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SUBJECT NAME: FOOD PROCESS TECHNOLOGY –III (Milk and milk products)

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Module I 8L

Lecture 1: Definition of milk

Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by complete milking of one or more healthy milch animals, excluding the milk obtained within 15 days before or 5 days after calving or such periods as may be necessary to render the milk practically colostrum-free and containing the minimum prescribed percentages of milk fat and milk-solids-not-fat. In India, the term 'milk', when unqualified, refers to cow or buffalo milk, or a combination thereof. Milk SNF means Milk Solids-not-Fat, comprising protein, carbohydrates, vitamins, minerals, etc in milk other than milk fat.

As an agricultural product, milk is extracted from mammals during or soon after pregnancy and is used as food for humans. The different milks tend to vary according to the way they are produced, and their fat content. The fat content of milk varies depending on the product e.g. whole milk has a fat content of about 4% fat, whole standardised milk, that which is widely available for sale, has a minimum fat content of 3.5% fat, semi skimmed milk contains 1.7% fat, skimmed milk contains about 0.1% fat, and in addition there is 1% fat milk.

Dairies in India have to market milk by standardizing, as per the various types of milk prescribed under Food Safety Standard Act, 2006. These type of milk differ in their Milk fat and Milk SNF contents.

S. No.	Type of Milk	Milk Fat (% Not less than)	Milk SNF (% Not less than)
1	Full Cream Milk	6.0	9.0
2	Baffalo Milk	5.0	9.0
3	Standardize Milk	4.5	8.5
4	Cow Milk	3.5	8.5
5	Toned Milk	3.0	8.5
6	Double Toned Milk	1.5	8.5
7	Skimmed Milk	Not more than 0.5	8.7

Standardized milk- This is made by combining buffalo milk and skimmed milk. The fat percentage is maintained at 4.5% while the SNF is 8.5%.

Whole milk: Natural whole milk is milk with nothing added or removed. Whole milk, also called full cream milk is usually consumed by children, teenagers and body builders. Whole milk is called so because it contains all the milk fat found them. Whole milk is also creamier and full of flavour.
Whole milk must contain at least 3.25% milk fat and 8.25% milk solids by weight—which means it derives about 50% of its calories from fat. Because of this relatively high fat content, whole milk is best used only for infants and young children.

Reduced-fat milk (2%): This milk contains 2% milk fat. The percentage of milk fat refers to the percentage of fat by weight, and much of milk's weight is water. Once the water subtract from 2% milk, for example, a product that left with 20% fat contains by weight; such milk actually derives 35% of its calories from fat. Drinking 2% milk is a good way to wean oneself from whole milk at first, but is too high in fat as a permanent choice, unless the diet is otherwise very low in fat.

Low-fat milk (1%): One-percent milk gets 23% of its calories from fat. Many people find low-fat milk more appealing and a good compromise. The EU regulations for milk classification previously divided milk into three categories defined by the fat content; whole, semi-skimmed or skimmed. Prior to 2008, any milk that contained a different fat content was defined as a 'milk drink'.

Skimmed milk/non-fat milk: This type of milk has as much fat removed as possible. It may not contain more than 0.5% milk fat by weight, and usually contains less than 0.5 gm of fat per cup, deriving just 5% of its calories from fat. Skimmed milk has about half the calories of whole milk. It is the best choice for adults, and is the only type of milk that should be consumed by people on strict low-fat diets. Unfortunately, skim milk has a very "thin" flavor and an unappealing bluish cast.
The lower level of fat in skimmed milk reduces its calorie (energy) content. For this reason it is not recommended for children under the age of 5 years as they need the extra energy for growth. However it is ideal for adults who wish to limit their fat or calorie intake. Skimmed milk has a slightly more watery appearance than other types of milk and has a less creamy taste due to the removal of fat.

Toned milk: Toned milk, also called the single toned milk is obtained by adding skimmed milk powder and water to whole milk. It contains about 3.0% fat and toned milk restricts the body from absorbing cholesterol from the milk to minimum. Toned milk contains the same nutrition as whole milk minus the fat soluble vitamins. One glass of toned milk provides around 120 calories.

Double Toned Milk: This milk is obtained by adding skimmed milk power to whole milk and has about 1.5% fat content. Double toned milk is ideal for those trying to maintain weight as it keeps the calorie intake under check and aids weight loss.

Lecture 2: History of milk

- India ranks first in milk production, accounting for 18.5 per cent of world production, achieving an annual output of 146.3 million tonnes during 2014-15 as compared to 137.69 million tonnes during 2013-14 recording a growth of 6.26 per cent.
- The Food and Agriculture Organization (FAO) has reported a 3.1 per cent increase in world milk production from 765 million tonnes in 2013 to 789 million tonnes in 2014.
- The target for milk production in the country fixed by the Government for the year 2016-17 was 163.7 million tonnes.
- The per capita availability of milk in India has increased from 176 grams per day in 1990-91 to 322 grams per day by 2014-15. It is more than the world average of 294 grams per day during 2013.
- The countrys estimated demand for milk is likely to be about 155 million tonnes by 2016-17 and around 200 million tonnes in 2021-22. To meet the growing demand, there is a need to increase the annual incremental milk production from 4 million tonnes per year in past 10 years to 7.8 million tonnes in the next 8 years (210 million by 2021-22), (T Nanda Kumar, chairman, NDDB).
- India has about three times as many dairy animals as the USA, which produces around 75 million tons milk, over 80 per cent being kept in herds of 2 to 8 animals.
- Annual milk yield per dairy animal in India is about one tenth of that achieved in the USA and about one fifth of the yield of a grass-fed New-Zealand dairy cow.
- A peculiar feature in our country is the wide variation between regions in respect of consumption of milk.

Milk production in India

Year	Production(million tonnes)	Per capita availability(g/day)
1991-92	55.7	178
1995-96	66.2	197
2000-01	80.6	220
2005-06	97.1	241
2008-09	108.5	258
2014-15	146.3	322

- In 2001-02 India became the world leader in milk production.
- Recommended value of milk consumption is 250-450 g. (Minimum recommended by NIN is 80 to 310g/capita-day.
- Per-capita availability in India was only 114 g in 1975.

Lecture 3: Composition of milk

Details Composition of Milk:

Water : Water constitutes the medium in which the other milk constituents are either dissolved or suspended. Most of it is free and only a very small portion is in bound form, being firmly bounded by milk proteins phospholipids etc.

Total solids : Total solids constitutes lipids (Fat) and solid not Fat.

Milk Fat (Lipids) : The bulk of the fat in the milk exists in the form of small globules, which average approximately 2 to 5 microns in size. This an oil - in - water type emulsion. The surface of these fat globules is coated with an adsorbed layer of material commonly known as the fat globule membrane. This membrane contains phospholipids, and proteins in the form of a complex and stabilizes the fat emulsion. In other words, the membrane prevents the fat globules
from coalescing and separating from one and another. The emulsion may, however, be broken by agitation (at low temperature), of heating, freezing etc. Chemically, milk fat is composed of a number of glycerid - esters of fatty acids milk fat on hydrolysis gives a mixture of fatty acids and glycerol.(The milk fat is a mixture of true fats in established from the fact that it has no sharp melting point). The fatty acids are saturated or unsaturated fatty acids. Saturated fatty acids are relatively stable. The fat associated substances are phospholipids, cholesterol, carotene and fat soluble vitamins (A, D, E, K).

Phospholipids : Three types of phospholipids, exists ie. Lecithin, Cephalin and Sphingomylin. Lecithin, which forms an important constituent of the fat globule membrane, contributes to the richness of flavour of milk and other dairy products. It is highly sensitive to oxidative changes, giving rise to oxidized / metallic flavours. Phospholipids are excellent emulsifying agents, and no doubt serve to stabilize the milk fat emulsion.

Cholesterol : This appears to be present in true solution in the fat, as a part of fat globule membrane complex and in complex formation with proteins in the non - fat portion of milk.

Fat Soluble Pigments : Carotene is fat soluble and responsible for the yellow colour of milk, cream, butter, ghee, and other fat rich products. Carotene acts as antioxidant and also as a precursor of Vitamin A. One molecule of B -carotene gives two molecules of Vitamin A, where as carotene give one.

Fat Soluble Vitamins : Milk is rich in fat soluble Vitamin ie. A, D, Eand K. Solid - not - fat content contains lactose, proteins and mineral contents.

Milk Sugar or Lactose : This exists in milk only. it is in true solution in milk serum. On crystallization from water, it forms hard gritty crystals. It is one - sixth as sweet as sucrose. Lactose, on crustullization is responsible for the defect known as sandiness in ice - cream or condensed milk. It is fermented by bacteria to yield lactic acid and other organic acids and is important both in the production of cultured milk products and in the spoilage of milk and milk products by souring.

Milk Proteins : The proteins in milk consists mainly of casein, lactaglobulin, lactalbumin, milk serum albumin, immuno globulins etc. Case in forms more than 80% of the total proteins of the milk.

Casein exists only in milk and is found in the form of calcium caseinate phosphate complex. It is present in colloidal state. It may be precipitated by acid,rennet, alcohol, heat and concentration. Casein compose of **a, b** and gamma fraction. **a** - casein micelle in milk. **b** and gamma forms constitutes 22 and 3 percent respectively. **a** – casein constitute two fractions as is calcium sensitive which is coagulated by calcium ions and another form is K-casein which is called calcium insensitive casein fraction, not precipitated by calcium ion. K-casein is the richest repository of carbohydrates as against other casein fractions. It is the site for rennin action. Lactalbumin and lactaglobulin are known as 'whey or serum proteins'.They are also present in colloidal state and are easily coagulated by heat. Milk serum albumin is same as blood serum albumin of the blood. Immunolobulins are present only in colostrum and gives immunity to the calves.

Non protein nitrogenous compounds : Eg : Ammonia, aminiocids, proteose - peptones, urea, uric acid etc.

Mineral Matter or Ash : The mineral matter or salts of milk although present in small quantities, exert considerable influence on the physico-chemical properties and nutritive value of milk. The major salt constituents i.e. those present in appreciable quantities, includes potassium, sodium, magnesium, calcium, phosphate, citrate, chloride, sulphate and bicarbonate.The trace elements includes all other minerals and salt compounds. The mineral salts of milk are usually determained after ashing. Although milk is acidic, ash is distinctly basic. Part of the mineral salts occur in true solution, while a part are in colloidal state.

Other Constituents

Pigments : Water soluble pigments are Riboflevin and Xanthophyll. Riboflavin besides being a vitamin, is a greenish yellow pigment which gives characteristic colour to whey. Earlier it is Known as lactoflavin or lactochrome.

Dissolved Gase : Milk contains gases like 02, Co2, N2 etc.,

Vitamins : Water soluble vitamin B complex and vitamin 'C'.

Enzymes : These are biological catalysts. Milk contains Amylase, Lipase, Phosphatase, protease, peroxidase and catalase enzymes.

Lecture 4: Varieties of milk

Class of milk	Designation	Locality	Minimum percent	
			Milk Fat (4)	MSNF (5)
Buffalo Milk	Raw, pasteurized, boiled, flavoured, sterilized	Assam, Bihar, Chandigarh, Delhi, Gujarat, Haryana, Jharkhand, Maharashtra, Meghalaya, Punjab, Sikkim, Uttar Pradesh, Uttarakhand, West Bengal	6.0	9.0
Buffalo Milk	Raw, pasteurized, boiled, flavoured, sterilized	Andaman and Nicobar, Andhra Pradesh, Arunachal Pradesh, Chhatisgarh, Dadra & Nagar haveli, Goa, Daman & Diu, Himachal Pradesh, Jammu& Kashmir, Karnataka, Kerala, Lakshadweep, Minicoy & Amindivi Island, Madhya Pradesh, Manipur, Mizoram, Nagaland, Orissa, Puducherry, Rajasthan, Tamil Nadu, Tripura	5.0	9.0
Cow Milk	Raw, pasteurized, boiled, flavoured, sterilized	Chandigarh, Haryana, Punjab	4.0	8.5
Cow Milk	Raw, boiled, pasteurized, flavoured, sterilized	Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhatisgarh, Dadra & Nagar haveli, Delhi, Goa, Daman & Diu, Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Lakshadweep, Minicoy & Adminidive Islands, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Puducherry, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, West Bengal	3.5	8.5
Cow Milk	Raw, boiled, pasteurized, flavoured and sterilized	Mizoram , Orissa	3.0	8.5
Goat or Sheep Milk	Raw, boiled, pasteurized, flavoured and sterilized	Chandigarh, Chhatisgarh, Haryana, Kerala, Madhya Pradesh, Maharashtra, Punjab, Uttar Pradesh, Uttarakhand	3.5	9.0
Goat or Sheep Milk	Raw, boiled, pasteurized, flavoured and sterilized	Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhatisgarh, Dadra and Nagar haveli, Delhi, Goa, Daman & Diu, Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Lakshadweep, Minicoy & Amindive Islands, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Puducherry, Rajasthan, Sikkim, Tamil Nadu, Tripura, West Bengal	3.0	9.0
Toned Milk	Pasteurised, flavoured and sterilized	All India	3.0	8.5
Double Toned milk	Pasteurised, flavoured and sterilized	All India	1.5	9.0
Standardized milk	Pasteurised, flavoured and sterilized	All India	4.5	8.5
Full Cream Milk	Pasteurised and sterilized	All India	6.0	9.0
Mixed Milk	Raw, pasteurised, boiled, flavoured and sterilised	All India	4.5	8.5
Recombined Milk	Pasteurised, flavoured and sterilized	All India	3.0	8.5
Skimmed Milk	Raw, boiled, pasteurised, flavoured and	All India	Not more than 0.5 percent	8.7

sterilized.

Lecture 5: Checks for purity of milk

Here are some simple tests that can perform at home to check the quality of the milk:

1. Starch test

Starch, a carbohydrate, is commonly found in potatoes. If added to milk, it reduces its fat content by boosting its carbohydrate content. Just add 2 tablespoons of salt to about 5 ml of the milk you want to test. If the mixture turns blue, then you can be certain that starch has been used for adulteration.

2. Water test

Water in the milk you buy is not going to harm your health as such, unless the water itself is impure. However, its presence means that your milkman or vendor is engaging in a practice that amounts to cheating. In order to check for this, just put a drop of the milk on your fist or a slanted surface and let it slide down. If the milk leaves behind a trail, it has been mixed with water.

3. Chemicals Test

Synthetic milk is usually made by mixing chemicals with soap, and adding them to natural milk. Usually the bad taste gives it away, but if you do not want to risk a taste, then the best ways to ascertain that the milk is synthetic are:

a. Rubbing - synthetic milk feels soapy when rubbed

b. Heating - synthetic milk turns yellowish in colour when heated

4. Reduce it to the last drop

Take about 80 ml milk, and boil it slowly for over 2 to 3 hours, until it solidifies and hardens slightly. If the residue is rock solid, and rough, that means the milk has been adulterated. However, if the residue is oily, then you can rest easy about its quality.

5. Urea Test:

Urea is added to milk by unscrupulous vendors and manufacturers to boost its shelf life. However, it doesn't affect the taste of the milk and, as such, is harder to detect, unlike other adulterants. To detect its presence, mix half tbsp of milk with soybean or arhar powder and shake well. After 5 minutes, place a litmus paper in this solution for 30 seconds. If the litmus paper changes colour from red to blue, your milk has urea.

Chemical tests

Here are some more tests you can perform to check the quality of milk.

1. Checking for Vanaspati/Dalda

Vanaspati is not good for health, especially if consumed in large quantities. To check for vanaspati adulteration, add 2 tbsp of Hydrochloric Acid and 1 tbsp of sugar to 1 tbsp of milk. The mixture will turn red if it the milk is impure.

2. Checking for Formalin

Formalin is a transparent preservative and can be used to store milk for long periods of time. As a result, there is a high chance of formalin being used in packaged milk. The test for formalin's presence however, requires certain precaution. Take 10 ml of milk in a test tube and carefully, add 2-3 drops of Sulphuric Acid to it. If the milk is adulterated with formalin, then a blue ring will appear at the top of the mixture.

Lecture 6: Method of detection of adulterant in milk

Detection of Adultrants of milk
1. Added water: Many methods are used for detection of milk adultration with water.
(a) By estimation of SNF : Estimate the sold not fat content of the sample of milk and calculate the percent of added water using the following formulae

% added water = (S – s)/S x 100
Where S = Standard SNF (9.0 for Buffalo milk, 8.5 for cow milk)
S = SNF of sample milk.
This method is not appropriate, as the people will make up SNF with addition of other adultration listed from 3 to 9 as given above.
(b) Detection of Nitrate : Natural water supplied usually contain nitrates, where as milk contains no appreciable traces, therefore the presence of nitrates in milk may be taken as evidence of watering the milk. The disadvantage of this method is some public water supplies are free of nitrates.
(c) Freezing point test : Freezing point of milk is its most constant property. By using hortvet cryoscope freezing point of milk is estimated. Addition of water will dilute the dissolved constituents so that the freezing point of milk on adultration with water causes less depression. The normal freezing point depression of cow milk is $0.547_{o}C$ and buffalo milk is $0.549_{o}C$. This method cannot detect addition of fat separated milk, as skim milk has the same freezing point will be normal, as acid will give soluble ions to depress the freezing point.
(d) Spectrometric method : Recently spectrometer has been suggested as a means of detecting addition of water to milk. This method will detect 10 % of adultration of milk with water. This method cannot detect pure water as rain water or may upland surface water incomplete.

2. Removal of Fat : Fat being the costly ingredient of milk, some portion of fat is removed. Removal of fat also comes under adultration of milk. Detect the fat Percentage of the sample of milk and calculate the percent of fat removed using the formulae

% of fat removed = (F – f)/F x100

Where F = Standard fat or fat in pure milk.
f = Fat percent in the sample of milk.

3. Addition of Cane Sugar
• Take 10 ml of milk in a test tube
• Add 1 ml of concentrated hydrochloric acid and mix
• Add 0.1 g of resorcinol powder and mix thoroughly.
• Place the test tube in a boiling water bath for 5 minutes and observe for colour
Red colour obtained with resorcinol indicates adultration of milk with cane sugar

4. Addition of starch / Cereal flour
• Take 3 ml of well mixed sample of milk in a test tube
• Boil the milk over a Bunsen burner
• Cool and add one drop of 1 percent Iodine solution ad observe for colour change.
Iodine solution gives intense blue colour with starch due to formation of an unstable complex starch – iodo compound. So development of blue colour indicates adultration of milk with starch / cereal flour.

5. Addition of skim milk powder.

• Take 50 ml in each of two centrifuge tubes and balance properly in the centrifuge.
• Centrifuge at 3000 RPM for 30 mts.
• Decant the supernatant liquid carefully.
• Dissolve the residue in 2.5 ml of concentrated nitric acid.
• Dilute the solution with 5 ml of water
• Add 2.5 ml of liquid ammonia and observe for colour development.

Skim milk powder being highly proteinacious in nature gives orange colour with nitric acid. While unadulterated milk being low in protein content gives only a yellow colour.

6. Addition of Gelatin

• Take 10 ml of milk in test tube
• Add an equal amount of mercuric nitrate solution mercury is dissolved twice of its weight of nitric acid of sp. G. 1.422. Before use this solution is diluted with distilled water to 25 times of its volume.
• Shake and add 20 ml of distilled water shake again and allow to stand.
• Filter after 5 minutes.
• Add to a part of the filtrate an equal volume of picric acid reagent (saturated solution of picric acid solution) and observe. White cloudiness shows the presence of gelatin in the milk. Yellow Precipitate indicates a large amount of gelatin added. Transparent yellow solution indicates absence of gelatin.

7. Addition of Urea

• Take 5 ml of milk sample in 50 ml of conical flask.
• Add 5 ml of sodium acetate buffer or 24% Tricloroacetic acid solution and heat for 3 min in boiling water bath (no heating if Tricloroacetic acid is used).
• Filter the precipitates through a what man no 42. Filter paper and collect 1 ml of filtrate in a test tube.
• Add one ml of sodium hydroxide solution (2% solution) to the filtrate, followed by 0.5 ml of sodium hypochloride solution (2% solution), mix thoroughly and finally add 0.5 ml of 5% (W/V) phenol solution and observe.

A characteristic blue or bluish green colour in the filtrate from the milk with extraneous urea indicate the presence of urea. Colourless indicate no urea added. This will detect even 0.1 percent of urea addition.

8. Addition of Ammonium Sulphate.

• Take 1 ml of milk in a test tube.
• Add 0.5 ml of sodium hydroxide (2%) solution and 0.5 ml of sodium hypochloride solution (2%) and mix thoroughly.
• To the solution add 0.5 ml of phenol solution (5%) and heat for 20 seconds in a boiling water bath, and observe.

