Food Oils and Fats: Chemistry & Technology

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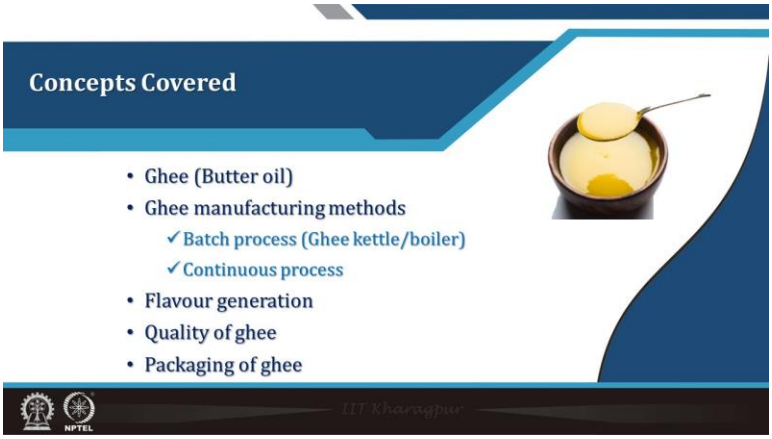
Module 8: Animal & Dairy Fats

Lecture 40: Ghee (Butter Oil)

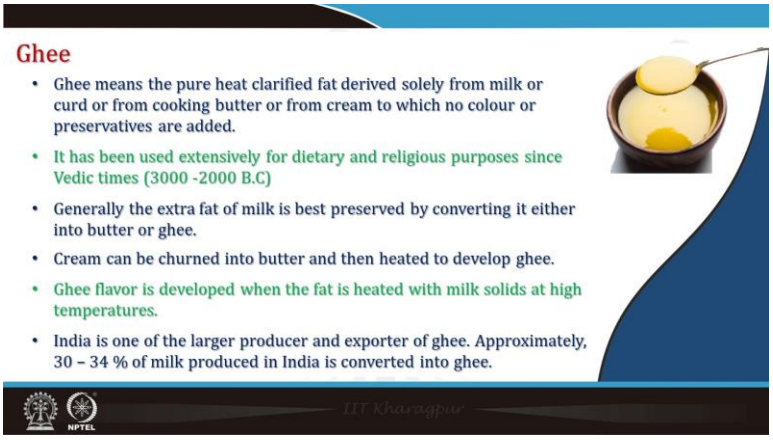
Hello everyone. Namaskar. Now, we are in the last lecture of this module 8 and in this lecture, we will talk about ghee. It is also popularly known as butter oil.



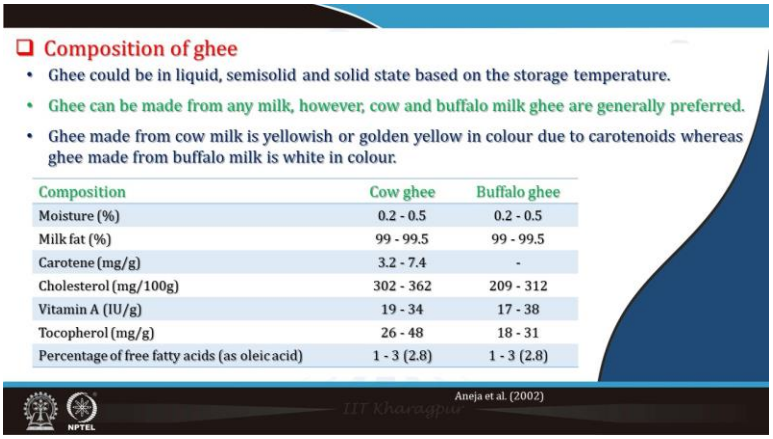
We will discuss, what is ghee. What are the ghee manufacturing methods both batch process as well as continuous process? We will also see, you find that there is a major significant difference in the flavor of butter and ghee and ghee. So, what are the flavors? How flavor is generated in to butter? I will throw some light then finally, the quality of ghee and the packaging of ghee we will discuss.

So, let us see what is ghee? You can see here in the figure, it is a very popular very common product at least in Indian households. Ghee means the pure heat clarified fat derived solely from milk or curd or from cooking butter or from cream to which no color

or preservatives are added. It is a pure clarified butter oil or ghee. It has been used extensively for delivery and religious purposes in India since Vedic times; you can say 3000 to 2000 BC; the records are available.



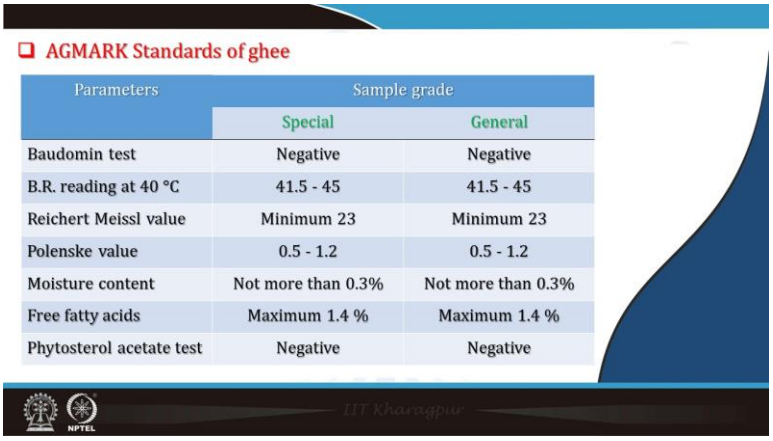
Even today also in most of the holy occasions you say, this ghee is used in performing in various purposes. Generally, the extra fat of milk is best preserved by converting it either into butter or ghee and I will say that ghee is a it has a product which is more stable, supply properly provided if it is properly handled and take. Cream can be churned into butter and then heated to develop ghee. Ghee flavor is developed when the fat is heated with milk solids at high temperature. India is one of the larger producers and exporters of ghee. Approximately 30 to 34 percent of the milk produced in India is converted into ghee.



