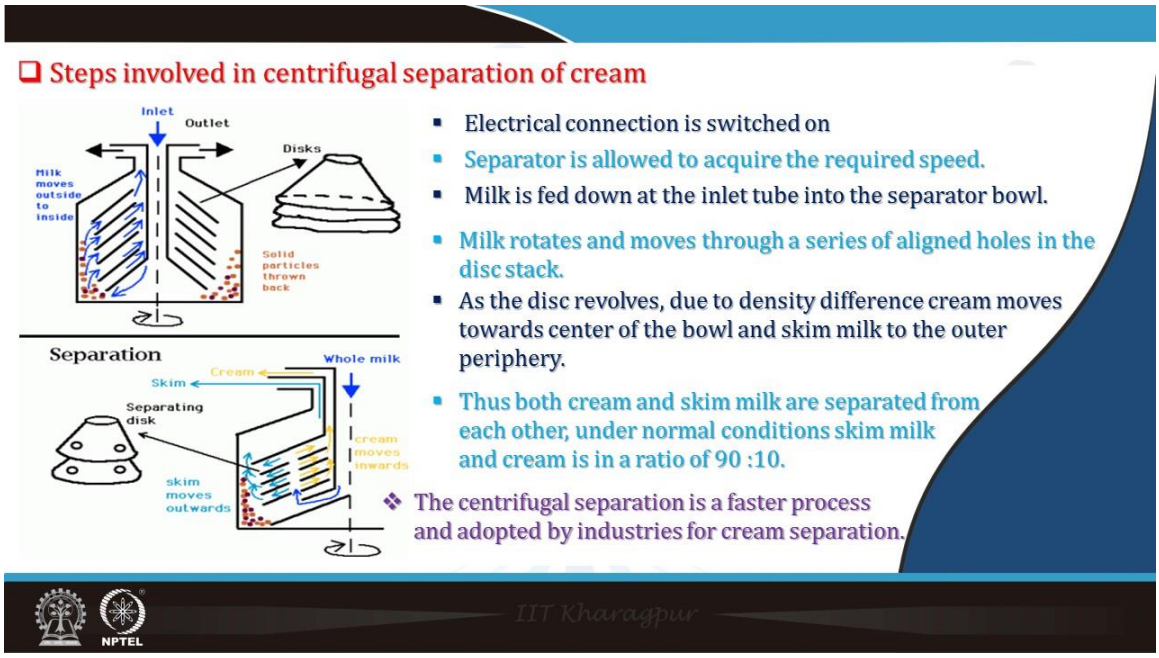
Now you see here in the picture there is a centrifugal cream separator has been shown its various components that is this. Here this is the right side it is a section through the bowl with a outlet of a modern hermetic separator and it is the whole component. So in this section it has outlet pumps bowl, hood, distribution hole, disc stack, lock ring, distributor, sliding bowl bottom, body bowl and hollow bowl spindle.

These are present in the top. Here it is the frame, hood, sediment cyclone, motor, brake, gear, operating water system and hollow bowl spindle. So, these are the different components which are provided in the centrifugal cream separator.



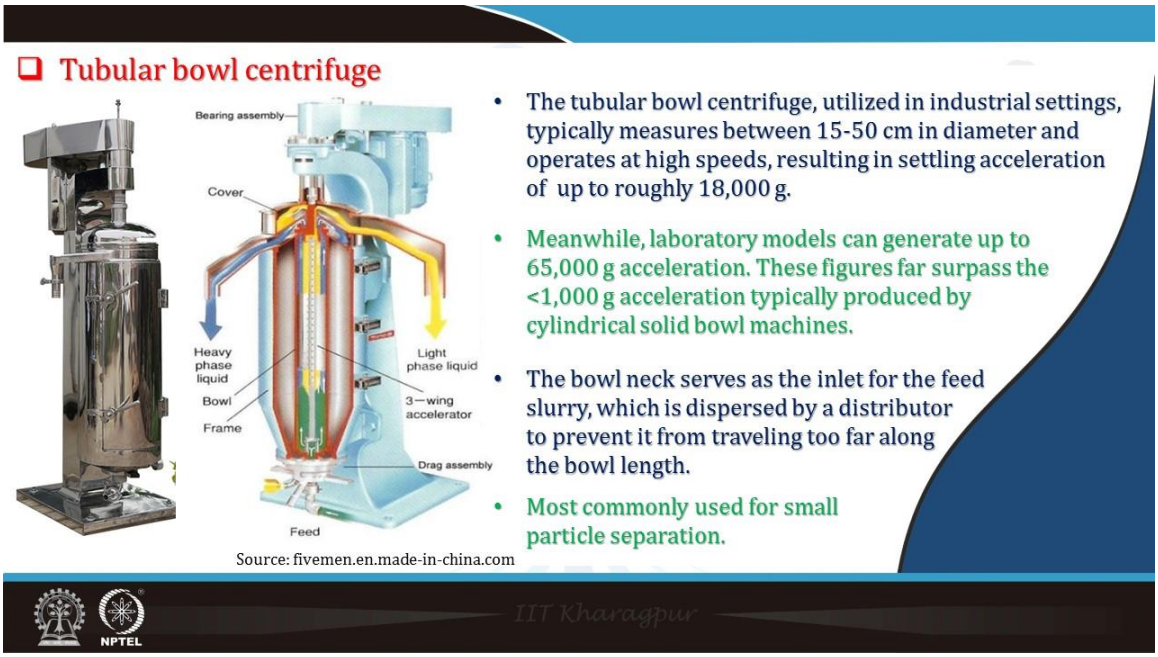
So, what happens in this from the given thing here that the milk enters through vertically aligned distribution holes from the edge of the disc stack. Due to centrifugal force the sediment that fat globules settle readily outwards or inwards according to the density difference relative to that the continuous medium that is skim milk and the cream that is the fat globules has a lower density than the skim milk and thus moves toward the axial rotation. The skim milk moves outwards and then through a channel between the top of the disc stack and the conical hood of the concerned skim milk outlet that you see how it moves in the yellow portion that is the cream will go toward the top side.

When it moves there are various bowels like this the milk comes from there. So obviously because of the centrifugal force here the skim milk it is heavier so it comes to the bottom cream which is lighter it goes and this disc stacks are equipped with vertically aligned distribution holes you can see. So, the finally, from these two holes that is the milk rise is cream goes on the top it out from here and the skim milk it from other outlet that is how the cream separator centrifugal cream separators work.