A bluish colour immediately forms, which turns deep blue after wards, in the sample of milk having added ammonium sulphate. In case of pure milk only a salmon pink colour forms which gradually changes to bluish in course about 2 hours, even 0.1 % addition of ammonium sulphate can be detected by this method.

9. Addition of Glucose

• Take 1 ml of milk sample in a test tube.
• Add 1 ml of Bar foed's reagent.
• Heat the mixture for 3 minutes in boiling water bath and cool for 3 min under tap water.
• Add one ml of phosphomolybdic acid reagent to the turbid solution and observe.

Immediate formation of deep blue colour indicates the presence of extraneous glucose, which is stable for 24 hours. In case of pure milk only faint bluish colour due to diluted barfoeds reagent appears. But this methods as low as 0.05% extraneous glucose in milk can be detected.

Lecture 7: Handling of freshly produced milk

Grade A milk is carefully produced, processed and packaged in order to protect the safety of the consumer. Grade A milk must be pasteurized to be sold by retailers in interstate commerce. Raw milk is usually pasteurized either by low temperature pasteurization in which the milk is heated to 145 °F or higher for at least 30 minutes, or by high temperature pasteurization in which the milk is heated to 161 °F or higher for at least 15 seconds and then quickly cooled. Pasteurization destroys disease-causing bacteria and extends the shelf life of milk. However, pasteurized milk can readily spoil and could cause foodborne illness if not properly protected and handled.

Maintaining the Safety of Milk: Refrigeration is the single most important factor in maintaining the safety of milk. By law, Grade A milk must be maintained at a temperature of 45 °F or below. Bacteria in milk will grow minimally below 45 °F. However, temperatures well below 40 °F are necessary to protect the milk's quality. It is critical that these temperatures be maintained through warehousing, distribution, delivery and storage.

The cooler refrigerated milk is kept, the longer it lasts and the safer it is. As the product is allowed to warm, the bacteria grow more rapidly. Properly refrigerated, milk can withstand about two weeks' storage.

Infants, pregnant women, the elderly and the chronically ill (such as those undergoing cancer treatments and individuals with AIDS, diabetes or kidney disease) are most at risk from serious illness due to eating any unsafe food. These individuals and those who care for them must be especially careful to handle milk safely.

Fresh Fluid Milk: Fresh milk is categorized mainly by the amount of butterfat it contains. In November 1997, the FDA announced a new rule for milk labeling that helps consumers clarify the difference between 1- and 2-percent milk and reinforces the fact that skim milk is fat-free. Under the new rule, 2-percent milk is renamed reduced fat; 1-percent milk is renamed low-fat; and skim milk is called fat-free or nonfat, although it may contain up to 0.5 grams of fat in a one cup serving.

Buying Fresh Fluid Milk: When selecting milk at the store, make sure it is properly displayed and pay close attention to the date on the label. All fresh fluid milks should be stored at temperatures below 40 °F and should not be stacked high in the display cases. If stored above 40 °F, milk will begin to develop signs of spoilage, including sour odor, off-flavor and curdled consistency. Remember that milk should be taken from the store and quickly placed in your refrigerator at home so that the temperature does not rise above 40 °F. Once you have purchased milk and refrigerated it promptly, it should retain its fresh taste for one to five days beyond the "sell-by" date if kept at the proper temperature. If it spoils before the date expires, this indicates it was not handled properly, and it should be returned to the store for a refund.

Storing Fresh Fluid Milk: Milk should not be left out at room temperature. Pour milk to be used into a serving container and return the original container to the refrigerator. Do not return unused milk that has been sitting out to its original container where it could contaminate the remaining milk. Milk can be stored frozen at 0 °F for up to three months and will be safe to drink if it is thawed in the refrigerator, although it does not retain its smooth texture.

Buttermilk: Originally, buttermilk was made as a by-product when making butter. Lactic acid bacteria are added to fresh, fluid pasteurized skim or part-skim milk to produce the thick, tangy buttermilk. Buttermilk should be handled with the same precautions as regular fluid milk.

Flavored Milk: Chocolate and other flavors – such as maple, strawberry and coffee – may be used for flavored milks. These milks are stored and used as fresh fluid milk.

Lecture 8: Cleaning and sanitization

Cleaning or washing of dairy equipment implies the removal of soil from the surface of each machine. Detergents or cleaning/ washing compounds are the substances capable of assisting cleaning.

The soil consists primarily of milk and milk product residues which may be more or less modified processing treatment or interacts on with water or cleaning materials previously used or by dust, dirt or other foreign matter.

Milk stone is an accumulation of dried milk solids and salts from hard water and washing solutions. All dairy equipment should be properly cleaned as milk provides an excellent medium for the growth of microorganisms. At the same time, detergents used for cleaning should be so selected as not to affect the material of the equipment.

Desirable Characteristics of a good Sanitizer

1. Non toxic
2. Quick acting
3. Relatively non corrosive to hands and equipment
4. Easily and quickly applied
5. Relatively inexpensive

The commonly used dairy sanitizers are hot water, steam, chemical sanitizers (chlorine compounds, iodophors and Quarternary ammonium compounds)

Hot Water: It is one of the most effective germicidal agents as it can contact all clean surfaces of the equipment. It is used in sufficient quantities and it kills a large percentage of the bacteria. To be effective as germicidal agent, water should have temperature of less than 80oC and be circulated for 15 mts. This temperature is taken at the outlet of the processing equipments.

Steam : It is very effective for sterilizing vats, pipe lines and equipments, which can be atleast partially closed during the process. The equipment should attain a temperature of 78^0C for atleast 15 mts or 93^0C for 5 mts.

Chemical Sanitizers

Chemical sanitizers or sterilants are very effective germicidal agents.

Chlorine compounds : Chlorine sanitizers generally corrosive to aluminium, copper tinned surfaces and stainless steel. Corrosion by chlorine is increased by higher temperatures and concentrations. Inorganic compounds include sodium hypochorited and chlorinated trisodium phosphate, and organic compounds are dichloroisocyanurate and chloramines – T, the inorganic agents may be used as sanitizing agents alone. Organic agents may be used with detergents.

Sodium hypochorite containing 10-15% active chlorine with a pH 7-8 will do a good job. The lower pH though increases its effectiveness, but solutions below 7 is highly corrosive to all metals. Chlorinated Trisodium phosphate contains about 3 – 3.5 % available chorine. It is used in combination with appropriate salts. The solution pH used is 8 -8.5. Chlorine – T contains 25% active chorine and rather a slow sanitizer. The working solution should be of pH 7 for satisfactory effectiveness. Halane has 68% available chlorine and behaves much like chloramine – T, Di and Trichloroisocyanuric acid and their salts have 60 – 90% available chlorine and are least corrosive for all chlorine compounds. They can be used at solution pH at as high as 9.5 – 10.0.

The methods of application can include circulation with 200 ppm (0.02%) for 5 mts through pumps, pipelines and coolers immersion in a 200 ppm solution for 5 mts; spraying large open holding vats with 300 ppm solutions with 5 mts contact time. Fogging is carried out closed vats and tankers with 500 ppm solution with special automizing equipment and brushing cheese vat surfaces and agitators weighting vats and similar open vessels with a 400 ppm solution.

Quarternary Ammonium Compounds (QAC) are non irritant to skin and cationic. They possess both antibacterial and surface active properties. They should not be used with anionic wetting agents in which case their effectiveness is greatly reduced. Hard water salts also reduce their bacterial effectiveness. They form deposits on glass surfaces and their last traces are difficult to remove from equipment by rising. Even small residues of QAC may be harmful to starter culture organisms. Their use therefore is limited.

Iodophores : Iodophores are prepared from iodine and suitable nonionic wetting agent which serves as "carrier" of Iodine. Acidified conditions enhance their bacterial activity and those approved for use in the dairying industry are invariably acidified, usually with phosphoric acid. The presence of surface active agents and acids confers detergent properties on these Iodophors and all are classified as detergent sanitizers. However they show only poor affectivity against fat residues.

They will if used regularly, help to prevent accumulation of milk stone, but they should not be expected to remove existing milk stone. They cannot be used at higher temperatures, say higher than 50 oC, as Iodine vapors will be released which are highly corrosive for all metals. Unless the acid content is fairly low, they can corrode all non stainless steel metals to some extent. Some plastic materials and rubber gaskets absorb Iodine and are stained brown.

Acids like nitric acid and phospharic acids are now being used as sanitizers or detergent sanitizers eg. 0.5 litres of nitric acid (60%) per100 litres of water is considered adequate. Sodium hydroxide at 1.5-2 % solution at 45^0C for 2 mts is effective against non- spore forming bacteria.

Principle : In the selection of any particular detergent, consideration should be given to type of soil, quality of water supply, material of surface and the equipment to be cleaned and method of cleaning viz., soaking, brushing, spraying and /or recirculation. Detergents are invariably used as an aqueous solution. In the selection of dairy sanitizers there are two types.

(a) High temperature Sanitizing : Advantages are penetrating ability and quick drying of equipment.

(b)Low temperature Sanitizing : Advantages are, permits sanitizing immediately before equipment is used (when hot equipment will be injurious to the quality of milk / milk products) avoids excessive strain on the equipment and permits flushing out of equipment immediately before use. Generally, chlorine at 15 - 20^0C containing 150-200 ppm available chlorine for 1-2 minutes contact time is used.

The usual procedure for cleaning and sanitization of major items of dairy equipment should consist of-

I. Draining : To remove any residual loose milk and any other matter.

II. Pre-rinsing : With cold or tap water to remove as much milk residue and other matter as possible.

III. Warm to hot detergent washing with detergent solutions of 0.15 to 0.60 % alkalinity, to remove the remaining milk solids.

IV. Hot water rinsing : To remove traces of detergents.

V. Sanitizing to destroy all pathogens and almost all non pathogens.

VI. Draining and drying : To help prevent bacterial growth and corrosion.

Lecture 1: Thermal processing of fluid milk

Introduction to Thermal processing of milk

Although a small amount of milk is still sold as ‘untreated’ or raw, the two main heat treatments used for milk sold in the retail sector are pasteurisation and sterilisation. Treatments somewhere between these are also being used for extending shelf life. The main aims of heat treatment are to reduce the microbial population, both pathogenic and spoilage, in raw milk to inactivate enzymes and to minimise chemical reactions and physical changes.

An overview of the changes taking place when milk is heated is given by Walstra & Jenness (1984). Some important ones are a decrease in pH, precipitation of calcium phosphate, denaturation of whey proteins and interaction with casein, lactose isomerisation, Maillard browning and modifications to the casein micelle. The overall effect is to alter the sensory characteristics, i.e. overall appearance, colour, flavour and texture and the nutritional value as well as making it safe and improving its keeping quality. Most of the milk destined for processing into dairy products is also heat treated in some form, although some cheeses are made from raw milk. One industrial process is thermisation, which involves heating milk at temperatures between 57 and 68◦C for about 15 s. Another is preheating or forewarming, applied to milks prior to evaporation and powder production. Conditions can be as low as 72^0C for low-heat powders and up to 90–95◦C for 5–10 min for high-heat powders, although temperatures above 100^0C for shorter times are also used.

Patterns of consumption and preferences for milk vary from one country to another. For example, in Great Britain in 2003, 92.9% of heat-treated milk for drinking was pasteurised, 1.4% (in-container) sterilised and 5.7% ultra-high temperature (UHT) treated (Anonymous, 2003a). In Australia, the corresponding figures for white milk are 91.9%, 0% and 8.1%, respectively. The balance is totally different in other European countries, and in some, such as France and Germany, UHT milk is the main milk product. Going back about 50 years, only a limited number of products were available. These were mainly white milk, limited flavoured milks and some creams. Domestic refrigeration was not widespread and pasteurised milk stored in the larder would keep for only 24–48 h. Sterilised milk with its characteristic flavour and slightly brown colour was quite popular in the UK and powdered, evaporated and sweetened condensed milks were available. UHT milk was in its infancy and fermented milks were for the future. Heat treatment was on a small to medium scale.

Milk composition

Although there are many sources of data for composition of milk and milk products (McCance & Widdowson (2002), these report average values, giving no indication of the variability of raw milk due to breed, diet, climate and stage of lactation. This should not be forgotten when processing milk or when using data from the literature. The complexity and changing composition of raw milk pose key challenges. Milk is an emulsion, containing fat globules in the range 1–10 microns in diameter, dispersed in an aqueous phase. Above 45^0C, all this fat will be in the liquid phase; below this temperature, it will start to crystallise. This is not an instantaneous process and during crystallisation, latent heat will be released. The proteins in milk are divided into two fractions: (a) the casein fraction and (b) the whey protein fraction. The casein fraction is complex and exists in micelles with a size range of 30–300 nm. In the context of heat treatment, heat stability is very important and is influenced by several factors, particularly pH and ionic calcium.

The casein micelle is remarkably stable to heat, and good quality milk can withstand temperatures of 140^0C for at least 10 min and often longer without coagulating. However, if the milk is not properly handled, its stability can deteriorate drastically. Some manifestations of poor heat stability are fouling or deposit formation on heat exchangers, sediment in milk and heat-induced thickening and coagulation. These problems tend to increase as the processing temperature increases, but are also dependent on raw milk quality. In this context, a very important property is milk acidity, measured as pH or titratable acidity. Whereas pH is a direct measure of H+activity, titratable acidity is a measure of buffering capacity between its own pH and that of the colour change (from colourless to red) in phenolphthalein, which is about 8.3. The pH of milk may influence many other aspects BLBK061-TamimeSeptember 19, 2008 15:19 related to quality, in particular, the colloidal stability of milk and other heat-induced reactions, such as Maillard browning and lactulose formation. Both microbial activity and microbial inactivation are also influenced by pH, as is enzyme activity. The pH of raw milk is usually between 6.6 and 6.7, but it can be outside this range – for example 6.40–6.89 (Tsioulpaset al, 2007a). Its exact value is influenced by its protein, mineral and acid contents. The pH of milk falls during heat treatment, but this is largely reversible on cooling. Walstra & Jenness (1984) illustrated that pH could fall to below 6.0, when the temperature exceeds 100^0C.

Another important determinant is ionic calcium, but its influence on heat stability is less well established, mainly because of difficulties in measuring it. Thus, the pH and ionic calcium in raw milk may be useful heat stability indicators, especially in sterilisation and UHT treatment of normal milk and in situations where milk is fortified with calcium or acidified. Milk is a bland fluid with a characteristic creamy flavour. Because of this blandness, it is very susceptible to off-flavours; for example, a rancid flavour may develop due to excessive agitation of raw milk (Deeth & Fitz-Gerald, 2006). Raw milk from healthy animals has a very low microbial count, but it easily becomes contaminated with spoilage bacteria and perhaps some pathogenic microorganisms. These need to be inactivated and this is readily achieved by heat treatment. From the standpoint of the milk processor, raw milk composition and its microbial loading will vary from day to day.

Reaction kinetics

All thermal processes involve three distinct periods: a heating period, a holding period and a cooling period. In theory, all three periods may contribute to the reactions taking place, although in situations where heating and cooling are rapid, the holding period is the most significant. However, procedures are needed to evaluate each of these periods individually to determine the overall effect. One such example of this approach is offered by Browning et al (2001).

The two reaction kinetic parameters of interest are the rate of reaction or inactivation at a constant temperature (e.g. D and k values), and the effect of temperature change on reaction rate (z and E values).

For pasteurisation processes, the range of interest is 60–80^0C, and for sterilisation, from 100 to over 150^0C. Chemical reaction rates are less temperature-sensitive than microbial inactivation rates. Thus, using heat treatment at higher temperatures for shorter times will result in less chemical damage occurring for an equivalent level of microbial inactivation. In practice, deviations from first order reaction kinetics are often encountered (Gould, 1989),as are deviations from the log–linear relationships between processing time and temperaturediscussed recently by Peleg (2006).

Principles of heat transfer

In thermal processing, the aim is to maximise the rate of heat transfer (Js^{-1}(W) or Britishthermal units(BTU) h^{-1}), i.e. to heat and then cool the product down as quickly as possible. This will improve the economics of the process and in many cases also lead to an improvement in product quality. Heating processes can be classified as direct or indirect.

The most widely used is indirect heating, where the heat transfer fluid and the milk are separated by a barrier; for in-container sterilisation this will be the wall of the bottle and for continuous processes, the heat exchanger plate or tube wall. In direct processes, steam is the heating medium and the steam comes into direct contact with the milk. Indirect heating also implies that the two fluids will not come into direct contact. It is important to ensure that this is the case, and the integrity of the barrier is a very important safety consideration, especially in the regeneration section where the heating medium is the hot heat-treated milk.

The heating medium is usually saturated steam but hot water and hot air are sometimes used. At temperatures above 100◦C, the steam and the hot water are above atmospheric pressure. For steam, there is a fixed relationship between its pressure and temperature, given by the steam tables (Lewis, 1990; Holdsworth, 1997). Thus, a steam pressure gauge will act indirectly as a second temperature-monitoring device. Discrepancies between temperature and pressure readings suggest that there may be some air in the steam or that the instruments are incorrect (Lewis & Heppell, 2000). Cooling is achieved using mains water, chilled water or glycol. Regeneration is used in continuous processes to further reduce energy utilisation. Heating can be by either batch or continuous processing.

Thermisation and tyndallisation

Thermisation is the mildest heat treatment given to milk. It is used to extend the keeping quality of raw milk when it is known that raw milk may be held chilled for some time, prior to being further processed. The aim is to reduce the growth of psychrotrophic bacteria, which may release heat-resistant proteases and lipases into the milk. These enzymes will not be totally inactivated during pasteurisation and may give rise to off-flavours if the milk is used for cheese or milk powders. Conditions used for thermisation are 57–68^{0}C for 15s, followed by refrigeration. Thermised raw milk can be stored at a maximum of 8^{0}C for up to 3 days (IDF, 1984). The milk should also be phosphatase-positive in order to distinguish it from pasteurised milk, which is phosphatase-negative. It is usually followed later by pasteurisation or a more severe heat treatment.

Another thermal process, which has been investigated, is tyndallisation; it involves successive heat treatments in order to inactivate spores. According to Wilbey (2002), Tyndall in 1877 suggested that if a medium was heated at 100^{0}C for 3 min on 3 successive days, first the vegetative cells would be killed and the spores would germinate, and then be killed on either the second or third days. In practice, such double heat treatments are rarely encountered, and the process is not successful in totally inactivating spores because of the unpredictability of the spore germination process. The same applies to double pasteurisation processes, which have not been found to be effective (Brown et al., 1979).

Lecture 2: Pasteurization (LTLT and HTST)

Introduction and principles

In terms of historical perspective, two key references still worth consulting are Cronshaw (1947) and Davis (1955). The first holder pasteurisation system was introduced in German in 1895 and in the USA in 1907. Thus by 1895, it was well recognised what was required for an effective pasteurisation process: 'we know that this process (pasteurisation) if properly carried out will destroy all disease germs' and 'a thoroughly satisfactory product can only be secured where a definite quantity of milk is heated for a definite period of time at a definite temperature. Then too, an apparatus to be efficient must be arranged so that the milk will be uniformly heated throughout the whole mass. Only when all particles of milk are actually raised to the proper temperature for the requisite length of time is the pasteurisation process complete.' This sound advice has withstood the test of time and forms the main thrust of current milk heat treatment regulations, reviewed recently by Komorowski (2006).

High-temperature, short-time (HTST)

High-temperature, short-time (HTST) continuous processes were developed between 1920 and 1927, and for some time, the ability of this process to produce safe milk was questioned. In 1927, North and Park established 15 combinations of temperature and time, which inactivated the tuberculosis bacillus (Cronshaw, 1947). These experiments were performed by heating milk heavily infected with bacilli under different conditions and injecting the treated bacilli into guinea pigs. Successful temperature–time combination heat treatments, i.e. those where the animals survived, ranged from 54.4^0C (130^0F) for 60 min up to 100^0C (212^0F) for 10 s. Others were 71.1^0C (160◦F) for 20 s or 60^0C (140^0F) for 10 min. Further developments were made in the classification of tests for evaluating the pasteurisation process. These included tests for raw milk quality: (a) as visual inspection and detection and removal of faulty milk on arrival at the dairy (i.e. the platform test, Davis, 1955), (b) assessing pasteurisability by the survival of thermodurics (c) measuring the efficiency of pasteurization by measuring pathogen inactivation and phosphatase activation, first described in 1935 on the basis of the finding that conditions required to inactivate Mycobacterium tuberculosis were just slightly less than those required to inactivate alkaline phosphatase, (d) assessing recontamination in terms of thermophilic and coliform bacteria, and the methylene blue test and (e) measuring general bacterial quality, including organisms surviving pasteurization together with contaminating organisms (plate count). The methylene blue test is now little used, but the detection of alkaline phosphatase activity is still used as a statutory test in many countries.