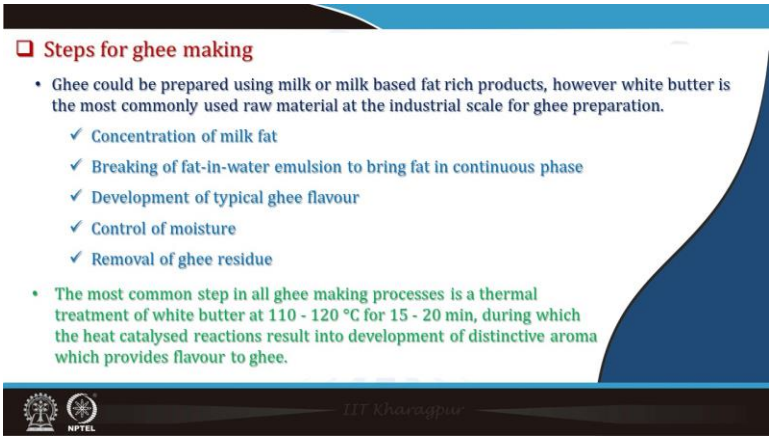
So, you see the composition of ghee. Ghee could be in liquid, semi-solid, and solid state based upon the temperature at which it is stored. Ghee can be made from any milk however cow and buffalo milk ghee are generally performed that is among this also buffalo milk ghee. In holy occasions, that is for pooja etcetera however the cow milk he is used more commonly. Ghee made from cow milk is yellowish or golden yellow in color due to the presence of carotenoid in it whereas the ghee made from buffalo milk is whiter in color.

So, on an average composition of cow ghee and buffalo ghee has been given in this table that is moisture content in both of them is to the tune of 0.2 to 0.5 percent that is it should be completely almost free very negligible moisture content might be present. Fat is around 99 to 99.5 percent in either case. Carotene in cow ghee it is around 3.2 to 7.4 milligram per gram. Cholesterol that is it contains milligram per 100 gram. In cow milk, it is 302 to 362, in buffalo milk it is in the range of 209 to 312.

Vitamin A international unit per gram, it is 19 to 34 in cow ghee and around 17 to 38 international unit per gram in buffalo ghee. Tocopherol content, in cow ghee is in the range of 26 to 48 milligram per gram whereas, in the buffalo ghee it contains around 18 to 31 milligram per gram. Percentage of free fatty acids as oleic acid, may be around in the range of 1 to 3 percent in cow ghee as well as in buffalo ghee both.

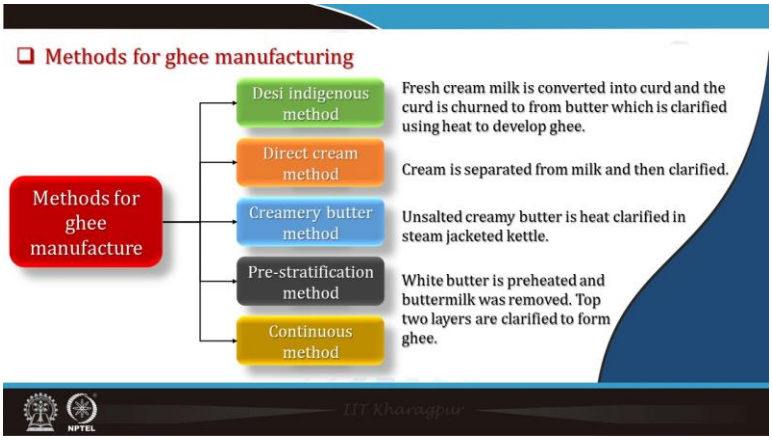


As for the AGMARK standard, the Baudomin test for the ghee should be negative, whether as a special as well as general, then B.R. reading at 40 degree Celsius should be 41.5 to 45. Reichert Meissl value should be a minimum of 23. Polenske value should be in the range of 0.5 to 1.2, and moisture content in no case no more than 0.3 percent. Free fatty acids should be more than it should be a maximum of 1.4 percent, and the phytosterol acetate test should be negative. So, this is the AGMARK standard of ghee.



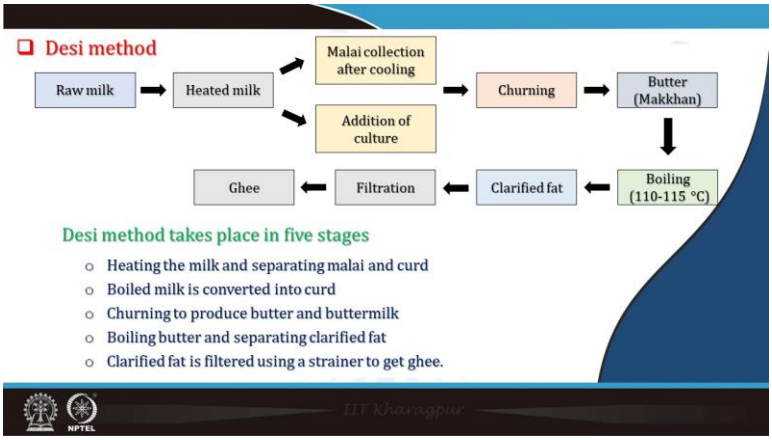
Now steps for ghee making let us discuss, that is ghee as I told you, ghee could be prepared using milk or milk-based fat rich products. However, white butter is the most commonly used raw material at the industrial scale for ghee preparation.