So, here it is further shown that is steps involved in the centrifugal separation of the cream. Obviously, the electrical connection is switched on then separator is allowed to acquired first the it is on the it gets the required that is the speed that is what is the it moves like this 3000 or 4000 whatever speed is there it is there then separator is allowed to acquire the speed and then milk is from the top the milk is fed into down the inlet tube into the separator bowels.

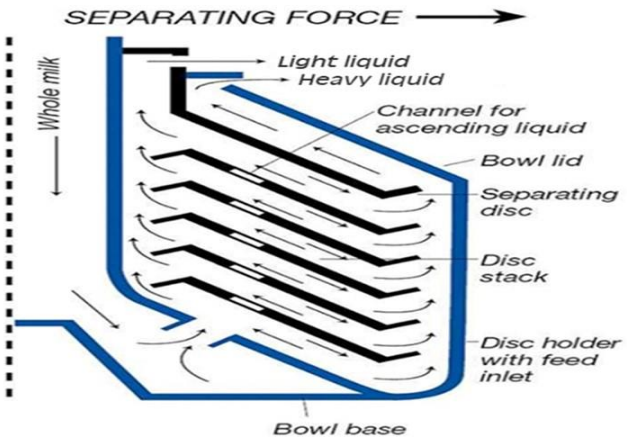
So, here there are different disc one stacked one above the above that the disc revolves the density difference cream moves toward the that is milk is spread in the thin thing over the different discs. At down the inlet tube into separator bowels milk rotates and move through the series of aligned holes in the disc and as the disc revolves the density difference cream moves toward the centre as you see here and the skim milk comes outer periphery. Thus the cream and the skim milk are separated from each other under normal conditions skim milk cream in the ratio of 90 is to 10. And the centrifugal separation is a faster process and adopted by the industry for the cream separation.



There are tubular bowl separator the principle is same that is the only thing that here the bowls are the tubular form tubular bowl centrifuges utilized in the industrial settings typically measures between 15 to 50 centimeter in diameter and operates at a speed resulting in a settling acceleration to up to roughly a 18,000 g.

Meanwhile a laboratory models can generate up to 65,000 g acceleration. These figures first surpass the less than 1000 g acceleration typically produced by cylindrical solid bowled machines. The bowl neck serves as the inlet for the feed slurry which is dispersed by a distributor to prevent it from travelling too far along the bowl length and most commonly used for a small particle separation. Here even a smaller particle size also they can be separated in this.

Disc bowl centrifuge



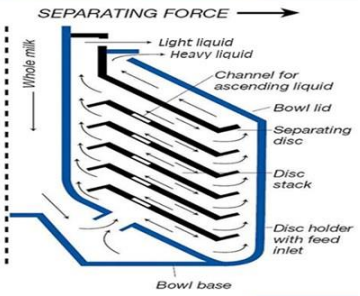
Source: Huading-separator

- Disc type centrifuge generates an acceleration of up to around 12,000 g, and thickens suspension into a thick slurry.
- The bowl of the centrifuge is equipped with between 50 and 150 conical discs that are spaced roughly 2 mm apart.

Then disc bowl separator disc type centrifuge generates an acceleration of up to around 12,000 g and thicken suspensions into a thick slurry as you can see here that is ok.

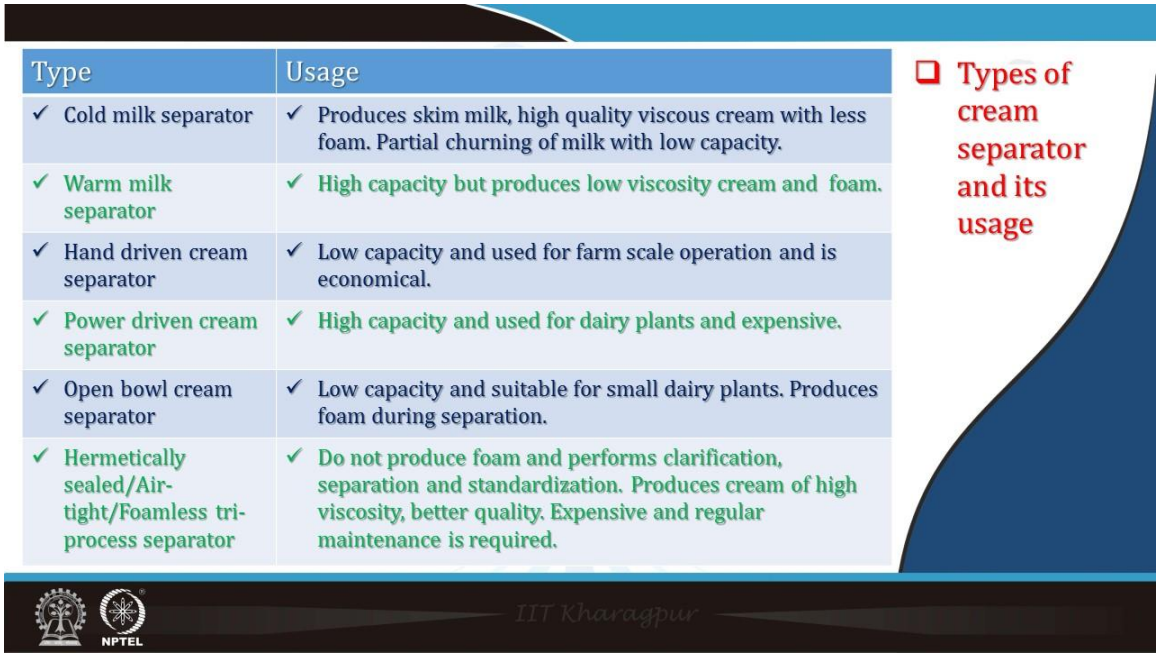
And the bowl of the centrifuge is equipped with between 50 and 150 conical disc that are spaced roughly 2 millimeter apart and they are used for separating the cream.

- As the suspension is fed into the disc type centrifuge, it flows towards the machine's axis through the spaces between the discs. Solid particles in the suspension settle onto the underside of each disc, slide outward along the disc, and are then flung to the wall of the bowl by the centrifugal force.
- After the solid particles have been separated from the suspension, the clarified liquid moves towards the center of the bowl and is discharged over a weir located at the top or bottom of the centrifuge.
- The thickened slurry, or solids, are typically discharged through ports at the periphery of the bowl. In an opening bowl centrifuge, these ports open at a timed cycle, whereas in a nozzle discharge centrifuge, the ports continuously release the solids.



