EXPERIMENT 1 PREPARATION AND STANDARDIZATION OF CREAM

Structure

1.1 INTRODUCTION

Cream is classified on the basis of its fat content. Standardization of Cream helps in production of uniform quality of butter. Cream for butter making is usually standardized between 35-40% fat. Standardization helps to produce butter of desired composition particularly in respect of its fat content and also minimized losses of fat in butter milk. Certain types of cream are required to meet the legal standards with respect to fat before it is marketed. The cream can be standardized by the addition of either water or skim milk depending upon its intended use. Generally, skim milk is used for standardization of cream for sale. Water may be used for standardization of cream for butter making but usually skim milk is preferred for profitable utilization of butter milk.

1.2 OBJECTIVES

- get familiar with separation of cream using centrifugal cream separator
- determine the fat per cent in cream
- standardize cream for retail sale or for preparation of butter

1.3 EXPERIMENT

i. Principle

Milk fat has lower density than that of other milk constituents. When milk is subjected to gravitational or centrifugal force, fat being lighter, separates out from the milk serum. Thus, milk is divided into two different portions. The portion, which is rich in milk fat is known as cream and the portion, which is devoid of fat as skim milk.

ii. Equipment / Machinery / Instruments /Chemical / Materials Required

Cream separator, stainless steel / plastic buckets (10-15 litres capacity), weighing balance, thermometer, milk strainer, plunger, sampling device and sampling bottles, milk, fat testing set and acid testing set

iii. Procedure

a) Preparation of cream

- Weigh the milk to be separated
- Warm the milk to 40°C
- Take a sample of milk for acidity and fat testing
- After all the water has run out, pour warm milk in the supply tank after straining
- Maintain the rated speed of bowl and allow milk to run through separator to start separation
- Note time when separation started
- Collect cream and skim milk separately in clean and dry cans of known weight
- When all the milk has been separated, pour about 1 litre warm and clean water slowly over the float
- Stop the separator and note the time
- Find out the net weight of cream and skim milk
- Take representative samples of cream and skim milk.

b) Standardization of cream to 25% fat

- Determine fat percent in cream and skim milk.
- Ascertain the quantity of standardized cream to be made
- Calculate the quantity of skim milk to be added to cream to obtain desired fat percentage in the final product (Use Pearson's Square method)
- Add the calculated quantity of skim milk to weighed quantity of cream and mix them thoroughly with the help of plunger or stirrer in a can or vat
- Take a representative sample of the final mixture and analyse it for fat

c) Cleaning and sanitization of the cream separator

- Dismantle the bowl and remove the slime deposited inside
- Rinse all parts with tap water
- Wash thoroughly with warm water and cleaning solution using a brush for scrubbing
- Rinse with scalding water
- Drain out all the water and place the parts in clean rack for drying
- Before assembling the separator for re-use, immerse all the parts in a chlorine solution (150-200 ppm).

iv. Results/Observations

a) Particulars of milk:

Type (cow/ buffalo/ fresh/ old/ processed/ stored in cold store)

Quantity ..... litre

Fat ..... %

Acidity ..... % L. a.

b) Preparation of cream:

Temperature of milk ..... °C

Time milk let in ..... hr ..... min

Time milk let off ..... hr ..... min

Speed of bowl ..... rpm

Rated capacity ..... l / hr

Rate per hour (given) ..... l / hr ..... l / hr (observed)

Quantity of cream ..... kg

Out-turn of cream ..... %

Quantity of skim milk l

Out-turn of skim milk ..... %

Quantity of separator slime ..... g

Efficiency of cream separator ..... %

Fat in cream ..... %

Total fat in cream ..... kg

Fat in skim milk ..... %

Total fat in skim milk ..... kg

Total fat recovered in cream ..... kg

Total fat lost in skim milk ..... kg

c) Production chart for standardization

Quantity of cream ..... kg

Quantity of skim milk to be added ..... kg

Quantity of standardized cream prepared ..... kg

Fat in standardized cream ..... %

1.4 PRECAUTIONS

- Carefully observe the condition of the driving mechanism.
- Strain the milk properly to make it free from sediment
- Maintain the temperature of milk between 37- 40°C

EXPERIMENT 2 PREPARATION OF STERILIZED CREAM

Structure

2.1 INTRODUCTION

Sterilization is a process of heat treatment of a food product to a pre-determined temperature time combination to destroy the viable microorganisms and enzymes and improves its shelf life and makes it safe for human consumption. The sterilized cream can stay on the shelves of a shop at ambient temperature for longer period. It does not require refrigerated storage. Thus it is easy to transport and market it. Sterilized cream can be used for several purposes but its most common use is in coffee, tea, salads etc.

2.2 OBJECTIVES

- To know the quality of cream and skim milk.
- To prepare sterilized cream.

2.3 EXPERIMENT

i. Principle

Microorganisms and the enzymes are destroyed or inactivated by the application of heat. In sterilization process, same principle is applied to make the cream free from microorganism and enzymes, which cause its spoilage and make the product safe for consumption.

ii. Materials /Equipment

Cream, skim milk, glass bottles, crown corks, pre-heater, homogenizer, bottle filler, crown corking machine, batch sterilizer

iii. Procedure

- Check the quality of cream by performing organoleptic tests, acidity test, alcohol test and 10 min Rezazurin test.
- Standardize the cream to 25% fat with the help of Pearson's Square Method.
- Heat the standardized cream to 50°C for homogenization.
- Homogenize the cream employing pressure of 200 kg / sq. cm. in the first stage and 35kg / sq. cm. in the second stage.
- Pre-heat the homogenized cream to 80°C (flash).

- Adjust the bottle filler machine to deliver cream up to the mark in the bottles.
- Bottle should be filled only up-to a maximum of 80 % of the total capacity.
- Crown cork the bottles
- Keep the filled bottles in the crate
- Load the crates in the sterilizer
- Make sure that there is enough water in the sterilizer, at least half full.
- Close the lid securely.
- Keep air-vent open.
- Close the air vent and allow pressure to rise to 1.2 kg / sq. cm
- Rotate the sterilizer for 20 minutes and maintain the steam pressure at 1.3 kg / sq. cm.
- Close the steam valve.
- Open the water in-let valve gradually and keep the drain valve open. Adjust the water in- let valve and drain valve in such a way that the steam pressure in the sterilizer drops gradually to zero.
- Continue letting in water until pressure shows zero on the dial of the pressure gauge.
- Allow the sterilizer to cool for a further period of 20 minutes until the temperature reaches 30 °C
- Stop rotating the sterilizer
- Drain all the water through the drain cock.
- Open the sterilizer door, draw the crate carrier and remove the crates.
- Examine random samples of sterilized cream for colour and sediment.
- Send the samples for detailed testing in the laboratory.

iv. Result/Observation

Production chart

Quantity of cream ..... kg Fat ..... % SNF ..... % Acidity ..... %

Alcohol test ..... Resazurin grade .....

Fore-warming temperature ..... °C

Capacity of bottle ..... ml

Number of bottles filled .....

Sterilization time started ..... hr ..... min

Time stopped ..... hr ..... min

Time of holding ..... min

Time of coming up ..... min

Time of cooling ..... min

2.4 PRECAUTIONS

1. Keep a constant watch on the pressure gauge
2. Inspect the bottles for chipped mouth before use.
3. Read the instructions for operation of sterilizer and follow closely.
4. Ensure that the sterilizer has cooled to room temperature before opening the door and taking out the bottles.

EXPERIMENT 3 PREPARATION OF BUTTER STARTER

Structure

3.1 INTRODUCTON

Flavour of butter is an important determinant for its marketability. Therefore, cream is ripened to impart characteristic flavour to butter. The starter culture is used for ripening of cream. The starter culture comprises of a mixture of micro-organisms, namely streptococcus lactis, Streptococcus cremoris, strptococcus diactelactis and Leuconostoc citrovorum. Ripening of cream for butter-making requires starter culture in large quantity. Therefore the student should know the method of preparation of bulk starter culture. It is always essential to prepare starter culture in utmost hygienic condition at proper incubation temperature. The culture must be pure and free from contaminants. It is always preferred to use freshly prepared starter culture for ripening of cream. The starter culture after preparation is stored at refrigerated temperature till it is used.

3.2 OBJECTIVES

To study the method of preparation of good quality butter starter.

3.3 EXPERIMENT

i. Materials Required

Starter can with lid and plunger, water bath, thermometer, starter culture (mother culture / seed culture), skim milk and low temperature incubator (B.O.D.)

ii. Procedure

- Clean the starter can, its lid and plunger with water and detergent solution, and sterilize them with steam.
- Check that the skim milk is fresh and normal in composition.
- Ensure that the mother culture is free from whey separation and gas pockets; and that it is full of flavour, homogeneous, smooth and active for starter making.
- Transfer the skim milk to the starter-can, taking care to fill up not more than four/ fifth of the can, replace the plunger and lid in position.
- Insert the can with its content in water bath adjusting the water level to that of the milk level.
- Allow inlet of steam in the water bath till the water begins to boil, agitating the milk frequently with the plunger all the time.

- Continue heating of milk for an hour.
- Close steam and open cold- water inlet with agitation of milk as before.
- Stop when temperature of water in bath reaches 20 **°C** constantly.
- Transfer the seed mother culture at about 1.0 % to the pasteurized and cooled milk in the can taking aseptic precautions.
- Mix the contents thoroughly.
- Remove the plunger and replace the lid. Set the inoculated skim milk to ripen at 20-22°C for 12-16 hours.
- Afterwards examine the set starter for appearance and flavour and store in cold store for further use.
- Check quality by starter activity test.

iii. Results/Observation

Particulars of milk:

Type ..... Fat ..... %

Quantity ..... L SNF .....%

Acidity ..... (% lactic)

Particulars of starter culture:

General characteristics .....

Acidity .....% lactic

Flavour

Incubation:

Amount of inoculum ..... kg

Temperature of milk at inoculation ..... -°C

Temperature of incubation ..... -°C

Total time of incubation ..... hr

Quality of starter:

Organoleptic characteristics .....

Acidity ..... % lactic

Starter activity: Slow / Fast / Medium

Amount of starter culture made ..... kg

Out-turn ..... %

3.4 PRECAUTIONS

1. Use only fresh and normal skim milk.
2. Maintain aseptic condition as far as possible during processing and transfer of culture.
3. Maintain temperature of water bath 1-2°C above processing temperature.

EXPERIMENT 4 PREPARATION OF CREAM FOR BUTTER MAKING

Structure

4.1 INTRODUCTION

Good quality cream is used for preparation of butter with desired characteristics. The quality of cream is normally assessed in terms of titratable acidity, fat content, temperature and period of ageing, flavour and its hygienic condition. Many dairy plants procure cream through the suppliers, which might be acidic or low in fat content. It is, therefore, always advantageous to process the cream before it is churned into butter. The following steps are involved in the preparation of cream for butter making: Standardization, neutralization, pasteurization, ripening, cooling and ageing. These processing steps help in minimizing the losses of fat in butter milk and produce butter of desired quality in terms of flavour, body and texture, consistency, composition and yield.

4.2 OBJECTIVES

- To prepare cream for butter making
- To learn the method of neutralization, pasteurization and ripening of cream

4.3 EXPERIMENT

i. Equipment/Machinery/Instruments/Chemical/Materials Required

Holding / multipurpose vat, stainless steel / plastic buckets (10- 15 litres capacity), weighing balance, thermometer, plunger, sampling device and sampling bottles, cream, fat testing set and acid testing set, neutralizer, sprinkler and butter starter

ii. Standardization of cream

- Ascertain the quantity of standardized cream to be churned.
- Calculate the quantity of skim milk to be added to cream to obtain desired fat percentage (usually 40 %) in cream (Use Pearson's Square method).
- Add the calculated quantity of skim milk to weighed quantity of cream and mix them thoroughly with the help of plunger or stirrer in a vat.

- Take a representative sample of the final mixture and analyses it for fat.
- Clean all the used equipment.

iii. Neutralization of cream

- Note the weight of cream in the vat.
- Mix the cream thoroughly and take a representative sample.
- Determine the acidity (% lactic acid) of cream by titration method in duplicate.
- Fix the standard for acidity for pasteurization of cream (usually 0.11 to 0.13 % L.A.).
- Calculate the exact amount of the neutralizer required for neutralization.
- Dissolve the calculated amount of neutralizer in clean water in the ratio of (neutralizer: water) 1:20.
- Add the dilute neutralizer from the sprinkler to the well agitated cream uniformly, the temperature of cream being held at 33-35°C
- Continue the agitation of cream for 5-10 minutes after addition of neutralizer solution
- Take representative sample of the neutralized cream and test the acidity (% Lactic acid).

iv. Pasteurization of cream

- Determine the acidity of standardized and neutralized cream.
- Run the stirrer provided in the vat and mix the cream thoroughly.
- Heat the cream in the vat either through a medium of hot water or steam to a temperature not less than 70°C or 71°C and regulate the steam valve so that the temperature is maintained for 30 minutes.
- After holding period, close the steam valve and open the chilled water valve, and circulate the chilled water in the jacket of the vat until the temperature drops to 5-6°C.
- Note the acidity of cream and cover the vat after removing the agitator for aging and conditioning of cream for churning.

v. Ripening, Cooling and Ageing of cream

- Beat the starter to homogeneous mass with sterile plunger.
- Check the acidity (% lactic acid) of the butter starter
- Agitate the cream
- Pour well mixed starter to the cream in the vat through a strainer distributing it uniformly
- Keep agitator working for 5-10 minutes after addition of starter
- Note acidity of cream after addition of starter
- Arrange to bring the temperature of the vat contents to 20-22°C (while stirring)
- Stop the agitator and maintain the temperature at 21-22°C throughout ripening period
- When the cream registers a serum acidity of 0.25-0.28 % lactic acid start the agitator and simultaneously cool the cream to about 10°C
- Hold the cream at that temperature for at least 2-4 h before churning

vi. Results/Observation

Particulars of cream:

Type .....

Fat ..... % Quantity ..... kg

Acidity ..... % Amount of fat ..... Kg

Standardization

Quantity of cream ..... kg

Quantity of skim milk to be added ..... kg

Quantity of standardized cream prepared ..... kg

Fat in standardized cream ..... %

Neutralization

Neutralizer used .....

Amount of neutralizer ..... g

Acidity of cream ..... %L.A.

Pasteurization

Fat in cream ..... %

Temperature/time ..... °C

Acidity after pasteurization ..... % l. a.

Ripening:

Amount of starter added ..... kg

Temperature of incubation ..... °C

Period of incubation ..... hr

Acidity of ripened cream(% L.A) .....

Pre conditioning:

Cooled to ..... °C

Period of cooling ..... hr

4.4 PRECAUTIONS

- Maintain the correct temperature of neutralization.
- Ensure uniform agitation before, during and after neutralization
- Avoid over-neutralization
- Avoid too much of agitation causing churning of fat
- Maintain time-temperature combination
- Avoid post pasteurization contamination of cream.

EXPERIMENT 5 CONSTRUCTION AND OPERATION OF POWER CHURN

Structure

5.1 INTRODUCITON

Butter churn is a device for making butter. It has evolved in various phases and has undergone several modifications starting from earthen pots to continuous machine. Modern butter churns are large barrel shaped revolving containers made of stainless steel. Cream is placed in these devices and agitated until it is converted into butter granules. The constructional material and the design of butter churn influence the quality of butter and the losses of fat in butter-milk.

5.2 OBJECTIVES

- To study the constructional features and operation of power butter churn
- To get familiar with preparation of butter churn for churning cream to butter

5.3 EXPERIMENT

i. Materials/Equipment's required

Metal churn, cream strainer, platform balance, butter moisture balance with accessories, fat and acid testing set along with standard solution, sampling bottle and sampling device, thermometer, butter-trier, butter colour and butter salt, good quality chilled water and cream

ii. Procedure

a) Constructional features

- Type of churn: Hand/ Power operated
  - i) Metal/wooden
  - ii) Cylindrical/Conical
  - iii) Roller type/Roll-less-type
  - iv) Front opening/Side opening
- Make and capacity of churns
- Floor space occupied
- Dimensions of the barrel
- Driving mechanism

- Number of speeds provided
- Fittings provided
- Cooling method used
- Lubrication procedure
- Cleaning procedure
- Special sanitary constructional features

b) Operation of butter churn

- Run scalding water into the churn at 90- 95°C till it is one fifth full.
- Revolve the churn for about 15 min.
- Stop the churn and run off the scalding water
- Run cold water into the churn at 5°C so as to fill the churn one fifth; and chlorine solution to make up a concentration of 100 ppm.
- Revolve the churn with cold water for 10 min.
- Stop the churn and drain the chilled water completely.
- Open the inlet of chilled water to the inside vanes.
- Fix the cream strainer to the end of the cream delivery pipe and insert it into churn through cream filling valve.
- Take a representative sample of the cream and determine its acidity and fat content.
- Note the temperature of cream and start pumping cream into the churn till it is full.
- Revolve the churn after noting the time it was started
- Ventilate the cream, a few times, during early stage of churning.
- Revolve the churn until the butter breaks and grains reach the size of peas.
- Wash the butter grains draining out the butter- milk as done in the case of butter making with hand churn.
- Take a sample of butter- milk for testing its fat content.

iii. Results/Observation

Record your observations in the production chart for creamery butter.

5.4 PRECAUTIONS

1. When power wooden churn is used for making butter, preparation of churn may be done as in the case of hand churn.
2. While scalding the power churn keep the ventilation open

EXPERIMENT 6 CONSTRUCTION AND OPERATION OF BUTTER PACKAGING MACHINE

Structure

6.1 INTRODUCTION

Introduction of modern packaging machine facilitates large-scale production of butter. Such machines eliminate the slow and intensive manual packaging systems. It also reduces the losses and delivers hygienically packaged butter in desired sizes and in different forms. Basically there are two types of packaging machines: semi-automatic and fully automatic type. Semi-automatic packaging machines are suitable for small-scale dairy plants while the fully automatic packaging machines are capable of meeting the demands of large dairy plants.

6.2 OBJECTIVES

- Study the constructional features of butter packaging machine.

6.3 EXPERIMENT

i. Materials/Equipments required:

Butter packaging machine, butter, packaging material, butter cutter, storage containers, weighing balance

ii. Procedure:

Observe the constructional features and operation of a power butter packaging machine and record the observations

a) Constructional features

- Type of butter packaging machine: Manual / Semi-automatic/ Automatic
- Make and construction material
- Capacity
- Floor space required
- Driving mechanism
- Lubrication procedure
- Sanitary constructional features

b) Operational features:

- Clean the machine thoroughly with water and detergent solution

- Sanitize the machine with steam or by running scalding water into the packaging machine at 90- 95°C for about 15 min.
- Stop and run off the scalding water
- Run cold water at 5°C followed by chlorine solution (concentration 100 ppm)
- Ensure that packaging material is properly placed
- Adjust the machine to obtain correct quantity of butter in the package
- Feed the butter in the hopper
- Run the machine
- Check the packages intermittently for weight and proper packaging
- Place the packages in storage containers
- Transfer the containers full of packaged butter to cold store maintained at –18°C
- Clean the machine and the accessories with hot water and detergent after use and leave them to dry

iii. Results

- Record your observations

6.4 PRECAUTIONS

- Butter should be tempered at right temperature before it is fed to the packaging machine

EXPERIMENT - 7 PREPARATION OF *DESI*, COOKING AND TABLE BUTTER BY HAND OPERATED BUTTER CHURN

Structure

7.1 INTRODUCTION

Butter is classified on the basis of cream type, ripening process, manufacturing methods etc. Desi butter and creamery butter are the most common varieties. Desi butter is commonly known as makkhan. It is made by hand churning of dahi or malai in an earthen pot with a wooden mathani (ladle). Creamery butter is made in a dairy plant. It is further classified as cooking butter and table butter. Cooking butter is plain unsalted creamery butter and is mostly used for ghee making or in the baking industry. Table butter is salted creamery butter and is a good bread-mate. Manufacture of table butter requires strict quality control and hygienic conditions of manufacture. Its moisture and fat contents must be adjusted to meet the legal requirements. The moisture, curd, and salt contents in butter are the sources of profit. The weight of butter obtained from a given lot of cream is always more than the amount of fat present in cream. The amount of butter, which exceeds the amount of fat present in cream is called overrun. In other words, it may be defined as the increase in the amount for butter made from a given amount of fat. It is usually expressed as percentage overrun. It is calculated by the increase in weight of butter made from a given weight of fat in cream. The formula used for the calculation of Theoretical overrun is given below:

7.2 OBJECTIVES

To prepare butter by a hand operated wooden churn.