So, the steps involving, involve the concentration of milk fat, then the breaking of fat in water emulsion to bring the fat in the continuous phase. Because in the butter or the cream, the fat is available in the form of fat in water emulsion. So, now here in the ghee there is water is removed and fat is brought into continuous phase. In the process there is a development of typical ghee flavor. There is also control of moisture and removal of ghee residue. In the cream or the butter if there is any proteinous matter etcetera is there, that are precipitated or denatured and that is removed. So, the most common step in all ghee making process is a thermal treatment of white butter that is butter is heated at around 110 to 120 degree Celsius for about 15 to 20 minutes and during which the heat catalysed reactions result into the development of the extensive aroma which provides flavor to the ghee.

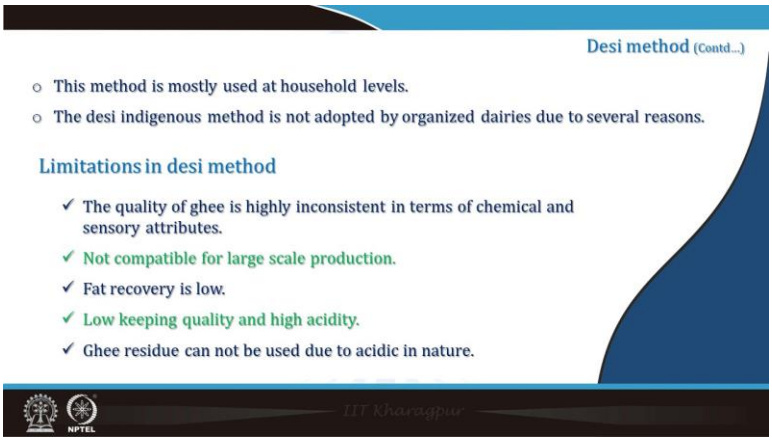


So, the common methods for ghee manufacture are desi indigenous methods, direct cream method, creamery butter method, pre-stratification method, or continuous method. In desi cream method, there is the fresh cream milk is converted into curd and the curd is then churned to form butter which is clarified using heat to develop ghee. In direct cream method, cream is separated from milk and then it is clarified into ghee. In creamery butter method usually, unsalted creamery butter is heat clarified in steam jacketed kettle whereas, in other pre-stratification method, or continuous method, white butter is preheated and butter milk is removed top two layers are classified clarified to form butter.

So, in the process flow chart of the desi milk method, you see the raw milk, heated, and malai collection after cooling, and the addition of culture. This we already discussed earlier then it is churned you get butter that is makkan and the butter is heated at around 110 to 120 degree Celsius, you get clarified, filtered, and the ghee.



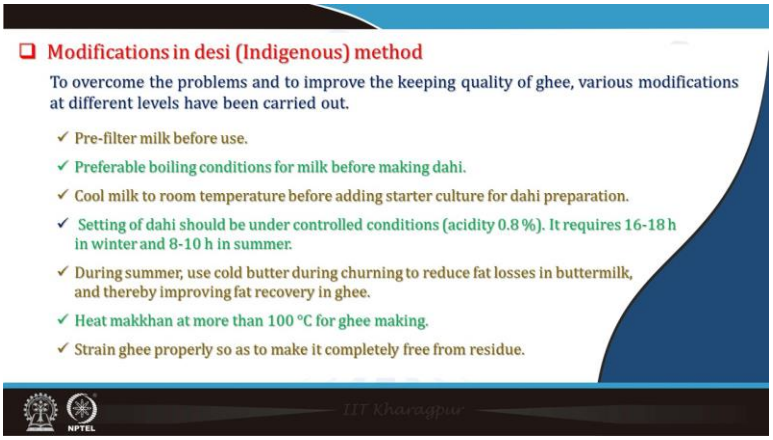
So, desi method takes place in five stages that is heating the milk and separating the malai and curd, boiling milk and converting it into churning to proceed butter and butter milk, boiling butter and separating clarified fat. and clarified fat is filtered using a strainer to get the ghee.



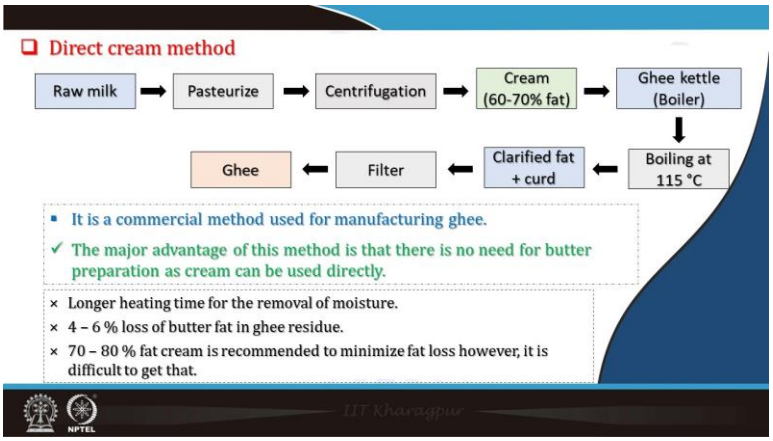
This method is the mostly used method at the household level. It is in Indian homes it is also used. The desi indigenous method is not adopted by organized dairy due to several reasons.