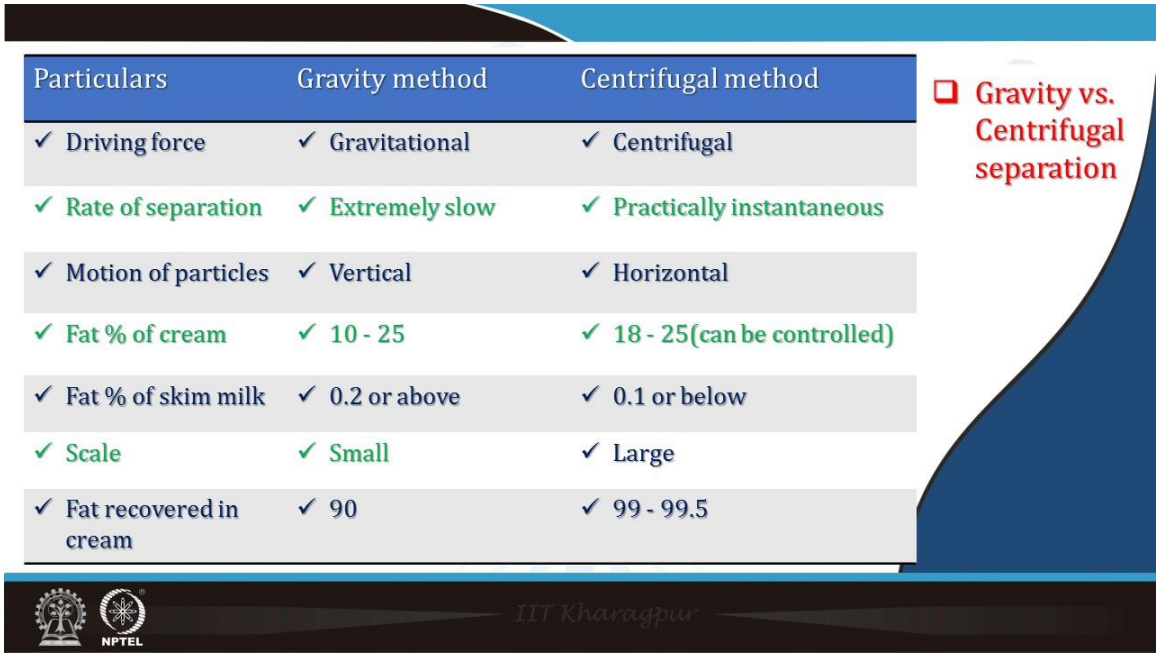
As the suspension is fed into the disc type centrifuge, it flows towards the machine axis you can see here it flows to the machines axis through the spaces between the disc. Solid particles in the suspension settle on to the undesirable of each other ok slide to outward along with the disc and are then plugged to the wall of the bowl by the centrifugal force. After the solid particles have been separated from the suspension, the clarified liquid moves towards the center of the bowl and is discharged over a wire located at the top or bottom of the centrifuge. The thickened slurry or solids are typically discharged through pores at the periphery of the bowl.

If in an opening bowl centrifuge, these pores open at a timed cycle whereas in a nozzle discharge centrifuge, the pores continuously release the solids.



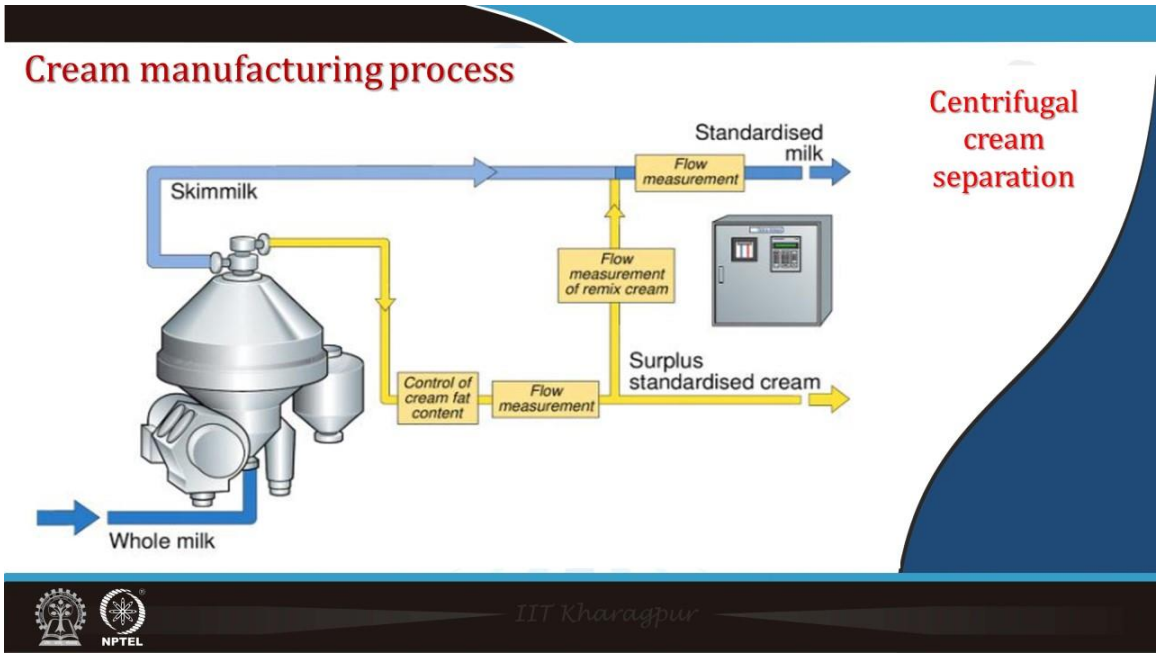
So here type of the cream separator and uses I have summarized in this table like cold milk separator, it produces skim milk, high quality various cream with less foam and partial churning of the milk with low capacity. Warm milk separator it is used for high capacity but produces low viscosity cream and foam. Hand-driven cream separators it is low viscosity and used for form scale operations and is economical power driven cream separator it is a high capacity and used for dairy plants and of course it is little expensive. Open bowl cream separator it is low capacity and suitable for small dairy plants produces foam during separation.