7.3 EXPERIMENT

i. Materials/Equipments required

Butter churn, platform balance, milk cans, strainer, butter moisture balance with accessories, acid- testing set along with standard solution, sampling bottle and sampling device, thermometer, butter- trier, butter colour and butter salt, good

quality chilled water and cream.

ii. Procedure for preparation of desi / cooking butter

a) Preparation of churn:

- Fill the churn one-third full with scalding water and rotate the churn for 15-20 min leaving the ventilator open. Empty the churn and cool it by filling it one-third full with chilled water, preferably chlorinated, at about 5°C and revolving for 15-20 min.
- Drain out the water

b) Filling of churn with cream and churning

- Adjust the temperature of the cream in the vat to 9- 12°C according to the season and then take a sample for acidity and fat tests.
- Load the known quantity cream in the churn through strainer.
- Add calculated amount of butter colour, if required.
- Note the temperature of cream in the churn.
- Close the door of the churn tightly and the air vent.
- Revolve the churn (at high speed) and note the time it was started.
- Open the air vent a few times during the early stage of churning.
- Allow the churn to run until the butter breaks and add break- water at 7-8°C at the rate of 25 % of volume of cream and record the temperature of the cream.
- Close the door of the churn and revolve the churn until the granules reach the size of peas or lower.
- Stop the churn.
- Drain out the butter- milk through strainer after noting its temperature.
- Record the weight of butter- milk and take sample for fat test.
- Flush the butter grains with chilled water of 5-10 % volume of buttermilk and drain out the diluted buttermilk.
- Fill the churn with chilled water at 1-2°C below the churning temperature through a strainer to the original level of the cream in the churn.
- Close the door and rotate the churn 8-10 times at slow speed.
- Stop the churn and drain out the wash water through the strainer
- Unload the butter in a container

iii. Procedure for preparation of creamery butter/table butter:

a) Cleaning and sterilization of butter churn

- Run scalding water into the churn at 90-95°C till it is one fifth full.
- Revolve the churn for about 15 min.
- Stop the churn and run off the scalding water
- Run cold water into the churn at 5 **°C** so as to fill the churn one fifth; and chlorine solution to make up a concentration of 100 ppm.
- Revolve the churn with cold water for 10 min.
- Stop the churn and drain the chilled water completely.
- Open the inlet of chilled water to the inside vanes.

b) Filling of churn with cream and churning

- Fix the cream strainer to the end of the cream delivery pipe and insert it into churn through cream filling valve.
- Take a representative sample of the cream and determine its acidity and fat content.
- Note the temperature of cream and start pumping cream into the churn till it is full.
- Revolve the churn after noting the time it was started
- Ventilate the cream, a few times, during early stage of churning.
- Revolve the churn until the butter breaks and grains reach the size of peas.
- Wash the butter grains draining out the butter -milk as done in the case of butter making with hand churn.
- Take a sample of butter- milk for testing its fat content.

iv. Working of butter to adjust its moisture content

- Stop the churn and remove the wash water through strainer
- Work the butter by revolving the churn several times, and remove the free water.
- Take a representative sample of butter and perform the first moisture test.
- Ascertain the per cent moisture desired in the final butter and calculate the amount of water to be added to the butter in the churn using the formula: Kg. of water to add = A x 1.5 B / 100 Where A is % moisture to be raised and B is kg> of fat in the churn.
- Ascertain the per cent salt desired in the finished butter and calculate the amount of salt to add.
- Add the calculated amount of salt to the butter by means of salt sprinkler, taking care to distribute the salt uniformly over the butter. Then sprinkle the calculated amount of water to be added over it (kg. of salt to add = Rate of salting x 1.25 x butter ft content in the churn).
- Work the butter until it looks dry (no free moisture) when cut with a scotch hand.
- Take a representative sample of the butter and perform final moisture test.
- Unload the butter, and record the weight
- Wash the churn by putting one-third full of warm water and revolving for about 5 min. Drain off the wash water.
- For Wooden churn: Fill the churn with one third full scalding water at about 85°C and revolve it for not less than 15 min. keeping the ventilator partially open.
- For metal churn: Fill the churn with one-third full of warm cleaning solution, revolve it for about 10 min. and drain. Give final washing with same amount of scalding water.
- Invert the churn with the door screen down-wards for the drainage and drying.
- Wash the outside of the churn when the churn is in inverted position.

v. Determination of overrun in butter

- Collect representative sample of the following products and determine as accurately as possible the quantities during the course of butter making:

- Milk and cream used
- Skim milk (wherever butter making started with milk)
- Buttermilk
- Wash water
- Unpacked butter
- Butter (number of packets made ready for sale)

- Determine the fat content (%) of the above products.
- Calculate the loss of fat during separation of milk, churning of cream, buttermilk, wash water and during packaging of butter.
- Calculate the percentage of actual overrun by formula
- List the factors affecting overrun in butter making under practical condition

vi. Results:

Particulars of cream*:*

Type .....

Fat ..... % quantity ..... kg

Acidity ..... % Amount of fat ..... Kg

Neutralization

Neutralizer used .....

Amount of neutralizer ..... g

Acidity of cream ..... %

Pasteurization:

Fat in cream ..... %

Temperature/time ..... °C/ sec

Acidity after pasteurization ..... %l. a.

Ripening:

Quantity of starter .....

Amount of starter added ..... kg

Temperature of incubation ..... °C

Period of incubation ..... hr

Acidity of ripened cream % L.A.

Pre conditioning:

Cooled to ..... °C

Period of cooling ..... hr

Churning:

Room temperature ..... °C

Acidity of cream ..... % l. a.

Fat in cream ..... %

Temperature of churning ..... °C

Churning temperature of cream ..... °C

Amount of colour added ..... ml

Rate of adding colour ..... %

Time break- water added ..... hr ..... min

Temperature of butter before adding break-water ..... °C

Amount & temperature of break-water ..... litre/°C

Temperature of butter after adding break-water ..... °C

Time churning completed ..... hr ..... min

Time taken ..... hr

Size and character of butter grains .....

Temperature of butter-milk ..... °C

Quantity of butter milk ..... Kg

Fat in butter milk ..... %

Amount of fat lost in butter- milk ..... g

Total fat lost ..... kg (Fat lost in skim milk and butter milk)

Washing:

Temperature of wash water ..... °C

Amount of wash water l

No. of washing given .....

Total time taken for washings ..... min

Working and salting:

Butter flavour added .....

First working time ..... min

First moisture test ..... %

Second working time ..... min

Amount of salt added ..... kg

Quantity of water added l

Final moisture ..... %

Final salt ..... %

Total time ..... hr

Ice used .....

Overrun:

Butter Quantity ..... kg

Out turn ..... %

Quantity overrun ..... kg

Salt ..... %

Moisture ..... %

Total fat recovered ..... %

Total time taken for butter making ..... %

Remarks:

7.4 PRECAUTIONS

- While revolving the churn with scalding water, leave the ventilator partially open to relieve the pressure built up inside.

- Ensure opening of the air vent a few times in the early stages of churning the cream.
- Ensure that the churn is cooled before the cream is let in.
- The churning temperature should be lower during summer and higher during winter, in the absence of air- conditioning facilities.
- If necessary, chilled water is required amount may be added after breaking stage to bring down the temperature to original level.
- Wash the butter with good quality chilled water and avoid addition of less wash water for washing butter
- The sample for first butter moisture test should be taken carefully

EXPERIMENT 8 STUDY OF MANUFACTURE OF TABLE BUTTER BY POWER CHURN

Structure

8.1 INTRODUCTION

Table butter is the most common creamery butter. It is made employing a power operated butter churn. The steps followed are the same as those for the table butter described in the previous exercise. The quality of butter obtained by the power churn is considered hygienically superior than that obtained by a hand churn simply because of the elimination of manual handling during working, salting etc.

8.2 OBJECTIVES

- get familiar with the details of manufacture of table butter in power butter churn in a dairy plant

8.3 EXPERIMENT

i. Materials/Equipments

Butter power churn with accessories, platform balance, milk cans, strainer, butter moisture balance with accessories, acid testing set along with standard solution, sampling bottle and sampling device, thermometer, butter- trier, butter colour and butter salt, good quality chilled water and cream.

ii. Procedure

Observe the operation of power butter churn and record the observations.

iii. Results/Observation

Particulars of cream

Type ..... Quantity ..... Fat % .....

Total fat ..... Acidity ..... % L.A. Temp ..... °C

Details of churn

Type ..... Capacity .....
Method of sterilization

i. Wooden churn

ii. Metal churn

Churning

Room Temperature ..... °C

Time churning started ..... hr ..... min Temp ..... °C

Amount of colour added ..... Rate .....

Time of break water added ..... hr ..... min Quantity ..... L Temperature ..... °C

Temperature of cream after addition of break-water .....

Time churning completed ..... Hours ..... Minutes

Size & character of butter grains .....

Quantity of butter milk ..... L Fat % ..... Total Fat .....

Fat lost in buttermilk ..... Kg.

Washing

Number of washings .....

Temperature of wash water ..... °C Amount ..... litre

Time washing started ..... hr ..... min Finished ..... hr ..... min

Total time taken for washing ..... hr

Salting and working

Amount of salt ..... Rate .....

Time working started ..... hr ..... min

Time at 1st moisture test ..... hr ..... min

1st moisture test ..... % Amount of water added ..... litre

Total working time ..... hr Final moisture ..... %

Butter

Total time taken for butter making ..... hr

Quantity ..... % Overrun ..... % Fat recovered .....

Flavour ..... Body and Texture ..... Colour .....

Packaging and storage of butter

Type of packaging used ..... Number of packages made .....

Quantity in each package ..... Total number of packages .....

Packaging losses .....

Storage temperature of butter .....

Length of storage time of butter .....

8.4 PRECAUTIONS

1. Follow the instruction manual of power churn.
2. Proper temperature should be maintained.
3. Avoid excessive churning of cream
4. Good quality cream should be used.
5. Don’t touch butter with hand.
6. Good grade of salt should be added.
7. After packaging butter should be in cold storage.

EXPERIMENT 10 AGMARK GRADING OF GHEE

Structure

10.1 INTRODUCTION

The purpose of marketing ghee under Agmark certificate is to assure the consumers that the product is of pre-tested high quality and purity. It thus develops goodwill and confidence, thereby increase the sale of such graded product. Under Agmark scheme ghee is graded into three categories, namely 'special' (Agmark Red Label), 'General' (Green Label) and 'Standard'.

10.2 OBJECTIVES

The students should be able to :

- learn the procedure of obtaining Agmark certificate.
- develop the necessary facilities, and set up refinery for packing ghee under Agmark grade.

10.3 EXPERIMENT

I. Principle

The main principle of producing ghee of Agmark grade is to obtain raw material of high quality, process or refine it under recommended conditions and package in appropriate containers. The precise testing of raw materials and finished product under the supervision of a highly qualified chemist is, therefore, very pertinent.

II. Requirements

i) An appropriate building having proper lighting and ventilation, good working conditions and facilities for employees' comfort and hygiene.

ii) Collection vessels/ tanks for raw materials.

iii) Heating pans/ kettles/ karahi.

iv) Stirrers/ scoops and strainers.

v) Settling tank.

vi) Heating source

vii) Tin filling and sealing machine.

viii) A well-developed laboratory having facilities for testing raw materials and

finished product for:

- Butyro-refractometer reading
- Boudouin Test
- RM value
- Polenske value
- FFA
- Moisture
- Phytosterol acetate test

ix) A qualified chemist, supervisors & other staff.

x) Sampling bottles

The size and capacity of above facilities depends on the quantity of product to be prepared.

III. Procedure

i. Develop all the refining facilities and laboratory, and appoint qualified staff as described above.

ii. Apply to the Joint Agriculture Marketing Advisor, Nagpur for issuing authorization certificate.

iii. On the basis of recommendations of the State Agricultural Marketing Department, the Agri. Marketing Advisor will issue the certificate.

iv. Obtain raw materials (cream/ butter/ *kachcha* ghee) and inspect it for general characteristics, such as organoleptic quality (flavour, colour, appearance, etc.), BR reading, Boudouin test and acid value.

v. Prepare ghee from cream/ butter adopting recommended temperature (110 – 115^{o}C). *Kachcha* ghee may be refined by heating it to about 80^{o}C.

vi. Transfer clear ghee into a settling tank.

vii. Collect sample (by the chemist) from the settling tank and divide it into 3 parts. One part is analyzed by the chemist himself in the laboratory. The second part is sent to a control laboratory established by Agricultural Marketing Department, and the third part is sealed and maintained in the laboratory for future reference.

viii. Based on the quality of ghee (particularly free fatty acids) package ghee in lacquered tin cans as ‘special grade’ or ‘general grade’ or ‘standard grade’.

ix. Label the cans for: Name of the authorized packer, place of packing, date of packing and batch number.

x. In case, the sample fails to meet the Agmark specification, remove the Agmark label from the tins and don’t send the product to the market. Even if the product has been sent to the market, remove/ lift this particular batch from there.

IV. Observations

a) Qualify of raw material

Name of the raw material used .....

Quantity of raw material .....

Quality of raw material .....

Organoleptic .....

FFA (as oleic acid) .....

BR reading .....

Boudouin test .....

Phytosterol acetate test .....

b) Processing conditions

Type and size of heating kettle .....

Heating source .....

Temperature of heating/ refining .....

Quantity taken per batch .....

Method of filtration/straining .....

Type and capacity of settling tank .....

c) Analysis of refined ghee

Amount of sample taken .....

Moisture ..... % RM value .....

Polenske value ..... FFA .....

Organoleptic quality .....

d) Packing of ghee

Type and size of tins/ package .....

Grades of the Agmark used .....

Labeling of ghee .....

e) Remarks .....

10.4 PRECAUTIONS

1. All the raw materials and finished product must be most precisely analyzed by the chemist himself
2. Sample must be representative i.e. drawn after through mixing.
3. All care must be taken to use the right type of grade depending on the FFA of ghee.

EXPERIMENT 11 VISIT TO A SMALL SCALE DAIRY PLANT INVOLVED IN PRODUCTION OF AGMARK GRADE OF BUTTER AND GHEE

Structure

11.1 INTRODUCTION

Agmark grades for butter and ghee are voluntary. Any manufacturers of ghee is free to use this grade for their product provided he complies with the minimum requirements and facilities laid down by Agricultural Marketing Department. The purpose of visit to a dairy plat that process and package ghee and butter under Agmark grade is to observe actual processing units/ equipment, packaging and testing facilities and test conducted before the receipts of raw material and after packing of product. This will help the ghee and butter manufacturers developing these facilities and availing Agmark certification from the concerned depactment.

11.2 OBJECTIVES

The students should be able to :

- supervise the actual environment where ghee and butter are received and/ or produced and packing done for marketing under Agmark grade.
- make a list of all facilities needed and tests conducted.

11.3 EXPERIMENT

i. Procedure

i) No experiment is conducted in this exercise.

ii) It involves visiting a dairy plant involved in production of butter and ghee of Agmark grade after availing prior permission from the Manager of the dairy.

iii) All relevant information and activities are recorded in the Performa.

ii. Observations

Record all the observations in Performa developed for this purpose.

11.4 PRECAUTIONS

i) Don’t touch or operate any equipment/ machine.

ii) Don’t eat any thing in the plant.

Performa for Visit to A Dairy Plant Packing Butter & Ghee under Agmark

1. General Information
   - i) Name of the plant .....
   - ii) Date of establishment .....
   - iii) Name of the product packaged .....
   - iv) Total installed capacity .....
   - v) Amount of product handled/ packaged
     - a) Flush season .....
     - b) Lean season .....
2. Type and Quality of material received
   - i) Name of raw material received .....
   - ii) Source of procurement .....
   - iii) Quality .....
   - a) Organoleptic .....
   - b) FFA .....
   - c) Butyro-refractometer reading .....
   - d) Boudouin test .....
3. Processing conditions
   - i) Units/ equipments & their capacity .....
   - ii) Temp. used for refining/ preparation .....
   - iii) No. of samples drawn & method of their sealing .....
4. Packaging and quality check
   - i) Type & size of tin .....
   - ii) Particulars of label/ information on tin .....
   - iii) Type of tests conducted & their results .....
   - iv) Category of ghee as per the tests .....
5. Other information
   - i) Any byproduct & its disposal .....
   - ii) Cost of ghee/ butter .....
   - iii) Marketing method .....

UNIT 1 DEFINITION, COMPOSITION, STANDARDS AND PROCESSING OF CREAM

Structure

1.0 OBJECTIVES

After reading this unit, we should be able to:

- define cream and its varieties
- explain principle of cream production or separation of fat from milk
- operate cream separators
- specify the factors influencing efficiency of operations
- calculate theoretical yield of cream
- give composition of separator slime.

1.1 INTRODUCTION

The fat contents play an important role in pricing of milk. Cream is the fat rich portion of milk, it is extracted from milk as part of milk processing. At household level it is obtained as *Malai* from boiled and cooled milk. In the market, the cream is available with varying fat levels - low fat, medium fat, and high fat. Different types of cream are required for different purposes. All the commercial available cream is obtained by mechanical separation. Cream is used for making ice cream, butter, ghee and butter oil in the commercial dairy plant. Some portion of cream is utilized for dressing the product in bakery and coffee making. Cream is one of the important dairy products. If milk is allowed to stand undisturbed, the portion that rises naturally to the surface and forms a layer is known as cream. It is obtained by separation of milk before mixing or homogenization. Separation produces two

fractions. The fraction, which contains fat in highly concentrated form, is called cream. Another fraction, which is a non-fat fraction, is termed as skim milk. Cream is rich in butterfat. It also contains other constituents of milk but in lower proportion than milk. Milk can be separated either by gravity separation method or by mechanical separation method. In the dairy industry, cream is separated by mechanical method employing centrifugal cream separator.

1.2 DEFINITION AND CLASSIFICATION

i. Definition

Cream is defined as the fat rich portion of milk obtained by gravity or mechanical method of separation. It is the light weight portion of milk which still contains all the main constituents of milk but in different proportions. The fat content of cream varies widely in the range of 20- 80 % depending upon the method of separation. Two indigenous products, which resemble cream in certain respect, are *Malai* and *Sar*. These products are prepared by skimming fat during boiling of milk or from boiled milk during cooling.

Malai is obtained by hand skimming of heated and cooled milk. Usually it is prepared by housewives at home and by *halwais* in shops.

Sar is the skin or the clotted cream layer formed on the surface during simmering of milk that has been heated and being cooled slowly. The fat content in *Sar* and *Malai* may vary from 20-50% depending upon the skill of separation. Both the *Malai* and *Sar* are used as basic raw materials in traditional method of butter preparation.

ii. Classification

Cream on the basis of fat content has been categorized into following categories:

(i) Low fat cream- The cream in this group contains fat in the range of 25-39%, e.g., table cream, light cream, whipping cream, etc.

(ii) Medium fat Cream- Cream containing 40-59 % fat is grouped in this category, e.g., heavy cream, plastic cream.

(iii) High fat Cream - Cream containing above 60% fat are high fat cream, e.g., plastic cream, heavy cream.

(iv) Coffee cream is a popular variety of cream in which fat content ranges from 10-20 %. However, this type of cream does not meet the minimum legal standards prescribed for cream by the Prevention of Food Adulteration Act. Hence, it cannot be designated as cream.