Moving toward the present, pasteurisation has been defined by the International Dairy Federation (IDF, 1986) as a process applied with the aim of avoiding public health hazards arising from pathogenic microorganisms associated with milk, by heat treatment which is consistent with minimal chemical, physical and organoleptic changes in the product. According to Codex Alimentarius (Anonymous, 2003b),Pasteurisation is a heat treatment aimed at reducing the number of any harmful microorganisms in milk and liquid milk products, if present, to a level at which they do not constitute a significant health hazard. In addition, it results in prolonging the keepability of milk or the liquid milk product and in only minimal chemical, physical and organoleptic changes. Pasteurisation conditions are designed to effectively destroy the organisms (Mycobacterium tuberculosis and Coxiella burnetti). Pasteurisation of milk and cream results in a negative alkaline phosphatase reaction immediately after the treatment. For milk, the minimum pasteurisation conditions are those having bactericidal effects equivalent to heating every particle of the milk to 72^0C for 15 s (continuous flow pasteurisation) or 63^0C for 30 min (batch pasteurisation). Other equivalent conditions can be obtained by plotting a line joining these points on a log time versus temperature graph. Pasteurisation causes little change to the colour, flavour and appearance of the milk, (although devotees of raw milk will contest this), and no significant reduction in nutritional value. It causes minimal whey protein denaturation (5–15%) and does not alter enzymatic coagulation properties during the manufacture of cheeses.

Pasteurised products should last for up to 48 h without refrigeration (at, say, 20^0C), and for several days when stored refrigerated. However, longer keeping qualities and between 10 and 16 days at 4◦C are now achievable, when produced from high-quality raw milk, under optimum technical and hygienic conditions. Milk can still be pasteurised by the holder or batch process at 63^0C for 30 min, but as discussed earlier, the HTST process now predominates, with capacities over 50 000 l h1 and running times of up to 20 h.Minimal conditions are at 72^0C for 15 s, but the actual conditions will vary from country to country. A recent survey of the conditions used in Australian factories revealed a range from 72^0C for 15 s to 78–80^0C for 25 s (Juffs & Deeth, 2007). The more severe heating conditions are being used as a precautionary measure for the presence of any heat-resistant Mycobacterium avium subsp. Paratuberculosis (MAP). As described elsewhere, the holding tube temperature and time is not the whole story, and the heating and cooling periods provide an extra margin of safety.

The original phosphatase test for assessing the adequacy of pasteurisation was based on the reaction of phosphatase with disodium phenyl phosphate. If phosphatase is present, it will release phenol, which is determined colorimetrically (Davis, 1955). It was claimed to be able to detect the presence of about 0.2% raw milk (addition) in pasteurised milk, as well as under processing, for example 62^0C instead of 62.8^0C for 30 min or 70^0C rather than 72^0C for 15s. Since then, a more automated test based on fluorescence measurement (e.g. Fluorophos) has increased the sensitivity of the method further, being able to detect the presence of 0.006% added raw milk. This is a very useful quality assurance test procedure, and its introduction should further help detect low levels of post-pasteurisation contamination, which should also reduce the incidence of pathogens in pasteurised milk. Tests for detecting post-pasteurisation contamination are reviewed in IDF (1993).

Methods of pasteurization

Holder or batch heating

Cronshaw (1947) and Davis (1955) both provide excellent descriptions of equipment for the holder or batch process – individual vessels (heated internally) and externally heated systems with one or more holding tanks. The batch heating time and factors is still being used in many countries in some small-scale pasteurisation processes. In answer to the question – Does HTST pasteurisation result in as good a bottle of milk as does the holder process, Yale in 1933 concluded that one method of pasteurisation produces as good a bottle of pasteurized milk as does the other when sound methods are used and when conditions are comparable.

Continuous heating

The main types of indirect heat exchanger for milk are the PHE and the tubular heat exchanger (THE). PHEs are widely used for pasteurisation processes; they have a high overall heat transfer coefficient (OHTC), and are generally more compact than THEs. Their main limitation is pressure, with an upper limit of about 2 MPa (20 bar). The normal gap width between the plates is between 2.5 and 5 mm, but wider gaps are available for viscous liquids to prevent large pressure drops. In general, PHEs are the cheapest option, and the one most widely used for low-viscosity fluids. Maintenance costs may be higher, as gaskets may need replacing, and the integrity of the plates also needs evaluating regularly. This

is especially so for plates in the regeneration section, where a cracked or leaking plate may allow raw milk to contaminate already pasteurised milk. They are also more prone to fouling-related problems.
THEs have a lower OHTC than plates, and generally occupy a larger space. They have slower heating and cooling rates with a longer transit time through the heat exchanger. In general, they have fewer seals, and provide a smoother flow passage for the fluid. A variety of tube designs are available to suit different product characteristics. Most tubular plants use a multi-tube design. They can withstand higher pressures than PHEs. Although they are still susceptible to fouling, high pumping pressures can be used to overcome the flow restrictions. THEs give longer processing times than PHEs with viscous materials and with products, which are more susceptible to fouling. The viscosity of the product is one major factor, which affects the choice of the most appropriate heat exchanger and the selection of pumps. Viscosity will influence the pressure drop causing a problem in the cooling section and when phase transition may take place, for example if coagulation or crystallisation takes place. For more viscous or particulate products, e.g. starch-based desserts or yoghurt with fruit pieces, a scraped surface heat exchanger may be required.
One of the main advantages of continuous systems over batch systems is that energy can be recovered in terms of regeneration. The hot fluid can be used to heat the incoming fluid, thereby saving on heating and cooling costs. Regeneration efficiencies over 90% can be obtained. Although high-regeneration results in considerable savings in energy, it necessitates the use of higher surface areas, resulting from the lower temperature driving force, and a slightly higher capital cost for the heat exchanger. This also means that the heating and cooling rates are also slower, and the transit times longer, which may affect the quality.

Factors affecting the quality of pasteurised milk

The main control points for ensuring good quality pasteurised milk products are

- raw milk quality,
- processing conditions: temperature and holding time,
- post-processing contamination (PPC) and
- storage temperature.

Raw material quality

Raw milk may contain pathogenic microorganisms from the farm environment, including vegetative bacteria, such as Staphylococcus aureus, Campylobacter jejuni, Salmonella spp.,Escherichia coli, Yerisinia enterocolitica, and spore formers, such as Bacillus and Clostridium species. These major vegetative pathogens can be effectively controlled by pasteurisation, and are not the main determinants of keeping quality. The main interest is in what survives pasteurisation or mild heat treatments. Thermoduric bacteria are defined as those which survive pasteurisation conditions, e.g. 63^0C for 30 min or 72^0C for 15s, whereas spores produced by spore-forming bacteria survive 80^0C for 10 min.Bacillus cereus spores are relevant here, being the main pathogen which will survive pasteurisation and grow at low temperature. Bacillus can cause defects in heat-treated milk, for example bitty cream, and produce an intense bitter flavour, but it rarely causes food poisoning because infected products are so unacceptable.

Processing times and temperatures

Normal HTST conditions for milk are 72^0C for 15 s. One interesting question relates to the use of higher temperatures (up to 90^0C) for pasteurisation. In general, milk treated at such a temperature has a reduced keeping quality compared to milk heated at 72^0C for 15 s. This was first recognised by Kessler & Horak (1984), and then by Schroder & Bland (1984),Schmidtet al. (1989), Gomez Barroso (1997) and Barrett et al.(1999). It is a question that should be often revisited, since it would be logical to expect a more severe heating process to result in improved keeping quality. Another drawback is that a cooked flavor will start to be noticeable between 85 and 90^{0}C. Thus, those using or considering using more stringent pasteurisation conditions than the minimum conditions should be aware of these disadvantages. The usual explanation for this unexpected phenomenon is that the more severe conditions cause heat shocking of the Bacillus spp. spores which can then germinate, grow and reduce the keeping quality of the milk. However, recent evidence suggests that the lactoperoxidase system (LPS) also plays a role. The LPS involves the enzyme lactoperoxidase, hydrogen peroxide and thiocyanate, all of which are present in raw milk. The oxidation products, e.g. hypothiocyanite, exhibit strong anti-microbial activity by oxidising sulphydryl groups of bacterial cell walls (Reiter & Harnulv, 1982). One parameter which has been used for some considerable time to compare pasteurization processes is the pasteurisation unit (PU). One PU results from a heat treatment at 60^{0}C for 1 min, and the equivalent z-value is high (10^{0}C); thus, the number of PUs is given by:

PU=10T−6010t, where
t=time (min)
Thus, a treatment at 63^{0}C for 30 min would have a value of~60, whereas HTST conditions would give a value of about 4. Clearly, there is an inconsistency here, no doubt derived from the high z-value chosen for this calculation.

Post-pasteurisation contamination

Post-pasteurisation contamination (PPC) was recognized as a problem in the 1930s, and is now considered to be a very important determinant of keeping quality. Muir (1996a,b) describes how this was recognised both for milk and for cream in the early 1980s. PPC encompasses the recontamination of the product anywhere downstream of the end of the holding tube. It can occur in the regeneration or cooling sections, in storage tanks and in the final packaging of the product, due to poor hygienic practices. It can greatly be reduced by ensuring that all internal plant surfaces in contact with the product are heated at 95^{0}C for 30 min. It can only be completely eliminated by employing aseptic techniques downstream of the holding tube. One of the main safety concerns is recontamination of the product with pathogens from raw milk, and this could occur due to bypassing of the holding tube by a number of possible routes, including pinhole leaks in plates and through pipelines that have been set up for cleaning and disinfecting. In terms of reducing keeping quality, recontamination with Gram-negative psychrotrophic bacteria is very important.

Storage temperature and time

In general, the lower the storage temperature, the better will be the keeping quality, bearing in mind the costs and practical problems of ensuring low temperatures throughout the cold chain and in domestic refrigerators. Before domestic refrigeration was commonplace,Cronshaw (1947) reported that the shelf life of pasteurised milk was about 24 h. Household refrigeration helped to improve this considerably, and in the UK by 1957, 10% of households had a refrigerator, increasing to 30% by 1962 and up to 90% by 1979. Raw milk is stored at typically 4◦C; temperatures in the cold chain are slightly higher, and are likely to be higher still in domestic refrigerators. Many of our results have confirmed that pasteurized milk produced from good quality raw milk could be stored for up to 18 days at 8^{0}C and between 25 and 40 days at 4^{0}C (Ravanis & Lewis, 1995; Gomez Barroso, 1997). However, it must be emphasised that these experiments were performed with good quality raw milk, i.e. the counts immediately after pasteurisation were never above 10_3 colony-forming units(cfu) mL_{-1} even for raw milk stored for up to 8 days at 4^{0}C prior to pasteurisation. Also,care was taken to minimise PPC. These results also illustrate that good keeping quality can be achieved by eliminating PPC, and can be further enhanced by using low storage temperatures.

Lecture 3: Sterilization and UHT techniques

Sterilisation – safety and spoilage considerations

Sterilisation of milk to enable it to be kept at room temperature for several months became a commercial proposition in 1894. Milk can either be sterilised in bottles or other sealed containers, or by continuous UHT processing followed by aseptic packaging (see below). Very good accounts of the procedures for producing in-container sterilised milk and problems associated with it have been provided by Cronshaw (1947) and Davis (1955). From a safety standpoint, the primary objective is the production of commercially sterile products with an extended shelf life. The main concern is inactivation of the most heat resistant pathogenic spore, namely Clostridium botulinum. Since milk is a low-acid food (pH>4.5), the main criterion is to achieve 12 decimal reductions of Cl.botulinum. This occurs when a product is heated at 121^0C for 3 min, at its slowest heating point (Anonymous, 1991). The microbial severity of an in-container sterilisation process is traditionally expressed in terms of its Fo value. This takes into account the contributions of the heating, holding and cooling periods to the total lethality and is expressed in terms of minutes at 121^0C. It provides a useful means of comparing processes. The minimum Fo value for any low-acid food should be 3.

In-container sterilization

Foods have been sterilised in sealed containers, such as cans, for over 200 years. Milk was originally sterilised in glass bottles sealed with a crown cork, but more recently, plastic bottles have been used. Milk sterilisation really developed after 1930 with the advent of the crown cork, which helped with the mechanisation of the bottle-filling process, and the reuse of bottles. In general, the basic principles have remained the same. The main aim is to inactivate heat-resistant spores, thereby producing a product which is 'commercially sterile', with an extended shelf life. Practical drawbacks of in-container sterilisation processes are that the product heats and cools relatively slowly, and that temperatures are limited by the internal pressure generated. However, many dairy products are still produced this way worldwide, including sterilised milk, evaporated milk and canned desserts such as custard and rice pudding. Sterilised milk is still produced in many countries, and in essence, the manufacturing procedure is not too far removed from that used over 50 years ago. Milk is clarified using a centrifuge, e.g. a Bactofuge TM, with claimed spore removal of greater than 99% (2 log 10 reductions). It is heated using similar equipment to that used for pasteurisation. It is then homogenised at 63–82^0C, for example at a single-stage pressure of about 20 MPa or double stage at about 17 and 3.5 MPa. It is then filled into glass bottles between 74 and 80^0C under conditions which give minimal frothing, and sealed using a crown cork. Plastic bottles are sealed at a lower temperature of 54–55^0C. Care should be taken to avoid conditions in balance tanks, which may be conducive to growth of thermophiles.

UHT processing
Introduction and principles

UHT processing of milk combined with aseptic packaging was introduced to produce a shelf-stable product with minimal chemical damage compared with in-container sterilized milk. UHT milk may have a shelf life of up to 12 months, although in practice, it is usually consumed much earlier than this. In countries where it is a minor segment of the milk market, it is often used as a convenience product, and used when pasteurised milk is not available; whilst in countries where it is the major type of milk available, it is used regularly. In the former situation, UHT milk may need to be stable over a long period of time, while in the latter case, the desired shelf life may be $\leq$3 months. UHT treatment is normally in the range 135–150^0C in combination with appropriate holding times necessary to achieve 'commercial sterility'; i.e. microorganisms are unlikely to grow in the product under the normal conditions of storage (Burton, 1988; Lewis & Heppell 2000; Anonymous, 2003b). In practice, the products are checked for sterility by incubating at 55^0Cfor7daysorat30^0C for 15 days, and testing for bacterial growth.

Methods of UHT processing

Background

UHT heating can be either 'direct' or 'indirect'. In direct heating, superheated steam is mixed with milk while, in indirect heating, a heat exchanger transfers heat across a partition between the milk and the heating medium, either steam or hot water (Mehta, 1980; Burton, 1988). In THEs, the partition is the wall of the stainless steel tube, and in PHEs, it is the stainless steel plate. The UHT process involves the following stages: preheating with heat regeneration, holding at preheat temperature, heating to sterilisation temperature, holding at sterilisation temperature, cooling and aseptic packaging. In addition, a homogenization step is usually included either before or after the high-heat holding section. In commercial processing of UHT milk, preheating (to~80–95^0C) is usually achieved by using the hot processed milk to heat the incoming cold raw milk. This enables much of the heat used in the process to be regenerated and the cooling water requirement to be reduced (Lewis & Heppell, 2000). The preheated milk is often held for a short time (15 s to a few min) to denature the whey proteins, principally-lactoglobulin, to reduce their ability to foul, or deposit on, the hot surfaces of the high-temperature heating section (Burton, 1988). This processing approach, which is known as a 'protein stabilisation' step, is not usually employed in direct plants because they are much less likely to foul in the high-heat section than the indirect plants due to the reduced access of the milk to high-temperature surfaces.

Direct heating

There are two major types of direct heating UHT systems known as steam injection (steam into milk) and steam infusion (milk into steam). In the former, superheated steam is 'injected' into a stream of milk, while in the latter, milk is sprayed into or allowed to fall as a thin film or fine streams, through a chamber of superheated steam. A major feature of these two systems is the almost instantaneous rise in the temperature of the milk from preheats to sterilization temperature through the transfer of the latent heat of vaporization of the steam to the milk. During this heating stage, steam is condensed, and the milk is diluted with water. The degree of dilution depends on the temperature rise of the milk, but for an increase in temperature of 60^0C (e.g. from 80^0C to 140^0C), it is approximately 11% (Lewis & Heppell, 2000). After the milk passes through the high-heat-holding tube, the entrained water is removed in the vacuum chamber, which also rapidly cools the milk to approximately the same temperature as that of the preheated milk. To ensure neither dilution nor concentration of the milk occurs, the total solids of the incoming milk and the processed milk are monitored, and the temperature in the vacuum chamber adjusted if necessary. The steam used in direct UHT plants must be of high-quality, culinary grade. Poor-quality steam can lead to carry over of off-flavours into the milk (Burton, 1988).

Indirect heating

In indirect heating using PTEs or THEs, the heating medium is either steam or superheated water. When water is used, it flows in the reverse direction to that of the milk. The reverse flow minimises the temperature differential between the two liquids and, in turn, minimizes the amount of burn-on. Hot water is a significantly better heating medium than steam with respect to burn-on and flavour of the product as it enables a smaller temperature differential between the milk and the heating medium (Dentener, 1984). Heating from the preheat temperature to sterilisation temperatures and initial cooling of the sterilised milk is much slower in indirect systems than in direct systems. For example, Biziak et al.(1985) reported less than 1 s for each heat transfer operation in direct heating compared with greater than 10 s with indirect methods. In practice, the heating times frompreheat to final UHT temperature can be up to 100 s (Tran et al.,2008). Therefore, for a given temperature increase, indirect processes are more severe than direct processes.

Lecture 4: Packaging of fluid milk

FLIUD MILK

Liquid milk forms a major item of food in our country especially in rural areas. It forms the major ingredient in beverages, tea and coffee and essential part of the diet either as milk itself or as curd, butter milk,ghee and savories. Surplus milk is marketed by door-to-door vending and the containers used are often unhygienic. Also, loose-vending introduces the possibility of mixing with water and also harmful ingredients. Hence, proper packaging assumes greater importance in the distribution of raw and pasteurized milk in hygienic and wholesome form in specified volumes leading to consumer convenience and safety.

Milk, being a complex physico-chemical system, consists of a water solution of salts, lactose, lactalbumin, etc. Proteins are dispersed in a colloidal form while milk-fat solids are present in a partially emulsified suspension.Milk is susceptible to oxidation of fat (phospholipids in milk) which produces a waxy odour. This deteriorative change is enhanced by heat, acid and metallic ions. Exposure of milk to natural and artificial (fluorescent) light leads to deterioration in quality and loss of vitamins. Hence, a package intended for milk should possess the following protective functions:

i)Protection against contamination due to dirt and microorganisms.
ii)Protection against light and heat
iii)Protection against external odours.
iv)Physical protection to withstand distribution hazards.

Bulk Distribution of Milk

The conventional containers for bulk packaging and distribution are the aluminium cans with lids, while in recent years, bulk vending by machines through operation by token system has become popular. This system is now operating successfully in many cities. Bulk vending is well suited to Indian consumers since it allows the purchase of relatively small quantities of milk, two times a day and use of buyersí own containers avoiding the costand inconvenience of handling bottles or pouches. The system ensures hygienic, good quality milk at a price reflecting low overheads and low packaging costs. It is claimed that the capital cost of bulk vending system is nearly 20% less than the bottling system and the operating and running cost less than 50%. The milk losses are claimed to be between 0.50 and 0.65%.

Distribution in Bottles

This was the most universally accepted milk distribution system before the advent of single-serve containers. The bottling system is highly capital intensive ó not only the bottle filling and washing machines are costly, but the system requires larger operational areas, large store space, and fully automatic machines are difficult and expensive to maintain while the manual systems require a large labour force.

Distribution in Non-Returnable Containers

Plastic pouches:

Most of the dairies in cities of India have introduced packaging and distribution of milk through polyethylene pouches. The plastic pouches are single-trip packages, very light in weight, and hence distribution costs are less compared to glass bottles. Losses during pouch filling are less than bottle filling and less floor space is required for packing section and cold storage. Bureau of Indian Standards prescribes requirements and testing of polyethylene pouches for the packing of pasteurized liquid milk in

1 litre and Ω litre capacities in IS:11805-1986. According to this standard, the pouches should be made from virgin polyethylene (LDPE, LLDPE, HDPE or EVA) for meeting the food grade requirements. Initially, LDPE film was used for milk packaging but now LLDPE is the preferred choice.