Hermetically sealed, air tight, foamless type process separators they do not produce foam and perform clarification, separation and strain digestion. It produces cream of high viscosity, better quality, expensive and regular maintenance is required.

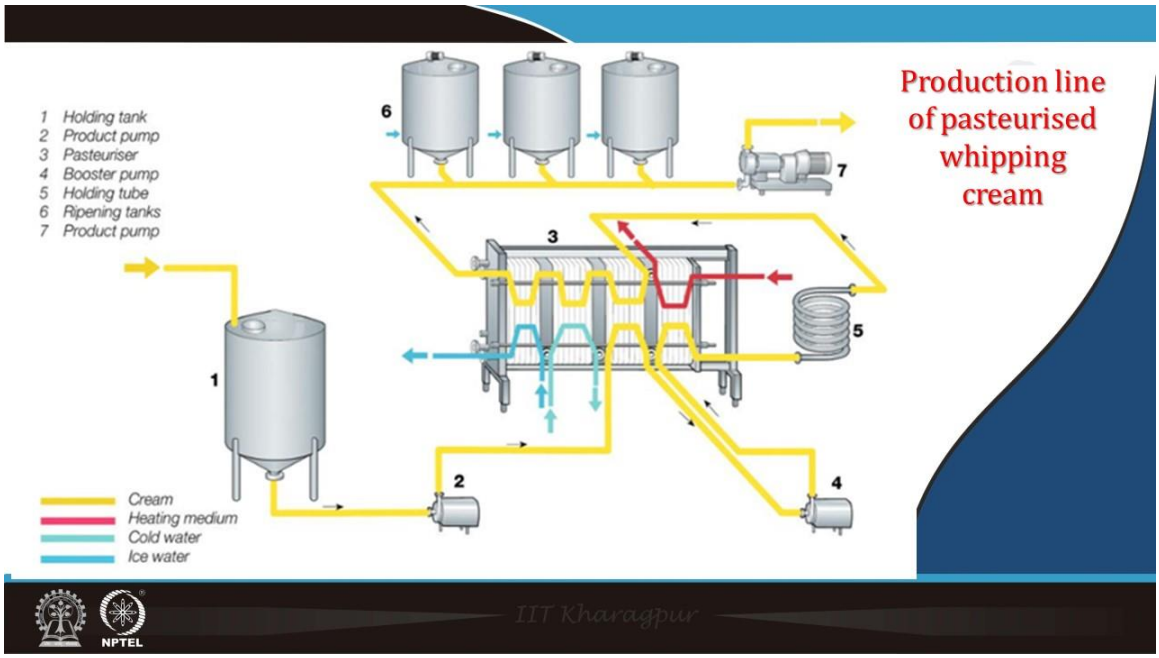


Then here gravity versus centrifugal separations if you see that is driving force in the gravity method, it is gravitational in other it is a centrifugal. Rate of separation is extremely slow in the gravity method whereas it can be practically instantaneous in the centrifugal method. Motion of the particles in the vertical in the gravity method whereas it is horizontal in the centrifugal method.

Fat percentage of the cream which is obtained in the gravity method it may be 10 to 25 whereas in 18 to 25 can be in the centrifugal method or even it can be controlled by having controlling the centrifugal force another parameter. Fat percentage of the skim milk may be 0.2 or above when it is done by gravity method but 0.1 or below in the centrifugal method. It is normally gravity method is used for a small scale, centrifugal method is used for large scale and fat recovery in the cream is around 90 percent in the gravity method and 99 to 99.5 percent in the centrifugal method.

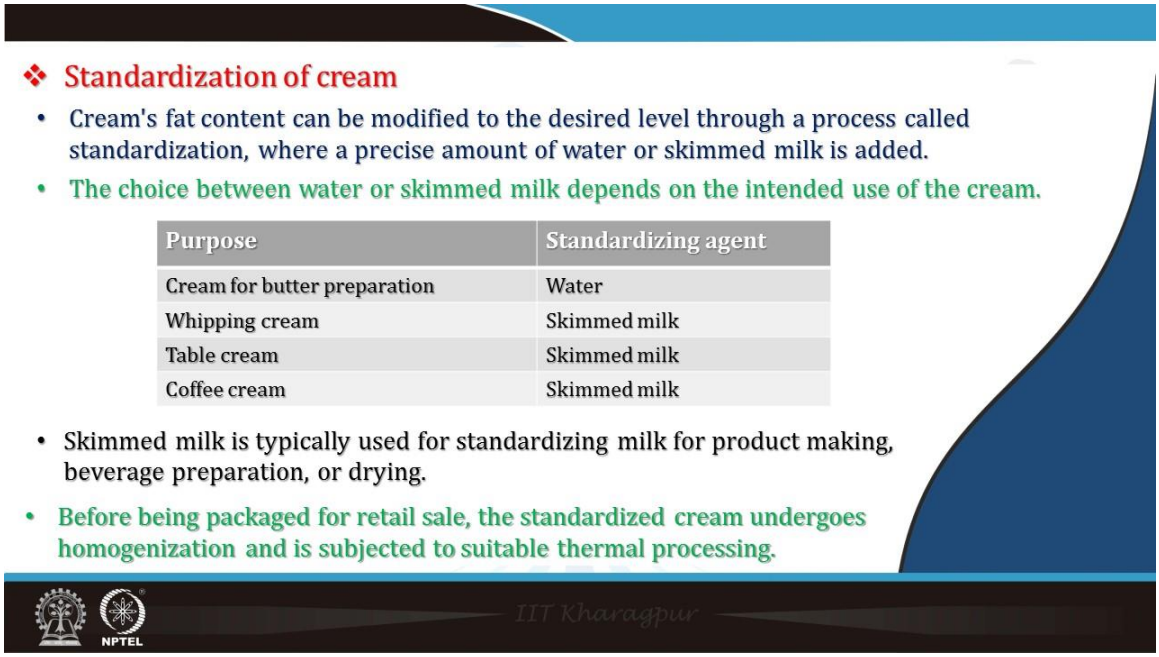


Cream manufacture centrifugal cream separator you see that it is a centrifugal cream separator machine whole milk process and the yellow line is the cream going it is standardized and blue line is going showing the skim milk flow line.