1.3 COMPOSITION OF CREAM

Cream is basically an emulsion of fat in water. This means that milk fat globules are dispersed as small droplets in a continuous medium of skimmed milk containing protein, lactose, minerals and some vitamins. Typical composition of cream varieties is given in Table 1.1.

Table 1.1: Chemical composition of cream

Constituents	Average composition (Value in %)		
	Half-half cream	Table cream	Whipping cream
Moisture	80.3	73.8	57.7
Protein	3.0	2.7	2.0
Fat	11.5	19.3	37.0
Carbohydrate	4.3	3.6	2.8
Ash	0.7	0.6	0.5

The composition of cream depends on the type of milk from which it has been produced and also on the fat content of cream. The compositions of cream containing different levels of fat and obtained from cow and buffalo milks are indicated in Table 1.2.

Table: 1.2 Chemical composition of cow and buffalo milk cream

Source	ConstituentsComposition (Value in %)		
	Fat	55.00	80.00
Cow milk	SNF*	4.05	1.80
	Protein	1.52	0.68
	Lactose	2.17	0.96
	Ash	0.36	0.16
Buffalo milk	SNF*	4.43	2.01
	Protein	1.83	0.81
	Lactose	2.33	1.04
	Ash	0.37	0.16

* SNF: Solid-Not-Fat

i. Physico-chemical Properties

Physico-chemical properties are mentioned below.

(i) **Viscosity:** The viscosity indicates the richness of cream. It is affected by the factors like fat content, temperature, separation conditions, homogenization, cooling, storage and clumping of fat globules in cream.

(ii) **Whipping quality:** It refers to the ability of cream to produce stable foam or froth when it is beaten with air. The whipping ability of cream is influenced by the fat content, separation conditions, ageing, acidity, homogenization pressure, addition of stabilizers, etc.

(iii) **Specific gravity:** The specific gravity of cream decreases with the increase in fat content.

(iv) **Titratable Acidity (T.A.):** The titratable acidity of fresh cream is inversely related to the fat content. It can be calculated by the formula given below:

$$\text{Per cent T. A.} = \frac{\text{Per cent serum in cream}}{\text{Per cent serum in milk}} \text{ X Per cent T.A. of milk}$$

OR

= (100 – per cent fat in cream / 100- per cent fat in milk) X per cent T.A. of milk

1.4 NUTRITIVE VALUE

Fresh cream contains all the constituents of milk but will invariably contain at least 5 times more fat than milk. Hence the energy value of cream will be several times higher than that of milk. The energy value can be calculated by assessing the composition of cream and taking into consideration the individual contribution of the constituents to the energy value as given below:

Milk Fat	9.3 k cal/g
Milk Sugar	4.1 k cal/g
Milk Protein	4.1 k cal/g

In addition to the calorific value the cream is richer in fat- soluble vitamins like A, D, E, and K than milk as it has more fat content.

1.5 LEGAL STANDARDS OF CREAM

As per the Prevention of Food Adulteration Act (1954) cream is defined as a product obtained from cow milk or buffalo milk or a combination thereof. It shall be free from starter and other ingredients foreign to milk. It may be of the following three categories namely:

(i) Low fat cream containing milk fat not less than 25.0 percent by weight.

(ii) Medium fat cream containing milk fat not less than 40.0 percent by weight.

(iii) High fat cream containing milk fat not less than 60.0 percent by weight.

Check Your Progress 1

1) Why cream is separated from milk?

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2) What are different types of cream?

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3) How do you estimate titratable acidity in cream?

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4) Give the legal standards of cream.

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1.6 PRINCIPLE OF SEPARATION

The fat is present in milk as fat-in-water type emulsion and is lighter than the skim milk. The mean density of milk fat is 0.93 as compared to 1.036 of skim milk at 16°C. Separation of cream is based on the principle that milk fat, because of its lower density is lighter than the skim milk portion. Hence it tends to rise to the surface and separates from the serum (skim milk). This principle is applicable to both gravity method and mechanical method of cream separation.

i. Gravity Method

In gravity method when milk is allowed to stand undisturbed for sometime the fat being lighter will rise and float on the surface under the influence of gravitational force. The fat floating on the surface will form a layer and can easily be removed or separated. It is common method of fat separation, which is governed by this principle and adopted at household level. However the rate at which the fat separates is governed by the Stoke's law as given by the following equation:

$$V = \frac{2G\ (ds\ -\ df)r^2}{9\eta}$$

Where

V = Rate at which fat globule rises

G = Acceleration due to gravity

ds = Density of skim milk

df = Density of fat

r = Radius of fat globule

η = Viscosity of skim milk

Thus, it can be inferred from the above equation that rate of separation of fat from milk increases with the following factors:

a) Increase in radius of the milk fat globule (clumping)

b) Increased difference in the densities of milk and fat (dilution)

c) Decrease in viscosity of milk

The gravity method of separation is a slow and simple process. It is followed at household and cottage level. It separates fat from milk in the form of cream. This is the easiest way to separate cream. Fresh or boiled and cooled milk is left to stand in a vessel and after a while the fat globules cluster together or aggregate and rise to the surface forming a layer of fat rich portion (cream). The layer can be removed by hand or ladle.

If the milk is not properly heat-treated it may undergo undesirable fermentation, sometimes leading to curdling of milk. The separation of fat will occur but the resulting cream and the skim milk will be of very poor quality. The fat separating on the surface of milk in the form of skin is scooped and the process is repeated at least two times to extract fat. By this method it is possible to extract about 50 % of fat present in milk. The fat thus obtained is preserved with lactic culture to avoid putrefaction. The rate of separation of fat by gravity method is affected by the following factors:

i) **Size of fat globules:** If the size of fat globules is bigger, the separation will be faster. This is the reason separation is faster in buffalo milk as compared to cow milk.

ii) **Temperature:** It affects the viscosity, which in turn, influences the flow or velocity with which the fat will separate. Hence separation at higher temperature is faster because of the reduced viscosity of milk.

iii) **Clumping:** Clumping of fat globules together increases the size and thus increases the velocity and rate of separation.

ii. Mechanical Method

In the mechanically operated cream separator, which is used commercially, the separation of fat is achieved by application of the centrifugal force. The centrifugal force acting on the system is about 3000- 6000 times greater than the gravitational force. Hence the separation of fat, which is governed by the Stoke's law, is faster than the gravity method of separation. Fat globules of smaller size separate 6500 times faster in a centrifuge rotating at 5400 rpm than they do by gravity. The Stoke's law as applied to centrifugal separation process is expressed by the following equation:

$$V = \frac{r^2\ (ds\ -\ df)K.R.N^2}{9\eta}$$

Where,

V = Velocity of movement of fat globule

r = Radius of fat globule

ds = Density of skim milk

df = Density of fat

N = Speed of bowl (rpm)

R = Distance of fat globule from the axis of rotation

K = Constant

= Viscosity of skim milk

The mechanized process is also known as centrifugal method of separation. It is a faster process. It is adopted as an industrial method of cream production. In this case it is very essential to fix the mechanized cream separator firmly to avoid vibration during the course of its operation. The large capacity separators (250 litres milk / hr or above) are installed on the ground while the smaller ones or laboratory models on wooden stool or tables. To run the separator the electrical connection is switched on. The separator is allowed to acquire the requisite speed. Generally the milk is preheated to 37-50^{o}C before separation for optimum results. This makes the process easier and more efficient as the warm milk is less viscous than the cold milk. Milk is fed down as an inlet tube into the separator bowl where it rotates and moves up through a series of aligned holes in the disc stack. In-flow of milk, is regulated by adjusting the milk in-let valve to the separator. As the disk stack revolves the cream moves towards the center of the bowl and the skim milk is directed outwards by the centrifugal force. Thus milk is separated in two streams, a highly concentrated milk fat stream termed as cream and a nonfat stream of skim milk. Under normal conditions it produces skim milk and cream in the ratio of 90:10.

1.7 TYPES OF CREAM SEPARATORS

Common types of cream separators are listed below:

a) **Cold milk separator:** It produces skim milk and viscous cream of high quality with less foam. But it may cause partial churning of milk during separation and has low capacity.

b) **Warm milk separator:** It facilitates close skimming, and has high capacity but produces low viscosity in cream and also foam.

c) **Hand driven cream separator:** It is a low capacity machine suitable for farm scale operation and is economical.

d) **Power driven cream separator:** It is high capacity machine suitable for dairy plants but are expensive.

e) **Open bowl cream separator:** It has low capacity and so suitable for small dairy plants. But it produces foam during separation.

f) **Hermetically sealed/Air-tight/Foamless tri-process separator:** As the name indicates it does not produce foam and performs three operations. It can clarify, separate and standardize the milk or cream. It can deliver cream or skim milk to respective tanks without any additional pumps, produces cream of high viscosity and of desired fat content without stopping the machine. Since it is airtight there is no contact of cream or skim milk with outside atmosphere and hence the quality is better. But it is expensive and regular maintenance is required.

g) **Domestic cream separator:** Domestic food processors or mixers are usually provided with a speed variation from 1400 to 18000 rpm. However they lack a rigid foundation and sufficient mechanical strength of the driving unit. Therefore an attachment has been developed at the National Dairy Research Institute, Karnal. The attachment consists of raw milk, cream and skim milk pans of the matching size of the mixer. The lowest pan has built-in- power transmission assembly and is fixed with the mixer to give a fairly rigid base to the bowl. The bearings are so designed that they take care of the vibrations and overheating of the mixer. It has 8-9 discs and operates at 3250 rpm. It can separate about 4 litres of milk in 10 min and produces cream containing 40% fat.

1.8 FACTORS INFLUENCING FAT PERCENTAGE OF CREAM

The following factors influence the fat percentage in cream

a) **Position of cream or skim milk screw:** Any of the screws can be moved IN or OUT. Thus it comes nearer to or moves away from the center of rotation. Adjusting the cream screw towards IN position or Skim milk screw towards OUT position yields high fat percentage in cream or vice-versa.

b) **Fat percentage of milk:** Milk containing high fat yields rich cream.

c) **Bowl speed:** The higher and recommended speed of the bowl yields cream of higher fat content.

d) **Rate of milk in-flow:** Faster rate of inflow of milk to the separator produces cream with lower fat percentage.

e) **Temperature of milk:** Lower temperature of milk during separation yields cream with higher fat percentage.

f) **Quantity of water:** If the amount of water used to flush the bowl is more the fat percentage in cream will be low.

1.9 FAT LOSSES IN SKIM MILK

There are several factors, which influence the efficiency of cream separation process. Consequently the entire fat present in milk is not recovered during centrifugal separation. The percent of total fat recovered in cream from milk is referred to as skimming efficiency. The skimming efficiency is calculated by the equation given below.

$$\text{Skimming Efficiency (\%)} = \frac{\text{Total fat in cream}}{\text{Total fat in milk}} \times 100$$

Factors affecting the skimming efficiency are listed here:

i) **Temperature of milk:** The temperature of milk at the time of separation should be around 37-50°C. Separation at lower temperatures results in higher fat loss in skim milk and may lead to partial clogging of the bowl due to the increased viscosity of cream.

ii) **Speed of bowl:** The fat loss in skim milk will be higher at lower speed of the bowl. This loss is ascribed to the insufficient centrifugal force generation. Hence, milk should not be fed in to the cream separators unless the cream separator attains its full speed.

iii) **Rate of milk inflow:** The flow of milk to the cream separator should be at optimum level. If the flow is at higher rate it will result in greater loss of fat in skim milk.

iv) **Size of fat globules:** Smaller the size of fat globules in milk higher will be the fat content in skim milk. Due to this reason, it is observed that generally cow milk and goat milk have lower separation efficiency in comparison to buffalo milk.

v) **Presence of air:** Greater the amount of air in milk higher will be the fat loss in skim milk. The entrapped air reduces the efficiency of hermetically sealed separators more than that of the normal cream separators.

vi) **Acidity of milk:** Higher acidity of milk reduces the efficiency of separators. This is mainly due to the partial coagulation of milk, which in turn, increases the sludge formation in the bowl affecting the efficiency of separation.

vii) **Mechanical condition of separator:** Vibration in the machine, use of deformed/dirty/scratched/rough discs and accumulation of separator slime causes increased losses of fat in skim milk.

viii) **Fat percentage in cream:** Production of cream containing more than 50-60% fat causes more losses of fat in skim milk.

ix) **Degree of agitation and temperature of milk:** Higher temperature of milk and more agitation cause higher losses of fat in skim milk.

x) **Position of cream screw:** As high fat in cream causes more losses the cream screw should be appropriately adjusted.

Check Your Progress 2

1) What are the principles of fat separation?

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2) Compare mechanical separation v/s gravity separation?

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3) List the factors affecting the fat content in cream.

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4) How do you control loss of fat in skim milk?

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1.10 YIELD OF CREAM

The yield of cream from milk can be calculated by the formula given below:

$$\text{Quantity of cream} = \frac{\text{(Fat per cent in milk - Fat per cent in skim milk)}}{\text{(Fat per cent in cream - Fat per cent in skim milk)}} \times \text{Quantity of milk}$$

In a dairy plant for practical purpose approximate yield of cream can also be calculated in the following manner:

i) Calculate the total quantity of fat in milk.

ii) Deduct the fat loss amounting to about 3% of total fat, which is lost in skim milk under standard operating conditions.

iii) The approximate yield of cream containing different fat percentage per kg of available fat is obtained by multiplying it by a multiplication factor given in Table 1.3 below. However the multiplication factor for cream containing fat percentage other than that mentioned in the table has to be calculated separately.

Let,

Quantity of milk = M

Fat per cent in milk= f_m

Total fat in milk = $M f_m /100 = F$

Loss of fat at the rate of 3 % of total fat = $3 F / 100 = 3 M f_m / 10,000$

Available fat = F_1 = Total fat in milk – Fat in skim milk

$= F - 3F / 100 = 100 F – 3 F / 100$

$$= \frac{100 F – 3 F}{100}$$

$= 97 F / 100 = 0.97 \times M \times f_m /100 = .0097 \times M \times f_m$

Yield = $Y = K \times M \times f_m$

Where,

M= quantity of milk

f_m = Fat percent in milk

K = Constant=0 .0097

In order to estimate the yield of cream the total fat is multiplied by the multiplication factor as shown in Table 1.3 depending on the fat content desired in cream.

Table 1.3: Multiplication factor for calculating yield of cream

Fat in cream (%)	Multiplication factor
30	3.33
40	2.50
50	2.00
60	1.67
70	1.43
80	1.25

If 4.0 kg milk fat is available from 100 litres of milk after loosing in skim milk (i.e., 3% of fat available in skim milk), then the yield of cream will be:

4 x 2.5 = 10.0 Kg (40% fat cream)

4 x 2.0 = 8.0 Kg (50% fat cream)

4 x 1.67 = 6.68 Kg (60 fat cream)

$$\text{Percent fat recovered in cream} = \frac{\text{Kg fat in cream}}{\text{Kg fat in milk}} \times 100$$

The yield of skim milk can be calculated by the following formula:

$$\text{Quantity of skim milk} = \frac{\text{(Fat per cent in cream- Fat per cent in milk)}}{\text{(Fat per cent in cream- Fat per cent in skim milk)}} \text{ X Quantity of milk}$$

$$\text{Per cent fat loss in skim milk} = \frac{\text{Kg fat in skim milk}}{\text{Kg fat in milk}} \times 100$$

1.11 SEPARATOR SLIME AND ITS COMPOSITION

During the course of operation of cream separator a slimy mass consisting of foreign matter, milk proteins, fat calcium phosphate, leucocytes, bacteria and red blood cells are accumulated in the bowl shell of the cream separator. This accumulated mass is called separator slime. As the accumulation of slime increases, the efficiency of fat separation from milk decreases. The reduction in efficiency of separation is ascribed to the decreased effective diameter in the bowl due to accumulation of sludge. In the modern separators there is a provision to discharge this slime automatically and maintain the efficiency of the cream separation. The average composition of the slime is presented in the Table 1.4.

Table 1.4 : Composition of separator slime

Constituent	Composition (value in per cent)
Water	66-68
Fat	1.5 – 2.0
Protein	25 - 26
Lactose	1.5 – 2.0
Minerals	3.0 – 3.5

The quantity of slime depends on quality of milk. Under Indian conditions this is observed to vary between 0.05 – 0.20%.

In certain parts of Southern India, the slime is coagulated with commercial acids and casein of industrial grade is extracted.

1.12 PROCESSING OF CREAM

The processing of cream depends on the purpose for which it is required. In general following processes are involved for different types of cream.

i. Standardization

The fat content of cream is adjusted to the desired level either by the addition of calculated quantity of water or skimmed milk. This step is referred to as standardization. The use of water or skim milk depends on the purpose for which the cream is required. If the buttermilk is to be used for drying or standardization of milk for products making or for beverage preparation the standardization is done with skim milk. The purpose for which cream is to be used and the suggestion for use of skim milk or water are indicated below in Table 1.5

Table 1.5: Standardizing agents for cream

Purpose	Standardizing agent
Cream for butter preparation	Water
Whipping Cream	Skimmed Milk
Table Cream	Skimmed Milk
Coffee Cream	Skimmed Milk

The cream after standardization is subjected to homogenization and appropriate thermal processing prior to packaging for retailing.

ii. Homogenization

Cream is an oil-in water emulsion. Therefore the cream standardized to various fat levels with skim milk must be homogenized to reduce the fat globule size and increase the stability i.e., prevent fat separation. Homogenization is a process whereby cream is forced through a narrow orifice under considerable pressure. This breaks up the fat globules to smaller size and ensures they are evenly distributed throughout the cream. By homogenization various grades of viscosity in cream products can be obtained. Usually lower pressures are used for cream than that used for milk products. Whipping cream is rarely homogenized as this process greatly reduces the whipping ability of cream. Stabilizers such as mono-glycerides are added to improve whipping ability. On the other hand, homogenization of high fat cream is utilized in the production of spoon-able whipped cream products, which are used as dessert toppings. Homogenization is employed for UHT pasteurized whipping cream in order to prevent fat separation, which increases with UHT pasteurization.

iii. Thermal Processing

The thermal processing of cream involves either pasteurization or sterilization. The cream could be pasteurized by either batch or continuous method. The sterilization could also be done by either of the two methods, i.e., by batch method using counter pressure autoclaves referred to as retorts or by continuous method followed by aseptic packaging. The time-temperature combination for cream is higher in comparison to milk processing. This is simply because it contains more total solids than milk. The possible time-temperature combinations are indicated below.

Batch Pasteurization	-	74°C/30 minutes
Continuous Pasteurization	-	85°C/25 seconds
Batch Sterilization	-	115-120°C/15 minutes
UHT Processing	-	135°C/1-3 seconds

As soon as the heat processing of cream is completed it is cooled to less than 10°C to avoid the growth of heat resistant micro-organisms during storage. In practice it is cooled to 4-5°C.

iv. Packaging and storage

The cream after processing is packaged in suitable containers and stored at low temperature (below 5 °C). If the cream is sterilized or UHT cream it can be stored at ambient temperature.

Check Your Progress 3

1) Given 1000 kg of milk testing 5.4% fat. What will be the theoretically yield of cream of 45% and 62% fat.

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2) How do you process cream for retail-sale?

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3) Calculate skimming efficiency of a centrifugal cream-separator, which produces 8.5 kg of cream containing 45 % fat from 100 kg of milk testing 4.0 % fat.