Paperboard Cartons

The material cost for paper board cartons is very high so also the capital cost of filling machines. The overall distribution cost for pasteurized milk in carton is said to be more than 1Ω times as compared to the bottles and for sterilized milk aseptically packed, it is more than twice. Since this precludes the capture of major share of market, however, it can be used to meet the requirement of specific market segment. Liquid milk is packed in carton systems of Tetrapak, Tetrabrik and Purepak. The equipment necessary to produce tetrabrik is expensive to instal, but its advantages include a PE-lining which is strong and does not leak, and a lower price per unit of milk in running costs.

Sterilized Milk

The ultra-high temperature treatment of milk sterilization kills all vegetative cells and spores with very little effect on flavor or loss of nutrients. The milk is then filled in sterile containers (for ex., Tetrabrik cartons) under aseptic conditions. Such cartons made of paper board/aluminium foil/PE, in the absence of ambient air provided best protection against loss of ascorbic acid and vitamin B (riboflavin and folic acid) and maintained best organoleptic properties when stored upto 4 months at ambient temperature conditions. In the presence of air, the keeping quality was maintained upto 3 months. Sterilized milk when packed in ordinary plastic containers acquired unacceptable smell and taste.

Lecture 5: Fermentation of milk and fermented milk products

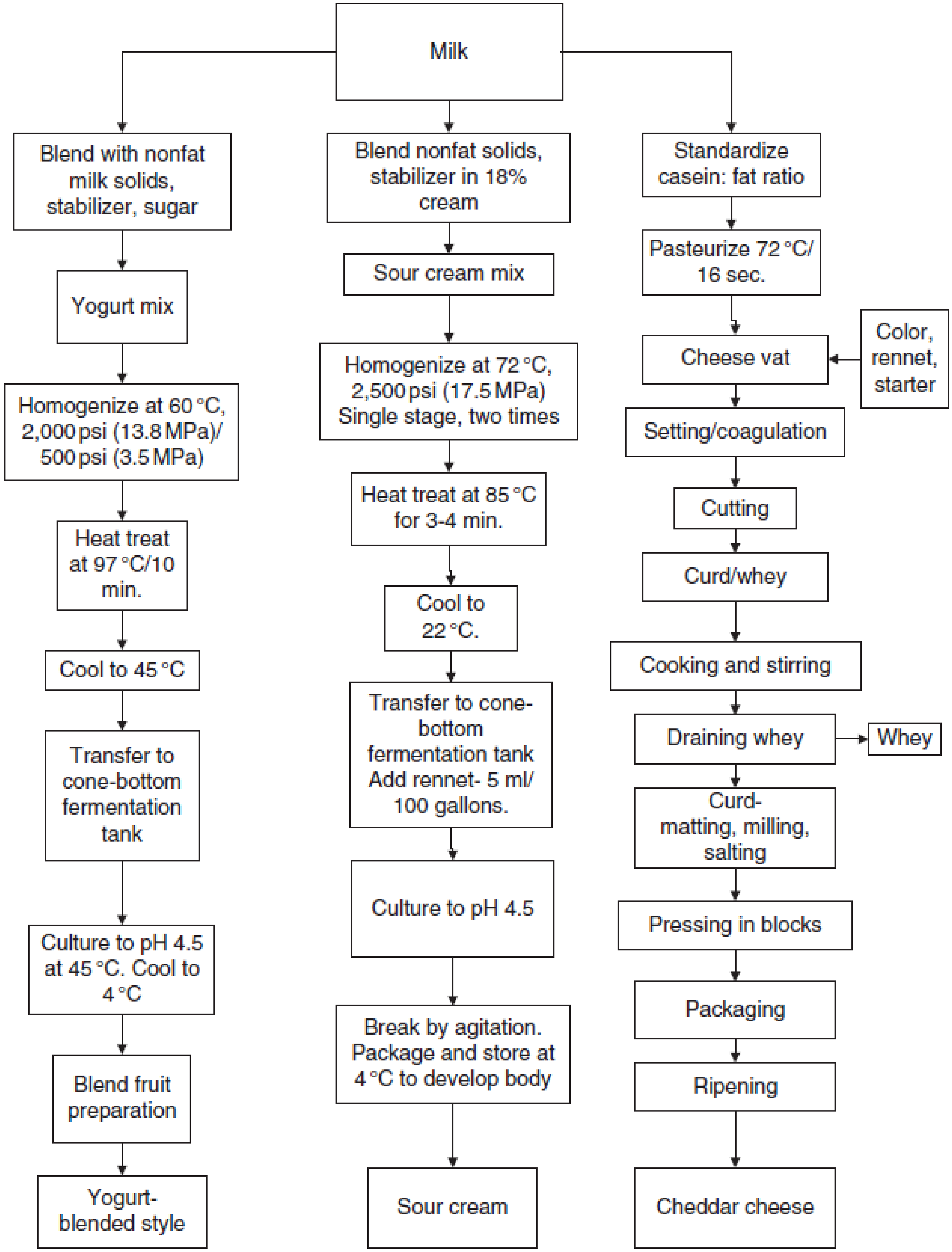
Fermented milk foods with desirable characteristics of flavor, texture, and probiotic profiles can be created by formulating the desired chemical composition of the milk substrate mix, judicious selection of lactic acid bacteria (starter), and fermentation conditions (Chandan, 1982; Chandan & Nauth, 2012; Chandan & Shahani, 1993, 1995). A starter is made up of one or more strains of food-grade microorganisms. Individual microorganisms utilized as a single culture (single or multiple strains), or in combination with other microorganisms, exhibit characteristics impacting the technology of manufacture of fermented milks.

The most common lactic acid bacteria employed for fermented dairy foods are:*Lactobacillus delbrueckii* subsp.bulgaricus, *Streptococcus thermophilus*, *Lactobacillus acidophilus*, *Lactococcus lactis* subsp. lactis, and *Lactococcus lactis* subsp.cremoris. They are responsible for the acidic taste arising from lactic acid elaborated by their growth.Leuconostoc spp. are used for typical flavor in sour cream.In cheeses, Lactococcus lactis subsp. lactis/cremoris,*Lactobacillus helveticus*, *Lactobacillus delbrueckii* subsp.bulgaricus, and *Streptococcus thermophilus* are employed for acid and distinct flavor development, while Propionibacterium shermanii secretes propionate, a natural shelflife extender. Furthermore, it is possible to deliver health-promoting microflora to the consumer of the food.In this regard, yogurt cultures,Lactobacillus delbrueckii subsp. bulgaricus(LB),Streptococcus thermophilus(ST),Lactobacillus acidophilus, Lactobacillus casei, and Bifido-bacterium species are notable examples.

General principles of fermented dairy foods manufacture

Fermented milks are generally made from a mix standardized from whole, partially defatted milk, condensed skimmilk, cream and/or non-fat dry milk. Yogurt is made from fat-standardized milk fortified with non-fat milk solids.Cultured sour cream is made from 18% fat cream supplemented with some non-fat milk solids for textural improvement. Many cheeses are made from pasteurized milk standardized for fat:solids-not-fat ratio. Standards of identity established by regulatory authorities in each country assure the consumer a defined product.

Yogurt is produced from the milk of various animals (cow, water-buffalo, goat, sheep, yak, etc.) in various parts of the world. Cow's milk is the predominant starting material in industrial manufacturing operations in the US. In order to achieve a custard-like semi-solid consistency, the cow's milk is fortified with dried or con densed milk. In the production of cheeses, acid formation accelerates the activity of coagulating enzymes (chymosin), leading thereby to the formation of curd. The activity of the starter and other organisms during the aging of cheese leads to breakdown of casein and milk fat, giving particular cheeses their typical flavor and textural characteristics (Fox, 2003b; Singh & Cadwallader,2008). The reader is referred to extensive literature on cheeses, including a series of articles on types, starter cultures, their chemistry and microbiology, manufacture of various types, and flavor generation (Bottazzi, 2003;Chandan, 2003; Farkye, 2003; Fox, 2003a, 2003b; Fox & McSweeney, 2003; McSweeney, 2003; Olsen, 2003;Stanley, 2003).


Milk
Blend with nonfat milk solids, stabilizer, sugar
Yogurt mix
Homogenize at 60 °C, 2,000 psi (13.8 MPa)/ 500 psi (3.5 MPa)
Heat treat at 97 °C/10 min.
Cool to 45 °C
Transfer to cone-bottom fermentation tank
Culture to pH 4.5 at 45 °C. Cool to 4 °C
Blend fruit preparation
Yogurt-blended style
Blend nonfat solids, stabilizer in 18% cream
Sour cream mix
Homogenize at 72 °C, 2,500 psi (17.5 MPa) Single stage, two times
Heat treat at 85 °C for 3-4 min.
Cool to 22 °C.
Transfer to cone-bottom fermentation tank Add rennet- 5 ml/ 100 gallons.
Culture to pH 4.5
Break by agitation. Package and store at 4 °C to develop body
Sour cream
Standardize casein: fat ratio
Pasteurize 72 °C/ 16 sec.
Cheese vat
Color, rennet, starter
Setting/coagulation
Cutting
Curd/whey
Cooking and stirring
Draining whey
Whey
Curd-matting, milling, salting
Pressing in blocks
Packaging
Ripening
Cheddar cheese

Lecture 7: Therapeutic value of Fermented Products

For several thousand years people have been consuming fermented milks. It is an old consideration that they are health beneficial. They itself have all the milk components modified by lactic acid bacteria (LAB) fermentation. Lactic acid is produced by fermentation of lactose. It minimizes the pH, affects the casein physical properties and consequently enhance digestibility. It also meliorates the usage of calcium and different other minerals and suppress the development of potentially injurious bacteria. Fermented milk can be endured by individuals having a reduced ability for lactose digestion due to its smaller lactose content (McBean, 1999). Protein degradation is due to the effect of proteolytic activity of LAB that results in some bioactive peptides and free amino acids. Bioactive peptides are a common supplement to the functional foods and milk proteins are the major source of a variety of Biologically active peptides for instance, casokinins, casomorphins, immunopeptides, lactoferricin, phosphopeptides, and lactoferrin. Several bioactive peptides derived from milk protein are inactive inside the parent protein sequence and can be generated by enzymatic proteolysis in food processing or gastrointestinal digestion. Immunomodulation, anti-thrombotic activity, mineral or vitamin binding, blood pressure regulation and anti-microbial activity are the major biological activities of such peptides. The fermented milks also are main source of whey proteins like lactalbumin, lactoperoxidase, lactoglobulin, immunoglobulins and lactoferrin. These proteins have exhibited a number of biological effects having various effects on the functions of digestion and anti-carcinogenic activities.

During the process of fermentation the digestibility of fat is also improved. High percentage of saturated fatty acids is present in milk fat. It is frequently advised to avoid its use as it leads to coronary heart disease and an atherogenic profile of blood. The composition of milk fat shows that only three (palmitic, myristic and lauric acids) of the several different saturated FAs in milk have the property to raise the blood cholesterol level. At least about one third of the FAs are unsaturated having a tendency to lower the level of cholesterol. Moreover, fermented milks contain components that are protective if they do not have hypoholesterolemic effect. These comprise conjugated linoleic acid (CLA), linoleic acid, calcium, probiotic bacteria or lactic acid bacteria and antioxidants (Rogelj, 2000). The milk fat comprises of several components like sphingomyelin, CLA, butyric acid, carotene, ether lipids and vitamins D and A, having anti-carcinogenic effects. Several animal studies reveal that fermented milk inveterate the anti-carcinogenic action of CLA as well as its part in atherosclerosis prevention and in modulation of immune system (MacDonald, 2000).

BENEFITS OF FERMENTED FOODS

1.Optimize your immune and defense system against disease.The skin and the lining of our intestinal system is the first line of defense against the outside world. Housed in the lining of our gut are intraepithelial lymphocytes, key players in our immune system that are activated by compounds in cruciferous vegetables such as broccoli and cabbage. Maintaining the conditions in our gut is crucial for our health. Prebiotics,such as fiber rich fruits and vegetables not only are covered in lactic acid bacteria(the good bacteria) but also provid the fiber on which the good bacteria thrive. Live good bacteria also Known as probiotics also play a crucial role in the development and operation of the immune system In our digestive tract, aiding in the production of antibodies to pathogens.

2.Improve your mood and behavior. Our gut is now known as our second brain due to the size,complexity and similarity in terms of neurotransmitters with our brain. In fact,“good bacteria” can stimulate cells in the lining of our intestine to produce the feel good neurotransmitter serotonin.

3.Help control diabetes. There is evidence that certain intestinal bacteria may actually produce compounds that increase estrogen,which in turn has been linked to increased risk for diabetes.

4.Fight obesity. Studies have found that certain bacteria may help our bodies retain calories and others may help us shed calories.

5.Detoxification. The beneficial bacteria in fermented foods are detoxifiers, capable of drawing out a wide Range of toxins and heavy metals from the body.

Lecture 8: Probiotics and probiotics dairy products

Probiotic concepts

The word "probiotic" comes from Greek and means "for life" (Fuller, 1989). Over the years, the term "probiotic" has been given several definitions. "Probiotic" is used to refer to cultures of live microorganisms which, when administered to humans or animals, improve properties of indigenous microbiota (Margoles and Garcia, 2003). In the food industry, the erm is described as "live microbial food ingredients that are beneficial to health" (Clancy, 2003).

Application of probiotic bacteria in dairy foods

There is evidence that food matrices play an important role in the beneficial health effects of probiotics on the host (Espirito Santo et al., 2011). Fermented foods, particularly dairy foods, are commonly used as probiotic carriers. Fermented beverages provide an important contribution to the human diet in many countries because fermentation is an inexpensive technology which preserves food, improves its nutritional value and enhances its sensory properties (Gadaga et al., 1999). However, the increasing demand for new probiotic products has encouraged the development of other matrices to deliver probiotics, such as ice cream, infant milk power and fruit juice. Davidson et al. (2000) evaluated the viability ofprobiotic strains in low-fat ice cream. They used cultures containing Streptococcusalivarius ssp. thermophilus and Lactobacillus delbrueckii . Bulgaricus, Bifidobacterium longum and Lactobacillus acidophilus and verified that culture bacteria did not decrease in the yogurt during frozen storage. Also, th e presence of probiotic Probiotics bacteria did not alter the sensory characteristics of the ice cream. The ice cream matrix may offer a good vehicle for probiotic cultures due to its composition, which includes milk proteins, fat and lactose, as well as other compounds. Moreover, its frozen state contributes to its efficiency. However, a probiotic ice cream product should have relatively high pH values 5.5 to 6.5, in order to favor an increased survival of lactic cultures during storage.

The lower acidity also results in increased consumer acceptance, especially among consumers who prefer milder Products. (Cruz et al.,2009b). Growth of a probiotic yeast, boulardii in association with the bio-yogurt microflora, which is done by incorporating the yeast into commercial bio-yogurt, has been suggested as a way to stimulate growth of probiotic organisms and to assure their survival during storage. Lorens-Hattingh and Viljoen (2001a) studied the ability of probiotic yeast to grow and survive in dairy products, namely bio-yogurt, UHT yogurt and UHT milk. S.boulardiiwas incorporated into these dairy products and stored at 4^{0}C over a 4-week period. It was observed that the probiotic yeast species, S. boulardii had the ability to grow in bio-yogurt and reach maximum counts exceeding 107CFU g1.

Lecture 1: Processing of evaporated and dried milk products

INTRODUCTION

In order to preserve the milk constituents in a concentrated form, condensed milk/concentrated milk is manufactured from whole or skim milk by evaporating part of water under vacuum. Its main purpose is to diminish the volume and to enhance the shelf life. But this form of milk still has limited shelf life. Attempts to prolong the shelf life of this product have been made through the addition of sugar (sweetened condensed milk) or by heat processing (evaporated milk) to destroy the microorganisms.

PRINCIPLE OF EVAPORATION

Evaporation is a unit operation which involves simultaneousheat and mass transfer. Evaporation means the removal of solvent as vapour from asolution or slurry under such conditions that no attempt is made to separatecomponents of the vapour. In majority of evaporation process the solvent is waterand latent heat for evaporation is supplied by condensing steam and heat from thesteam is transmitted to the solution indirectly through the metallic surfaces.The unit in which heat transfer takes place is called heating element or calandria.An effect is one or more bodies boiling at the samepressure. A multiple effect evaporator is one in which vapour from one effect isused as heating medium for another effect boiling at a lower pressure.

BASICS OF EVAPORATORS

Vacuum Pan

This type of evaporator is employed in the majority of condenseries for the manufacture of condensed milk. Batch operating type evaporator is preferred when relatively small quantities of milk are to be handled in a batch operation for product like sweetened condensed milk.

The pansare internally fitted with steam coils and the lower portion is steam jacketed.The operation is usuallycarried out at 54-63°C, the milk boils at this temperature owing to reducedpressure (63.5 cm of mercury) which is maintained in the pan. A vacuumpump is used to maintain the vacuum in the pan. When the water vapour, which rises fromboiling milk inside the pan, comes in contact with cold metal surface orcold spray of water in the condenser, it is condensed and carried off aswater by means of pumps or other means.

Falling Film Evaporators

This type of evaporator consists of verticaltube bundles heated by condensing steam on the outside. Theliquid to be evaporated is fed to the top of the tube and allowed to flowdownwards on the inside of the tubes. The liquid will flow downwards forming a thin film, from which the boiling/evaporation will take place because of the heat applied by the steam.The resulting vapourand concentrated liquid flow into a separator at the foot of the evaporator.The vapour is drawn off from the top of the separator and liquid from thebottom by a pump.This type of evaporator is desirable from a product point of view, as it offers a short holding time.

As vapour, from the evaporated milk contains almost all the applied energy, it is obvious to utilize this to evaporate more water by condensing the vapour. This is done by adding another calandria to the evaporator. This new calandria - the second effect - where the boiling temperature is lower, now works as condenser for the vapours from the first effect, and the energy in the vapour is thus utilized as it condenses.

Evaporated Milk- means the product obtained by partial removal of water from milk of cow and/ or buffalo by heat or any other process which leads to a product of the same composition and characteristics. The fat and protein content of the milk may be adjusted by addition and/ or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk being adjusted. It shall have pleasant taste and flavour free from off flavour and rancidity. It shall be free from any substance foreign to milk.

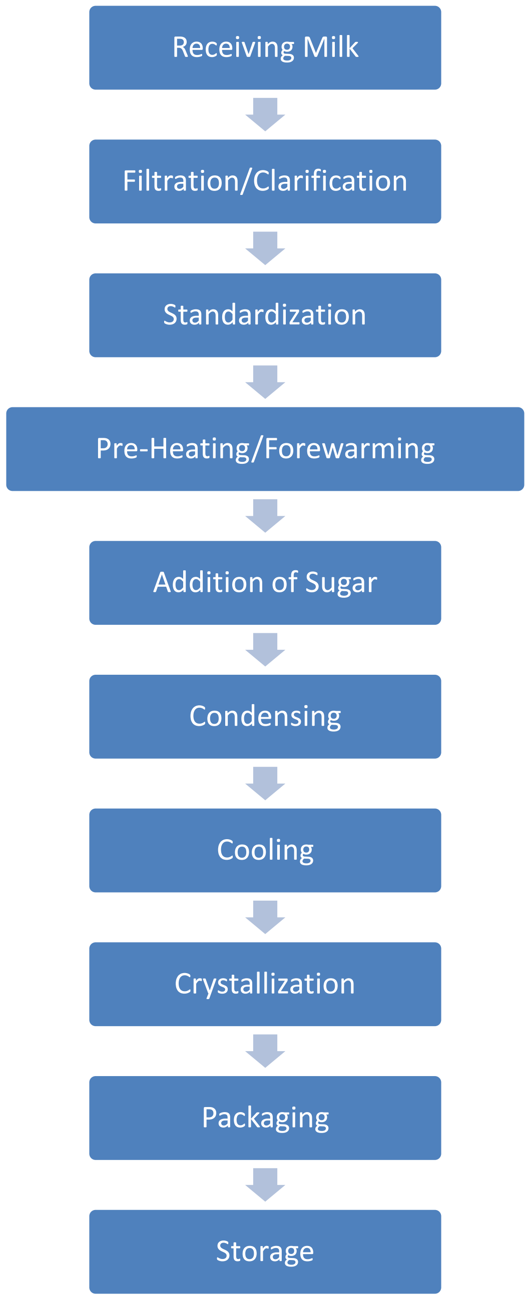
Sr. No.	Product	Milk Fat (m/m)	Milk Solids	Milk Protein in milk solids not fat
1	Evaporated milk	Not less than 8.0%	Not less than 26.0%	Not less than 34.0%
2	Evaporated partly skimmed milk	Not less than 1.0% and not more than 8.0%	Not less than 20.0%	Not less than 34.0%
3	Evaporated skimmed milk	Not more than 1.0%	Not less than 20.0%	Not less than 34.0%
4.	Evaporated high fat milk	Not less than 15.0%	Not less than 27.0%	Not less than 34.0%

Sweetened Condensed Milk- means the product obtained by partial removal of water from milk of Cow and/or Buffalo with the addition of sugar or a combination of sucrose with other sugars or by any other process which leads to a product of the same composition and characteristics. The fat and/ or protein content of the milk may be adjusted by addition and / or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk being adjusted. It shall have pleasant taste and flavour free from off flavour and rancidity. It shall be free from any substance foreign to milk.