What are the limitations of this method? The quality of the ghee is highly inconsistent in terms of chemical and sensory attributes because, no standardized method is used in the homes, not compatible for large-scale production, the fat recovery is generally low, and low keeping quality and high acidity is there. So, ghee residue cannot be used due to acidic in nature.

So, there have been some modifications suggested in the desi method in the indigenous method. So, basically to overcome the problems which we discussed in the last slide as well as to improve the keeping quality of the ghee. What are those modifications? That is a pre-filter milk before use, number one. Preferable boiling conditions for milk before making dahi. Cool milk to room temperature before adding starter culture for dahi preparation.



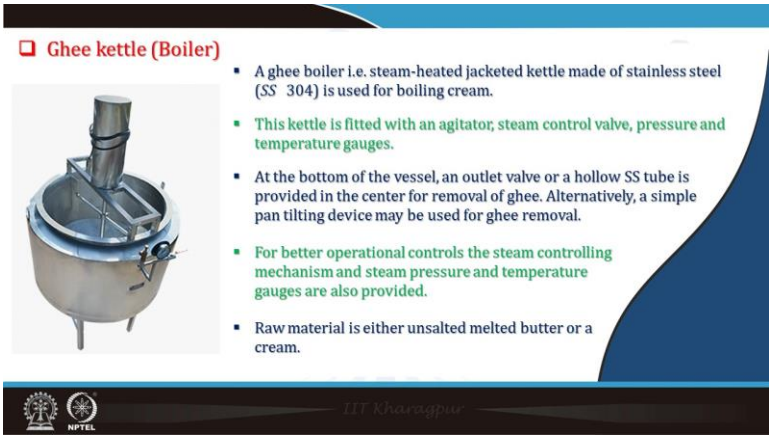
Then setting of dahi should be under controlled condition; that is, acidity should be 0.8 percent it requires 16 to 18 hours in winter and 8 to 10 hours in summer. During summer use cold butter during churning to reduce fat losses in the buttermilk and thereby improving the recovery of fat in ghee and then heat this makhan at around temperature of 100 degree Celsius for ghee making and strain ghee properly so as to make it completely free from the residues. So, these are some of the modifications that are incorporated in the desi method. The next is the direct cream method.



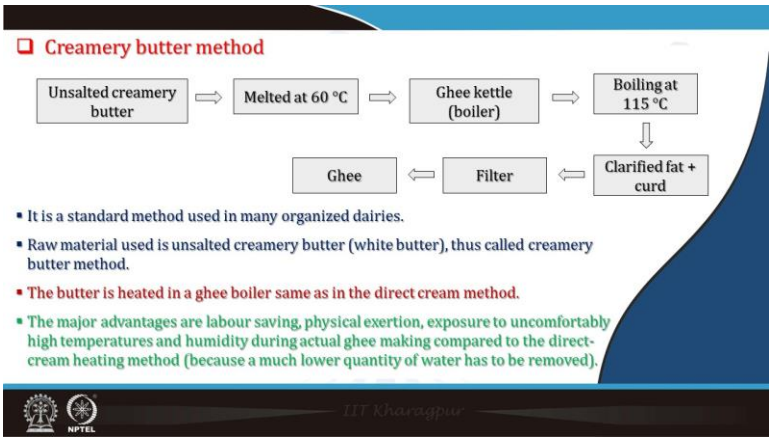
As you see here, there is the cream obtained that is there are standard methods of cream separation, we discussed in the earlier class. So, you get the cream and this cream is from the raw milk pasteurized cream; it is standardized or concentrated to about 60 to 70 percent fat content. Then this cream is boiled at around 115 degree Celsius and it gives clarified fat and curd, it is filtered into ghee means that is in, from cream it is directly made; the butter process is eliminated.

It is a commercial method used for the manufacture of ghee in India by industry also used it. The major advantage of this method is that there is no need for butter preparation as the cream is directly converted into clarified fat or butter oil. So, the additional step of butter making is eliminated. There is the longer heating time for removal of moisture may require 4 to 6 percent loss of the butter fat in the ghee residue and about 70 to 80 percent

fat cream is recommended to minimize the losses. However, it is very difficult to get a cream of 70 to 80 percent fat content because it will require very precise and difficult standardization process.

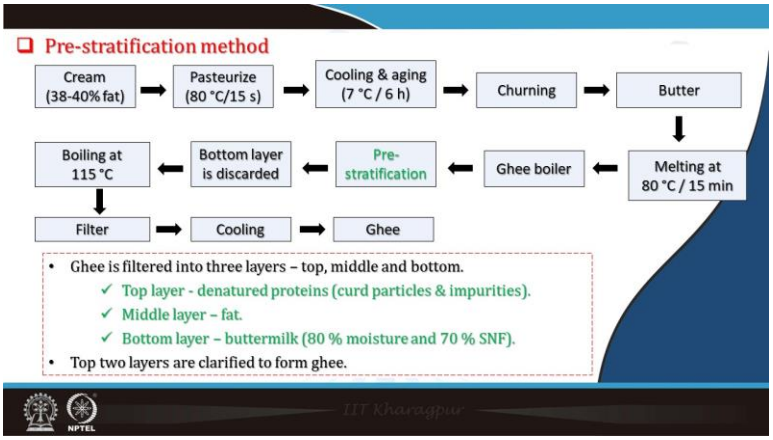


The ghee kettle and boiler as you can see here in the figure that is; it is basically the where the cream or butter is heated it is a very simple device. It is a ghee boiler called or steam-heated jacketed kettle made of stainless steel SS304. It is generally used for making or for boiling the cream, and this kettle is fitted with an agitator. Steam control valve pressure and temperature gauges are provided. At the bottom of the vessel there is an outlet valve or a hollow SS tube is provided in the center for the removal of the ghee; or also there are some kettles which have a simple that is simple pan tilting device this is used for removing the ghee. For better operational controls, the steam controlling mechanism and steam pressure and temperature gauges are also provided, and raw material is either unsalted, melted butter, or a cream.