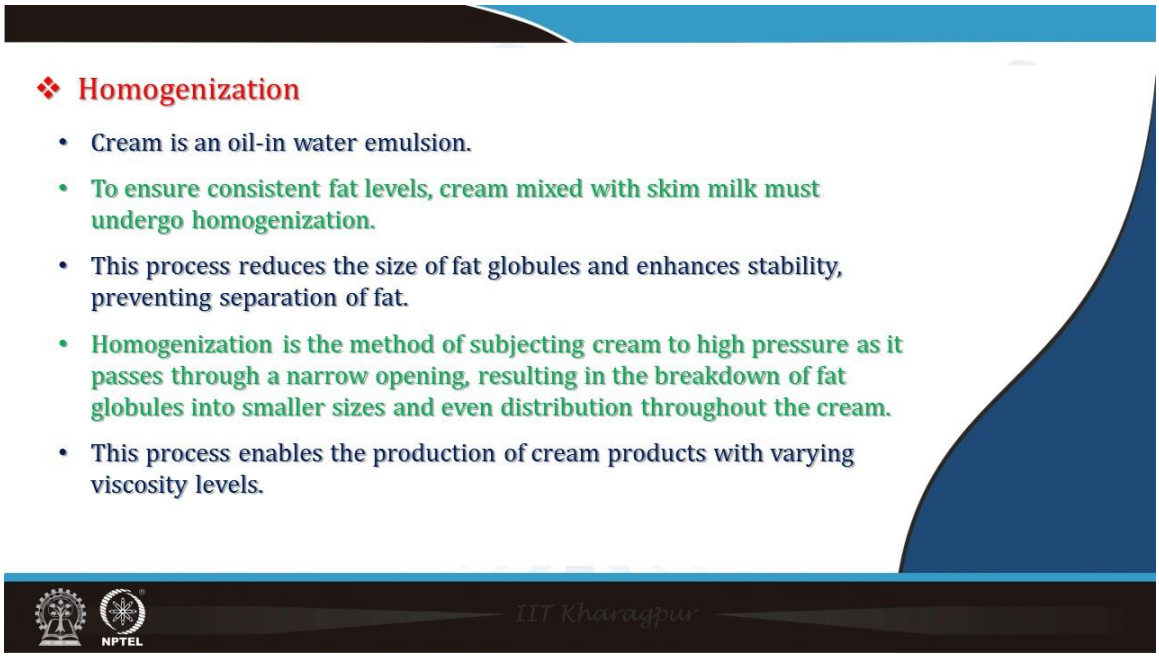
Similarly it is the production line of pasteurized whipping cream and it has holding tube, product tube, pasteurizer, booster pump, holding tube again, ripening tank and product pump and again here the yellow line is the flow line of the cream that is the

cream is concentrated here heating medium this red line and cold water is a light blue and deep blue is the ice water. So, this show how different through different machines it moves and the cream can be concentrated here pasteurized whipped cream here in corporation can be done.



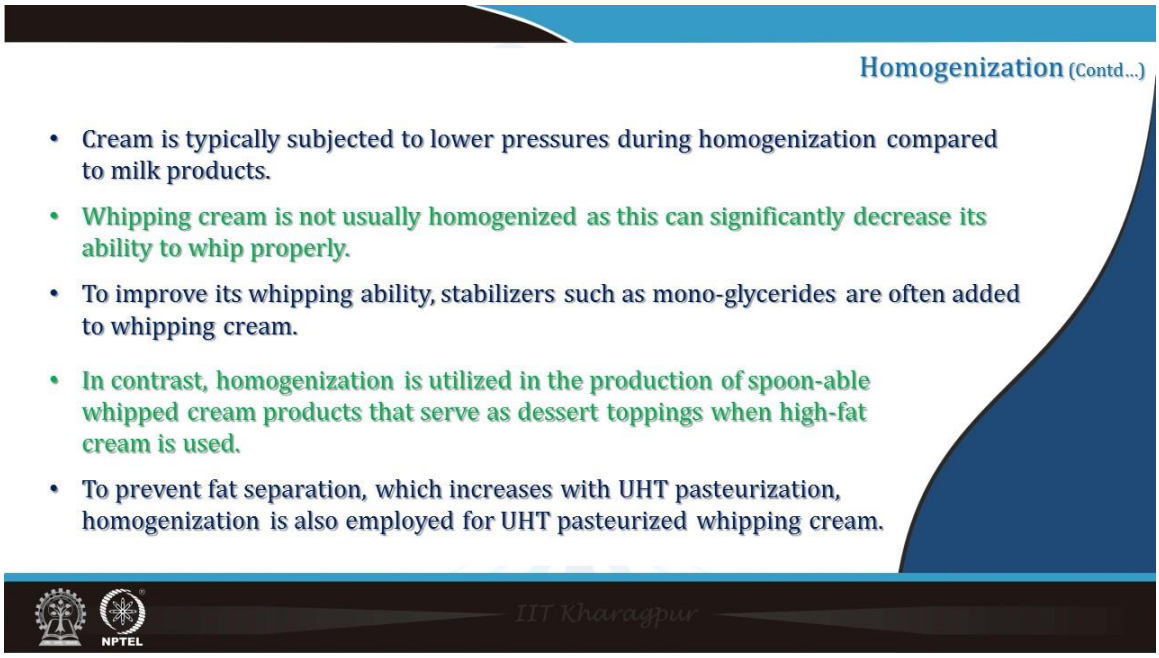
Even standardization of the cream is another for the cream fat content can be modified to the desired level because many a times it is required that cream of a particular fat content should be used for particular operations. And then it is a standardized by the cream level can be adjusted to desired content by the process known as standardization where a precise amount of water or skim milk is added into it.

The difference between the water or skim milk depends upon the intended use of the cream. For example, when the cream is used for butter preparation normally water is used for standardization whereas, for making whipping cream, table cream or coffee cream normally skim milk is used to a standard standardize the fat content in cream. Skimming milk is typically used for standardization milk for producing making beverage preparation or for drying purposes before being packaged for retail sale the standardized cream undergoes homogenization and is subjected to suitable thermal processing.