Sr.No.	Product	Milk Fat (m/m)	Milk Solids	Milk Protein in milk solids not fat
1	Sweetened condensed milk	Not less than 9.0%	Not less than 31.0%	Not less than 34.0%
2	Sweetened condensed skimmed milk	Not less than 1.0%	Not less than 26.0%	Not less than 34.0%
3	Sweetened condensed partly skimmed milk	Not more than 3.0% and not more than 9.0%	Not less than 28.0%	Not less than 34.0%
4	Sweetened condensed high fat milk	Not less than 16.0%	Not less than 30.0%	Not less than 34.0%

Manufacture of sweetened condensed milk

Sweetened condensed milk is milk that is concentrated by evaporation, to which sucrose is added to form an almost saturated sugar solution, after which it is packed. The high sugar concentration is primarily responsible for the keeping quality of the product and for its fairly long shelf life, even after the can has been opened, although it then will eventually become moldy. Different steps involved in the manufacture of Sweetened Condensed Milk are given in the Figure below



Manufacture of evaporated milk

Various steps involved in the manufacture of evaporated milk are depicted in Figure below

Lecture 3: Simple problem based on milk drying

Example: Size of the rotary dryer can be estimated for the following case. A moist non hygroscopic granular solid at 260C is to be dried from 20% initial moisture to 0.3% final moisture in a rotary dryer at a rate of 1500 kg/h. The hot air enters the dryer at 1350C with a humidity of 0.015. With condition that the temperature of the solid leaving the dryer must not exceed 1100C and the air velocity must not exceed 1.5 m/s in order to avoid dust carry over. Cps = 0.85 kJ/kg.K. Recommend the diameter of the dryer.

Solution: Basis of calculation is 1 hr operation

Solid contains 20% initial moisture
Mass of dry solid = MS = 1500 (1-0.2) = 1200 kg/hr
Moisture in the wet solid = X1 = 20/80 = 0.25
Moisture in the dry solid = X2 = 0.3/99.7 = 0.00301
Water evaporated, mS, evaporated = MS (X1 – X2) = 1200 (0.25 – 0.00301) = 296.4 Kg
Given data: TS1 = 26^0C; TG2 = 135^0C; Y2 = 0.015
Let us assume that the exit temperature of the gas is TG1 = 60^0C and for solid TS2 = 100^0C
Now enthalpy of different streams (suppose ref temp = 0^0C)
HS1 = [CPS + (4.187) X1] [TS1 – 0] = [0.85 + (4.187) 0.25] [26 – 0] = 49.31 KJ/kg dry air
HS2 = [CPS + (4.187) X1] [TS1 – 0] = [0.85 + (4.187) 0.0.00301] [100 – 0] = 86.2 KJ/kg dry solid
Hg2 = [1.005 + (1.88) 0.015] [135 – 0] + (0.015) (2500) = 177 KJ/kg
Hg1 = [1.005 + (1.88) Y1] [60 – 0] + Y1 (2500) = 60.3 + 2613 Y1
Overall mass balance
GS (Y1 – Y2) = MS (X1 – X2) GS (Y1 – 0.015) = 296.4
GS = 296.4/(Y1 – 0.015) MS [HS2 – HS1] = GS [Hg2 – Hg1]

1200 [86.2 – 49.31] = 296.4/(Y1 – 0.015) × (177 – 60.3 -2613Y1)

Y1 = 0.04306 and Gs = 296.4/(Y1 – 0.015) = 10560 Kg/h

Shell Diameter

Volume of humid inlet gas (135^0C and Y2 = 0.015) VH2 = 1.183 m3/Kg dry air

Volume of humid exit gas (60^0C and Y1 = 0.04306) VH1 = 1.008 m3/Kg dry air

The max. volumetric gas flow rate = Gs.VH2 = 10560 × 1.183 = 12490 m3/h

The working velocity i.e. superficial velocity = 1.5 – 0.2 × 1.5 = 1.2 m/s / 4 × d2 (1.2) = d = 1.98 m, *say 2.0 m*

Lecture 4: Ice Cream

Ice cream is made by freezing and simultaneously beating air into (aerating) a liquid mixture that contains fat, sugar, milk solids, an emulsifying agent, flavouring and sometimes colouring.
The fat can be from milk, cream or butter or from a non-dairy source. However, the composition of ice cream is legally defined in many countries. Typically this is:

1. Standard ice cream that contains not less than 5% fat and not less than 2.5% milk protein (from casein or whey solids).
2. 'Dairy' ice cream must contain a minimum of 5% fat that is only milk fat and not any other type of fat.

Ingredient	Fat (%)	MSNF1 (%)	Sugar (%)	Water (%)
Full cream milk	4.0	8.8	44.0	87.2
Liquid skim milk	-	9.0		86.0
Full cream milk powder	27.0	70.0		3.0
Skim milk powder	-	97.0		3.0
Double cream	48.0	4.5		47.5
Single cream	18.0	7.2		74.8
Butter	84.0	-		16.0
Sweetened condensed milk	9.0	22.0		25.0
Evaporated milk	9.0	22.0		69.0

Product variations

There are a large number of potential product variations, including a wide range of flavours (e.g. vanilla, chocolate or fruit flavours) and corresponding colours, and different textures that depend on the addition of additives or differences in the method of production. Fruit pulp may also be added during or after making ice cream, and fruit, chocolate or nut pieces can be used to decorate ice cream. In temperate climates, ice milk was the traditional lower-fat ice cream product, and in places where there is a demand for reduced-fat products (with fat contents as low as 4%) this may be an additional product in a range. Another product variation is frozen yoghurt (see Technical Brief: Soured milk and yoghurt production), which is frozen in a similar way to ice cream (below).

Ingredients

Fats

Fats increase the richness of the ice cream flavour, produce a smooth texture, give 'body' to the ice cream and produce good melting properties when the ice cream is eaten. Although dairy fats (Table 1) are most commonly used to make ice cream, a number of vegetable fats (including hydrogenated palm oil, coconut oil or salt-free margarine) may be cheaper and are used to reduce the cost of ice cream.

Milk solids-not-fat

Milk solids-not-fat is included as skimmed milk powder or full-fat milk powder. They improve the body and texture of ice cream, allow a higher overrun (below), and produce a thicker, less icy product.

Sugars

Sweeteners improve the flavour, texture and palatability of ice cream. They contribute to a lower freezing point, so that the ice cream has some unfrozen water. Without this the ice cream would be too hard to eat. They also reduce the 'fattiness' of ice cream and help to produce a smooth texture. Granulated or castor sugar (sucrose) is used, but other sugars (such as dextrose powder) are also used to make the ice cream softer. Corn syrup produces a firmer and 'chewier' ice cream than sugar. It is available in different dextrose equivalents1 (DE). The sweetness increases with higher DE values. Lower DE corn syrups have a greater stabilising effect.

Stabilisers

Stabilisers are used to help bind together the complex mixture of fats, sugars, air and tiny ice crystals that are present in ice cream and give a smooth texture. They increase the viscosity in the unfrozen water to produce a firmer ice cream that resists melting (see 'Product control' below). Historically gelatine was used, but now the most widely used commercial stabiliser is carboxymethyl cellulose (CMC), which may have small amounts of vegetable gums (such as guar gum or locust bean gum), or seaweed extract (available as sodium alginate) mixed with it to improve its stabilising action. The vegetable gums may also be used instead of CMC. The amounts of stabiliser used should follow the manufacturer's recommendations.

Emulsifiers

Emulsifiers create a smooth texture and good melting characteristics. The traditional emulsifier used in ice cream was egg yolk, but now mono- and di-glycerides and Polysorbate 80 are used in most ice cream formulations.

Flavourings and colourings

Few people like unflavoured ice cream and both synthetic and natural flavours are used. The colouring normally matches the flavour (e.g. green colour with mint flavour or orange with mango). The flavours and colours must be 'food grade' and are usually available in supermarkets in major towns and cities or from bakery ingredient suppliers. Vanilla flavour is often the most popular flavouring, but producers should find out local preferences before deciding the range of flavours to offer (see for example ice cream makers such as Ben and Jerry's, makeicecream.com, or flavour suppliers such as H. E. Stringer or other large producers for the range of possible flavours).

Formulating an Ice Cream Mix

It is important that small producers understand how to develop new ice cream mixes to meet changing customer demands. 'Balancing' the mix involves maintaining the correct balance between:

Fat and sugar which controls the 'fattiness' of the product in the mouth.

Water and solids which controls the texture or hardness/softness.

The formulation of an ice cream mix should also take into account the cost and availability of ingredients.

Production method

Stage in process	Notes
Weigh	Premix dry ingredients with 3 or 4 times their weight of sugar. Weigh all main ingredients, except fat, into pasteurisation vessel.
Heat	To 50C and add any solid fats.
Pasteurise	At 65°C for 30 minutes or 72°C for 10 minutes with thorough mixing.
Cool	For a minimum of 4 hours at 3-5C to allow fats to crystallise and the viscosity to increase.
Freeze and aerate	Using an ice cream machine to reduce the temperature to –5°C as quickly as possible.
Pack	Fill into pots or cardboard cartons.
Harden	At below -20C
Cold store	At –18 to -20C

Lecture 5: Cream

Introduction

In the Indian dietary regimen, milk fat in the form of cream, butter and ghee contributes significantly towards nourishment of people of almost all age groups. These products are good sources of fat soluble vitamins A, D , E and K. I n the ancient vedic literature it is mentioned that ghee derived from cow milk has got excellent nutritional and tonic qualities specially beneficial to persons convalescing after chronic illness and bone fracture. C ream is a fat rich component and has been known from time immemorial as the fatty layer that rises to the top portion of the milk when left undisturbed. C ream is sold in many varieties. Although used for several purposes, it is primarily something of a luxury because of its excellent flavor, body and texture.

Definition

Cream may be defined as that portion of milk which is rich in milk fat or that portion of milk into which fat has been gathered and which contains a large portion of milk fat, or when milk fat is concentrated into a fraction of the original milk.

According to the FSSR R ules (2011), cream excluding sterilized cream is the product of cow or buffalo milk or a combination there of which conations not less than 25 per cent milk fat (Table 1.1). **Cream** is rich in energy giving fat and fat-soluble vitamins A, D , E , and K, the contents of which depends on the fat level in cream.

Classification

Cream is not a definite specific substance. I t contains all the milk constituents but in varying proportions. C ream for sale to consumers is produced with different fat contents.Cream of lower fat content, 10 – 18%, is often referred to as half cream or coffee cream, it is increasingly used for desserts and in cooking. C ream with a higher fat content, typically 35 – 40 %, is usually considerably thicker. I t can be whipped into a thick froth and is therefore referred to as “whipping cream”. T he milk fat in cream may vary from 10 to 75 per cent.

Cram may be classified broadly as: (a) market cream, which is used for direct consumptions, and (b) manufacturing cream, which is used for the manufacturing of dairy products.

The various types of cream are:

1. Table cream
2. Light cream
3. Coffee cream
4. Whipping cream
5. Heavy cream
6. Plastic cream

Chemical composition of cream

Water 45.45 - 68.2%
Fat 25 - 60%
Protein 1.69 - 2.54%
Lactose 2.47 - 3.71%
Ash 0.37 - 0.56%
Total solids 31.8 -54.55%
Solids not fat 4.55 - 6.80%

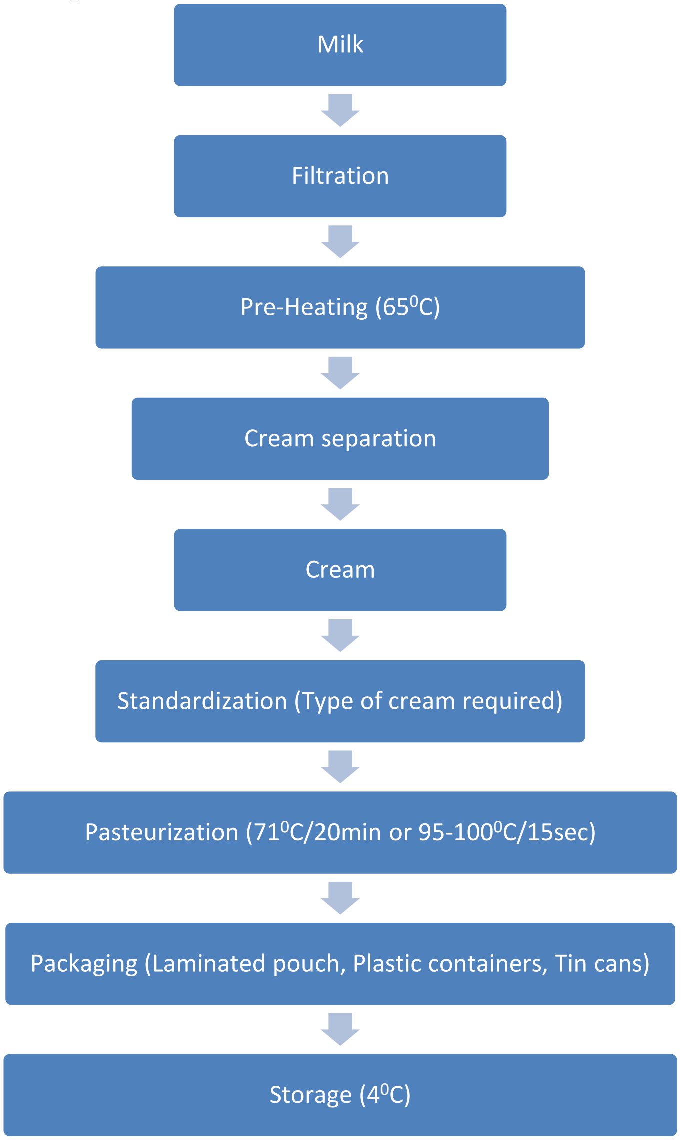
Production of Cream: The basic principle of cream separation, whether by gravity or centrifugal method, is based on the fact that milk fat is lighter than the skim milk portion.

At 160C the average density of milk fat is 0.93 and skin milk 1.036. Hence when milk, which may be considered to be a mixture of fat (as cream)and skin milk, is subjected to either gravity or a centrifugal force, the two components, viz. cream and skin milk, by virtue of their differing densities stratify from one another.

Centrifugal method is used commercially to separate cream from milk. When milk enters the rapidly revolving bowl of the cream separator, it is immediately subjected to a centrifugal force, which is 3000 to1600 times greater than gravitational force. While both the fat and skim milk are subjected to the centrifugal force, the differences in density affects the heavier i.e. portion skim milk more intently and forced to the periphery while the fat portion moves towards the centre.

The skim milk and cream both form vertical walls within the and are separated by led through separate outlets

Flow Diagram for the production of cream



Lecture 6: Butter

Introduction

Butter is a fat rich dairy product, generally made from cream by churning and working. It contains 80% fat, which is partly crystallized. Butter making is one of the oldest forms of preserving the fat component of milk. Its manufacture dates back to some of the earliest historical records, and reference has been made to the use of butter in sacrificial worship, for medicinal and cosmetic purposes, and as a human food long before the Christian era. Butter can be produced from the milk of cow, buffalo, camel, goat, ewe and mares. Fat is separated from milk in the form of cream using cream separator. T he cream can be either purchased from fluid milk dairy or separated from whole milk by the butter manufacturer. The cream should be sweet (pH greater than 6.6), not rancid, not oxidized, and free from off flavors. The cream is pasteurized at a temperature of 80°C or more to destroy enzymes and micro-organisms.

Composition of Butter

Butter is principally composed of milk fat, moisture, salt and curd. It also contains small amount of lactose, acids, phospholipids, air, microorganisms, enzymes and vitamins. The proportion of principal constituents in butter is largely controlled by the method of manufacture and this inturn is chiefly regulated to conform to the standards of butter prescribed by regulatory authorities such as codex and FSSAI. General composition of butter is given in table below

Constituents	Quantity (% w/w)
Fat	80-83
Moisture	15.5-16.0
Curd	1-1.5
Salt 0-3	0-3

Definition of Butter as per FSSR, 2011

Butter can be defined as the fatty product derived exclusively from milk of cow and/or buffalo or its products principally in the form of an emulsion of the type water-in-oil. The product may be with or without added common salt and starter cultures of harmless lactic acid and / or flavour producing bacteria. Table butter shall be obtained from pasteurized milk and/ or other milk products which have undergone adequate heat treatment to ensure microbial safety. I t shall be free from animal body fat, vegetable oil, mineral oil and added flavour. It shall have pleasant taste and flavour free from off flavour and rancidity.

Classification of Butter

Butter may be classified based on treatment given to cream, salt content, method of manufacturing and end use.

I. Classification based on acidity of cream used for butter making

1. **Sweet cream butter**: Sweet cream butter (made from non-acidified cream; this includes butter in which no bacterial culture have been added to enhance diacetyl content) having pH of 6.4 (acidity of the churned cream does not exceed 0.2%).
2. **Mildly acidified butter** (made from partially acidified sweet cream) having pH in the range of 5.2 to 6.3
3. **Sour cream butter** (made from ripened cream which has more than 0.2% acidity) having pH 5.1.

II. Classification based on salt content

1. **Salted butter**: Butter to which salt has been added. I t is added to improve flavor and keeping quality of butter.

2. **Unsalted butter**: T his type of butter contains no salt. I t is usually prepared for manufacturing other products such as ghee and butteroil.

III. Classification based on end use (as followed by BIS)

1. **Table Butter**: the product made from pasteurized cream obtained from cow or buffalo milk or a combination thereof with or without ripening with the use of standard lactic culture, addition of common salt, annatto or carotene as colouring matter and diacetyl as flavouring agent.

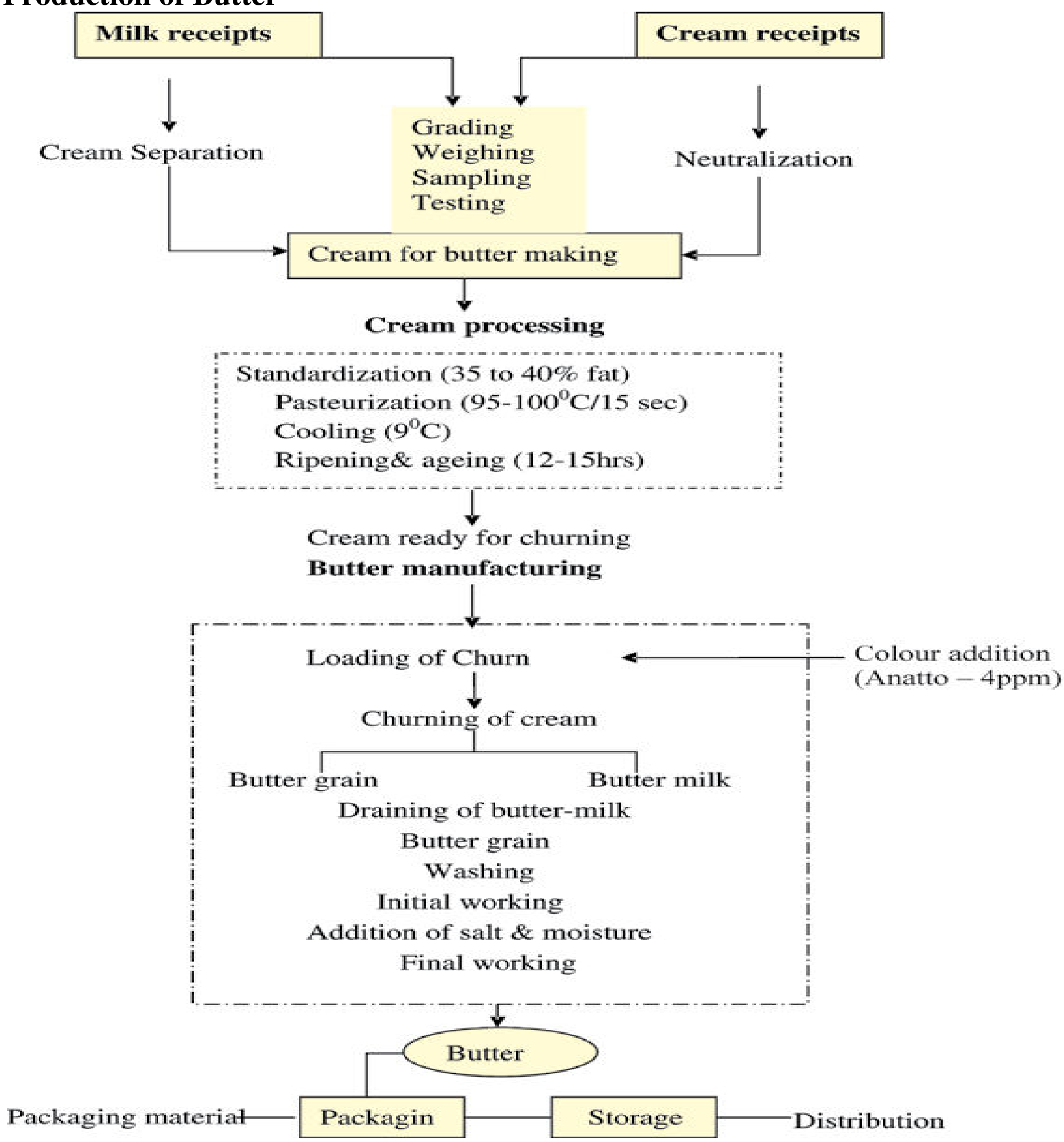
2. **White Butter**: the product made from pasteurized cream obtained from cow or buffalo milk or a combination thereof without ripening and without addition of any preservative including common salt, any added colouring matter or any added flavouring agent.