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1.13 LET US SUM UP

Cream is the fat rich portion of milk obtained by gravity or mechanical method of separation. Cream can be classified as low fat cream with less than 25 % fat, medium fat cream with less than 40 % fat and high fat cream with less than 60 % fat. The composition of cream depends on the type of milk from which it has been separated and also on the fat content of cream. Fresh cream invariably contains at least 5 times more fat than milk in addition to all the constituents of milk. Therefore, it has high nutritive value and is a rich source of fat-soluble vitamins like A, D, E, and K. Fat content of cream varies widely in the range of 20-80% depending upon the method of separation. The principle of separation is based on the fact that the milk fat, being lighter than the skim milk portion, tends to rise to the surface and separate. The specific gravity of milk fat is 0.93 and that of milk serum is 1.032 at 16°C. Gravity method is a common method of fat separation

adopted at household level. Mechanical method of cream separation involves separation of fat by the application of about 3000-6000 times greater centrifugal force than the gravitational force. Hence, the separation of fat, which is governed by the Stoke's law, is faster than the gravity method of separation. The centrifugal method of separation of cream is suitable for medium or large-scale dairy operation. In general, centrifugal separator has supply can, faucet, float, cream screw, bowl shell, milk distributor, cream spout, skim milk spout, top disc, discs, bowl unit, rubber rings, spindle and set of gears. There are different types of cream separators viz., cold milk separator, warm milk separator, hand driven cream separator, open bowl cream separator, hermetically sealed/ air-tight/foamless tri process separator. The latest development in this sector is the self de-sludging cream separator. Position of cream or skim milk screw, fat percentage of milk, bowl speed, rate of milk in–flow, temperature of milk and quantity of water influence fat content of cream. Temperature of milk, speed of bowl, rate of milk inflow, size of fat globules, presence of air, acidity of milk, mechanical condition of separator, fat percentage in cream, degree of agitation and position of cream screw affects the skimming efficiency of milk.

Yield of cream from milk can be calculated by the ratio of difference in fat per cent in milk and fat per cent in skim milk to difference in fat per cent in cream and fat per cent in skim milk multiplied by the quantity of milk taken for separation. Similarly, the yield of skim milk can be calculated by difference in fat per cent in cream and fat per cent in milk to difference in fat per cent in cream and fat per cent in skim milk multiplied by the quantity of milk taken for separation.

A slimy mass consisting of foreign matter, milk proteins, fat, calcium phosphate, leucocytes, bacteria and red blood cells are accumulated in the bowl shell of the cream separator is termed 'slime'. The quantity and composition of slime depends on quality of milk taken. The cream after processing is packaged in suitable containers and stored at low temperature (below 5°C). Sterilized cream or UHT cream can be stored at ambient temperature. Processing of cream basically includes, standardization, pasteurization/sterilization followed by packaging.

1.14 KEY WORDS

Cream : The fat rich portion of milk obtained by gravity or mechanical method of separation.

Gravity separation : Process employed for separation of cream from milk wherein, fresh or boiled and cooled milk is allowed to stand in a vessel and after a while, the fat globules cluster together or aggregate and rise to the surface forming a layer of fat rich portion called cream, which is then removed by hand or ladle.

Centrifugal separation : The mechanized process of cream separation, wherein, milk is subjected to centrifugal force during which, the cream moves towards the center of the bowl and the skim milk is directed outwards by the centrifugal force.

Skimming efficiency : The percent of total fat recovered in cream from milk during cream separation process.

Slime : A slimy mass consisting of foreign matter, milk proteins, fat, calcium phosphate, leucocytes, bacteria and red blood cells, which are accumulated, in the bowl shell of the cream separator.

1.15 SOME USEFUL BOOKS

De Sukumar (1980), *Outline of Dairy Technology*, Oxford University Press, Delhi.

Tufail Ahmed (1990), *Dairy Plant Engineering and Management*, Kitab Mahal, Allahabad

1.16 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include the following points:

Check Your Progress 1

1) i. Cream is separated from milk as part milk processing operations.

2) i. Low fat, Medium fat and High fat cream

3) i. $$\text{Percent T. A.} = \frac{\%\ \text{serum in cream}}{\%\ \text{serum in milk}} \times \%\ \text{T.A. of milk}$$

4) i. As per the Prevention of Food Adulteration Act (1954) cream is defined as a product obtained from cow milk or buffalo milk or a combination thereof. It shall be free from starter and other ingredients foreign to milk. It may be of the following three categories namely:

   ii. Low fat cream containing milk fat not less than 25 percent by weight.

   iii. Medium fat cream containing milk fat not less than 40.0 percent by weight.

   iv. High fat cream containing milk fat not less than 60.0 percent by weight.

Check Your Progress 2

1) i. Separation of cream is based on the principle that milk fat, because of its lower density is lighter than the skim milk portion. Hence it tends to rise to the surface and separates from the serum (skim milk). This principle is applicable to both gravity method and mechanical method of cream separation.

2) i.

Gravity method	Centrifugal method
Slow method	Fast method
Gravitational force	Centrifugal force
Fat moves vertically upwards while skim milk vertically downward	Fat and skim milk both move in horizontal direction
Yields low fat cream	Can give high fat cream
Causes more losses of fat in skim milk	Less fat loss in skim milk
Suitable for house hold purpose only	Suitable for industrial use
Fat recovery is less	More fat recovery
Bacteriological quality of products is poor	Bacteriological quality of cream and skim milk is good

3) i. Position of cream or skim milk screw, Fat percentage of milk, Bowl speed, Rate of milk in-flow, Temperature of milk, Quantity of water.

4) i. The following factors should be properly taken care of to control the losses of fat in skim milk:

Position of cream or skim milk screw, Fat percentage of milk, Fat percentage in cream, Degree of agitation of milk, Condition of separator, Acidity of milk, Size of fat globules, Presence of air, Bowl speed, Rate of milk in-flow, Temperature of milk.

Check Your Progress 3

1) i. 118.04 and 85.62 kgs. respectively.

2) i. Cream is standardized, homogenized and pasteurized or sterilized for retail sale.

3) i. Skimming Efficiency (%) = $\frac{\text{Total fat in Cream}}{\text{Total fat in Milk}} \times 100$

$= \frac{8.5 \times 45 \times 100}{4 \times 100} = 95.625\%$

UNIT 2 PREPARATION OF DIFFERENT TYPES OF CREAM

Structure

2.0 OBJECTIVES

After reading this unit, we should be able to:

- define different forms of Cream
- outline methods of manufacture of different types of cream
- specify composition and standard requirements
- enumerate uses of cream in food industry.

2.1 INTRODUCTION

Cream is classified on the basis of its fat content. The fat content in cream may vary over a wide range (10.0 % to 85.0 %). The heavier the cream, the higher is the proportion of fat contents. The fat content in half and half cream is approx. 10% fat. Various grades of cream include half-and-half cream, light cream, medium and heavy cream, etc. Low fat cream is also called as market cream which includes table cream, sterilized cream, light-cream, coffee cream etc. and usually contains 12-25% fat. The market cream is used for direct consumption. The cream containing more than 40% fat is known as manufacturer's cream and include whipping cream, heavy cream, plastic cream, etc. Whipping cream usually contains fat between 28-35% while plastic cream between 60-85%. In this unit, we will learn various grades/types of cream, their method of preparation and uses.

2.2 STERILIZED CREAM

It is also known as Table cream. The objective of preparation of sterilized cream is to prolong the shelf life of cream and make it available to the consumers in a ready-to-use form and in good condition. Sterilized cream should be smooth and free from lumpiness and separation of serum. The high heat treatment, however imparts it a peculiar flavour. Homogenization increases its viscosity. The whipping quality of sterilized cream is also poor. The fat content in sterilized cream ranges between 20-25 % and solids-not-fat content between 6.5-9.5 %.

Manufacturing steps

The steps involved in preparation of sterilized cream are given in fig. 2.1.

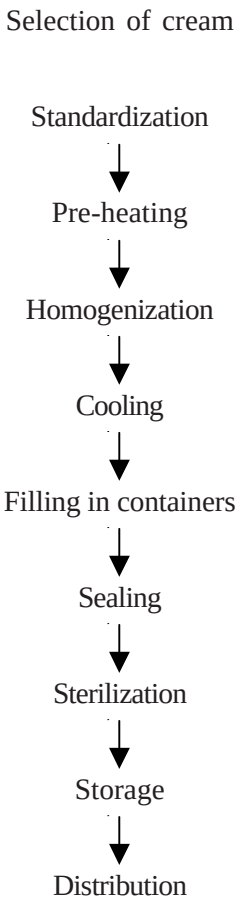

Fig 2.1 Flow diagram for preparation of sterilized cream

Selection of cream: Fresh and sweet cream is collected for the preparation of sterilized table cream. The percent titratable acidity (TA) of freshly separated cream is always lower than that of the milk from which it has been separated. The T.A can be calculated by the following formula:

$$\text{Percent T.A. of cream} = \frac{\text{Percent serum in cream}}{\text{Percent serum in milk}} \times \text{Percent T.A of Milk}$$

$$= \frac{100 - \text{Percent fat in cream}}{100 - \text{Percent fat in milk}} \times \text{Percent T.A of Milk}$$

Standardization: Standardization refers to the adjustment of milk fat level in cream to the desired level i.e. conforming to the standards requirement. The fat level (percent) in cream is usually adjusted or decreased to the desired level by addition of calculated quantity of skim milk. The quantity of skim milk to be added to cream is calculated by the Pearson's square method as explained below (Fig. 2.2):

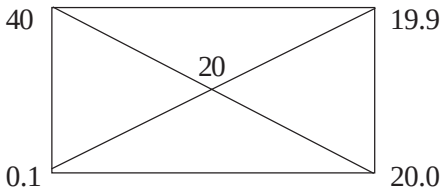

Fig. 2.2: Pearson's Square

Let us assume that the fresh sample of cream contains 40 percent fat. It is required to reduce its fat to 20 percent. The available skim milk for standardization contains only 0.1 per cent fat.

The required quantity of skim milk to be added to cream is calculated as follows by drawing a square and writing the fat percentage of cream (40%) and skim milk (0.1%) on the two corners on the left side of the square.

(i) The desired fat percent level (20%), in cream is written in the centre of the square.

(ii) Now subtract the number in the centre (20) from the larger number (40) at the left-hand side of the square and place the remainder (20) at the diagonally opposite right-hand corner.

(iii) Again subtract the smaller number (0.1) on the left hand side from the number in the centre (20) and place the remainder (19.9) at the diagonally opposite right-hand corner.

The numbers on the right-hand side now represent the number of parts of cream and skim milk to be mixed to obtain cream containing 20% fat. It means that if 19.9 parts by weight of cream containing 40% fat is blended with 20 parts by weight of skim milk (0.1% fat) will yield cream containing 20% fat.

Pre-heating: The purpose of pre-heating of cream is to delay its spoilage during subsequent processing steps. Pre-heating inactivates undesirable micro-organisms and the enzymes particularly lipase. It also helps in efficient homogenization of cream. Standardized cream is pre-heated by heating it to 80-90°C without holding.

Homogenization: The purpose of homogenization of cream are as follows:

i) To prevent rising of fat during sterilization and storage.

ii) To prevent formation of a fat plug in the container.

iii) It also improves taste, whipping power and flocculation stability of the product. Flocculation of coffee cream is a major problem. When cream is added to hot coffee, flocculation occurs mainly because of the precipitation of casein. Homogenization of casein free cream enriched with whey protein and pre-heated to 90°C for 5 min. improves the flocculation stability probably because of whey-protein denaturation.

Homogenization of pre-heated cream at 80-90°C is carried out in two stages employing homogenization pressure of 25-30 kg/sq cm in first stage and 5kg/sq cm in the second stage. In the first stage the fat globules are sub-divided in smaller size globules and distributed uniformly in the whole mass of cream; it increases viscosity. The second stage reduces viscosity and prevents the fat globules from clumping together and forming lager clusters. Clumping refers to the tendency of fat globules to loosely adhere to one another to form clusters. The tendency of clumping is influenced by the following factors.

i) Fat Globule size - Large fat globules clump more readily than smaller ones.

ii) Temperature - Clumping tendency decreases with increase in temperature.

iii) Agitation - It increases clumping tendency at lower temperature (7°C) while at higher temperature (60°C) the tendency of clumping decreases.

iv) Separation Method - Gravity separation yields cream with increased tendency of clumping than that obtained by centrifugal separation with the same fat content.

v) Adhesive - Addition of adhesive helps in clumping.

Cooling: Since filling of cream in the containers requires holding of cream for sometime there is every possibility of increase in the titratable acidity of cream.

This may cause problems during sterilization process. Therefore, it is essential to cool the cream to about 15-16°C to prevent any change in the acidity of cream if the manufacturer requires enough time to fill the cream in containers in good condition and seal them. However, if filling and sealing do not require holding of cream, it can be filled directly from the homogenizer in to the containers and transferred immediately to the sterilizer. Thus, it does not require cooling.

Filling and Sealing: Homogenized cream is filled in containers (lacquered tin cans, glass bottles, retortable pouches etc.) leaving minimum head space and sealed. These containers are then transferred to the sterilizer.

Sterilization: Sterilization of cream improves the shelf life of cream by making it free from viable organisms. In-can sterilization of cream is done in retorts. The filled cans or bottles are packed in retorts/batch sterilizer and then heated allowing15 minutes for coming up time to desired temperature (118°C), 12-15 minutes holding time at 118°C and 15 minutes for cooling to room temperature. Thus, it takes 45 minutes to complete one cycle of sterilization process for one batch. After completion of the process the tins/bottles are cleaned and tested for leakage by a immersing them in clean water. Leaking tins/bottles are then discarded separately.

Storage and Distribution: The leak proof tins/bottles or packages are staked properly in cardboard cartons and stored at room temperature. Properly sterilized cream is expected to keep good for few months.

2.3 PLASTIC CREAM

Plastic cream is a highly viscous product than any other type of cream. It resembles to paste in texture. It contains fat between 60-85 %. However it differs from butter in that it is still a fat in water type emulsion in spite of containing fat near or equal to butter. The plastic cream is used directly for the manufacture of butter oil or in the preparation of standardized milk. It may also replace use of butter oil in the preparation of recombined milk. Plastic cream can be prepared by any of the following methods.

i. Re-separation of normal cream containing 30-40% fat in a normal cream separator.

ii. Separating milk in a specially designed plastic cream separator to yield high fat cream.

For preparation of plastic cream by any of the above two methods, it is essential to pasteurize the initial product i.e. cream and milk. In case of milk it is heated before separation to about 50°C and then separated. Pasteurization of cream is done by heating to a temperature of about 74°C for 30 minutes followed by cooling to 60-66°C before re-separation. Resulting products of the separation will be plastic cream and skim milk. The cream is then packaged and stored for further use.

Check Your Progress 1

1) Why is cream homogenized?

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2) What is the purpose behind preparation of sterilized cream?

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3) What are the methods of preparation of plastic cream?

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2.4 FROZEN CREAM

As the name suggests the cream in frozen state is called frozen cream. Freezing of cream inhibits bacterial growth. It is prepared to improve keeping quality of cream so that it can be transported without spoilage over a long distance in a refrigerated van. Freezing also helps to store surplus cream for use during shortage. Ice-cream manufacturers use most of the frozen cream. It is also used in recombined milk and cream soups. Addition of 10-15% sucrose by weight to cream before freezing is helpful in preventing oiling-off after thawing of frozen cream. During freezing ice crystals are also formed. These crystals rupture the membrane enclosing the fat globules. Frozen cream, therefore, tends to oil-off on thawing especially at higher temperature. Oiling-off in cream also impairs whipping property of the product. Preparation of frozen cream also starts with collection of good quality of milk, its filtration and separation. Resulting cream is then standardized to contain 40-50% fat and then pasteurized. Pasteurization is done by heating cream at 74°C for 30 minutes in a batch type of pasteurizer or plate heat exchanger. The heated cream is cooled after the holding period to 4°C. The pasteurized and cooled cream is then filled in paper/plastic containers or cans and sealed. These containers are then transferred to a freezing chamber maintained at a very low temperature (-20°C). The cream freezes after a sometime in the containers. The frozen cream is stored below -12°C. Preparation of frozen cream involves the following steps as shown in Fig. 2.3

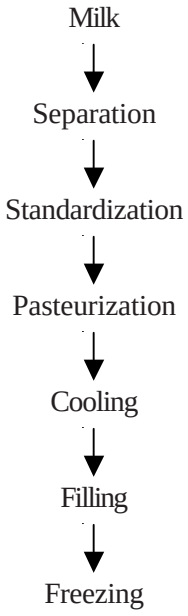

Fig. 2.3 Flow diagram for preparation of frozen cream

Freezing of cream could also be achieved by employing any of the following methods:

i) Blast freezing chamber- Bulk containers, containing cream, are allowed to pass through a chamber where they meet a current of chilled air effecting freezing.

ii) Plate freezers

iii) Rotating drum freezers

iv) Cryogenic freezing tunnels

2.5 SOUR CREAM

It is a cream product, which is prepared by ripening or souring of sweet cream to a titratable acidity of 0.60%, L.A with desirable lactic acid bacteria. It has slightly acidic flavour and smooth texture. Sour cream is usually used in the preparation of different foods and sometimes in drinks and beverages. The following steps are involved in the preparation of sour cream (Fig 2.4).

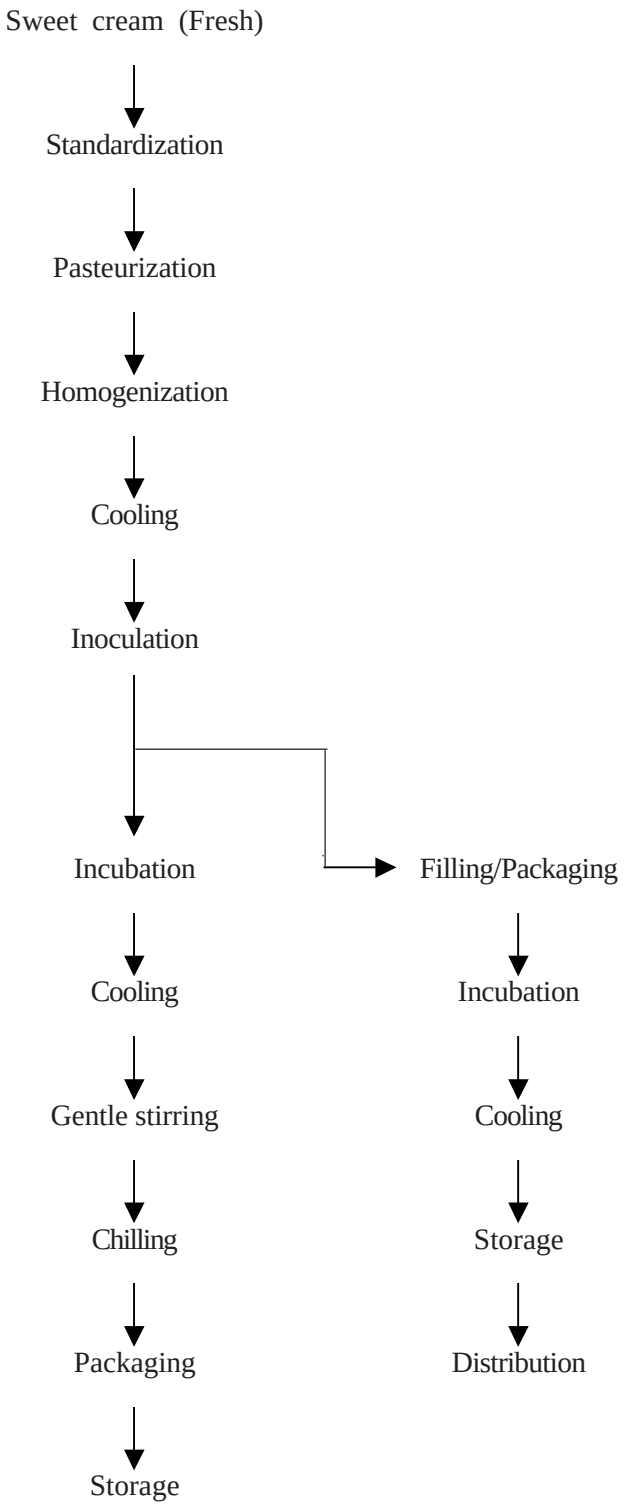

Fig 2.4: Flow diagram for preparation of Sour cream

Sour cream is prepared from fresh and sweet cream standardized to contain 18-20 % fat. The standardized cream is pasteurized by LTLT or HTST Method and cooled to 60-65°C. At this temperature it is homogenized employing two-stage homogenization process. Low temperature homogenization is preferred to promote formation of fat clusters, which during ripening flocculate and also increase the viscosity of the product and improve the texture. Homogenized cream is then inoculated with 2-4% fresh and active starter culture containing lactic acid and flavour producing microorganisms, namely, Streptococcus lactis, Streptococcus cremoris and diacetyl lactis. The inoculated cream is then incubated at a temperature of 22°C and allowed to develop titratable acidity and desired body and texture. Usually, it takes 10-12 hrs to attain the desired acidity. Sometimes some thickening agent or rennet is also added to sweet cream to increase the firmness of the sour cream. When the cream has attained the desired acidity (0.60% LA or pH 4.5) it is cooled with gentle stirring and chilled to 2-4°C followed by packaging.