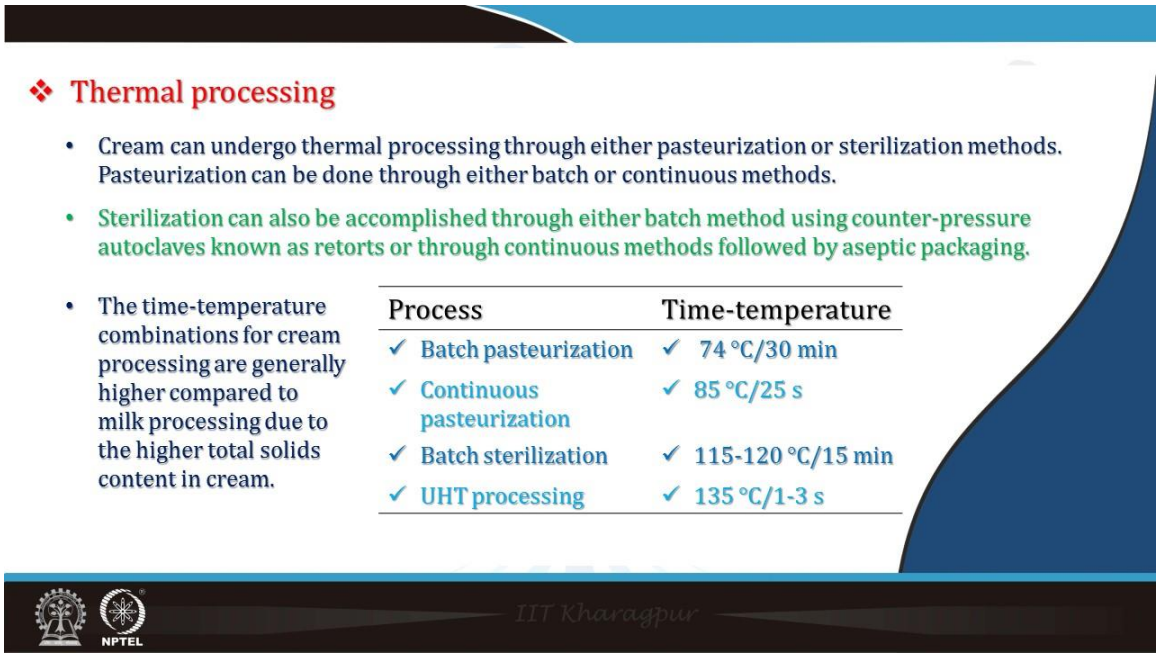


Homogenization obviously, is the process where it is cream in an oil in water emulsion to ensure fat content levels cream is mixed with skim milk it must go undergo homogenization and this process reduces the size of the fat globules and enhances the stability preventing the separation of fat. Homogenization is the method of subjecting cream to a high pressure as it passes through a narrow opening resulting the breakdown of fat globules into a smaller size and even distribution through the cream it is passed through a very small hole.

So, larger fat globules are broken into a smaller one. This process is capable of production of cream particles with varying viscosity levels.

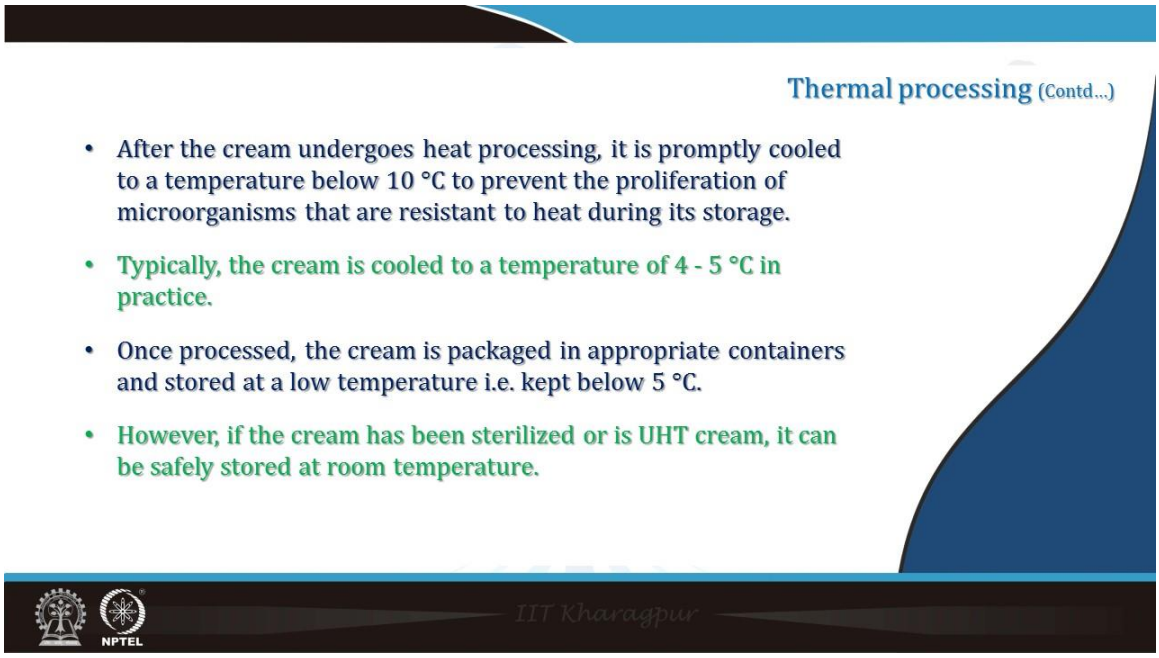


Cream is typically subjected to lower pressure during homogenization compared to the milk product whipping cream is not usually homogenized as this can significantly decrease ability to whip properly. To improve the whipping ability, stabilizer such as mono-glycerides are often added to the whipped cream. In contrast, homogenization is utilized to in the production of a spoon-able whipped cream products that serve as a dessert toppings when high-fat cream is used. To prevent fat separation, which increases the UHT pasteurization homogenization is also implied for UHT pasteurized whipping cream.