IV. Classification based on the manufacturing practice (as followed by FSSAI)

1. **Pasteurized cream butter/ Pasteurized Table butter**: This is made usually from pasteurized sweet cream. Such butter usually has a milder flavour than that made from similar cream not pasteurized.

2. ***Desi* butter**: T he butter obtained by traditional process of churning dahi or malai as practiced at domestic levels.

Production of Butter



Lecture 7: Ghee

Ghee

Introduction

Since time immemorial, ghee has been used in Indian diet as the most important source of fat. Ghee, the Indian name for clarified butterfat, is obtained by heat clarification and desiccation of sour cream, cream or butter. Because of its characteristics flavor and pleasant aroma, besides being a source of fat-soluble vitamins, ghee occupies predominant position amongst milk products in India.

Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added. Ghee essentially consists of 99 to 99.5% milk fat.

Chemical composition of ghee

Constituents	Cow	Buffalo
Fat (%)	99-99.5	99-99.5
Moisture	<0.5	<0.5
Carotene (mg/g)	3.2-7.4	-
Vitamin (IU/g)	19-34	17-38
Cholesterol (mg/100 g)	302-363	209-312
Tocopherol (mg/g	26-48	18-31
Free Fatty Acid	2.8	2.8

Methods of Preparation

The principle involved in ghee preparation includes concentration of milk fat in the form of cream or butter, followed by heat clarification of fat rich milk portion and thus reducing the amount of water to less than 0.5%. T he brown colored residue (curd) is then removed as ghee residue from clarified fat.

There are five methods of ghee making:

i. Desi or Indigenous Method
ii. Direct Cream Method
iii. Creamery Butter Method
iv. Pre-stratification Method
v. Continuous Method

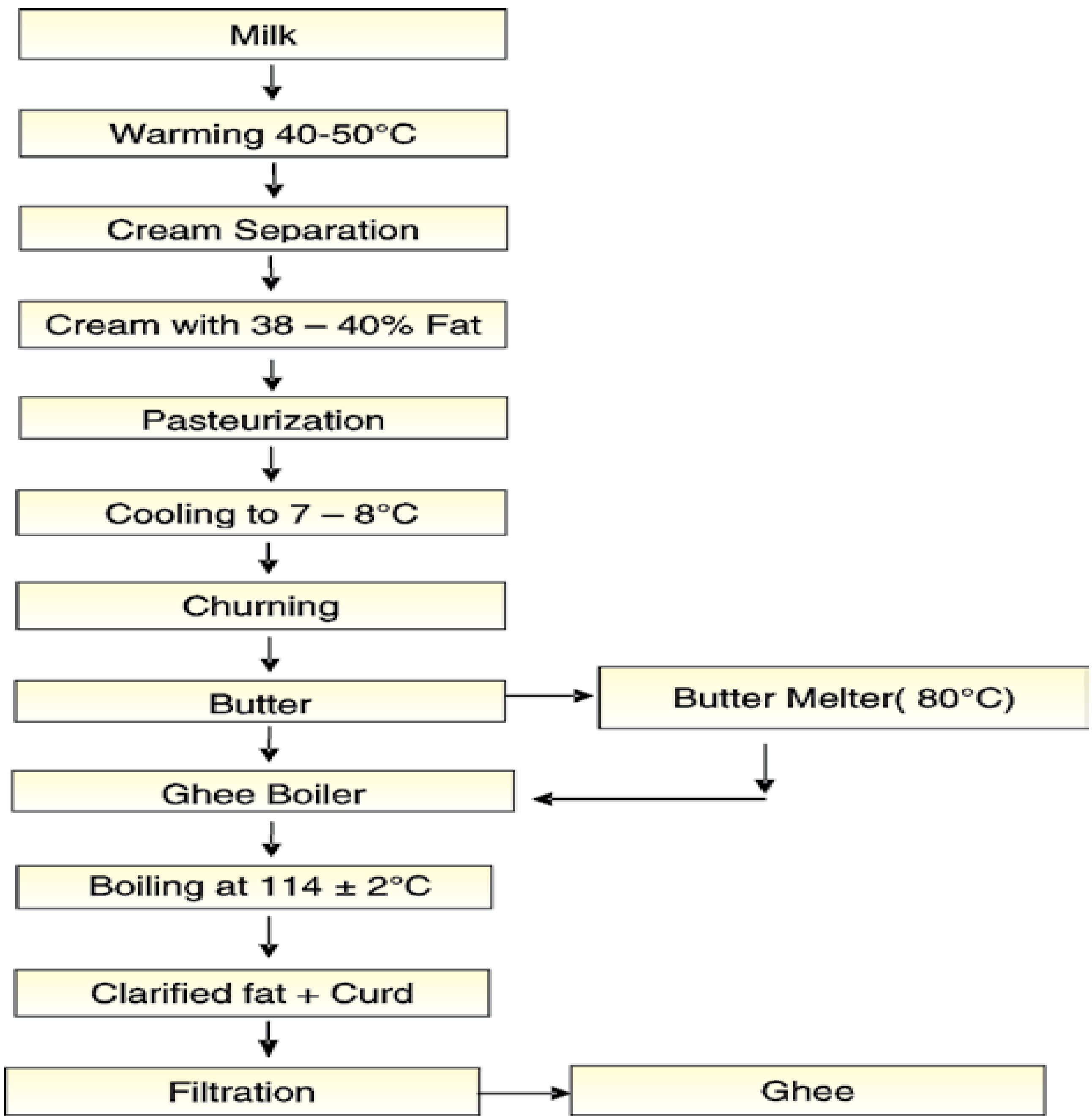
Most of the Indian ghee is produced through butter route and there are only a few installations where the cream is concentrated to 85% fat and above and converted to ghee by conventional boiling. Pre stratification of molten butter to save energy in final boiling is now an integral part of ghee process design. Melting of butter is mostly done in conventional butter melting vats. Few installations exist with on-line butter melting. The conversion of butter block into molten butter and separation of moisture from molten butter aimed at minimizing the quantity of moisture for evaporation in ghee manufacture. Centrifugal clarification of ghee is becoming more popular in recent times. T he ghee produced by centrifugal clarification has got better optical clarity. Continuous ghee making process has been reportedly developed; its commercial adoption is still awaited by Indian dairy industry.

Desi Method

This was the practice from age-old days in rural areas where excessive milk will be cultured and kept for overnight for fermentation. T he resultant curd was churned using hand driven wooden beaters to separate the milk fat in the form of desi butter. S ome follow slightly different method wherein milk is heated continuously to about 800C, the malai (creamy layer) that forms over the surface was collected manually. This malai is then churned to get the desi butter. After collection of desi butter over a period of time, this butter is melted in a metal pan or earthenware vessel on an open fire. Extent of frothing is an index to judge when to terminate heating. Heating must be stopped when sudden foaming appears and leave the contents undisturbed after heating. Curd particles starts settling down over a period of time and decant the clear fat carefully. In this method it is possible to achieve only 75 – 85% fat recovery.

Creamery Butter Method

Flow diagram for production of ghee from creamery butter method



Lecture 8: Butter oil, Infant formulae

Butter Oil

EU Classification Butter fat containing min. 89.3% fat and max. 0.5% moisture

Physical Specifications

- Colour: yellow to light yellow
- Taste and flavor: free from rancidity and off-flavours
- Anti Oxidants/Preservatives: not added

Chemical Specifications

- Total fat content: min. 99.8 %
- Humidity: max. 0.1 %
- Free Fatty Acids: max. 0.3 %
- Peroxide Value: max. 0.2 meq/kg fat
- Copper: max. 0.05 mg/kg
- Iron: max. 0.2
- Heavy Metals: max. 0.5 mg/kg

To be stored in a cool,dry place, at a temperature of max. 20^0C

Infant formulae

What is infant formula?

Most infant formulas are made from cow's milk which has been processed to make it suitable for babies. There are several brands of infant formula with different company names. There is no evidence that one company's milk is better for your baby than any other. If you think that one company's milk disagrees with your baby, try another company's milk and speak to your midwife or health visitor.

There are also different types of milk e.g. first milk, second milk, follow–on milk, etc. You need to be very careful about which type of milk you use as this could affect your baby's health. Always read the labels very carefully.

What types of infant formula are there?

First milks

These milks are often described as for newborns. They are based on the whey of cow's milk and are more easily digested than the other milks

Second milks

These are often described as for 'hungrier babies'. There is no evidence that babies settle better or sleep longer if given these milks. They are based on the curd of cow's milk and take your baby longer to digest than first milks. They are not recommended for young babies.

Follow–on milks

Follow–on milks are described as suitable for babies from six months of age. It is not necessary to move your baby on to these milks. Follow–on milks should never be used for babies under six months old as they are not nutritionally suitable.

Module IV **8L**

Lecture 1: Introduction of Traditional Indian sweets

Indian sweets or Mithai, are a type of confectionery that rely heavily on sugar, milk and condensed milk, and cooked by frying, however the bases of the sweets vary by region. In the Eastern part of India for example, milk is a staple, and most sweets from this region are based on milk products.

Varieties of Indian Sweet

- **Barfi**

Barfi is a popular sweet made of dried milk with ground cashews or pistachios.

- **Parwal Ki Mithai**

Parwal Ki Mithai is a dry sweet made of parwal. The outer covering is made of parwal, and the filling is made of milk products. It is rather popular in Bihar, but also found in Uttar Pradesh and West Bengal.

- **Khaja**

Khaja is a sweet delicacy of Orissa and Bihar states in India. Refined wheat flour, sugar and edible oils are the chief ingredients of khaja. It is believed that, even 2000 years ago, Khajas were prepared in the fertile land on the southern side of the Gangetic Plains of Bihar. These areas which are home to khaja, once comprised the central part of Maurya and Gupta empires. Presently, Khajas are prepared and sold in the city of Patna, Gaya and several other places across the state of Bihar, yet Khajas of Silao and Rajgir areas have a distinct superiority over khajas of all other places. Silao and Rajgir are the places where one can get puffy khaja, which melts in the mouth.

From Bihar and Orissa, Khajas have travelled to some other parts of India, including Andhra Pradesh. Khaja of Kakinada, a coastal town of Andhra Pradesh, is famous. At first, a paste is made out of wheat flour, mawa and oil. It is then deep fried until crisp. Then a sugar syrup is made which is known as "Pak". The crisp croissants are then soaked in the sugar syrup until they absorb the sugar syrup. The speciality of Kakinada Khaja is that it is dry from outside and full of sugar syrup from inside and is juicy. It melts as soon as one puts it in one's mouth.

- **Chena Murki**

A sweet made from milk and sugar available in Indian province of Orissa. The milk is boiled for a long time and condensed. Sugar is added and the sweet is given a round shape. It is also known by many Bangladeshi and Guyanese people as pera.

- **Rasgulla**

Rasgulla is one of the most popular relished sweetmeats in India, originated in Orissa, in the eastern region of the country, but was made known to the outside world by Nobin Chandra Das of Kolkata. Originally a dessert in Orissa for centuries, this dish made its way to West Bengal when the Oriya cooks started migrating to West Bengal in search of jobs, bringing along the recipe of this heavenly sweet. It was only after that Nobin Chandra Das of Kolkata modified its recipe to give it its current form. This dish is produced by the boiling of small balls of casein in sugar syrup. This sweet dessert can be found in almost all eastern Indian households.

- **Payasam**

Payasam (or Kheer as it is called in Hindi) has been an important cultural dish throughout the history of India, being usually found at ceremonies, feasts and celebrations. In southern India, ancient traditions maintain that a wedding is not fully blessed if Payasam is not served at the wedding feast, this tradition being kept alive with each generation, still being practiced by newly married couples, mostly in the southern regions, from where the tradition started in the first place.

Laddu is a popular sweet in India. It is made of flour and other ingredients formed into balls that are dipped in sugar syrup. The popularity of Laddu is due to its ease of preparation. In fact the laddu is so popular that it can be used as a lighthearted nickname for chubby children in South Asia.

Variations in the preparation of Laddu result in diverse tastes. Laddu is often made to celebrate festivals or household events such as weddings. 'Tirupati Laddu', the most famous laddu made at Tirumala in Andhra Pradesh is immensely popular for its great taste.

- **Motichoor**

Motichoor Ka Ladoo is a sweet delicacy of the central Bihar made from grilled gram flour flakes which are sweetened, mixed with almonds and pressed into balls and fried in ghee. Originally from Maner, a small town near Patna, it is now made and enjoyed throughout India and Pakistan. It is a traditional gift at weddings, engagements and births. Some of the original families who made the Ladoo in Maner have now shifted to Patna and sell it in the city.

- **Pathishapta**

This is a Bengali dessert. The final dish is a rolled pancake that is stuffed with a filling often made of coconut, milk, cream, and jaggery from the date palm. These desserts are also popular in Thailand.

- **Narkel Naru**

A dessert from Bengal. These are ball-shaped sweets made from khoa/condensed milk and coconut, a traditional favourite during pujas such as the Lakshmi Puja celebrated throughout India.

- **Malpoa**

Several versions are prepared in different parts of India, including one from Bengal and Orissa that is typically a cream pancake deep fried with raisins and sugar syrup.

- **Other Indian Sweets**

Other important traditional Indian sweets and desserts, famous throughout the history of Indian food, include the following: Gulab Jamun (a popular Indian dessert made out of fried milk balls in sweet syrup), Mysore Pak (a dessert made out of ghee, sugar and chick pea flour), Halwa(Persian dessert or Halva in modern English spelling; made out of flour, butter and sugar, the Halwa is one of the most popular Indian desserts that have spread in every corner of the World), the Kulfi (often referred to as Indian ice cream, the Kulfi is made out of boiled milk and a wide variety of mango, kesar or cardamom flavors), the Jalebi and Jangiri. In Orissa, several chhena based confections, such as Chhena Kheeri, Chhena Jalebi, Rasaballi, and Chenna Poda are very popular.

Lecture 2: Kheer

Kheer or **Meoa** is a sweet from the Bengal region of the Indian subcontinent. It is not only a sweet, it is also used as main ingredient of many other sweets. In North India Kheer (Payesam) is different dish. But in Bengal, in the same spelling and sound, Kheer is different. It is also different to Khoa.

Preparation

To prepare kheer, pure and genuine cow or buffalo milk is the only ingredient. Pure milk is being boiled over an hour to make one-third of its original volume. Then kheer is being prepared. Sometimes to make more sweet and different taste suger, arrarute, suji are mixed with it during boiling. But the taste of original one is far different and delicious than it.

Whereas to make Khoa boiling process extended to make the original volume up to one forth or one fifth. Then khoa is prepared. Khoa is harder than kheer. And this hardness also makes difference in taste. This thing differs these two dishes.

Uses

As in Bengal kheer is one of the most important ingredients for making sweets, so it has a high demand in the market. In terms of hardness, it can be categorised in two forms.

- **Khoa** – hard kheer
- **Kheer** – semi-liquid kheer

Khoa is used to make some bengali sweets like **Cansat** etc. Kheer is used for **Rosmalai** like sweets, where small ball of channa are immersed in kheer.

Lecture 3: Dahi

Dahi is a fermented dairy product, produced by fermentation process by deliberately adding live, harmless, lactic acid producing bacteria in the form of bacterial culture to milk. Lactic acid bacteria added in the form of starter culture multiply and grow, produces lactic acid, acetic acid and carbon dioxide by utilizing lactose present in the milk. Some bacteria use the citric acid of milk to produce certain volatile organic compounds mainly diacetyl, which is mainly responsible for flavor of dahi. Judicious combination of acid producing and flavour producing microorganisms in the starter helps in the production of Dahi with a firm body and good flavour. Fermentation gives an acid taste to milk which is particularly refreshing in hot climate and also possess certain therapeutic values originally absent in milk. Hence fermented dairy products are playing a very important role in human diet in many regions of the world. Fermentation leads to partial breakdown of milk constituents particularly lactose and proteins and increases the digestibility of cultured milk products.

In Vedic literatures also we could find many references about fermented milk products, some of the popular I ndian fermented milk products are Dahi, Lassi, Shrikhand Mishti Doi and Raita.

Food safety and standards regulation (FSSR, 2011) defines: Dahi or curd means the product obtained from pasteurised or boiled milk by souring, natural or otherwise, by a harmless lactic acid culture or other harmless bacterial culture may also be used in conjunction with lactic acid bacteria cultures for souring. Dahi may contain added cane sugar. Dahi shall have the same minimum percentage of milk fat and milk solids-not-fat as the milk from which it is prepared.

Components	Whole milk Dahi (%)	Skim milk Dahi (%)
Water	85-88	90-91
Fat	5 - 8	0.05 - 0.1
protein	3.2-3.4	3.3-3.5
Lactose	4.6-5.2	4.7-5.3
Lactic acid	0.5-1.1	0.5-1.1
Ash	0.7-0.75	0.7-0.75

Where dahi or curd is sold or offered for sale without any indication of class of milk, the standards prescribed for dahi prepared from buffalo milk shall apply. Milk solids may also be used in preparation of this product.

Method of Preparation

Traditional Method

In traditional method of dahi preparation, milk is heated intensively to boil for 5 to 10 min and then it is cooled to room temperature. T hus boiled and cooled milk is added with previous day's curd or buttermilk, stirred and allowed undisturbed, to set, usually for overnight.

At halwai's shop the milk is considerably concentrated before being inoculated with starter culture. So that the total solid content of milk is increased, particularly increase in the protein content of milk results in custard like consistency of the dahi and keep the product from wheying off.

Industrial Method of Making Dahi

Selection of Raw Material

Production of cultured/fermented milk demands high quality raw materials with respect to physical, chemical and microbial standards.

Filtration/Clarification

Fresh raw milk is heated to 35 to 40°C to aid clarification or filtration process then it is filtered to ensure the milk is free from extraneous matter.

Standardization

Fat is standardized based on type of product ranging from fat free to full fat and SNF level is increased by min. 2% than that of milk. It is common to boost the SNF content of the milk to about 12% with the addition of skim milk powder or condensed skim milk.

Increased SNF inturn increases the protein, calcium and other nutrients and resulted with improved body and texture, custard like consistency. Higher milk solids prevent wheying off of the product during storage.

Homogenization

The standardized milk is subjected to homogenization after heating it to 60°C to increase the efficiency. Homogenization reduces the cream layer formation during incubation, Single stage homogenization with 175kg/cm2 pressure would be sufficient.

Heat Treatment

Milk intended for dahi or any other fermented milk product is given severe heat treatment i.e. 95°C for 15min or 85°C for 30min. following are the benefits of high heat treatment

– Denatures and coagulates milk albumin and globulins which enhance the viscosity and produce custard like consistency

– Kills contaminating and competitive microbes

– Development of relatively sterile medium

– Removal of air form the medium – more conducive for the growth of culture bacteria

– Effective thermal breakdown of protein releasing peptones and sulfhydryl groups, this inturn provide nutrients to starter bacteria

Packaging and Fermentation

The heat treated product mix is cooled to 37°C and it is inoculated with specific dahi culture at the rate of 1 to 1.5%. S tarter culture is the most crucial component in the production of high quality fermented milks. For the production of dahi mixed mesophilic cultures of *Lactococcus lactis* subsp *lactis, Lc. Lactis* subsp. *cremoris, Lc. Lactis* subsp *diacetylactis*, along with *Leuconostoc* species are grown together. Proper selection of culture strains decides the good quality product. D airy cultures are available in various forms like freeze dried, liquid and frozen forms. I n India freeze dried cultures are generally used. After the product mix is inoculated with dahi culture it is thoroughly mixed and filled into plastic cups, sealed properly to avoid any contamination and spillage of the product. Thus packed product is arranged in cases or crates and transferred to incubation room maintained at 37°C. T he product mix is incubated till the pH of the product reaches 4.4 to 4.5 and then it is cooled rapidly to less than 5°C by exposing the cups to high velocity cold air or by circulating chilled water.