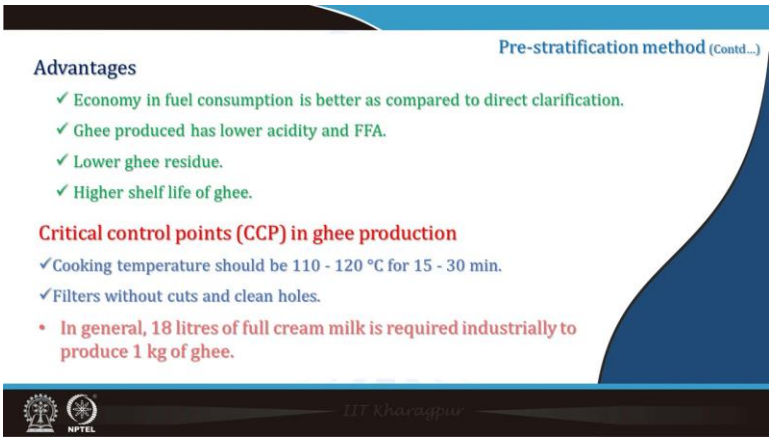
In the creamery butter method, unsalted creamery butter it is melted at 60 degree Celsius, and the ghee is made and ghee is put into the ghee kettle boiler where it is boiled at 115 degree Celsius and then clarified plus fat plus a curd is obtained, it is filtered and clarified fat or ghee is obtained.

So, it is a standard method used in the organized dairies. Raw material used is unsalted creamery butter (white butter), thus called creamery butter method. The butter is heated in a ghee boiler same as in the case of direct cream method. The major advantage of the this method are labour saving, physical exertion, exposure to uncomfortably high temperature and humidity during actual ghee making process compared to the direct cream boiling method because a much lower quantity of the water has to be used here in this process.



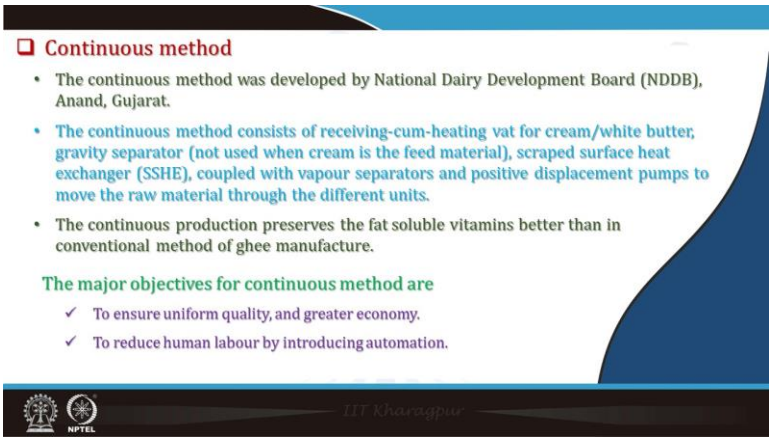
Then let us see pre-stratification method. This is the again, in this method, the cream of 38 to 40 percent fat is taken, it is pasteurized at 80 degree Celsius for 15 minute, then cooled and aged cooled to around 7 degree Celsius aged for 6 hour. Then, churning, butter making, the butter is melted at 80 degree Celsius for 15 minute then it sent to the ghee boiler. After that, it comes to pre-stratification method, that is here the ghee is filtered into three ways that is top, middle, and bottom. Top layer is denatured protein that is contains curd particles etcetera, middle layer is fat, and bottom layer is the buttermilk that is 80 percent moisture and 70 percent SNF.

So, the top two layers are clarified to form ghee; means bottom layer is discarded and the top two layers are taken; boiling is done at 115 degree Celsius; it is filtered cooled and ghee is obtained. So, it is the pre-stratification method.

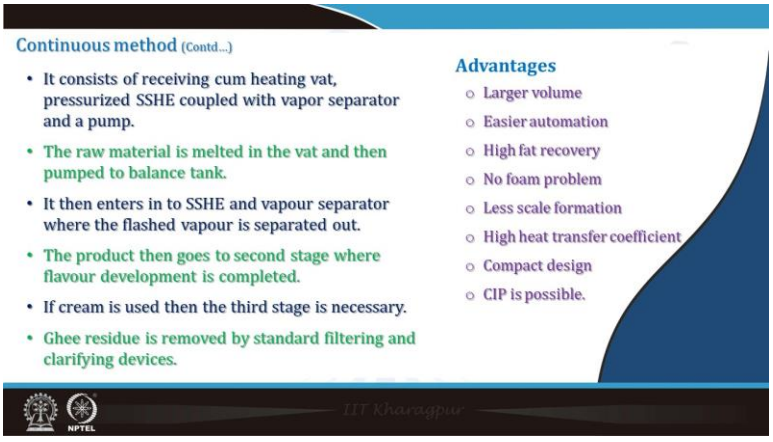


The advantages of the pre-stratification method include economy in fuel consumption is better as compared to direct clarification method. Ghee produced has lower acidity and FFA, lower ghee residues, and a higher shelf life of the ghee obtained from this method.

Critical control points in ghee production are - cooking temperature should be in the range of around 110 to 120 degree Celsius the time normally for 15 to 30 minutes. Filters without cuts and clean holes etcetera should be used. In general, 80 liters of full cream is required industrially to produce a 1 kg of ghee.