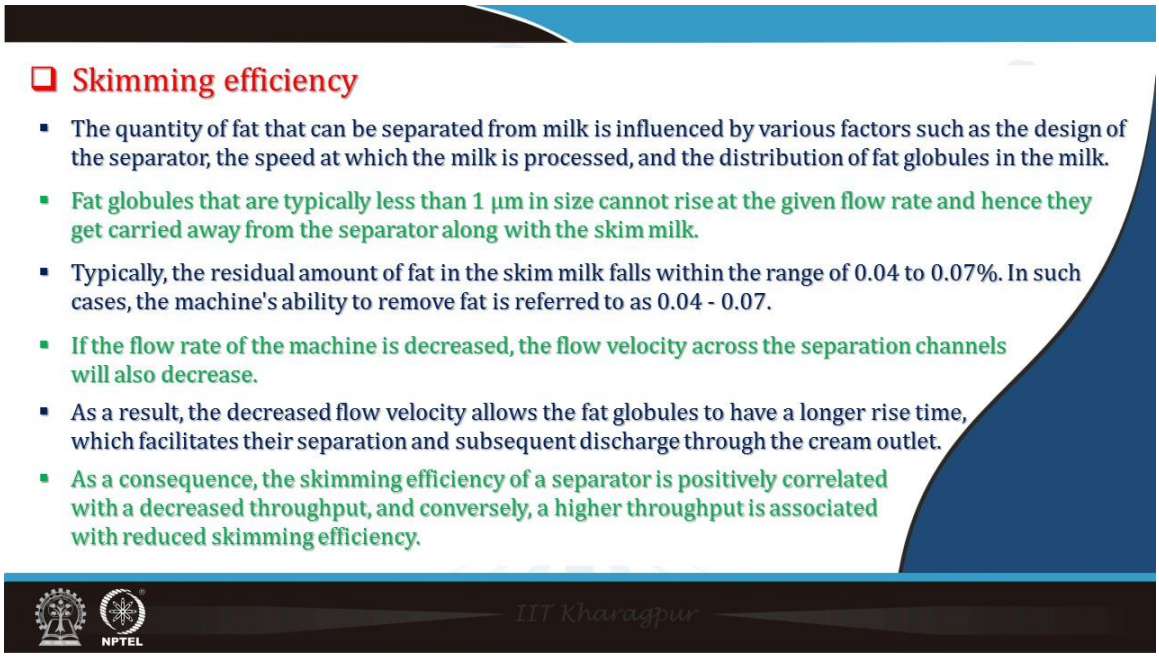
Now the thermal processing of the cream actually the cream can undergo thermal processing through either pasteurization or sterilization method.

Pasteurization can be done through batch or continuous process. Sterilization can be accomplished through either batch or using computer pressure counter pressure autoclaves known as retards or through continuous method followed by a septic packaging. So, the time temperature combinations for cream processes are generally higher compared to the milk processing due to the higher total solids content in the milk. So, in the case of batch process for cream pasteurization that is batch pasteurization 74 degree Celsius for 30 minutes whereas, continuous pasteurization it is 85 degree Celsius for 25 seconds. For sterilization batch sterilization of the cream is done at 115 to 120 degree Celsius for 15 minutes and UHT processing is done at 135 degree Celsius for 1 to 3 seconds.



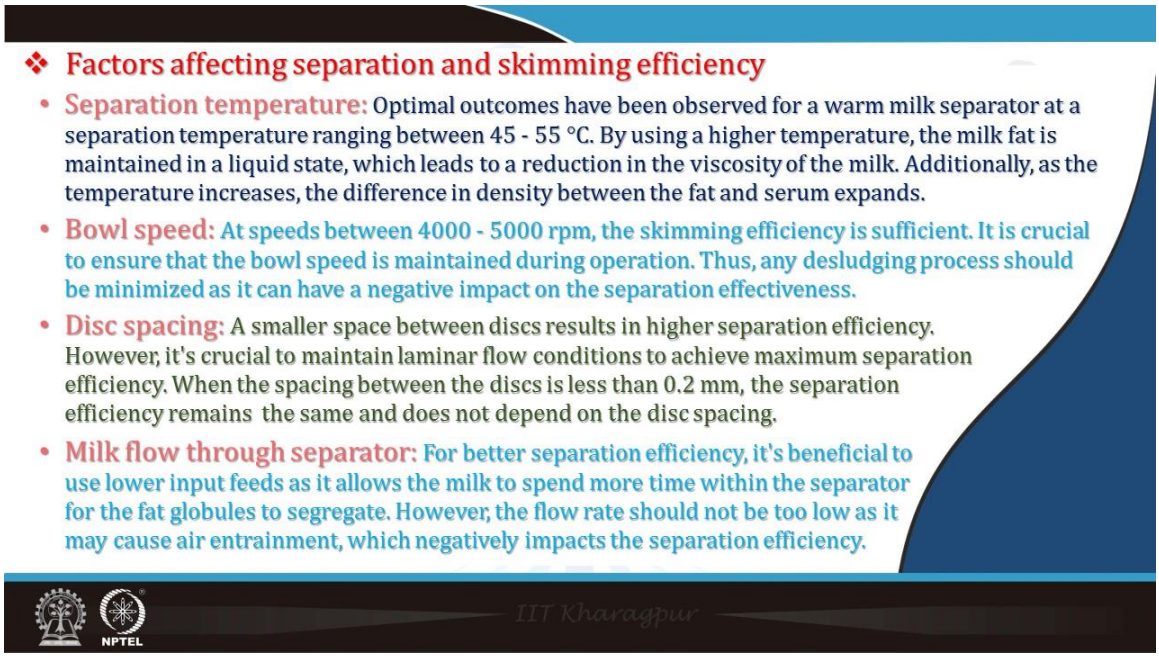
After the cream undergoes heat processing, it is promptly cooled to a temperature below 10 degree Celsius to prevent the proliferation of the microorganisms that are resistant to heat during its storage.

Typically, the cream is cooled down to a temperature of around 4 to 5 degree Celsius in practice. Once processed, the cream is packaged in appropriate containers and stored at low temperature and it is kept below 5 degree Celsius. However, if the cream has been sterilized or in UHT cream it can be safely stored at room temperature.