Storage

Dahi is normally stored at 4 – 5°C. Storage area should be maintained clean and tidy to avoid any sort contamination.

Packaging of Dahi

Dahi is packed in food grade polystyrene and polypropylene cups in 100g, 200g and 400g pack sizes. Various packaging machines of upto 400cups/min speed are available to package cultural dairy products in different sizes. T he packaged product should be stored at 1-4°C for extended shelf life.

Lecture 4: Paneer

Paneer is an acid coagulated product obtained when standardized milk coagulated with the permitted acids at specified temperature, resultant coagulum is filtered and pressed to get the solid curd mass. Paneer has firm, close, cohesive and spongy body and smooth texture. Paneer is mainly prepared from buffalo milk and used for large number of culinary dishes. Though originally it was localized in North Western part of India but now it has traveled almost all parts of the country. Paneer is generally sold as blocks or slices, it also refer as Indian fresh cheese. It was reported that, 5% of the milk produced in India is converted into paneer, around 4500MT was paneer made in 2003-04, and growth rate of paneer production is 13% annually.

FSSR, 2011 Standards

Paneer means the product obtained from the cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid, or citric acid. I t shall not contain more than 70% moisture and milk fat content shall not be less than 50% of the dry matter. Milk solids may also be used in the preparation of this product (Table 1.13). Low fat paneer shall contain not more than 70% moisture and not more than 15% milk fat on dry matter basis.

Physico-Chemical Changes during Manufacturing

The phenomenon of coagulation involves formation of large structural aggregates and network of protein in which milk fat get embedded. Acid and heat treatment causes the physical and chemical changes in casein. Heating causes the interaction of ß-lactoglobulin with 8-casein and complex formed between ß-lactoglobulin and /-lactalbumininteract with 8-casein. Acidification initiates the progressive removal of tri-calcium phosphate from the surface of the casein and it gets converted into mono-calcium phosphate. Further calcium is progressively removed from calcium hydrogen caseinateto form soluble calcium salt and casein. Colloidal dispersion of discrete casein micelles changes into large structural aggregates of casein. Under such circumstance dispersion is no longer stable, casein gets precipitated and forms coagulum. Fat will be embedded in the casein network.

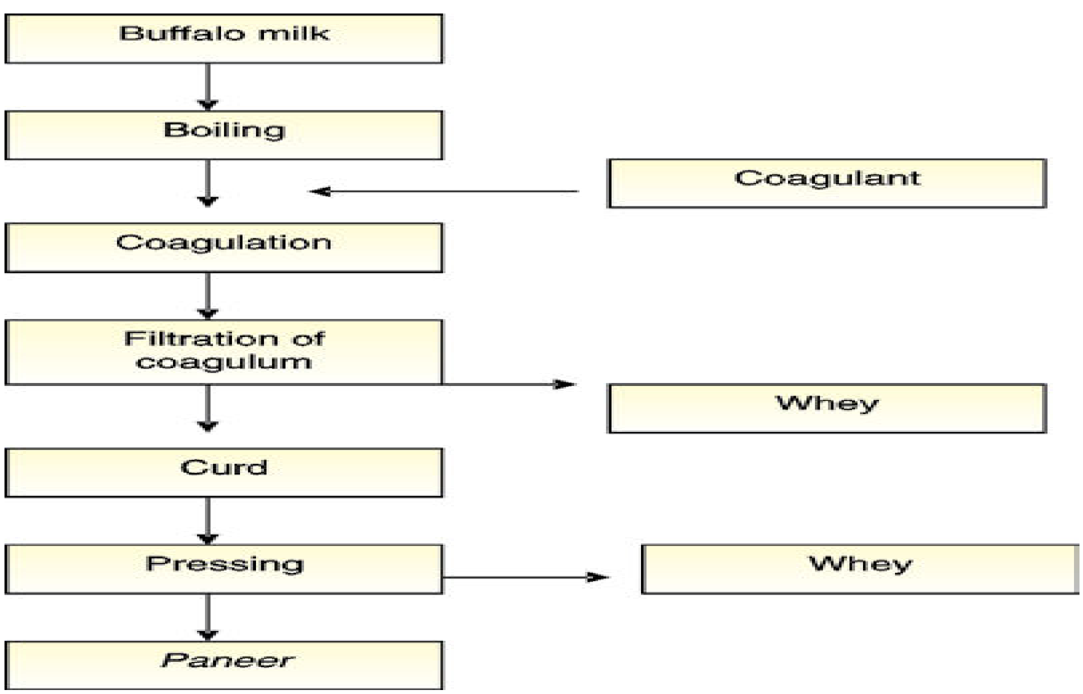


Fig.Traditional method of paneer manufacture

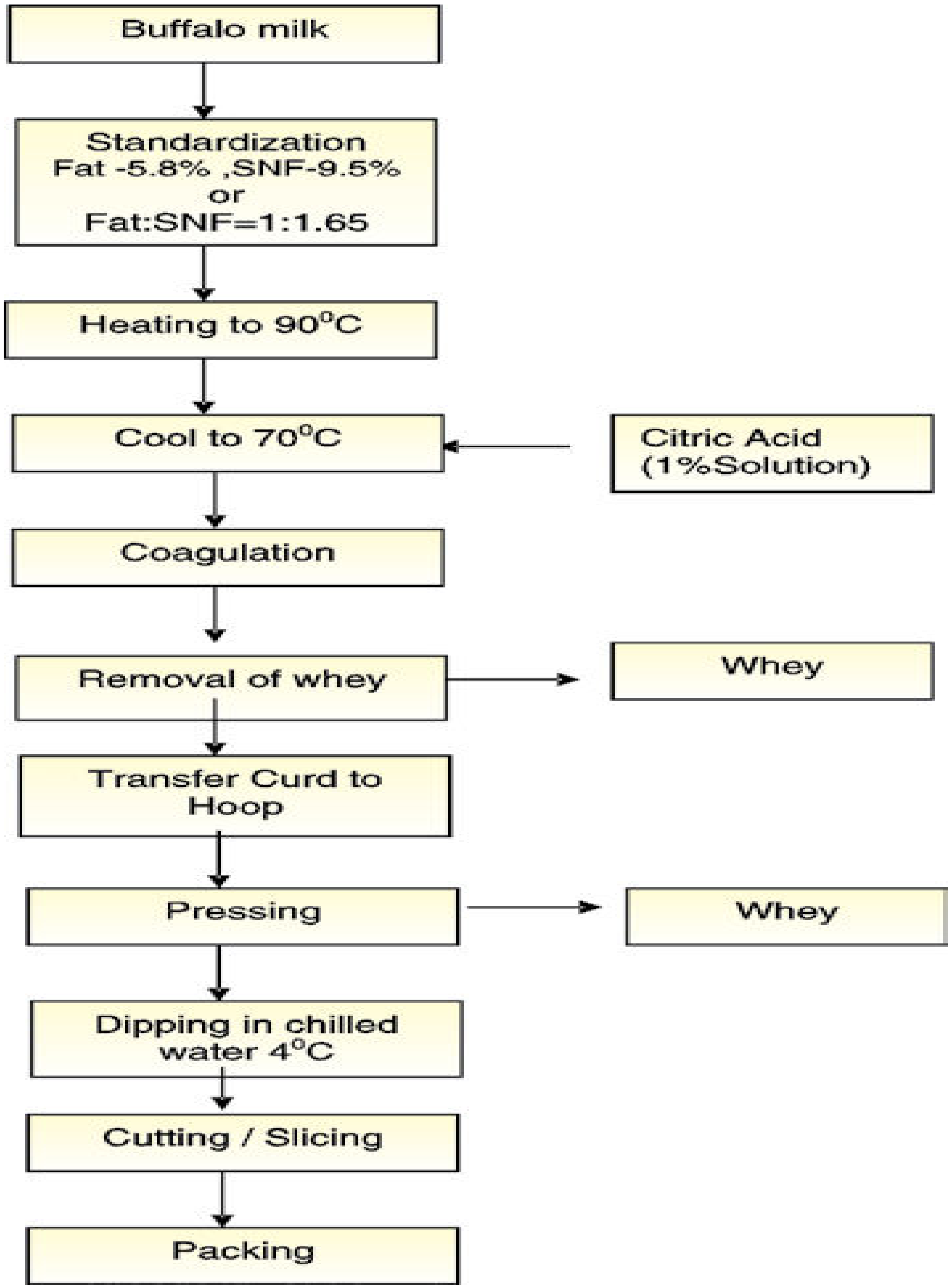


Fig. Method followed in the organized dairy plant

Lecture 5: Channa and Srikhand

Channa

Chhana is an acid coagulated product obtained when milk coagulated with the permitted acids at nearly boiling temperature. Solid curd obtained after filtration of coagulum is called chhana. It looks off-white, tastes mildly acidic, and has characteristic spongy texture. Chhana is mainly prepared from cow milk and used for preparation of verities of Bengali sweets. Production of chhana is confined to mostly in Eastern region of the country notably West Bengal, Bihar, Orrisa. About 4 to 4.5% of the total milk produced in India is used for chhana making. Chhana is used as a base for the preparation of a variety of sweets like Sandesh, rasogolla, chamcham, rasmalai, pantoa, channamurki etc.

Food Safety and Standards Regulation, 2011 definition

Chhana as a product obtained from cow or buffalo milk or combination thereof by precipitation with sour milk, lactic acid or citric acid. I t should not contain more than 70% moisture, and its milk fat content should not be less than 50% on the dry matter basis. If skim milk is used, moisture should not exceed 70% milk fat should not exceed 13% of dry matter.

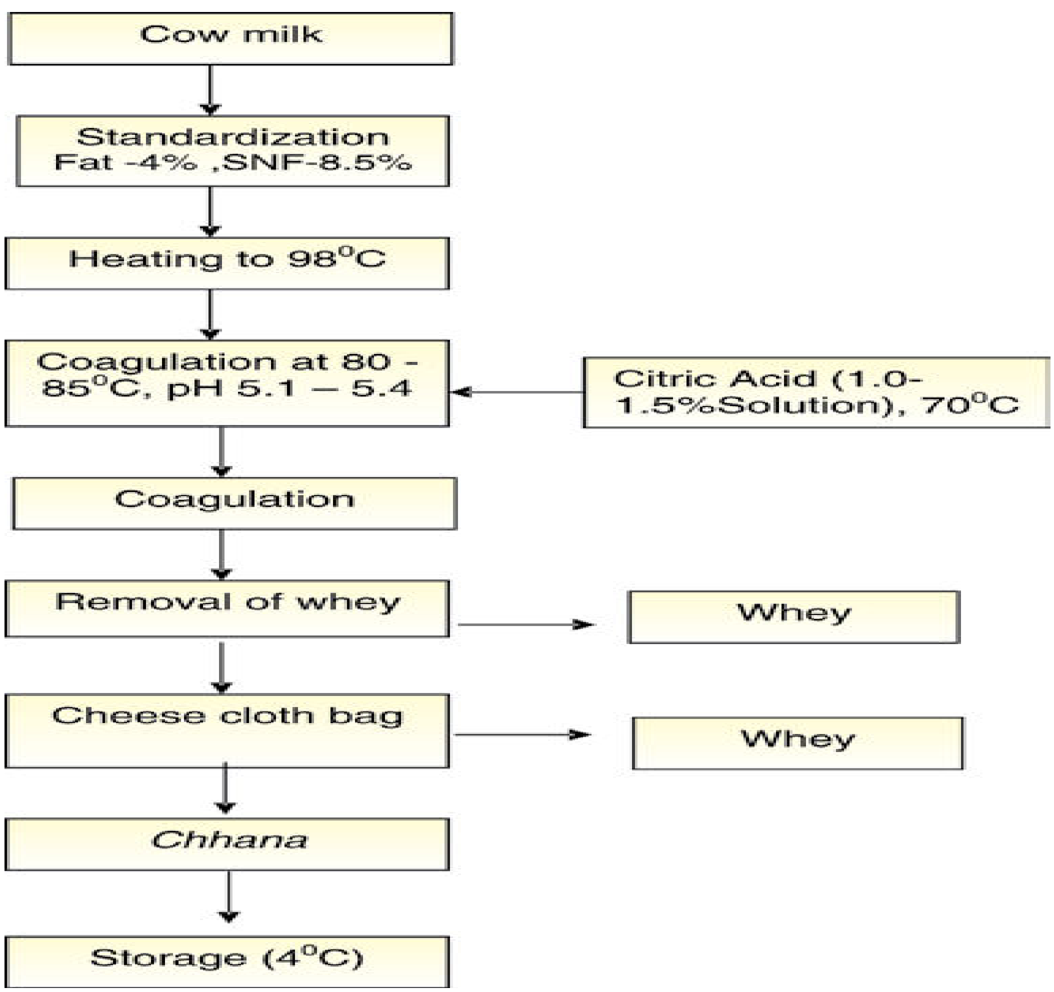


Fig. Flow diagram for Industrial production of chhana from cow milk

Srikhand

Shrikhand is a popular fermented, sweetened, indigenous dairy product having semi solid consistency with typical sweetish-sour taste. I t is very popular in the state of Gujarat, Maharashtra and part of Karnataka. I t is prepared by mixing chakka (Strained dahi), with sugar, color, flavor, spices and other ingredients like fruit pulp, nuts etc. to form soft homogenous mass.

Chakka is the intermediate product obtained during the production of shrikhand. It can be defined as a semi solid product obtained by draining off the whey from the curd prepared by acid fermentation of cow's/buffalo's/mixed/skimmed/standardized milk or reconstituted milk.

Traditional Method of Making Shrikhand

Traditionally shrikhand is prepared by boiling cow or buffalo or mixed milk and cooled to room temperature (30°C). T hus heated and cooled milk is then added with previous day dahi at the rate of 0.5 to 1 %. Milk is left undisturbed overnight at room temperature to set firmly. I t is then stirred and hung in a muslin cloth for 10 to 12 hrs to drain off whey. The curd mass obtained after removal of whey is called as chakka. C hakka is then added with calculated amount (40-45% w/w) of sugar, color, flavour and other optional ingredients like fruits, nuts, spices, herbs and cooled to 10°C or less. The yield of chakka produced traditionally is about 650g per 1000g of milk and yield of shrikhand is about 1.5 to 2.0kg per kg of chakka.

The chakka obtained from whole milk/ standardized milk has smooth body, whereas the one obtained from skim milk is little rough and dry. T his is majorly due to less fat in the curd. When whole milk is used for chakka making high fat losses occurs in whey thereby affecting the recovery of fat in chakka. Therefore it is preferred to use skim milk for chakka making and then mixing of cream or unsalted butter to adjust the fat in the finished product. Homogenization of milk leads to slow drainage of whey giving higher moisture content in the chakka and a product with very soft consistency which is not liked by the consumers. Conventionally made chakka lacks uniformity from batch to batch with regards to moisture and acidity. Moisture content affects the yield, consistency and composition, whereas acidity affects the taste and quantity of sugar to be added.

Industrial Production of Shrikhand

With a view to overcome some of the limitation of the traditional method and to partially mechanize the shrikhand production a semi-mechanized large scale production is employed Fig. 2.4. S hrikhand is the first traditional milk product for which large scale production technology was adopted. T he first modern plant has been established at the Baroda district cooperative milk producers union ltd. Baroda D airy has adopted a process which involves use of basket centrifuge for speedy draining of whey and a planetary mixer for kneading and mixing purposes.

On industrial production of shrikhand fresh skim milk is used as a raw material. Use of skim milk has got many advantages as listed below

- Fat losses are eliminated
- Faster moisture expulsion
- Less moisture retention

Skim milk is heated to 85°C for 30min, cooled to 30°C and inoculated with LF-40 culture containing *Lactococcus lactis* subsp. *lactis* and *Lactococcus Lactis* var. *diacetilactis* at the rate of 1.0 – 1.5%. After the required acidity of 0.8 to 1.0% lactic acid is reached, the curd is taken into basket centrifuge or quarg separator to remove whey from the curd. Thus produced curd mass or chakka is taken into planetary mixer or scraped surface heat exchanger. T o this chakka, sugarat the rate of 80% w/w, calculated amount of plastic cream (80% fat) to give atleast 8.5% FDM in the finished product is added and mixed thoroughly. Optional ingredients like color, flavor, fruits, nuts etc. can also be added at this stage. T hen it is packed at room temperature and stored at refrigeration temperature (<7°C).

Yield of chakka prepared from the above process is about 20% and Yield of shrikhand is 38.5%.

Lecture 6: Introduction of dairy processing by-products

A dairy by-product may be defined as a product of commercial value produced during the manufacture of a main product. The newly acquired economic importance of a by-product will make it a main product in the future.

Important by-products available from the dairy industry and their principles of utilization

S.No	Main Product	By Product	Processing method	Products Made
1	**Cream**	Skim milk	Pasteurization	Flavoured milk
			Sterilization	Sterilized flavoured milk
			Fermentation	Cultured Buttermilk
			Fermentation and Concentration	Concentrated sour skim milk
			Concentration	Plain and Sweetened Condensed skim milk
			Drying	Dried skim milk or Skim milk powder or Non Fat Dry Milk NFDM)
			Coagulation	Cottage cheese, Quarg, edible casein
2	**Butter**	Buttermilk	Fermentation and Concentration	Condensed buttermilk
			Concentration and drying	Dried buttermilk
			Coagulation	Soft cheese
3	**Cheese**, Casein **Channa**, **Paneer**	**Whey**	Fermentation	Whey beverage, Yeast whey
			Concentration	Plain and sweetened condensed whey, whey protein concentrate, whey paste, lactose
			Drying	Dried whey
			Coagulation	Ricotta cheese
4	**Ghee**	Ghee residue	Processing	Sweetmeat, Toffee, Sweet paste

Lecture 7: Fermented, condensed and dried products from whey

Whey and Whey Protein Concentrate

Whey is the largest by-product of the dairy industry. I t may be defined, broadly, as the watery part of milk remaining after separation of the curd that results from the coagulation of milk by acid or proteolytic enzymes.It is obtained during the manufacture of cheese, casein, *paneer*, *chhana,* and *shrikhand*. I n I ndia, milk products like *paneer*, *shrikhand*, and *chhana* are very popular and are in great market demand, while cheese consumption is steadily increasing due to changing food habits. With the increase in their production levels, there is a corresponding increase in the whey as a byproduct. I n general, the manufacture of 1 tonne of cheese or casein results in the production of 8 or 25 tonnes of liquid whey, respectively.Whey is a multicomponent solution of various water-soluble milk constituents in water; the dry matter of whey consists primarily of carbohydrate (lactose), protein (several chemically different whey proteins) and various minerals.Normal bovine milk contains about 3.5% of protein, of which casein constitutes 80% and whey proteins 20%. Liquid whey, contains approximately 20% of the original proteins of milk ranging from 4 to 7g/lt of which 3.7g is / ß-Lactoglobulin, 0.6g is / a–Lactalbumin, 0.3g is Bovine Serum Albumin, and 1.4g is proteose – peptone fractions. I n addition, it contains other proteins such as lactoferrin, immunoglobulins, ceruloplasmin, and milk enzymes such as lysozyme, lipase, and xanthine oxidase, which present in low concentrations.

There is wide variation in composition of the whey depending on milk supply and the process involved in the production. I n general, whey produced from rennet coagulated cheeses and casein is sweet whey, whereas the production of acid casein and fresh acid cheeses, such as R icotta or C ottage cheese, yields acid whey. When we use rennet, most part of calcium and phosphorus of the casein complex remain with the curd. T he ash content of the whey is, therefore, less than when the coagulating agent is acid, which transfers part of the phosphorus and most of the calcium to the whey. Production of *chhana* and *paneer* yields medium acid whey. Based on acidity, whey can be conveniently classed into three groups namely sweet whey, medium acid whey and acid whey.

Physical Properties of Whey

Whey is the greenish translucent liquid. T he greenish colour of most types of whey, regardless of the processing conditions used, is caused by the water-soluble and heat-stable riboflavin. However, riboflavin is sensitive to light as well as to ionizing radiation treatments and whey systems exposed to these conditions will show fading of the green colour. Whey has mixed flavours such as acidic flavour caused due to volatile and non-volatile acids; saltiness and astringency. N eutralization of the whey, however, results in change ofthese flavour characteristics.The surface tension of whey is low (42 dynes/cm) compared to that of skim milk (48 dynes/cm).The viscosity of whey at 20°C is 1.26 centipoise (cP). However, it decreases with increasing temperatures andhydrolysis of lactose.