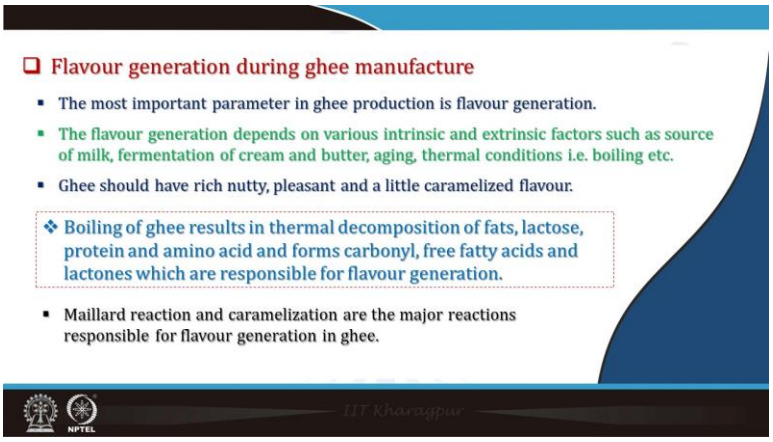
The continuous method; The continuous method was developed by the National Dairy Development Board, Gujarat. The continuous method consists of receiving-cum-heating vat for cream/white butter, gravity separator (not used when cream is the feed material), then scraped surface heat exchanger that is commonly known SSHE, coupled with vapour generator, vapour separators, and positive displacement pumps to move the raw material through the different units are used. The continuous production preserves the fat-soluble vitamins better than in the conventional method for ghee manufacture. The major objectives of the continuous methods are to ensure uniform quality and greater economy, and to reduce human labour by introducing automation.



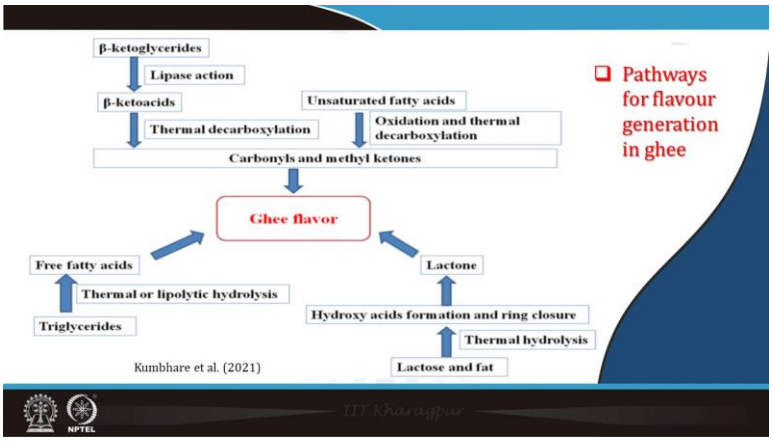
So, it consists of receiving-cum-heating vat pressurized SSHE coupled with vapour separator and a pump. The raw material is melted in the vat and then pumped into the

balance tank. It then enters the scrap surface heat exchanger and vapour separator where the flash vapour is separated out. The product then goes to secondary stage where flavour development is completed and if cream is used then the third stage is necessary. Ghee residue is removed by standardizing, filtering, and clarifying devices.

The advantages of this method are - there is a larger volume can be used here, it is easier for automation, high fat recovery, there is no problem of foam, less scale formation, and high heat transfer coefficient. It is a compact design and, in this method, the even CIP clean in place is possible.



So, how that the flavour generation during ghee manufacture. It is the most important parameter in ghee production is the flavour generation. The flavour generation depends on various intrinsic and extensive factors such as source of milk, fermentation of cream and butter, aging, thermal conditions like boiling etcetera, and the ghee should be rich, nutty, pleasant, and a little caramelized flavour it should have. It should have a rich nutty flavour pleasant and caramelized flavour. So, boiling of ghee results in thermal decomposition of fat, lactose, proteins which are present there although in small quantity, and amino acid. These forms carbonyl compounds, free fatty acids, and lactones which are responsible for the flavour generation. Maillard reaction and caramelization reactions are the major reactions which are responsible for flavour generation in ghee.

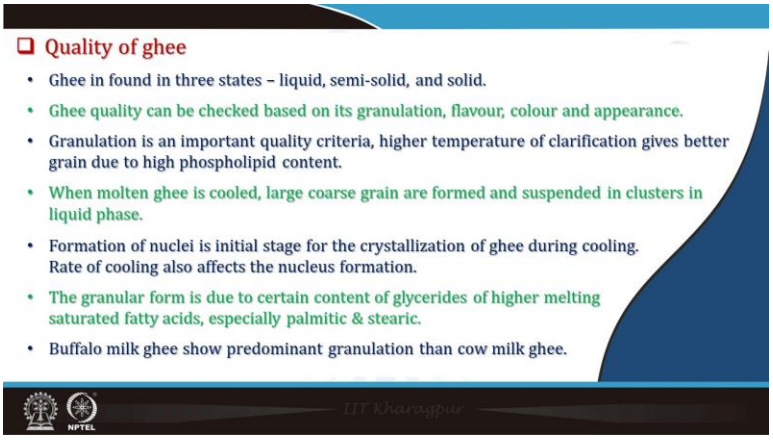


You can see pathways for the flavour generation like beta-ketoglycerides they with the action of lipase, they are converted into beta-ketoacids and then they are decomposed by thermal decarboxylation that is carbonyls and methyl ketones which are responsible for the flavour.