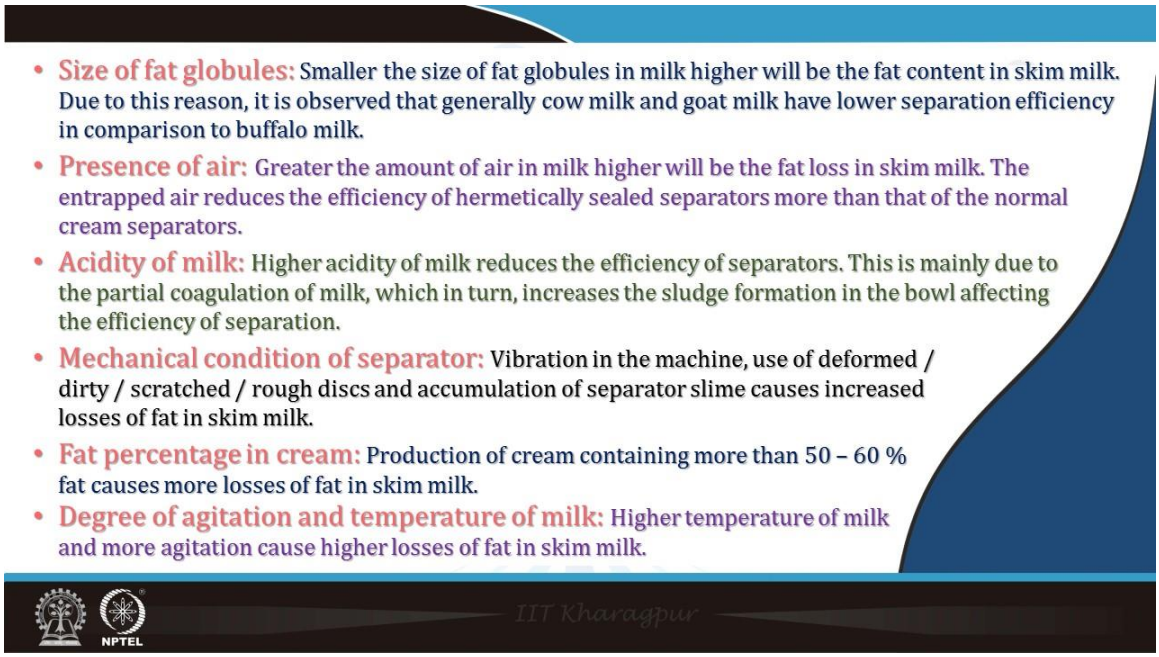
Then the skimming efficiency, the quantity of fat that can be separated from the milk is influenced by various factors such as the design of the separator, the speed at which the milk is processed and the distribution of the fat globules in the milk. Fat globules that are typically less than 1 micron in size cannot rise at the given flow rate and hence by if they get carried away from the separator using the skim milk.

Typically, the residual amount of fat in the skim milk falls within the range of 0.04 to 0.07 percent. In such case the machine's ability to remove fat is referred to as 0.04 to 0.07. If the flow rate of the machine is decreased, the flow viscosity across the separation channel will also decrease. As a result the increased flow viscosity allows the fat globules to leave or to have a longer rise time which facilitates their separation and subsequent discharge through the cream outlet. As a consequence the skimming efficiency of a separator is positively correlated with a decreased throughput and conversely a high throughput is associated with a reduced skimming efficiency.

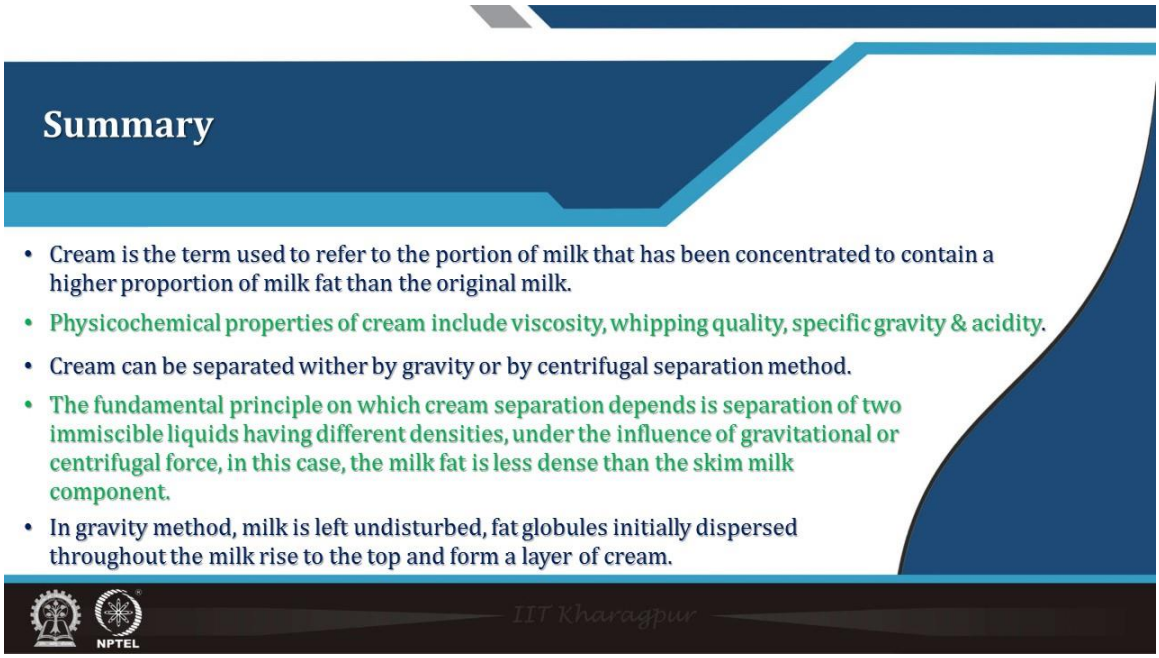


The factors affecting the skimming efficiency include separation temperature, bowl speed, disc opening and milk flow through the separator. Optimal outcomes have been observed for a warm milk separator at a separation temperature ranging between 45 to 55 degree Celsius.

At speeds between 4000 to 5000 rpm the skimming efficiency is sufficient. A smaller space between the discs results in higher separation efficiency. For better separation efficiency it is beneficial to use lower input feeds as it allows the milk to spend more time within the separator for the fat globules to segregate.



Even the size of the fat globules, presence of air, acidity of milk, mechanical conditions of separator, fat percentage in the cream and degree of agitation and temperature of the milk also influence the skimming efficiency to a greater extent.



Finally, I would like to summarize this lecture that cream is the term used to refer to the portion of the milk that has been concentrated to contain a higher proportion of milk fat than the original milk. Physico-chemical properties of the cream include

viscosity, whipping quality, specific gravity and acidity. Cream can be separated either by gravity or by centrifugal separation method. The fundamental principles on which cream separation depends is a separation of two immiscible liquids having different densities under the influence of gravitational or centrifugal forces. In this case, the milk is less dense than the skim milk component. In gravity method, milk is undisturbed, fat globules initially disperse throughout the milk rise to the top and the formal layer of the cream. And then cream is separated and processed for various products for different purposes.

So, these are the references used in this lecture.

With this, thank you very much for your patience here. Thank you.