Whey Powder

Conversion of whey to whey powder is the one of the options to preserve whey solids. Whey powder is essentially produced by the same method as other milk powders. Composition of whey can be modified by removal of lactose and minerals to give whey protein products of 15 to 40 percent protein on dry matter basis. T he material that remains after lactose has been crystallized and separated from concentrated whey is known as delactosed whey powder, which contains about 25 percent protein. D elactosed whey powder has a high mineral concentration (up to 25 percent). Whey powder when subjected to electrodialysis results in demineralized whey powder. Whey powder production consists of three main operations: evaporation, crystallization, and drying. During evaporation whey is concentrated to 42 to 60 percent total solids. Lactose crystallization is necessary prior to drying of whey because lactose is amorphous and sticky in nature. This causes problems during drying. Hence, lactose is converted into crystalline /-hydrate form. When dried conventionally without lactose crystallization, whey concentrates yield powder that are very hygroscopic and the manufacturer runs the risk of the powder caking on storage, or even in the drier. I n addition, the efficiency of the drying is reduced, since it is not possible to concentrate whey to solids content greater than 42 to 45 percent total solids for a non-crystalline product. The advantage of lactose crystallization lies both in energy savings and in improved powder properties.

Whey Protein Recovery from Whey

Whey proteins are recovered from whey either in the form of whey protein concentrates (WPC) or whey protein isolates (WPI). WPC contain about 35to 80 percent on dry matter basis, while WPI contain more than 90 percent protein on dry matter basis. The principal manufacturing processes of whey protein products are based on known behaviour of whey components under defined conditions. Properties that have been exploited commercially include molecular size differences (ultrafiltration, gel filtration), insolubility of protein at high temperature, charge characteristics (demineralization, protein removal by ion exchange), aggregation by polyphosphates and crystallization of lactose. Capital cost for most of these processes are high and product yields are characteristically low.

Manufacture of Whey Protein Concentrates using UF

One of the prerequisite to UF processis to minimize fouling (deposition of minerals especially calcium) of the UF membranes by either sequestering of calcium, demineralization, heating plus calcium precipitation or pH adjustment, replacement of calcium with sodium, clarification and filtration. Hence, whey, regardless of type, usually must be filtered or centrifuged to remove suspended cheese or casein particles and for cheese whey, to remove fat also. Manufacturing process of whey protein concentrate (WPC) involves separation for fat and fines from whey followed by pasteurization and cooling to 55°C. Holding of whey at a temperature higher than the UF temperature (60-70°C) causes the precipitation of calcium phosphate to take place in the balance tank itself. However, there is much less tendency for the precipitation of calcium phosphate in the membrane system.Whey is then pumped into UF plant, from which WPC is produced (retentate).Also a protein depleted permeate (the stream which passes through the semi permeable membrane) is produced. T he protein content of the retentate stream will depend on the volume of permeate removed from the whey. Due to the UF treatment, the total solids concentration in the retentateincreases up to 25 percent. As the protein content increases, the fat content increases and lactose, moisture, and ash contents decrease. T he membranes not only retain the protein, but also the fat. On the other hand, in this process lactose and minerals are lost in the permeate resulting in their proportional decrease in the remaining solids. With diafiltration, the protein purity of the product improves significantly. The UF retentate, thus obtained is evaporated to 25 to 40 percent solids using an evaporator and subjected to spray drying for obtaining WPC powder. The resulting powder may be blended to ensure good product uniformity, and then bagged. Low temperature processing is necessary for the manufacture of WPC because of the heat sensitivity of the product.

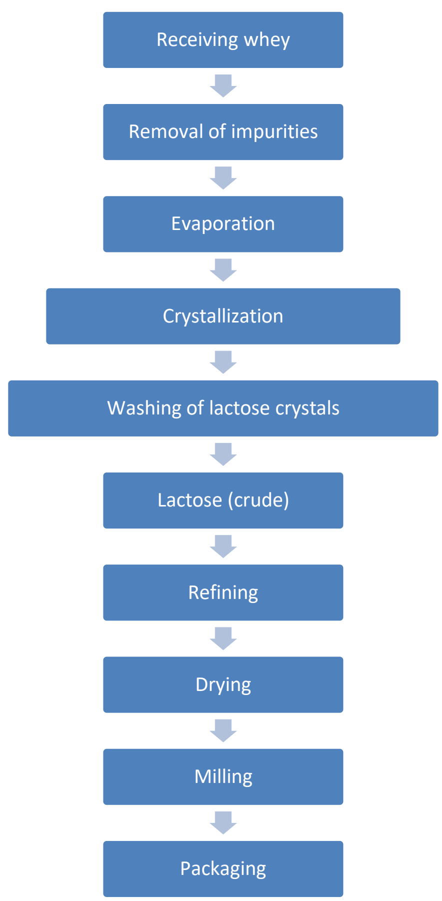
Lecture 8: Production of lactose and protein from whey

Manufacture of Lactose

Lactose is a characteristic carbohydrate of milk and is the only sugar of animal origin. It is white, water soluble crystalline powder in its pure form and moderately sweet in taste. Crystalline lactose occurs in two forms: /-hydrate and /-anhydride lactose or a mixture of both forms. T he most common form of commercial lactose is /-hydrate, very little lactose is in the form of /-anhydride. Lactose crystallises as /-hydrate from saturated solution at temperature below 93.5°C. T he crystals contain one molecule of water per molecule of lactose. T he /-anhydride which contains no crystalline water is formed when the crystallization takes place at temperature higher than 93.5°C. The crystallisation of lactose from saturated solution is the /-form which is less soluble. Lactose can be manufactured both from sweet whey and acid whey. Generally, unfermented whey is preferred because of its high lactose and low ash content. Acid whey if neutralised, changes the whey characteristics and increases the cost of manufacture. Lactose can be isolated on a commercial scale from whole whey or from deproteinized whey.

Manufacturing Process of Lactose

Lactose is separated from whey by the simple process of concentration and crystallization. The whey is pre-treated or clarified for the removal of impurities viz. whey proteins, salts and acidsand other impurities (dust, dirt, microbes) from whey, primarily for two reasons: (i) to reduce the viscosity of the concentrated whey so as to make the separation of lactose crystals possible, and (ii) to increase the purity of the recovered lactose. The lactose crystals are then removed from the concentrate in a centrifuge, while most of the whey proteins and salt pass on to the remaining liquid called the **mother liquor**. Degree to which the proteins and salts are removed from whey prior to concentration and crystallisation, determines the purity of lactose. The general flow diagram for the process of manufacture of lactose is given in Fig.



Removal of maximum amount of proteins and minerals from cheese whey can be achieved by adjusting pH of whey to 4.8 and heating it to 85 to 87°C and followed by filtration while in case of paneer whey higher deproteinization could only be obtained by heating to 90 to 92°C for 10 min at pH 6.6. UF process has also successfully been applied industrially for the deproteinisation of whey. T he UF permeate, particularly the acid whey permeate has a very high calcium content. During lactose crystallisation, the insoluble calcium salts may contaminate the lactose crystals, and because of their low solubility, they are not readily removed by washing with water. Therefore, UF permeate must be pre-treated prior to or during evaporation. Removal of approximately 50 percent calcium is sufficient to avoid difficulties during evaporation.

The concentration of whey to particular total solids is very critical because, a high total solids concentrate will be too viscous to pump, while a lower total solids concentrate will result in insufficient lactose crystallisation. T he UF permeate is concentrated to a solid content of 60 percent or more. T his is performed either by a pre-concentration through reverse osmosis, followed by evaporation or merely by evaporation. Reverse osmosis, when employed as a pre-concentration step, has the potential for removing a major portion of the water from whey or permeate more economically and in more energy efficient way than the evaporator process. Evaporation is carried out in falling film multi-effect evaporators for economic reasons. The concentration process must be conducted in such a way that no lactose crystallisation takes place in evaporator and piping.

The purpose of crystallisation is to secure the formation of crystals that can be separated from the mother liquor. The crystallisation rate depends on available crystal surface for growth, purity of the solution, degree of supersaturation, temperature, viscosity and agitation. Crystallisation is initiated in the hot concentrated whey or UF permeate. T he nucleation process is initiated by seeding and agitating the supersaturated solution. Cooling of lactose syrup to a temperature below saturation temperature is necessary for crystallisation of lactose. During crystallisation, ß-lactose is converted into /-lactose which is crystallized out. For easy recovery of lactose crystals, their size must be sufficiently large to ensure quick settling of crystals. E asy recovery is obtained with an average size of 0.2 mm. T he number of crystals and their average size can be controlled by seeding the concentrate with a known number of very fine lactose crystals. T he seed crystals must be added in the form of fine particles of /-lactose monohydrate (200 mesh) at the rate of 0.1% of concentrate. The entire crystallisation process lasts between 15-24 h under constant slow agitation.

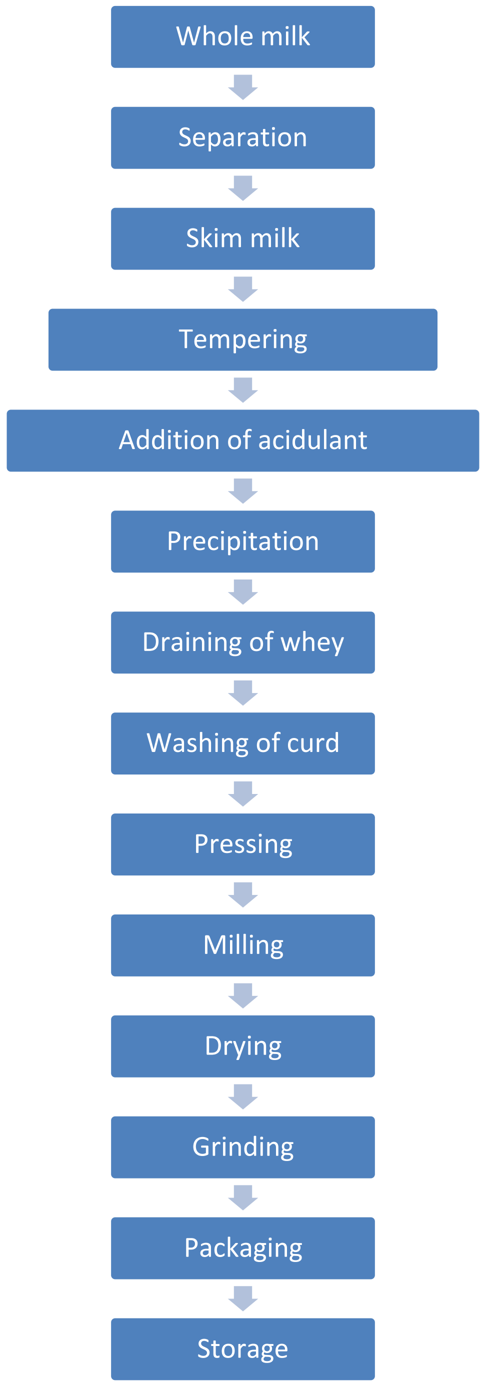
The lactose crystals can be harvested either in a basket centrifuge batch-wise or in a continuous decanter attached with a screw conveyor. Wash water is introduced into the centrifuge during the separation of lactose crystals to assist in the removal of the remaining impurities. The use of 10 percent wash water can reduce the ash level of the lactose by more than 66 percent. T he obtained lactose crystals are refined and dried to a final moisture content of 1.5 to 2.0 percent. The dried lactose crystals usually have a size of 40 µm.

Casein and Caseinates

An important utilization of skim milk is in the production of casein. Casein, the principal protein in milk, has been produced commercially for more than a century. Edible casein is a long established dairy byproduct finding its use as an ingredient in many dairy and food products. T he general development in technologies and the new uses in foods have increased the production and demand of this byproduct. Manufacture of edible casein differs from that of non-edible casein (also called industrial casein).Edible casein is produced under sanitary conditions, with the use of food grade chemicals and sufficiently heat treated to make it safe for human consumption. Edible non-animal rennet casein is the product obtained after washing and drying the coagulum remaining after separating the whey from the skimmed milk which has been coagulated by non-animal rennet or by other coagulating enzymes. Edible caseinate means the casein product obtained by reaction of edible casein or fresh casein curd with food grade neutralizing agents which have been subjected to an appropriate heat treatment. It may be spray or roller dried.

Casein proteins, which comprise approximately 80% of the total proteins of fluid milk, are distinguished from the so-called whey proteins by their insolubility and tendency to precipitate and coagulate at the isoelectric point (pH 4.6). Casein isolated by adjusting the pH of skim milk to 4.6 is generally known as acid-casein, although this product is more specifically defined by the type of acid used to reduce the pH of milk to the isoelectric point i.e. hydrochloric, phosphoric or lactic casein. In commercial practice, pH adjustment is achieved either by direct addition of the appropriate acid to skim milk or in the case of lactic acid, by formation of lactic acid from lactose fermentation using a bacterial culture. Although casein is a heterogeneous mixture of several individual casein components (a, b, k) each of which has slightly different properties, for the purpose of commercial production, whole casein which contains all these components is considered.

Method of Manufacture of Acid Casein



Sample Questions

MCQ:

1. i) The addition of water to milk can be detected by-

a) measuring freezing point, b) measuring protein content,

c) measuring somatic cell count, d) none of the above

ii) Which of the following dairy products has the least calcium?

a) cheddar cheese, b) colby cheese, c) cottage cheese, d) mozzarella cheese

iii) The formation of free fatty acids causes a ______ flavor in blue cheese.

a) salty, b) sweet, c) bitter, d) rancid

iv) A plant will reject specific milk from a producer if the milk fails to meet requirements for...

a) color and appearance, b) sediment, c) tests positive for drug residue, d) all of the above

v) The presence of coliform bacteria in a pasteurized milk sample is an indication of...
a) poor sanitation, b) improper storage, c) high quality milk, d) none of the above

vi) Generally, which breed produces the largest volume of milk?

a) Aryshire, b) Jersey, c) Holstein, d) Brown Swiss

vii) Most UHT pasteurized milk has a shelf life of at least ____ days.

a) 50, b) 180, c) 10, d) 120

viii) One serving of Cheddar cheese (28g) provides ___% of the RDA of calcium.

a) 20, b) 75, c) 10, d) 50

ix) A Federal Milk Marketing Order is a regulation issued by the...

a) Senate, b) Secretary of Agriculture, c) House of Representative, d) none of the above

x) The base material used for preparation of Chamcham is

a) Chhana, b) Maida, c) Khoa, d) Suji

xi) Example of calcium-insensitive casein is

a) K-casein, b) α_s- casein, c) β-casein, d) both (b) and (c)

xii) Acinol-N is used in dairy industry as

a) surface active agent, b) sequestering agent, c) sanitizing agent, d) Wetting agent

xiii) The energy value of milk carbohydrate is

a) 9.3 C/g, b) 4.1 C/g, c) 9.9 C/g, d) 4.5 C/g

xiv) The origin of Chhanapodo- a famous sweet meat, is

a) Orissa, b) Tamil nadu, c) Rajasthan, d) West Bengal

xv) The full form of FDV is

a) Float Division Value, b) Flow Diversion Value , c) Flow diversion Valve, d) Float Division Valve

xvi) The index organism for Pasteurization is

a) Staphylococcus aureus, b) *Bacillus subtillis*, c) *Coxelliae burnettii*, d) *Leuconostoc citrovorum*

xvii) The greenish yellow colour of milk whey is due to pigment

a) Lycopene, b) riboflavin, c) carotene, d) melanoidin

xviii) COB test is performed to determine

a) Protein content of milk, b) Heat stability of milk, c) Fat content of milk, d) None

xix) The term ETP is related with

a) Industrial waste management system , b) Dairy Sanitizing agent, c) Packaging material, d) none of these

xx) Example of milk protein having antibacterial activity

a) BSA, b) Lactoferrin, c) K-casein, d) α_s- casein

5 Marks Questions:

1. Briefly discuss about milk fat and milk sugar. 5

2. What is the chemical composition of Ghee? What do you mean by butter oil? (2+3=5)

3. Discuss briefly the history of milk of India. Explain white revolution. (3+2=5)

4. Define milk. What is chemical composition of milk? (2+3=5)

5. Discuss checks for purity of milk. 5

6. Discuss methods of detection of adulteration of milk. 5

7. Short note: Nutritive value of ghee. 5

8. Define regeneration efficiency of Pasteurizer. How do you estimate regeneration efficiency? If milk enters at 10^0C into the regeneration section then at what temperature it will leave the regeneration section of a HTST pasteurizer (having 95% RE)? (1+2+2=5)

9. Milk is pasteurized in a HTST unit using regenerator at a rate of 10630LPH. Calculate the regeneration efficiency of the pasteurizer if given that milk enters in the regenerator at 2.94^0 C and leave the regenerator at 68.5^0C. (Consider the pasteurization temperature at 78^0C). What is milk stone? (2.5+2.5)

10. The success of UHT milk depends on aseptic packaging"- Justify. Classify UHT plant according to the heating medium used. Give the advantages of UHT processing. (2+2+1=5)

15 Marks Questions:

1. a) Prepare an ice cream mix containing a fat about 10% , SNF – 11% , Sugar – 15% and stabilizer 0.5% . Given whole milk testing 6.8% fat, 9.6% SNF, and cream testing 40% fat and 5.4% SNF. Skimmed milk powder testing 0.5% fat and 97% SNF.

b) Fresh milk contains 12.3% total solid and condensed milk contains 31% total solid. How much sugar should be added to milk to give 43.1% sugar in condensed milk?

c) Calculate the percentage of overrun when the volume of ice cream is 4.72 liters and that of ice cream mix is 3 liters. (5+5+5=15)

2. a) A drum drier is being design for drying a product an initial total solid content of 12% and final moisture content 4%. An average temperature differences between the roller surface and the product of 65^0C will be used and overall heat transfer coefficient is 1500 kcal/hr-m^{20}C. Determine the surface area of roller required to provide a product rate of 50 kg product/hr. Given that Latent heat of vaporization is 540kcal/kg.

b) Milk of 18.5% solids is dried to 3.8% on a drum drier at a rate of 10.5kg dried product per hour. The diameter of drum is 60cm and length is 90cm. Product is scraped at half revolution, the stream temperature is 160^0C, and vaporization point of moisture is 104^0C. Find out the overall heat transfer coefficient. Given that Latent heat of vaporization is 540kcal/kg. (8+7=15)

3. Give the flow diagram of manufacturing of ice cream? What is the over run in this process? Name five defects in ice cream, their cause and prevention? Discuss the ingredients needed for the production of ice cream? Mention their role. What are the changes occurring during the freezing process? (2+2+3+3+3+2=15)

4. Define butter according to PFA rules. Give the flow diagram of manufacturing of Butter? What do you mean by churning? What do you mean by overrun of butter? Write down flow diagram of manufacturing of Recombined milk? (3+3+3+3+3=15)

5. (a) Milk is pasteurized in a HTST unit using regenerator at a rate of 3000 Kg/h using counter current flow heat exchanger. The hot milk inlet temperature is 73^0C, efficiency of regenerator is 85% and U= 2500 Kcal/h-m^2-^{0}C. Compute amount of saving in steam (Kg) and refrigeration in tonnes by using regenerator.

(b) With schematic diagram explain the principle of different types of batch pasteurizer. Give the advantages and disadvantages of batch pasteurization process. (7+5+3=15)

6. (a) What are the advantages and disadvantages of HTST Pasteurization process used in Dairy Industry for processing of milk? With schematic diagram explain the milk flow through HTST pasteurizer.

(b)What is the time necessary to heat milk from 10^0C to 75^0C with steam at 101^0C? If given that; volume of milk= 3.5 m^3; heat transfer area A= 9.0 m^2; heat transfer value at the steam side h_v = 4000 kcal/m^2-h-^{0}C, and at the milk side h_m = 900 kcal /m^2-h-^{0}C; wall thickness of the vat = 0.004m, thermal conductivity of the wall of the vat k= 13 kcal/m-h-^{0}C; density of milk ρ_m = 1030 kg/ m^3; specific heat of milk= 0.93 kcal/ kg^{0}C. (3+6+6=15)

7. Write down the FSSAI standard of Cheese. What is Kumiss? Give the process flow diagram of Cheddar cheese. Give one example each of soft cheese, hard cheese and externally mold ripened cheese. (2+2+8+3=15)

8. Write short notes on: (Any five) (5x 3= 15)

a. Kefir
b. Vaccreation
c. HDPE and Polystyrene as packaging material in dairy industry
d. Lactose Crystallization
e. Mozzarella Cheese
f. Heat stability of milk
g. Turbidity test
h. Working principle of FDV