Alternatively, the cream after homogenization and inoculation is filled in the containers and the packages are incubated at 22-25°C. The acidity develops. Then the packages are transferred to cold rooms where cooling of the product is achieved.

Check Your Progress 2

1. Differentiate between frozen cream and frozen sour cream?

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2. Name the microorganisms used for souring of cream.

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3. What should be the acidity of sour cream?

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2.6 WHIPPING CREAM

It may be defined as a cream product containing air bubbles captured in a network of fat globules. Cream containing more than 30% fat can be converted into whipping cream by beating it with air to nearly double the volume of cream. Beating cream produces foam by incorporating air in the cream. The foam thus produced has remarkable stability. If whipping is continued it yields butter because of the joining of the fat globules together. Homogenization of high fat whipping cream produces excessively viscous product and hence not desired. It also decreases the functional property of whipping cream. Homogenization, however, is used for the production of spoon-able whipped cream and in UHT pasteurized whipping cream to prevent fat separation.

Whipping cream is used in cakes, ice creams and for decorative toppings. It is available in small bottles, plastic cans or large cans. It is also marketed as in-can sterilized cream and even supplied with sugar and a driving gas in an aerosol-can that delivers a ready-made whipped cream.

Cream is usually whipped immediately prior to use. Whipping cream should posses a pleasing flavour, good keeping quality, good whipping ability and stability after whipping. The whipping quality of cream is influenced by the following factors:

i) Fat content 35-36% is preferred

ii) Composition of fat i.e. proportion of crystalline fat and liquid fat. More crystalline fat is preferred.

iii) Combination of cream-protein: It is needed in the composition to help formation of air cells.

iv) Surface-active substances: Addition of surface-active substances like mono-glyceride or Tween helps.

v) Temperature of cream: Higher temperature lowers the whipping quality.

vi) Separation temperature of cream.

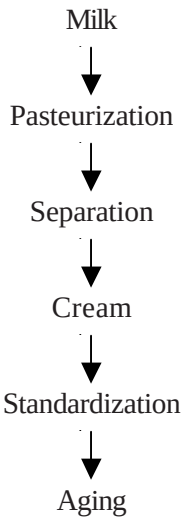
vii) Ageing: Ageing at 4°C is desirable to produce more crystalline fat in cream.

viii) Acidity of cream: If the acidity of cream is higher it reduces whipping quality.

ix) Addition of stabilizers: It reduces whipping ability.

Cream obtained from pasteurized milk is standardized to contain 35-36% fat. The standardized cream is stored for 24 hours at 4°C so that all the fat globules contain some crystalline fat. A thickening agent like k-carrageenan @ 0.01% is added to cream to prevent creaming or serum separation during storage. The aged cream is then pasteurized preferably by holder method at a temperature of 74°C for 30 min. In-can sterilization of whipping cream is not advisable as it causes coalescence of fat globules unless it is homogenized. But homogenization impairs the whipping ability of cream. UHT heating of cream homogenized at low pressure (e.g. 2 and 0.7 M Pa at 35°C) and containing some emulsifiers is preferred. However, fluctuation of temperature during UHT treatment may increase the viscosity, decrease whipping properties and cause churning.

The pasteurized and cooled cream is stored in cold store to effect crystallization of liquid fat. Whipping i.e. beating of cream with air is done prior to use of whipped cream. Whipping produces stable foam by enclosing air bubbles in network of fat. Slow beating of cream may cause churning of cream while vigorous beating results in high over-run and finally smooth foam. Prolonged whipping may also cause churning and yield butter and butter milk. Whipping effect can also be produced in aerosol can without clumping of fat globules and beating. The foam is formed when the gas pressure in cans is released. The foam thus produced is unstable. Therefore, it requires addition of some surfactants or presence of proteins to impart some degree of stability by protein. The process of preparation of whipping cream involves the steps outlined in Fig 2.5.



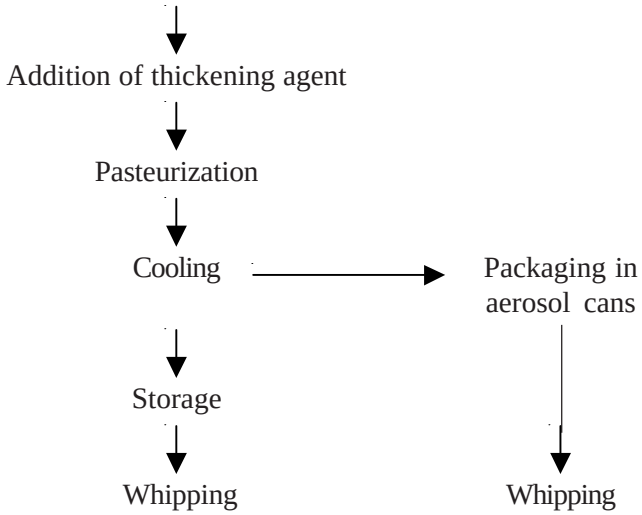


Fig. 2.5: Flow diagram for preparation of Whipping cream

2.7 USES OF CREAM

The unique natural flavour of cream imparts richness to many food products and enhances flavour quality. Cream contains milk fat, which has melting points in a narrow range. This facilitates quick release of flavours. Cream also imparts smoothness and viscous mouthful to many food products. Milk fat in cream serves as a carrier of fat-soluble vitamins like A, D, E and K. Hence it enriches the food products with vitamins. The presence of protein in cream acts as an emulsifier and helps in emulsification, aeration, foaming. It helps in whipping of cream giving over-run to food products. Cream adds a whitening effect to the product and improves the appearance and colour. It can also impart browning to cooked food due the reaction between proteins and lactose present in cream. The functional properties of cream mentioned above make it suitable for use in many food products. It may be used directly from the container as an ingredient in the preparation of several food products or serve an intermediate product. Some of the common uses of cream in which it used in food industry are listed below:

i) Directly in tea/coffee hot chocolate/other beverages to impart richer characteristics colour, texture, flavour and preparation of table/coffee/ whipping cream to used directly as toppings to fresh fruits, desserts and cereals.

ii) Preparation of some special dishes like fruit cream, cream salad, sauces cheese cakes, etc.

iii) Production of plastic cream, frozen cream, whipping cream, sour cream, as intermediary product.

iv) Manufacture of butter, ghee, cream cheese, ice-cream, butter-oil.

v) Creaming cottage cheese

vi) Standardization of milk and milk products.

vii) Sweet-syrups like caramels, fudges, fruit syrup.

viii) Bakery products and confectionary products.

ix) Alcoholic cream beverages.

x) Piping cream-whipping cream is often piped onto cakes and desserts.

2.8 COMPOSITION AND STANDARDS

Cream is not a specific product. It can be produced with different fat content. Other constituents in cream vary in their proportion depending on the fat content of cream. As the fat content in cream increases, the other constituents (solids-not

fat) decrease in their proportion. The average chemical composition of cream containing different fat levels and of different types is given in the following tables (2.6 & 2.7).

The solids-not fat (SNF) content of cream can be calculated by the formula given below:

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

Table 2.6: Average chemical composition of cream of different fat content

Constituents	Per cent Composition		
Fat	25	30	50
Protein	2.54	2.40	1.69
Lactose	3.70	3.50	2.47
Ash	0.56	0.40	0.37
Solid-not-fat (SNF)	6.80	6.00	4.55
Total solids	31.80	36.00	54.55
Water	68.20	64.00	45.45

Table 2.7: Average chemical composition of different types of cream

Type of Cream	Percent Composition				
	Fat	Protein	Lactose	Ash	Moisture
Half-and-half cream	11.50	3.00	4.30	0.70	80.50
Table cream	19.30	2.70	3.60	0.60	73.80
Whipping cream	37.00	2.00	2.80	0.50	57.70

i. Standards Requirements

It is the responsibility of dairy industry and the Governmental agencies to safe guard the interest of the consumers with respect to the safety and quality of the product. Cream is not a product of any fixed composition. Hence, it becomes necessary to set standards of quality to meet the above responsibility effectively. In India, we have standards of quality set by Prevention of Food Adulteration Act and Bureau of Indian Standards. It is essential to meet the quality standards set by the PFA before marketing of any dairy product.

PFA specifies that cream, excluding sterilized cream, is the product obtained from cow milk or buffalo milk or a combination thereof, which contain not less than 25 per cent fat.

United Nations Food and Agricultural Organization (FAO) and World Health Organization (WHO) have also specified quality standards for different products. As regards cream FAO and WHO have specified standards for fat content in designated cream for international marketing (Table 2.8.).

Table 2.8: Standards for cream for international marketing

Designation of Cream	Per cent Milk Fat	
	FAO	WHO
Cream	18-26	-
Pasteurized, sterilized UHT cream	-	18
Light cream coffee cream	More than 10	-
Half cream	-	10-18
Whipping cream	More than 28	28
Heavy Whipping cream	-	35
Heavy cream	More than 35	-
Double cream	More than 45	45

2.9 LET US SUM UP

There are various grades of cream, which include half-and-half cream, low fat, medium and heavy cream, etc. Composition of cream depends on its fat level. The proportion of other constituents varies depending on the fat content of cream. PFA specifies that cream, excluding sterilized cream, is the product obtained from cow milk or buffalo milk or a combination thereof, which contains not less than 25 per cent fat. United Nations Food and Agricultural Organization and World Health Organization have different quality standards for different cream products.

Low fat cream also called ‘market cream’, includes table cream, sterilized cream, light-cream, coffee cream etc; and usually contains 12-25% fat. Sterilized cream is also known as ‘table cream’ and is available to the consumers in a ready-to-use form. . It has low whipping-ability. Its fat content ranges between 20-25% and solids-not-fat content between 6.5- 9.5%. The desired characteristics of sterilized cream include smooth body and texture, absence of lumps and no separation of serum. The cream containing more than 40% fat is known as ‘manufacturer’s cream’. It includes whipping cream, heavy cream, plastic cream, etc. Whipped cream may be defined as a cream product containing air bubbles captured in a network of fat globules. Cream containing more than 30% fat can be converted into whipped cream by beating it with air to nearly double the volume of cream. Whipping cream usually contains 28-35% fat while plastic cream contains 60-85%. It has a pleasing flavour, good keeping quality, good whipping ability and stability after whipping and used in cakes, ice creams and for decorative toppings. It is available in small bottles, plastic cans or large cans. Plastic cream is a highly viscous product than any other type of cream. It contains fat between 60-85%. It is used directly for the manufacture of butter oil or in the preparation of standardized milk. Plastic cream can be prepared by either re-separation of normal cream containing 30-40% fat in a normal cream separator or by separating milk in a specially designed plastic cream separator. Frozen cream, as the name suggests, is the cream in frozen state. Freezing also helps to store surplus cream for use during the period of shortage. Frozen cream is prepared by filling pasteurized and cooled cream in containers, sealing and transferring the containers in a freezing chamber maintained at a very low temperature (-20°C). Various freezing systems include blast freezing chamber, plate freezers, rotating drum freezers and cryogenic freezing tunnels. Frozen cream is used in the manufacture of ice cream, preparation of recombined milk and cream soups. Sour cream is prepared by ripening or souring of sweet cream to a titratable acidity of 0.60%, L.A with desirable lactic acid

bacteria namely, Streptococcus lactis, Streptococcus cremoris and diacetyl lactis. It has slightly acidic flavour and smooth texture. It is used in the preparation of different foods and sometimes in drinks and beverages.

2.10 KEY WORDS

Sterilized cream : It is a smooth textured and ready-to-use cream obtained by sterilizing cream. It is also referred as 'table cream'. It has long keeping quality.

Plastic cream : It is a highly viscous product with paste like texture and containing fat between 60-85%.

Frozen cream : It is the cream in frozen state and is stored below – 12°C.

Sour cream : It is a cream product, which is prepared by ripening or souring of sweet cream to a titratable acidity of 0.60%, LA with desirable lactic acid bacteria like Streptococcus lactis, Streptococcus cremoris and diacetyl lactis.

Whipping cream : It is a cream product containing air bubbles captured in a network of fat globules.

2.11 SOME USEFUL BOOKS

De Sukumar (1980), Outlines of Dairy Technology, Oxford University Press, Delhi.

2.12 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include following points:

Check Your Progress 1

1) i. To prevent rising of fat during sterilization and storage
   ii. To prevent formation of a fat plug in the container.
   iii. It also improves taste, whipping power and flocculation stability of the product.
2) i. The objective of preparation of sterilized cream is to prolong the shelf life of cream and make it available to the consumers in a ready-to-use form and in good condition.
3) i. Re-separation of normal cream containing 30-40% fat in a normal cream separator.
   ii. Separating milk in a specially designed plastic cream separator to yield high fat cream.

Check Your Progress 2

1) i. Frozen cream is prepared by freezing fresh and sweet cream while freezing of sour cream gives frozen sour cream.
2) i. Str. lactis, Str. cremoris and diacetilactis.
3) i. Desired acidity in sour cream s 0.6 %.

UNIT 3 PACKAGING, STORAGE AND COMMON DEFECTS IN CREAM

Structure

3.0 OBJECTIVES

After reading this unit, we should be able to:

- define packaging and its requirements
- indicate packaging methods
- specify common defects in cream during storage and their preventive measures

3.1 INTRODUCTION

Packaging is a technique used to contain, protect and identify a product. It facilitates its transportation, distribution and safe delivery of a product to the consumers. Thus, it contributes significantly to marketing and sale of a product. The packaging requirements to preserve natural quality of a product vary with the products. For example, skim milk and cream require materials with different characteristics. Skim milk does not require a material, which is impermeable to light whereas for cream or any other fat rich product impermeability to light is an essential requirement for packaging material. Consequently, a large number of packaging materials like polymers (single layer polymer, multi-layered polymer), metallic foils, metal cans, glass-bottles and coatings have been developed to meet the requirements of different products. In addition, different packaging machines and methods are also available to pack the product in different forms and shapes. In this unit, we will study the packaging requirements for cream and the common defects, which may develop during its storage. This until will also deal with the probable causes of such defects and their preventive measures.

3.2 DEFINITION AND PACKAGING REQUIREMENTS

The protection offered to a product against any damage caused by the outside influences of environment (humidity, light, oxygen, temperatures), foreign odour, chemicals, and insects, physical hazards, etc. during storage, transportation, distribution and retailing is referred to as packaging. In other words, enclosing a product in specially designed containers to achieve the desired protection against spoilage is packaging. Packaging is different than packing. Packaging is the primary package,

which is in direct contact of the product. It provides initial and major barrier against spoilage of the product. It is the primary package in which the consumers purchase the product from a retail shop. Packing refers to enclosing several individual items packed in primary packages in a container for shipment from one place to another. Thus, packing forms a secondary package and contains a number of primary packages.

The following factors must be considered if the product is to be protected against spoilage and remain acceptable until it is consumed.

a) Composition of the product.

b) Storage conditions (temperature, humidity, light, gases, dust, microorganisms).

c) Type and probable cause of spoilage.

d) Physical hazards during storage and subsequent handling and transportation. (Shocks, vibrations, compression).

e) Consumer's requirement in terms of capacity, and functional properties.

f) Availability.

g) Interaction between product and package.

h) Economics of packaging.

i. Advantages of Packaging

- Contains and protects the product against damages caused by mechanical, biological and environmental agents.
- Informs about the product, e.g. nutritional and compositional quality, date of manufacture, weight, cost, conditions for storage, shelf life, uses, etc.
- Convenience of handling to the retailers and buyers both.
- Facilitates storage, transportation and distribution of product.

ii. Requirements of Packaging

Cream is that part of milk which is rich in milk fat and has been obtained by gravity separation (hand skimming) or by mechanical separation of milk. It may be considered as an intermediate product between milk and butter. The aqueous phase (water) in cream is reduced but the oil-in-water emulsion is not broken unlike butter, which is a water-in-oil type emulsion. Cream contains all the constituents of milk but the solids-not-fat content is inversely proportional to its fat content. Thus with the increase in fat content of cream the proportions of protein, lactose, mineral salts and also water soluble vitamins decrease while the proportion of fat soluble constituents such as phospholipids, cholesterol and fat soluble vitamins increase.

Cream has unique natural flavour. But the flavour of cream is very susceptible to spoilage because of high percentage of fat (normally 18-80%). Thus it requires protection. For example, the presence of light may initiate auto-oxidation of milk fat and produce flavour defect like rancidity in cream. Homogenized cream is more susceptible to the action of light than un-homogenized cream. Cream may also absorb odours from outside environment like gases, moisture or fat and develop flavour defects. Thus, it requires a packaging material, which provides protection against all the agents causing spoilage of cream.

The cream requires protection against light, gases, and absorption of outside odour and gain or loss of moisture. The packaging material, therefore, must be impermeable to all these agents. In addition it should have sufficient mechanical strength, tear strength, burst strength and wet strength to provide protection against mechanical hazards during storage, and subsequent handling to prevent the loss of cream. The packaging material should not produce any toxic substance or impart its own flavour

or colour to the product. Metal cans, coloured glass jars or bottles, plastic containers, incorporating one or more layers of nylon, containers made of laminated materials in which one layer is of aluminum foil or similar material are common which meet most of the desired requirements for cream packaging. The packaging material may contain compounds like printer's ink, dyes or monomers from plastic materials. These materials may migrate to or interact with the cream constituents causing gradual deterioration in quality. Hence, proper selection of packaging material is very important.

Check Your Progress 1

1) Define packaging.

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2) Why different dairy products require packaging materials of different characteristics?

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3) What is the difference between packaging and packing?

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3.3 PACKAGING AND STORAGE

i. Packaging Machines

Packaging machines used for milk or condensed milk can also be used for packaging of cream. These include

- Bottle filling machine (wide mouthed bottles)
- Capping machine
- Can filling
- Can sealer
- Form/Fill/Seal machine for Sachet filling
- Heat-sealing machine

ii. Physical Characteristics of Cream

We know that several types of cream are available in the world market. They differ in their physical characteristics from each other. Some of them are free flowing and easily pourable (light cream), while others are highly viscous, difficult to pour or non-pourable but spoon able (heavy cream). The physical characteristics of different types of cream demand different forms of packaging material. Therefore, it is essential to use the most suitable form of packaging, which protects the product and at the same time has appealing influence on the customers.

The physical characteristics are influenced by the following factors:

i) Method of production.

ii) Fat content

iii) Treatment of cream

iii. Packaging Materials

Traditionally, fresh cream was packed in metal cans, glass bottles/jars, waxed paperboard cartons with press-in-lids of the same material, etc. The paperboard cartons have a tendency to absorb moisture and are damaged during storage under refrigerated temperature. Now many packaging materials of different characteristics are available in the following forms, which are commonly used for cream.

a) Plastic Cups/Collapsible tubes/Plastic tubs with crimped-on-skirted caps of aluminum-foil (Al-foil).

b) Plastic tubs with Al-foil sealed to the rim of the container.

c) Polystyrene tubs with heat- sealed Al-foil closures.

d) Rectangular gable topped waxed or plastic coated paper board packages.

e) Plastic bag-in-box for bulk packaging of cream.

f) Tinned steel cans with slip-on lids (Small capacity).

g) Wide mouthed omni a-sealed opaque glass jars.

h) Heat -sealed collapsible plastic tubes.

i) Cartons of tetrahedral types.

j) Aerosol packaging system.