So, simultaneously unsaturated fatty acids, they undergo oxidation and thermal decarboxylation, they give various carbonyl compounds.

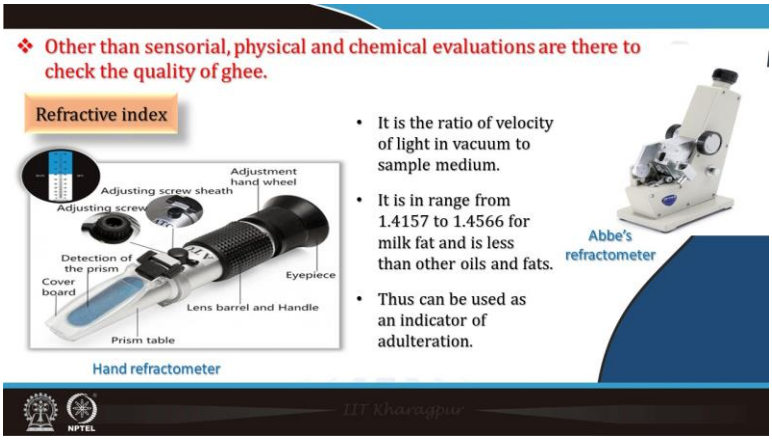
Triglycerides, they are subjected to thermal or lipolytic hydrolysis, they give free fatty acid and then free fatty acid further go various reactions. So, that it gives you the flavour.

Lactose and fat, thermal hydrolysis results into hydroxy acid formation and ring closure and then it goes converted into lactone and then lactose is further decomposed and it reacts with various compounds. And finally, in the system, there will be various carbonyls, methyl ketones and other compounds etcetera which are responsible for the ghee flavour.

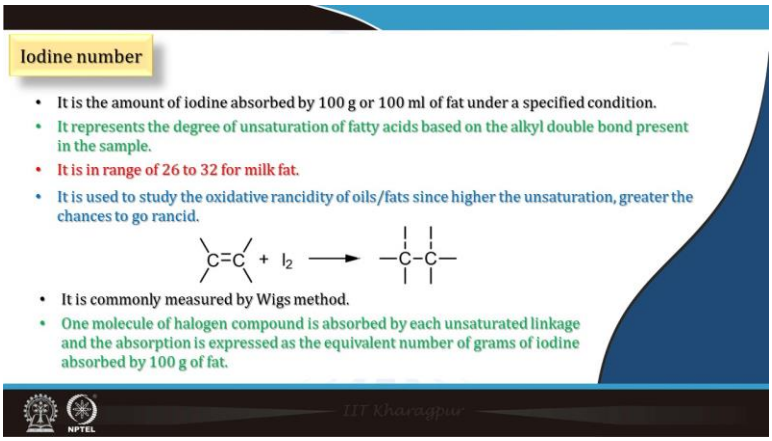


As far as the quality of the ghee is concerned; it is found in three states ghee depending upon the storage temperature liquid, semi-solid, and solid. Ghee quality can be checked based on its granulation, flavour, colour, and appearance. Granulation is an important quality criteria, higher temperature of clarification gives butter grain due to high phospholipid content. When molten ghee is cooled, large coarse grain are formed and suspended in clusters in the liquid phase. Formation of the nuclei is initially staged for the crystallization of ghee during cooling. Rate of cooling also affects the nucleus formation. The granular form is due to certain content of glycerides of higher melting saturated fatty acids especially palmitic and stearic. So, buffalo milk ghee shows more predominant granulation than cow milk ghee.

The normal methods which are used that is other than the sensorial, physical, and chemical evaluations. There are various other methods which are used to control the quality check in ghee; that is one is the refractive index.

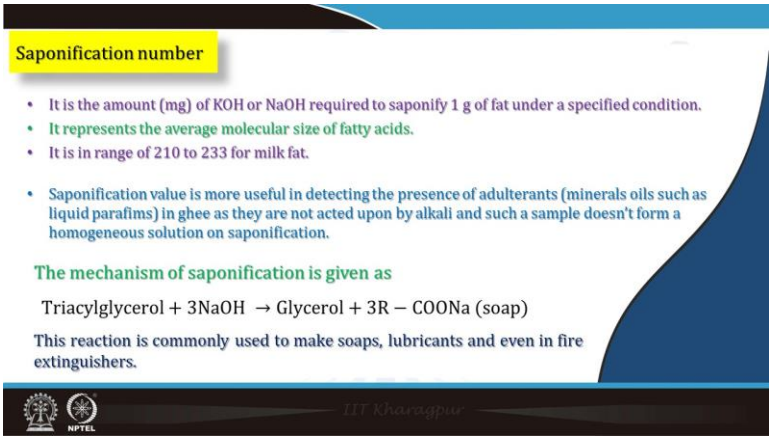


You know that popularly either hand refractometers or airway refractometers; they are used to measure the refractive index of these materials. It is the ratio, refractive index is the ratio of velocity of light in vacuum to the sample medium. It is in the range of 1.4157 to 1.4566 for milk fat and is less than that in the other oils and fats. Thus, this can be used as an indicator for adulteration. If you found the refractive index is less than that it shows that there is a adulteration of ghee with the vegetable oil etcetera.