Earlier pasteurized cream was packed in glass-bottles or in waxed or polyethylene-coated cartons. Now the most common form of packaging is the injection moulded polyethylene tubs or flat-topped round containers. The containers are filled with the product and closed with heat sealed polyethylene-Al-foil laminate. A clear plastic lid is often provided to consumers to reseal the containers once opened. Bag-in-box system of packaging is used for bulk packaging of pasteurized cream.

Sterilized cream is packaged in cans and in containers like crown-capped bottles using machines similar to that used for sterilized milk. Wide mouthed omni-a-sealed opaque glass jars, and hermetically sealed tinned steel cans are also used for sterilized cream. UHT cream requires aseptic packaging. Various packaging formats exist for packaging UHT cream. The form-fill-seal type laminated cartons are one option in which case the presence of an Al-foil layer in the laminate is essential to protect the product from the influence of light and initiation of auto oxidation during storage. Thermo formed containers made from co-extrusion of polyethylene and poly-vinylidene chloride are also used. These containers are closed with heat-sealed polyethylene-Al-laminate foil. Blow moulded polyethylene or polypropylene containers formed at the point of filling may also be used. Bag-in-box packages made from metalized plastic laminates may be aseptically used for bulk packaging of UHT cream.

Pasteurized heavy cream requires wide mouthed containers while pasteurized, homogenized cream does not require such containers. Sterilized or UHT low fat cream requires opaque containers so that the phase separation (serum separation) is not visible to the customers. Phase separation usually occurs in high heat treated low fat cream on prolonged storage.

Clotted cream is packed at 4-7°C in polystyrene flat-topped round containers. These are filled and closed with a polyethylene-Al-laminate foil. Alternatively, it is often packed in square or rectangular shallow high-density polyethylene containers closed with a clear plastic film and inserted in a paper sleeve carrying the product

information. Small capacity tinned steel cans with slip-on lids are also used for clotted cream. Aerosol cans and PE tubs with-snap-on lids are suitable for packaging whipping or whipping cream.

iv. Packaging Methods

Packaging methods for cream are similar to those used for packaging of milk. It requires correcting dosing of cream by volume in the containers and then properly closing with lids or treat sealing. It is important to remember that all the operations involved in supply, filling and sealing of containers must be carried out in highly hygienic conditions. The containers, machines, pipelines, etc. must be thoroughly cleaned and properly sterilized before they are used.

v. Storage

Cream is considered as a short shelf life product. In general, pasteurized cream packed in a closed container is expected to remain whole some for 5-7 days under refrigeration storage (5-10°C). UHT aseptically packaged cream is stored at ambient temperature and is expected to remain acceptable for 1-6 months. Sterilized cream might remain good for 6-12 months at ambient temperature. However, once the containers containing UHT or sterilized cream is opened it should be treated as only pasteurized cream. Storage of cream in frozen state destabilizes the emulsion (oil in water type) of cream. On thawing of frozen cream, separation of fat phase and serum phase takes place. Such cream is not useful for whipping but can be used for some products like soups to impart flavour.

vi. Distribution

It is advisable to distribute pasteurized cream to the consumers as early as possible preferably within 3 hrs of removing it from the cold store. Always fresh cream should be delivered to the dairy plant for manufacture of products.

Check Your Progress 2

1) What are the advantages of packaging a product?

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2) Name the environmental agents, which cause spoilage of cream during storage.

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3) What are the packaging requirements of cream?

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4) Which are the machines used for packaging of cream?

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5) What are the common forms of packaging cream?

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3.4 DEFECTS IN CREAM AND THEIR CONTROL

The requirements of high quality table cream or manufacturing cream are the same as given here under.

i) Clean, sweet, pleasant flavour.

ii) Smooth, uniform and reasonably viscous body and texture.

iii) Low titratable acidity.

iv) Packaged in clean, leak-proof containers under hygienic conditions.

Defects in cream develop during storage. These defects may be due to poor initial quality of milk from which it is separated or faulty methods of production, processing, packaging and storage. As the storage period advances, the titratable acidity of cream also may increase. This may lead to defects like the curdling/serum separation. During storage, usually cream is prone to the development of flavour defects more rather than body and texture defects.

i. Flavour Defects and Control Measures

Common flavour defects likely to develop during storage are given here with their probable causes and control methods.

Acidic flavour may develop due to all or any of the following causative factors:

i) Use of sour milk for cream separation,

ii) Holding raw cream for longer period at ambient temperature,

iii) Using less than recommended time-temperature combination for pasteurization,

iv) Prolonged storage,

This requires strict maintenance of sanitary condition in the plant, reception of only good quality milk, using proper processing methods and storage temperature.

Cooked flavour: Uncontrolled excessive heating at any stage of processing of cream may lead development of cooked flavour. Hence, it requires check on pasteurization temperature in particular.

Oxidized/Oily/Metallic/Tallowy flavour: These kinds of flavour develop due to oxidation of fat caused by exposure of cream to light, metals, like copper/iron. Hence, its control requires proper packaging material and avoiding any metallic contamination during processing of cream.

Rancid or Bitter flavour: This is due to hydrolysis of fat by the action of enzyme lipase. Lipase may come from initial under heating and high microbial population. Entrance of moisture through packaging enhances the problem. Therefore, proper heat treatment, prevention of post processing contamination and proper packaging may serve as control measures. Bitter flavour may also come from milk if the animal is fed on some bitter weeds.

Cheesy flavour: The flavour of cream resembles that of cheddar cheese. Presence of proteolytic bacteria in cream leads to breakdown of protein causing this defect. Prolonged storage may allow psychrotrophic bacteria to grow at low temperatures

and cause the defect. Prevention of post pasteurization contamination and quick disposal of the product may help reduce the problem.

Yeasty/Fruity flavour: Microbial contamination, use of improper processing methods, post processing contamination, unhygienic conditions prevailing in the plant lead to the development of undesirable flavour like that of vinegar, etc. It requires proper hygienic control at every stage of processing besides plant hygiene.

Utensils flavour: Use of dirty utensils imparts this objectionable flavour to cream. Therefore all the utensils and equipment should be properly cleaned and sterilized before and after use.

Feed/Weed flavour: This type of flavour defect comes from milk from the milch animals fed on some objectionable flavour imparting feed or weeds. Therefore strict control should be exercised while receiving the milk to control the defect.

ii. Body and Texture Defects

Curding: This defect is indicated by the appearance of flakes or coagulated particles in cream. This defect may result due to the following reasons:

i) Initial poor quality.

ii) Development of acidity.

iii) High temperature of storage.

iv) Post processing contamination.

Phase Separation: When this defect develops the watery portion and coagulated particles or lumps form two layers in the containers. It mostly happens due to thawing of frozen cream. It is, therefore, better to avoid frozen storage of cream to control the problem.

Undesirable fermentation: It may result in flavour as well as body & texture defect. This is mainly caused by the contamination of cream at any stage of processing particularly after pasteurization. It is, therefore, necessary to take all the precautionary measures to control contamination during and after processing including packaging to avoid the problem.

Check Your Progress 3

1) What is the major difference in the composition of cream and milk?

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2) What are the desired properties of good cream?

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3) Name some of the common defects in sterilized cream.

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3.5 LET US SUM UP

Cream is a fat rich but short shelf-life milk product. Cream demands packaging materials with certain unique characteristics like impermeability to light, gases and moisture, mechanical strength, etc; for its packaging. Consequently, a large number of packaging materials like polymers, metallic foils, metal cans, glass-bottles and coatings have been used to meet the requirements of the product. Metal cans, coloured glass jars or bottles, plastic containers incorporating one or more layers of nylon, containers made of laminated materials in which one layer is of aluminum foil or similar material meet most of the desired requirements for cream packaging and are commonly used. Packaging machines used for milk or condensed milk, which include bottle filling machine, capping machine, can filling, can sealer, form/ fill/seal machine for sachet filling and heat-sealing machine can be used for packaging of cream. Different forms of packaging materials used for cream, which include plastic cups/ collapsible tubes/plastic tubs with crimped-on-skirted caps of aluminum-foil, plastic tubs with aluminum-foil sealed to the rim of the container, polystyrene tubs with heat- sealed aluminum-foil closures, rectangular gable topped waxed or plastic coated paper board packages, plastic bag-in-box for bulk packaging of cream, tinned steel cans with slip-on lids, wide mouthed omni-a-sealed opaque glass jars, heat-sealed collapsible plastic tubes and cartons of tetrahedral types. Pasteurized cream packed in a closed container is expected to remain wholesome for 5-7 days under refrigeration storage. UHT and aseptically packaged cream is stored at ambient temperature and is expected to remain acceptable for 1-6 months. Sterilized cream might remain good for 6-12 months at ambient temperature. However, once the container containing UHT or sterilized cream is opened it should be treated as only pasteurized cream.

Storage of cream in frozen state destabilizes the emulsion of cream. On thawing of frozen cream, separation of fat phase and serum phase takes place. Such cream is not useful for whipping but can be used to impart flavour in some products like soups. If cream is not processed and stored under proper conditions it is bound to develop defects in flavour and body and texture.

3.6 KEY WORDS

Packaging : It is the protection offered to a product against any damage caused by the outside influences of environment, foreign odour, chemicals, insects, physical hazards, etc; during storage, transportation, distribution and retailing.

Packing : It is the process of enclosing several individual items packed in primary packages in a container for shipment from one place to another.

Tallowy flavour : It is a flavour defect, which developed due to oxidation of fat caused by exposure of cream to light, metals like copper/iron, etc.

Yeasty/Fruity flavour : It is a flavour defect developed in cream due to microbial contamination, use of improper processing methods, post processing contamination and unhygienic conditions prevailing in the plant which, lead to the development of undesirable flavour like that of vinegar.

Phase Separation : It is the texture defect in frozen cream, wherein, the watery portion and coagulated particles or lumps form two layers in the containers upon thawing of frozen cream.

3.7 SOME USEFUL BOOKS

De Sukumar (1980), Outlines of Dairy Technology, Oxford University Press, Delhi.

3.8 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points:

Check Your Progress 1

1) i. Enclosing a product in a specially designed container to provide protection against influences of outside environmental, biological agents, mechanical hazards and facilitates storage, transportation and sale of the product is packaging.

2) i. The natural qualities of products vary from each other. Hence the products require packaging materials with different characteristics to preserve their natural quality.

3) i. Packaging is primary package, which is in direct contact with the product. Packing refers to enclosing several individual items in primary packages in a container for shipment from one place to another.

Check Your Progress 2

1) Packaging of product offers following advantages:
   i. Contains and protects the product against damages caused by mechanical, biological and environmental agents.
   ii. Informs about the product, e.g., nutritional and compositional quality, date of manufacture, weight, cost, conditions far storage, shelf-life, uses etc.
   iii. Convenience of handling to the retailers and buyers both.
   iv. Facilitates storage, transportation and distribution of product.

2) i. Environmental agents include light, humidity, gases, temperature, and outside odour.

3) i. Cream requires packaging material, which provide protection against light, foreign-odor, humidity, and possesses sufficient strength.

4) i. Packaging machines used for milk or condensed milk can also be used for packaging of cream. These include Bottle filling machine (wide mouthed bottles), Capping machine, Can filling, Can sealer, Form/Fill/Seal machine for Sachet filling, Heat-sealing machine.

5) i. Tubs, Glass Bottles, Cans, Bag-in-box, Collapsible tubs, Aerosol packaging systems.

Check Your Progress 3

1) i. Milk contains more solids-not-fat whereas cream is rich in milk fat and poor in solids-not-fat.

2) i. The requirements of high quality table cream or manufacturing cream are as follows: Clean, sweet, pleasant flavour, smooth, uniform and reasonably viscous body and texture, low titratable acidity, packaged in clean, leak-proof containers under hygienic conditions.

3) i. Cooked flavour and sometimes phase separation.

UNIT 4 DEFINITION, STANDARDS AND PRINCIPLE OF BUTTER MAKING

Structure

4.0 OBJECTIVES

After reading this unit, we should be able to:

- define and specify chemical composition and standards
- state the food and nutritive value
- explain the principle of butter making
- comprehend the churning theories
- identify the churning devices/type of churns
- outline the features of continuous butter making

4.1 INTRODUCTION

Butter is essentially milk fat made from milk, *dahi* (curd) or cream by agitating or shaking it until the fat separates as semisolid mass from the liquid portion (serum) of milk. Its colour varies from pale yellow to deep yellow to nearly white. At room temperature, butter is a semisolid but soft mass which melts easily. The fat in the milk, cream or dahi exists in the form of globules of the size 0.1 – 10.0 micron. These globules are dispersed in milk serum and are surrounded by a membrane, which is composed of surface active agents like phospholipids and lipoproteins. This membrane prevents the fat globules from coming closer and joining together. Agitation in the churn ruptures the membranes and thus enables the globules to coalesce (join together) to form large granules of fat and separate. The separated milk fat is known as butter, while the watery portion as buttermilk. The process of agitation/ shaking is known as churning and the device used for the purpose is butter churn. Butter is used as a food ingredient, cooking medium, in medicines, in cosmetics and as offering during worships.

Conventional butter making involves letting a pan of milk to stay undisturbed until a layer of fat (cream) forms on the surface, skimming off the cream layer, natural souring and finally agitating or shaking the cream to separate milk fat from the serum. Subsequent knowledge and experience gained over the years in terms of hygiene, bacterial acidification and heat treatment coupled with rapid advancement in the machinery moved the butter making practice from household level to highly commercial scale. Today, butter is available in many forms - unsalted, reduced and low salt, cultured butter etc., in order to accommodate all consumer needs.

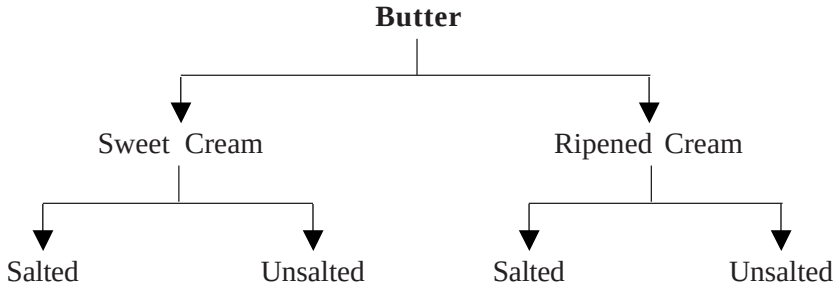
4.2 DEFINITION AND CLASSIFICATION

i. Definition

Butter is the product obtained from cow or buffalo milk or a combination thereof or from curd with or without the addition of any preservatives including common salt, any added colouring matter or flavouring agents. It shall be free from other animal fat and shall contain not less than 76 per cent of milk fat by weight.

ii. Classification

Butter may broadly be classified into four groups:



Butter can be classified on the basis of type of cream, manufacturing process and ripening process etc. as listed below:

a) **Sweet cream butter** - is the butter made from non-acidified cream with a pH of e" 6.4 or acidity lower than 0.20% L.A.

b) **Sour cream butter** - is the butter made from cream acidified by bacterial fermentation to a pH d" 5.1 or acidity more than 0.20% L. A.

c) **Mildly acidified butter** - is the butter made from partially acidified cream with a pH d" 5.2 – 6.3 (0.16-0.20% L.A.)

d) **Pasteurized cream butter** - is the butter made usually from pasteurized sweet cream. It possesses usually milder flavour than that made from similar cream but not pasteurized.

e) **Ripened cream butter** - is the butter made from cream in which a pleasant and delicate aroma known as 'real butter flavour' has been developed by ripening before churning. Ripening is a process in which the cream is inoculated with a butter culture and allowed to stay overnight at controlled temperature. During this period the titratable acidity of cream increases and the pH varies in the range of 4.4- 5.6.

f) **Un-ripened cream butter** - is the butter made from un-ripened or fresh cream. The flavour of such butter is usually mild.

g) **Salted butter** - is the butter made by the addition of a maximum 3.0 per cent salt after the buttermilk has been drained off. The salt added, enhances the taste and prolongs the preservation of the product by inhibiting the growth of microorganisms. It is more often referred as 'table butter'

h) **Unsalted butter** : It contains no added salt. It is also referred to as 'sweet

butter' or 'cooking butter'. It is preferred for use in cakes, pastry and ghee making.

i) **Fresh butter :** Butter, which has not undergone for cold storage is referred as 'fresh butter'. Usually, it is not kept for more than 3 weeks.

j) **Cold storage butter** : Butter, which has been stored at a temperature of about –18°C (O°F) for some time is cold storage butter. Generally, it is one to six months old when offered for retail trade.

k) **Dairy butter (**USA) : It is usually made, from un-pasteurized sour cream, which has not been standardized for acidity. Dairy butter generally has a sour flavour due to the high acid content of the cream.

l) **Creamery butter** : Made in a creamery or dairy factory. It is more uniform in quality than 'dairy butter'.

4.3 COMPOSITION AND NUTRITIVE VALUE

i. Composition

Butter consists of milk fat, non-fat-constituents and water. The water is uniformly dispersed as fine droplets in butter so that it looks dry. Main constituent of butter is milk fat comprising glycerol and fatty acids. Milk fat is comprised mostly of triglycerides, with small amounts of mono and diglycerides, phospholipids, glycolipids and lipoproteins. The triglycerides (98% of milk fat) are of diverse composition with respect to their component fatty acids, approximately 40% of which are unsaturated. Butter melts at about 35°C (96 °F) and re-solidifies at 23°C (73°F). The firmness of butterfat varies with the proportion of saturated and unsaturated fatty acids, chain length, degree of un-saturation (mono or poly), and position of the fatty acids on the glycerol molecule. The change in butter softness is associated with the changes in fatty acid and triglyceride structure of the milk fat. On an average, butter contains about 50.5% saturated fatty acids, 23.5% mono-unsaturated fatty acids, 3.0% poly-unsaturated fatty acids and 0.22% cholesterol. A typical fatty acids composition of butter is depicted in Fig.4.1.

Fatty acids play an important role in development of butter flavor. These are present various concentrations. Although long-chain fatty acids are present at higher concentrations in butter, they do not make a significant contribution to its flavor. Short-chain fatty acids (SCFA), on the other hand, do play an important role in the flavour of butter. Typically, SCFA's are found in the serum portion of butter (aqueous solution of all non-fat components) where their flavor potential is stronger. Butter flavour can be enhanced and sharpened by emulsifying fats with skimmed milk that has been cultured with lactic acid bacteria. The flavour of butter can also be simulated by the addition of butanedione.

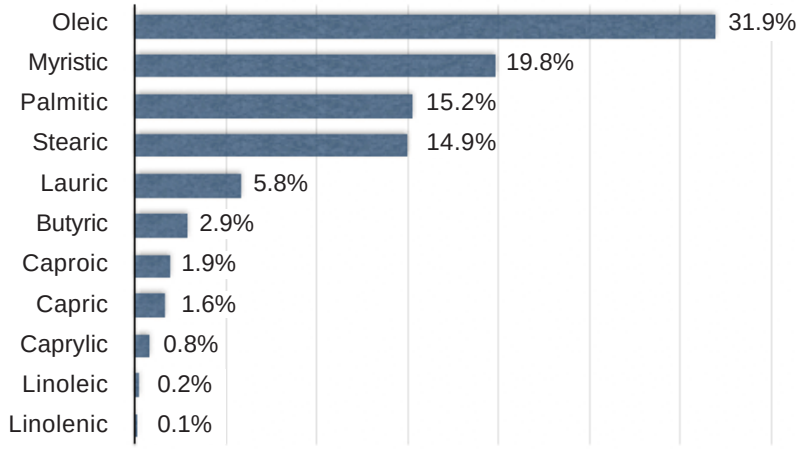


Fig. 4.1: Fatty acid composition of butter

Non-fat constituents of butter include protein, calcium and phosphorus, sometimes referred to as curd residue and are present as minor constituents of butter. Butter also contains fat-soluble vitamins like A, D, E and K. Chemical composition of butter depends upon on the method of manufacture. . On an average butter contains 80% fat, 16% moisture and 2% non fat milk solids . The titratable acidity of butter should be below 0.2% L.A.

ii. Nutritive Value

Butter is a water-in-oil emulsion, with 80% milk fat, 16% moisture, and 2% milk solids-not-fat either with or without salt. Butter has very high-energy value. Butter containing 80 per cent fat provides 7.2 cal/g. Milk fat provides some essential fatty acids and also serves as a carrier of fat-soluble vitamins like A, D, E and K and promotes their absorption. It contains significant amounts of vitamin A (30 I U / g), which is important for eye-sight, to maintain healthy skin and resistance to infection. Vitamin D is also found in butter, which is required for bone strength and calcium absorption aids to provide good bone strength and calcium absorption. Conjugated linoleic acid present in milk fat assists in preventing certain types cancer, in particular breast cancer, helps to keep the heart healthy and enhances the immune function in the body. Fresh butter being in emulsified form is easily digestible than melted form. Vitamins and mineral contents of butter are given in Table 4.1.

Table 4.1 Vitamin and Mineral content (mg/100 g of butter)

Vitamins and minerals	Salted Butter	Unsalted Butter
Sodium	826	11
Potassium	26	26
Calcium	24	24
Phosphorus	23	23
Magnesium	2	2
Zinc	0.05	0.05
Iron	0.16	0.16
Copper	0.016	0.016
Manganese	0.004	0.004
Selenium	0.001	0.001
Vitamin A	0.754	0.754
Thiamin	0.005	0.005
Riboflavin	0.034	0.034
Niacin	0.042	0.042
Vitamin B_6	0.003	0.003
Folate	0.003	0.003
Vitamin B_{12}	0.00013	0.00013
Pantothenic Acid	0.110	0.110
Vitamin C	0	0
Vitamin E	1.58	1.58

Butter is generally considered to be safe from pathogens as the moisture content is low and uniformly distributed in the whole mass as numerous microscopic droplets that is relatively high in sodium chloride concentration. The fat portion of butter is also safe from microbial degradation.

Check Your Progress 1

1) Define butter?

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2) Classify butter?

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3) Name the major component of butter?

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4) State the other constituents of butter?

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5) Difference between cooking butter and creamery butter?

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6) Give the nutritive value of butter having 80% fat?

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4.4 STANDARDS

Regulatory bodies such as Prevention of Food Adulteration Act, Bureau of Indian Standards etc., have laid quality standards for butter so that a customer gets a uniform and quality product from the market.

i. Prevention of Food Adulteration (PFA) Act

According to the Prevention of Food Adulteration Rules (1976), Table/Creamery butter means the product obtained from cow or buffalo milk or a combination thereof or from cream or curd obtained from cow or buffalo milk or a combination thereof with or without the addition of common salt and annatto or carotene as colouring matter. It shall be free from animal fat, wax and mineral oils, vegetable oils and fats. No preservative except common salt and no colouring matter except carotene or annatto may be added. It shall contain not less than 80 per cent by weight of milk fat, not more than 1.5 per cent by weight of curd, and not more than

3.0 per cent by weight of common salt. Diacetyl may be added as flavouring agent but shall not exceed 4.0 parts per million.

ii. Bureau of Indian Standards (BIS) for Butter

Table butter means the product made from pasteurized cream obtained from pasteurized milk of cow or buffalo or a combination thereof with or without ripening with the use of standard lactic culture, addition of common salt, annatto or carotene as the colouring matter and diacetyl as flavouring agent. BIS specifications for butter are given in the Table 4.2.

Table 4.2: BIS (IS13690: 1992) standards for butter

Constituents	Compositional standard requirement	
	Table butter	White butter
Milk fat	80% min.	82% min
Moisture	16% max	16% max
Acidity	1.5% LA max.	0.6% LA max
Curd	1.0% max.	1.5% max.
Common salt	2.5% max.	-
Coliform count	5/ml max.	5/ml max.
Total yeast & mould count	20/ml max.	120/ml max.

4.5 PRINCIPLE OF BUTTER MAKING

There are essentially four types of butter-making processes:

i. Traditional batch - churning from 25-35% milk fat cream;

ii. Continuous floatation - churning from 30-50% milk-fat cream;

iii. Concentration process - whereby plastic cream of 82% milk-fat is separated from 35% milk fat cream at 55°C and this oil-in-water emulsion is inverted to water-in-oil emulsion butter with no further draining of buttermilk

iv. Anhydrous milk fat process - whereby water, SNF and salt are emulsified into butter oil.

The process of butter making is principally an inversion of fat-in water type emulsion of cream to water-in fat type of emulsion in butter. In other words the system in which fat droplets are dispersed in continuous water phase is converted into a system of a continuous phase of fat in which water droplets are dispersed. During whipping process, cream is kept cold and the agitation stopped to produce stable and airy foam. In churning process cream is warmed to the point that softens the fat globules to some degree so that the fat inside the globules gets liquefied. Ideally the cream should attain a temperature of 12 to 18°C during churning. The persistent agitation during the process makes the softened globules to collide with each other. During the collision the material around the fat globules serving as the protective membrane and preventing the globules from coalescence is damaged. Consequently the fat globules collapse and the liquid fat cements the exposed fat droplets together. The foam structure is broken both by the free fat and the released membrane materials, which include emulsifiers like lecithin. These materials disrupt thin water layers and thus cause bursting of the bubble walls. As soon as, enough of bubbles have been freed in the process of whipping or churning of cream, a stable foam is never formed again. Since the churning process continues further the foam gradually subsides and the butter granules are formed, which are worked together into larger and larger mass to produce butter. Fat globules typically aggregate in following three ways:

- Floculation
- Coalescence
- Partial coalescence

Check Your Progress 2

1) Differentiate between butter and cream.

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2) State the shelf-life of butter.

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3) Differentiate between whipping and churning processes.

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4) Which are the materials that break the foam?

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4.6 CHURNING AND ITS THEORIES

Churning refers to the process of agitation of cream at a suitable temperature until the fat globules adhere with each other forming larger and larger mass and leading to almost complete separation of fat and serum. During churning cream is slowly agitated with the paddles provided in the butter churn causing it to thicken and break into two parts, i.e., butter grains and buttermilk. At this stage, cold water at 10°C is added and agitation continued. Addition of water is necessary to help the cream to 'break' and hence it is known as break water. The volume of water should not exceed 25% of the total volume of cream. Churning continues until the butter granules are about the size of pea grains. In order to prepare good quality butter, the cream should possess good churnability. Good churnability refers to the ease of conversion of cream to butter, completeness of conversion and the time required for the formation of sufficiently firm butter grains. The body & texture of butter is also influenced by the duration of churning. Churnability of cream and body & texture of butter depends on the following factors:

a) Chemical composition of fat

b) Size of fat globules

c) Viscosity of cream

d) Temperature of cream at churning

e) Fat percentage of cream

f) Acidity of cream

g) Load of churn

h) Nature of agitation

i) Speed of churn

j) Pre-churning holding period

i. Events during Churning

The sequence of events that occur during churning can be summarized as follows:

i) Churning is initiated with agitation of cream causing incorporation of air bubble into the cream. This, in turn, increases the volume of cream and air plasma interface.

ii) Surface- active forces like frictional forces cause partial disruption of fat globules membranes. Consequently, a part of the liquid fat leaves the globule and spreads over the surface of air bubble in the form of a thin layer.

iii) The fat film thus formed serves as a foam depressant causing the air bubble to burst. Also, the liquid fat serves as cementing material causing fat globules to join together.

iv) Eventually butter grains are formed which floats in the plasma, i.e., butter milk.

ii. Theories

There are three main theories of the churning of cream into butter. These are Fisher and Hooker's Phase-Reversal Theory, Rahn's Foam Theory, and King's Modern Theory.

i) **Fisher and Hooker's Phase-Reversal Theory:** According to this theory, churning is a process of phase reversal, i.e. changing an oil-in-water type emulsion (such as cream) to a water-in-oil type emulsion (such as butter). Agitation of cream in the churning process causes coalescence and clumping of fat globules until eventually the ratio of the surface area to the volume of fat units becomes so small that it can no longer contain all the buttermilk in stable form. The fat-in-water emulsion then suddenly breaks, yielding butter grains (consisting of an emulsion of water-in-butter-fat) and free buttermilk.

   But this theory fails to explain the results of microscopic studies, which reveal that a proportion of fat globules in butter are still intact in the worked butter. Hence butter is not a true water-in-fat emulsion whereas this theory assumes that butter is a water-in-oil type of emulsion.

ii) **Rahn's Foam Theory**: According to this theory, the presence of foam/froth is essential for churning. It also postulates that there is a 'foam-producing' substance present in cream (and milk) and which gradually solidifies as the cream or milk is agitated. Foam is created during the churning period. The fat globules, due to surface tension effects, tend to concentrate and clump on the foam bubbles. The foam-producing substance assumes a solid character and causes the foam to collapse. The fat globules then coalesce and butter is formed.

   This theory also fails to explain continuous butter-making processes where in some cases foam formation (i.e. the presence of air) is not required. This theory assumes that the presence of foam is essential for churning.

iii) **King's Modern Theory**. According to this theory, the true explanation of what takes place during churning appears to lie midway between the first two theories. The current concept of mechanism of the churning process may be summarized as follows:

   - In cooled cream at churning temperature, the fat is present as clusters (clumps) of fat globules and within each globule it is present partly in solid and partly in liquid form.
   - Churning breaks up the clusters and causes foam/froth formation. The globules become concentrated to some extent in the film around the air bubbles in the foam and are thus brought into close contact with each other.

- The movement of the globules over one another in the foam film and the direct concussion between them causes a gradual wearing away of the emulsion-protecting surface layer of the phospholipids-protein complex. The globules then adhere together to form larger and larger particles. Eventually these particles become visible as butter grains (granules). As the granules form, they enclose some of the air from the foam. The fat in the granules is still mainly in globular form.
- The working of butter grains causes the globules to move over one another. Under the effect of friction and pressure, some of them yield up a portion of the liquid fat. Others are broken up during working. Finally there is enough free liquid fat present to enclose all the water droplets, air bubbles and intact fat globules.

Check Your Progress 3

1) Describe the principle of butter making?

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2) Define churning.

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3) State the existence of fat in milk, cream, and butter.

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4) Enumerate various churning theories.

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4.7 BUTTER CHURNS

Churn is a device for making butter. Traditionally, various types of churns such as Rocker churns, Dash churns, Wooden-barrel churns, Tin churns, Stone-ware churn, and Glass churn jars (as shown in the Fig 4.2) etc., are used for butter making.

i. Basic Designs

The basic designs of butter churn may be classified in three groups as follows.

a) **Swinging churns:** The cream moves backward and forward in a horizontal plane. There are internal diaphragms in the churn to obstruct the flow of cream to some extent and thus to increase the intensity of agitation.

b) **Rotating churns:** These are either barrel or alfa churns**.** Modern factory churns (wooden or metal) have been developed from rotating barrel type of churns.

c) **Dash churns:** In these, the cream-holding vessel is stationary, while the agitator or dasher (plunger, disc or rotating blade) is mobile.

Wooden churn

Hand operated churn

Rotating churn

Fig. 4.2: Butter Churns

ii. Modern Churns

Modern industrial churns are large, barrel-shaped, revolving containers in which the cream is agitated until the microscopic fat globules clump together to form butter and separate from buttermilk. The liquid buttermilk is drained, and the butter washed with potable cold water. Following types of modern butter churns have been developed over the years through the modification of the basic designs.

Combined-churn and butter worker: Early factory churns only churned the cream into butter, the working was done separately on circular/rectangular worker tables. The combined-churn-and-butter-worker was developed so that butter could be worked within the churn itself; the workers were installed on a trolley, which was pushed into the churn from either one of its ends or sides.

Roller-less (roll-less) churn: In these wooden churns, the working is effected without the aid of rollers, which were considered to be unsanitary. Vanes were fixed to vane churns, to help in the churning and the working of butter.

Modern metal churns. These have been developed mainly in Denmark and the USA. The usual shapes are cylindrical, cubical or conical. The metal used for the product contact surface is either stainless steel or aluminium alloy. The internal shape is so designed that the working is effected by the rolling action of butter. Metal churns offer following advantages:

- Ease of cleaning with alkali detergents
- Sterilization with steam without damaging the churn body
- Accuracy of moisture and salt control
- Intermittent use without deterioration in quality
- Better sanitary aspects

The major disadvantage of the metal churn is that it is difficult to control the temperature because of its low heat insulating capacity. However, it can be obviated by installation of the butter churn in an air-conditioned room or making provision for chilled water spray during churning and working.

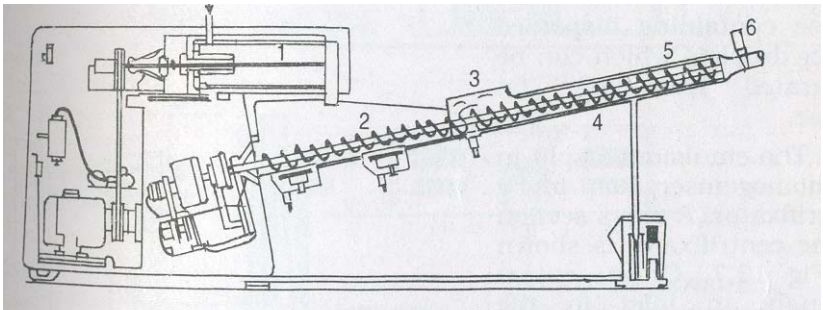
4.8 CONTINUOUS BUTTER MAKING

Attempts were made since 1890 to explore the possibility of producing butter by a continuous process. Consequently a number of different systems have now been developed for regular commercial use. Continuous butter making systems are more economical as it requires lower capital cost, reduced floor space, lower running

cost and reduced power, labour, refrigeration, steam, detergent, etc. It does not require expensive foundation. In preparation of butter by continuous method, there is no time loss for fat crystallization. Butter wastage is also very less. It is a closed and hygienic system. Hence, it yields a product, which is free from airborne contamination and longer shelf life. It is difficult to draw a representative sample for analysis due to fluctuation in the quality of butter during the production.

Basic principle: The continuous methods of butter production developed since 1935 may be divided into three main groups:

- **Group I:** The system is based on churning process. This involves the use of high-speed beaters to destabilize the fat emulsion in chilled cream, and cause the formation of grains of butter in a matter of seconds. The buttermilk is drained away and the resulting grains worked in a kneading section prior to extrusion. The examples of this system include Fritz; similar ones are Westfalia, Paasch and Silkeborg and Contimab.



1. churning cylinder 2. working section 3. dry working section 4. dosing section 5. vacuum section 6. probe for measuring the moisture content

Fig. 4.3 Contimab method of continuous butter making machine

- **Group II:** This group is based on the principle of concentration and phase reversal process. This involves a system whereby cream of 30-40 per cent fat is concentrated in a special cream separator to 80-82 per cent fat. After standardization, the concentrated cream or 'butter mix' is subjected to a combined cooling and mechanical action, which causes phase reversal and the formation of butter, followed by its expulsion from the machine. Examples of this group are Alfa-Laval and Meleshin.
- **Group III:** The systems in this group are based on phase reversal and emulsification process. This again involves the concentration of 30-40 per cent cream. During concentration, the emulsion is broken and the fat, water and salt content are standardized. This is followed by re-emulsification, cooling, working and finally extrusion. Such systems are Creamery Package and Cherry Burrell.

4.9 OTHER METHODS OF MANUFACTURE

i) **Concentration Method:** Cream containing 30% fat is pasteurized at 90°C, degassed in vacuum and cooled to 45-70°C. It is then re-separated into 82% fat plastic cream. The concentrated plastic cream is still an oil-in-water emulsion. It is cooled to 8-13°C to promote crystallization of fat and damage the fat globules membrane in the tightly packed globules. Thus liquid fat comes out of the globules and rapid phase inversion takes place, followed by working and salting of butter. Butter made by this method contains all membrane materials, and hence more phospholipids. No buttermilk is produced by this method.

ii) **Phase Separation Method**: Plastic cream prepared in the same way as above is agitated to destabilize the emulsion. Thus, oil (82-98% fat) is separated

from the aqueous phase. The butter oil is then blended with water; salt and milk solids in an emulsion pump and transferred to scraped surface heat exchanger for cooling and to initiate crystallization. Further it is worked to develop crystal structure and texture. Butter prepared in this way contains very less phospholipids.

4.10 USES OF BUTTER

Butter plays a prominent role in cooking in many countries, as it gives an unequalled taste and flavour to food. It is used particularly in sauces and pastries (butter cream, puff pastry). It is a basic ingredient in breads and sandwiches and also used in baking and grilling. It burns at a lower heat than oil or margarine and its fat decomposes between 120 and 130°C. Butter heated to a high heat will have an indigestible and unappealing brownish colour. However, when combined with oil, butter will decompose less rapidly. It is used for the preparation of ghee, ice cream and recombined milk. It is also used in medicines, cosmetics and during worship.

Check Your Progress 4

1) Define butter churn

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2) Give the various methods of butter-making

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3) State the advantages of metal butter churns

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4) Describe the uses of butter

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4.11 LET US SUM UP

Butter is essentially a semi-solid mass of the milk fat separated from the liquid portion of milk by churning of sweet or soured cream or *dahi* (curd). The liquid portion is known as buttermilk. In general, butter is a soft, smooth and yellowish or whitish emulsion of butterfat, water and air. There are various types of butter available viz., sweet cream butter, salted, cultured, etc., are available to cater the consumer needs. Quality standards for butter have been set as per Prevention of Food Adulteration (PFA) act and Bureau of Indian Standards (BIS) so that the customers get a product of uniform quality from the market. Butter is a water-in-oil emulsion, made up of more than 80% milk fat, 16% moisture and about 2% milk solids-not-fat. It can be made with or without salt. The salted butter may contain

added salt in concentrations upto 3 per cent. Unsalted butter is often referred to as 'sweet' or 'cooking butter'. Chemically, milk fat is comprised of glycerol and fatty acids mostly of triglycerides, with small amounts of mono and diglycerides, phospholipids, glycolipids, and lipoproteins. Fatty acids, mainly due short-chain fatty acids play an important role in development of flavor of butter. Butter melts at about 35°C and re-solidifies at 23°C. Butter has very high-energy value. It also provides some essential fatty acids. Butter contains significant amounts of fat-soluble vitamins A and D and promotes their absorption. Milk fat also provides conjugated linoleic acid, which assists in preventing certain type of cancers.

The process of butter making is principally an inversion of fat-in water type emulsion of cream to water-in fat type of emulsion in butter. There are three main theories of the churning of cream into butter viz., Fisher and Hooker's Phase-Reversal Theory, Rahn's Foam Theory, and King's Modern Theory. Churn is a device for making butter. Traditionally, various types of churns used for butter making include rocker churns, dash churns, wooden-barrel churns, tin churns, stone-ware churn, and glass churn jars, etc. The basic model of hand churn has metamorphosed to batch churn and later to continuous butter making machine. Various methods of butter making include: Continuous method, batch method, concentration method and phase separation method. Continuous butter making systems are more economical as it requires reduced floor space, lower running cost and reduced power, labour, refrigeration, steam, detergent, etc. It does not require expensive foundation. In preparation of butter by continuous method, there is no time loss for fat crystallization. Butter wastage is also very less. It is a closed and hygienic system. Hence, it yields a product, which is free from airborne contamination. Butter has many food uses viz., cooking, cakes and other bakery products, ghee making, cosmetics, medicines and during worship.

4.12 KEY WORDS

Butter : It is a fat rich dairy product, made from milk, *dahi* or cream by agitating or shaking it until the fats separate as semisolid mass from the liquid portion of milk.

Emulsion : It is a mixture of two or more liquids in which, one is dispersed in the other as microscopic droplets.

Ripening : It is a process of fermentation of cream or milk by selected type of microorganisms

Table butter : It is the product made from pasteurized cream obtained from pasteurized milk of cow or buffalo 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 agents.