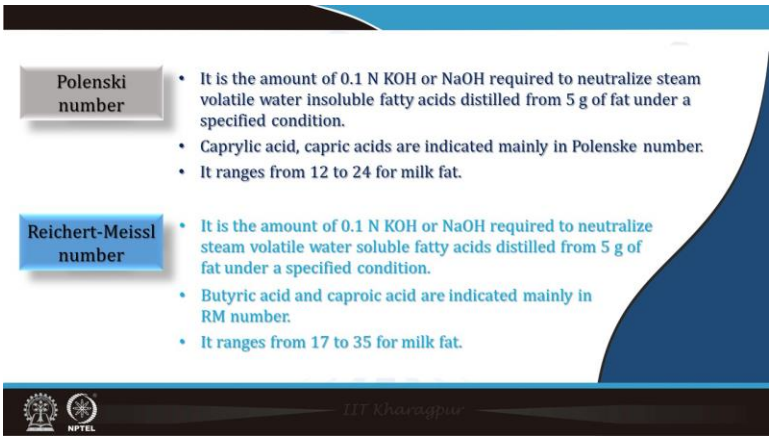


Iodine number, in the earlier class, we have discussed, it is the amount of iodine absorbed by 100 grams of fat or 100 ml of fat under a specified condition. It should be in the range of 26 to 32 for milk fat. Normally, it is used for study of the oxidative rancidity of oils and fat, since higher the unsaturation greater the chances to go rancid and it is a commonly measured by Wig's method. So, that is see that find iodine number and this is normally less because milk fat generally contains saturated fatty acid.

Saponification value, another that is a saponification number, it represents the average molecular size of fatty acids in the milk fat. It should be in the range of around 210 to 233, the value for milk fat. Saponification value is more useful in detecting the presence of adulterants that is mineral oil such as liquid parafims etcetera in the ghee as they are not acted upon by alkali and as such a sample does not form a homogeneous solution on saponification.



The mechanism of saponification and how the soap is formed in the earlier classes we had discussed in detail, but here also just I have given.



Then, Polenski number, it is the amount of 0.1 normal KOH or sodium hydroxide required to neutralize steam volatile water insoluble fatty acids distilled from 5 grams of fat under a specified condition. The caprylic acid or capric acids are indicated mainly in Polenski number and it should range from 12 to 24 for milk fat.

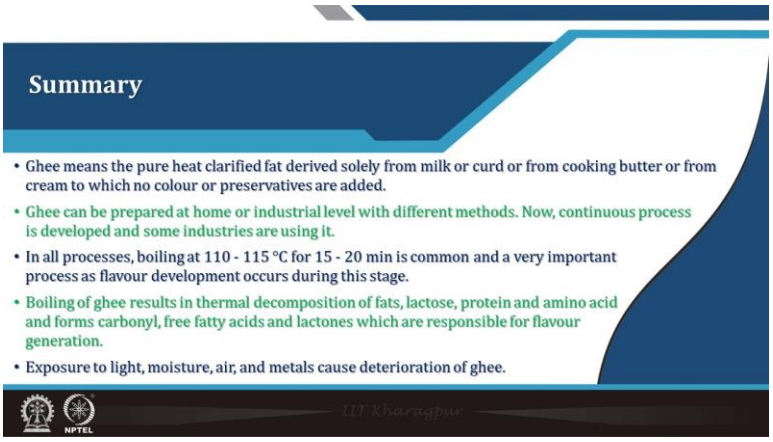
Then, R-M value, Reichert's Meissl value, it is the amount of 0.1 normal KOH or sodium hydroxide required to neutralize steam volatile water-soluble fatty acids distilled from 5 grams of fat under specified conditions. Butyric acid and capric acid are indicated mainly in the R-M number. It ranges from 17 to 35 for milk fat.

So, this Polenski number, Iodine number, Reichert Meissl value etcetera, they should be in the specified range.

Then comes finally, the packaging of the ghee, again like the butter we discussed here also. Under proper packaging conditions, ghee can be stored for up to around 6 to 12 months; under ambient conditions, ghee on exposure to light, moisture, air, and metals etcetera get oxidized, deterioration even in a traces of moisture if it is present you must be doing, that it is in our homes also that is our mothers or housewives and when they use spoon for taking out the ghee from the container they make sure that spoon is dry

completely. They will just rub it, clear it and it should not because even if the traces of moisture content is goes there; at low moisture content, the rate of oxidation is very high. So, butter is oxidized by autooxidation process, it is deteriorated.

So, basic properties of the packaging material which is used for packaging butter is also good for packaging the ghee etcetera; that is only thing that it should be the packaging material should be inert it should be nontoxic, non-tanting, low cost, easily available, and it should be that proved to rough handling it can be handled properly. In thin cans, ghee should be filled without leaving any space for air that is very important that air, oxygen etcetera or air, moisure etcetera that is ok. So, ghee is normally, it is exposed to light, it will be oxidized; if it is exposed to air, it will be oxidized; if it is exposed to water vapour, it will be hydrolyzed; if it is exposed to metals, copper and iron etcetera, it will become rancid. So, the packaging material which is used for ghee it should be impermeable to light, air, water vapour, metals, and so on.



So, finally, I will summarize this lecture by saying that ghee is a pure heat clarified fat which is derived solely from milk or curd or from cooking butter or from cream to which no colour or preservatives are added. Ghee can be prepared at home or at industrial level with different methods. Now, continuous process is developed and some industries are using it. In all processes, boiling at 110 to 115 degree Celsius for about 15 to 20 minute is

common and very important process as flavour development occurs during this stage. Boiling of ghee results in thermal decomposition of fats, lactose, protein, and amino acid and forms carbonyl, free fatty acids, and lactones which are responsible for flavour generation. Exposure to light, moisture, air, and metal can deteriorate ghee or can cause its spoilage. So, therefore, ghee should be prevented from these conditions.

These are the references that were used in this lecture.

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