Desi butter : It is the product obtained from cow or buffalo milk or a combination thereof or from curd obtained from cow or buffalo milk or a combination thereof without the addition of any preservatives including common salt, any added colouring matter or any added flavouring agents.

Churning : It is the process of agitation of cream at a suitable temperature until the fat globules adhere with each other forming larger and larger mass

and leading to almost complete separation of fat and serum.

Churn : It is a device for making butter, which includes rocker churns, dash churns, wooden-barrel churns, tin churns, stone-ware churn and glass churn jars, etc.

Continuous butter : It is a type of butter churn used for continuous manufacture of butter on a large scale.

4.13 SOME USEFUL BOOKS

De Sukumar (1980), *Outlines of Dairy Technology*, Oxford University Press, Delhi

Ahmed Tufail (1990), *Dairy Plant engineering and management*, Kitab Mahal Allahabad.

4.14 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include the following points:

Check Your Progress 1

1) i. Butter is a soft and smooth yellowish emulsion of milk fat, water, air and sometimes salt obtained by churning of milk or *dahi* or cream.

2) i. Butter is classified on the basis of type of cream, manufacturing process, ripening of cream, storage and addition of salt

3) i. Milk fat is the major component of butter.

4) i. Other constituents of butter include water, protein, minerals and sometimes salt.

5) i. Cooking butter contains no added salt and is also known as sweet butter. It is preferred for use in cakes or pastry. It is used for ghee making. Creamery butter is made preferably from pasteurized cream in a dairy plant. It is uniform in quality than cooking butter.

   ii. 80 x 9 = 72.0 k cal / g of butter

Check Your Progress 2

1) i. Butter is a water-in-fat type of emulsion while cream is fat-in-water type of emulsion.

2) i. The shelf life of butter is long, as it has uniformly distributed low moisture content containing salt.

3) i. In whipping some air is incorporated into the cold cream and the liquid is beaten. Bubbles are formed and the fat globules collect on the walls of the bubble. Thus, stable and airy foam is produced.

   ii. In churning process the cream is warmed to the point so that the fat globules liquefy to some degree, collide with each other and break the foam. Subsequently they join together and form a bigger mass known as butter.

4) i. Free fat and the emulsifier lecithin.

Check Your Progress 3

1) i. The basic principle of butter making is inversion of fat-in-water type emulsion of cream to water-in-fat type emulsion in butter by churning of cream.

2) i. Churning refers the process of agitation of cream at a suitable temperature until the fat globules adhere with each other forming larger and larger masses and leading to almost complete separation of fat and serum. Churning is a process of agitation or shaking of cream to obtain butter.

3) i. In milk/cream, the fat exists in the form of an emulsion, i.e., fat globules are dispersed in a continuous phase of water. In butter the milk fat forms the continuous phase in which water is dispersed as fine droplets.

4) i. Fisher and Hooker's Phase-Reversal Theory

ii. Rahn's Foam Theory

iii. King's Modern Theory

Check Your Porogress 4

1) i. Butter churn is a device in which butter is made.

2) i. Various methods of butter making include: Continuous method, Batch method, Concentration method and Phase separation method using anhydrous milk fat.

3) i. Metal churns offer following advantages: ease of cleaning with alkali detergents, sterilization with steam without damaging the churn body, accuracy of moisture and salt control, intermittent use without deterioration in quality and better sanitary aspects.

4) i. Butter has many food uses, cooking, cakes and other bakery products, ghee making, cosmetics and medicines and as offering during worship.

UNIT 5 METHODS OF MANUFACTURE OF BUTTER

Structure

5.0 OBJECTIVES

After reading this unit, we should be able to:

- state process of butter making
- specify manufacturing method of different types of butter
- yield calculation of butter
- identify factors affecting the fat losses in butter milk
- give composition of butter- milk
- control over-run in butter

5.1 INTRODUCTION

In India about 6.5% of total milk production goes for butter and 27.5% for other fat rich products like ghee, etc. Butter is essentially the milk fat obtained by churning of sweet or soured cream. It is made from the cream that has been skimmed-off from milk, which was allowed to stand undisturbed for sometime in a vessel. The fat being lighter rises to the surface and forms a layer, which is skimmed-off by hand or a ladle and used for butter making. Butter is also made on the dairy farm directly from the milk but in a dairy plant it is invariably made from cream. Cream may be made naturally sour by storing it for 1-2 days or by the addition of selected microorganisms and storing it overnight at controlled temperature. The natural souring process is not safe as the micro-organisms, which bring about souring are unknown and often yield a product of poor quality and sometimes may cause health hazards. Minor changes in the method of production produce a different variety of butter.

In this unit, we will study the method of manufacture of different types of butter and the technical details involved in the manufacture of butter.

5.2 METHODS

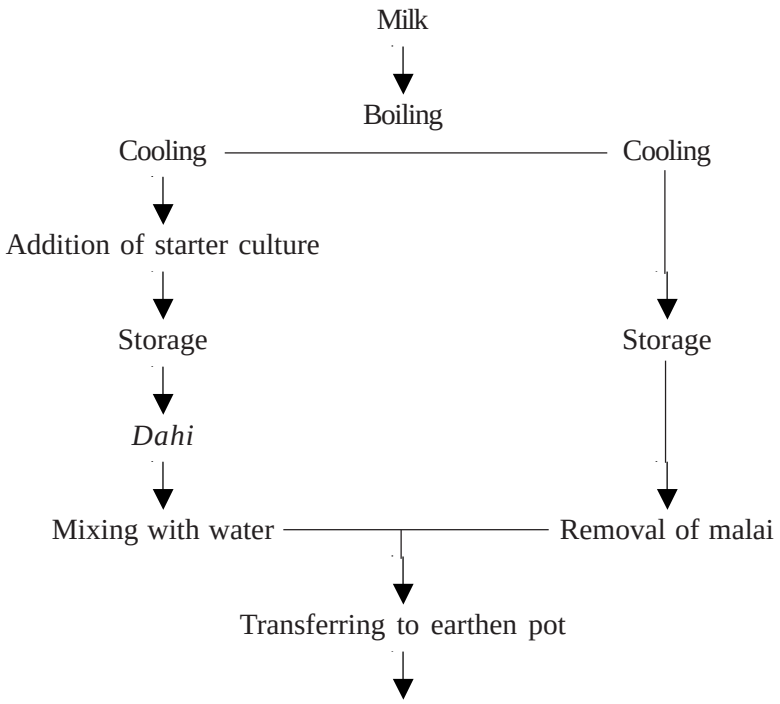
i. *Desi* Butter

It is a freshly churned butter prepared by rural households in a traditional method and commonly referred as *Makkhan*. It is made by hand churning of *dahi or malai* in an earthen pot with a wooden ladle usually known as *mathani*, *Desi* butter has unique flavour and rich attributes.

Cow, buffalo or mixed milk is boiled, cooled and cultured with lactic starter culture (0.8-0.9% lactic acid) obtained from previous days batch. Milk is then stored overnight at ambient temperature to convert it into *dahi* by lactic fermentation. Next morning *dahi* is mixed with equal amount of cold water and transferred in an earthen pot. A wooden ladle (*mathani*) is then immersed in *dahi* and rotated manually in circular motion with the help of a rope. Rope is encircled around the *mathani* in the centre. After continuous agitation for sometime grains of *Makkhan* are formed, which floats on the surface. These grains are skimmed off from the surface with a ladle and pooled in a suitable container.

It is then patted in a compact mass with the help of a corrugated flat wooden block resulting in a compact mass of butter with soft consistency. Since churning is usually carried out at ambient temperature, a portion of fat, which is in liquid state is lost along with the buttermilk. It contains higher moisture, curd, lactic acid and flavour components than the creamery butter. The yield of *Makkhan* in the range of 4.5-7.0 per cent of milk and is influenced by the fat content of milk and the loss of fat in buttermilk. Buffalo milk by virtue of its higher fat content and larger fat globules than cow milk yields higher. Buffalo milk butter is white with greenish tinge in colour while that obtained from cow milk is creamy yellowish. *Desi* butter has a distinct pleasant flavour without the addition of colour or salt. It has a low keeping quality of about 3-5 days at refrigerated temperature.

Alternatively, Makkhan can also be prepared from *Malai*. *Malai* is obtained by holding the boiled and cooled milk for sufficiently enough time at low temperature to form a layer of fat on the surface. This layer is skimmed off, pooled for few days and used for *Makkhan* preparation in the same way as it is made from *dahi*. The flow diagram for the manufacture of *Makkhan* is depicted in Fig.5.1.



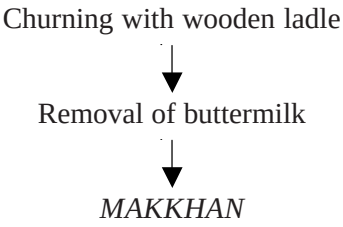
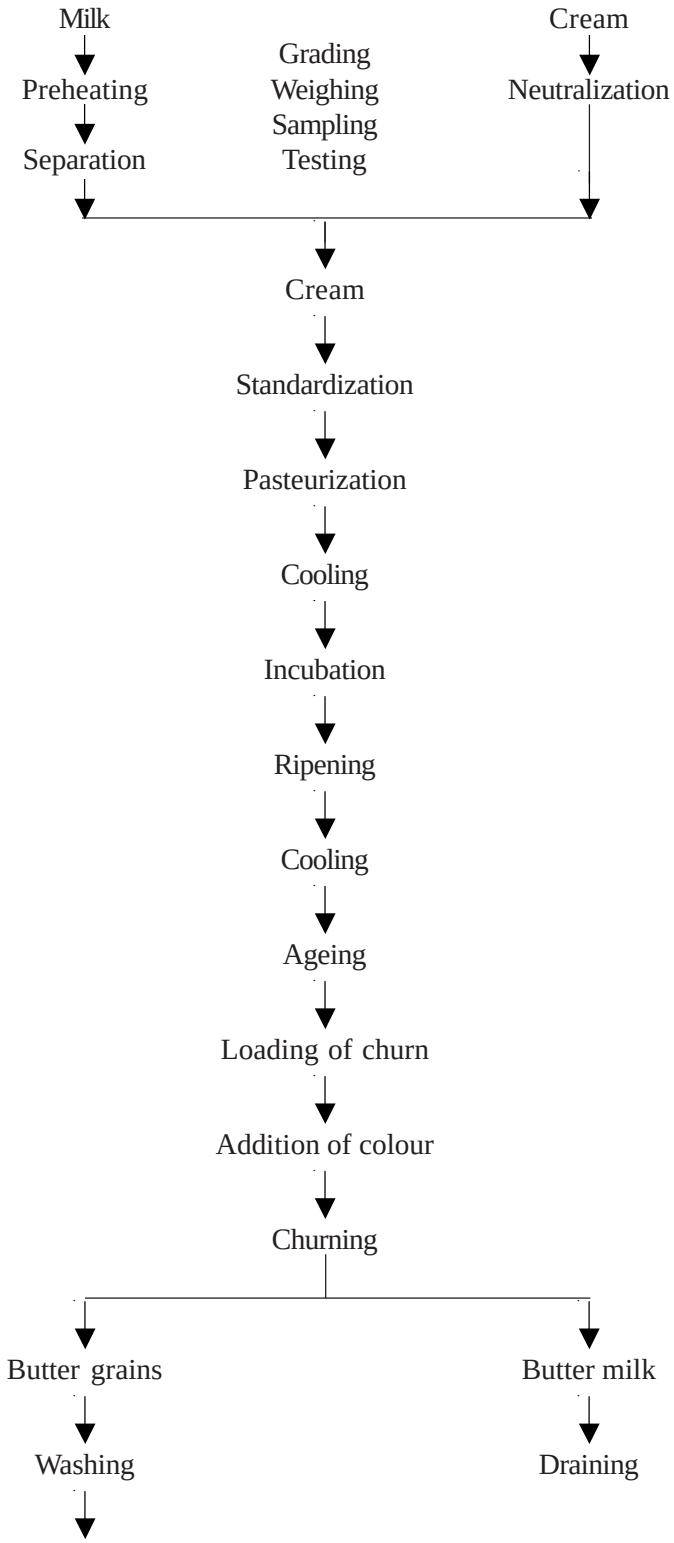


Fig 5.1 Flow diagram for manufacture of *desi* butter

ii. Creamery Butter

The steps involved in the manufacture of creamery butter are explained in Fig 5.2.



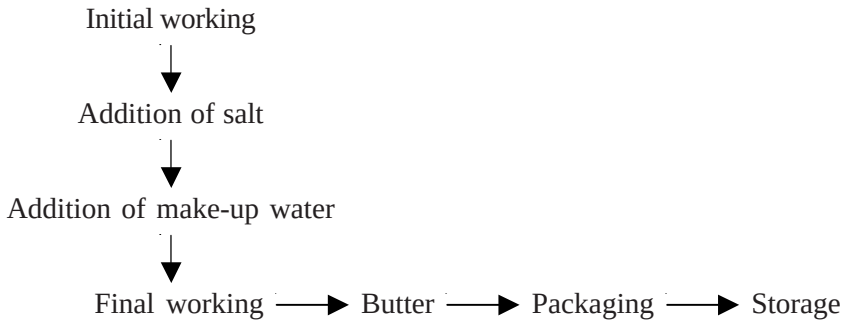


Fig. 5.2: Flow diagram for manufacture of creamery butter

Preparation of cream: For the manufacture of creamery butter, the cream is obtained by separation of milk in the dairy plant or by procuring it directly from the producers or through the contractors. Cream for good quality butter should always be obtained by separation of good quality milk and used fresh. The milk should be fresh and sweet with pleasant flavour without any foreign matter and developed acidity. Milk is preheated to about 50°C and then separated by centrifugal separation process. Cream thus obtained does not require any neutralization of developed acidity if used fresh. Most of the dairy plants in the country prepare good quality cream from fresh milk and use it for butter making or for preparation of any other product.

The other route of obtaining cream is directly from the dairy farm or collection centers or suppliers. The technique used for grading of cream before reception is similar to that used for milk at the reception platform. It is examined for smell, taste, sediment, appearance, temperature and acidity. Then it is weighed and a sample is drawn for chemical and microbiological tests. Generally such cream may have developed acidity and require neutralization before it is subjected to subsequent processing steps.

Neutralization: It refers to the partial reduction of acidity of cream to make it suitable for churning and produce good quality butter. It reduces fat losses in butter-milk during churning, controls development of undesirable flavour and improves the keeping quality of butter. The cream acidity is reduced to 0.06- 0.08% before churning by neutralization with standard alkali solution, if the butter is intended for longer storage. In case butter is made for early consumption the reduction of acidity to 0.25-0. 30% before churning may serve the purpose. The cream acidity is determined on 10 ml of thoroughly mixed cream sample by adding a known quantity (say, A ml) of standard alkali solution for partial neutralization of acidity. The mixture is boiled for one minute and again required quantity (say, B ml) of standard alkali solution is added in the presence of phenolphthalein indicator until complete neutralization. The pink colour, which develops on addition of alkali solution in presence of an indicator disappears on further addition of alkali solution. This indicates the neutral point. The total volume (A+ B ml) consumed to get the neutral point is recorded and the acidity calculated in the same manner as calculated for milk. It is essential to determine correct acidity as the quantity of neutralizer to be added in cream vary with the acidity level and is calculated on the basis of final acidity desired. Commonly two types of neutralizers, either singly or in combination, are used.

Soda neutralizer: This group of neutralizers consists of sodium bicarbonate, sodium carbonate or a mixture of these two compounds. These are relatively mild neutralizers. Soda neutralizers offer the advantages of being highly pure, highly soluble and neutralizing the acidity at a faster speed but they are costly and sometimes produce foam and impart soapy flavour to resulting butter.

Lime neutralizers: This group of neutralizers consists of calcium hydroxide or magnesium hydroxide or a mixture of these two compounds. This group has low purity, low solubility and low neutralizing speed. It also imparts lime flavour, but it does not produce foam and costs less. When calcium hydroxide is used alone, it is used 20% more than the calculated quantity because 20% of it is consumed in reaction with casein and phosphate present in cream and hence it is not available for neutralization of acidity.

The quantity of neutralizer is calculated by the formula given below:

$$\text{Quantity of neutralizer} = \frac{(a - b) \times \text{Quantity of cream} \times 100}{\text{Neutralization factor}}$$

Where,

a = Initial acidity of cream (% L. A.)
b = Desired acidity of cream for churning (% L. A.)

Neutralization factor (N. F.) = It is the part of lactic acidity neutralized per part of the neutralizer used. The neutralizer factor for some commonly used neutralizers is mentioned Table 5.1.

Table 5.1 Neutralization factor for various neutralizers

Type of neutralizer	Neutralization factor
Sodium bicarbonate	1.1
Sodium carbonate	1.7
Sodium hydroxide	2.43
Calcium hydroxide	3.10
Magnesium hydroxide	2.25

Cream is heated to 29- 32°C before addition of neutralizer. The calculated amount of neutralizer is dissolved or suspended in water (1 part in 10-15 parts of water), added to cream quickly and mixed thoroughly by vigorous stirring. Stirring is continued for 10- 15 min after addition of neutralizer. In case of neutralization of high acid cream it is always preferred to use double neutralization process, i.e., using both lime and soda neutralizers. High acid cream requires large amounts of neutralizer. In order to avoid the effect of large quantity of any one type of neutralizer and production of excessive amount of carbon dioxide, double neutralization is suggested. First lime neutralizer is used to bring down the cream acidity to 0.3- 0.4% and then soda neutralizer to bring down the acidity to desired level as mentioned above.

Standardization: The fat content of cream after neutralization is standardized to 35-40%, which is considered optimum for butter production. More or less fat content than this level causes increased loss of fat in buttermilk. Cream is standardized for fat content with the addition of skim milk or water depending upon the intended use of buttermilk. Reduction of fat by addition of water should be avoided as it interferes with the ripening process of cream and yields a flat flavoured butter.

Pasteurization: It refers to heating every particles of cream to a suitable time-temperature combination to meet the following objectives:

i. Destroy pathogenic microorganisms and make cream and the resulting butter safe for human consumption.

ii. Destroy other bacteria, yeast and mould, enzymes and other biochemical agents (enzymes) that may lower the keeping quality of butter.

iii. Eliminate some of the gaseous and taint producing substances.

There are several methods to accomplish the pasteurization process. Low temperature- long time method (LTLT) or batch method prescribes heating of cream to 74°C for 30 min; whereas high temperature short time method recommends heating to 85°C for 15 sec. Yet in another method direct steam is injected to heat the cream to a suitable temperature. The equipment is known as Vacreator and the method as vacreation. Severe heat treatment is avoided as higher temperature increases the migration of copper from milk serum to fat globules. This, in turn, produces butter, which is prone to development of oxidative rancidity and has short keeping quality. However, for ripened cream butter, cream is heated to 90- 95°C for 15 min or 105- 110°C with no holding. Heating to such temperatures, coagulates whey proteins and releases sulphahydryl group, which enhances the growth of starter organisms and also acts as anti-oxidant. Thus, it improves the keeping quality of butter.

Ripening: The process in which, the cream is allowed to develop acidity (fermentation) with the use of selected microorganisms is known as ripening process. Ripening of cream aims at producing butter with pleasant characteristic butter flavour and low fat losses in buttermilk. Ripening improves the keeping quality of un-salted butter but reduces the keeping quality of salted butter. Ripening involves addition of starter culture, mixing it thoroughly and storing the cream (incubating) at controlled temperature. The starter culture consists of a mixture of acid forming microorganisms like *Streptococcus lactis, Streptococcus cremoris* and flavour producing microorganisms like *Streptococcus diacetilactis, Leuconostoc citrovorum or dextrnicum.* Usually starter is added at the rate of 0.5- 2.0% of the weight of cream at 22°C followed by incubation at the same temperature. The cream is held at this temperature until the acidity develops to 0.2- 0.4%. Subsequently cream is cooled to 5-10°C to arrest the further development of acidity and stored at this temperature. However, many of the dairy plants prefer to make butter from sweet cream because the resulting butter- milk can be used for drying along with skim milk or for the manufacture of some other dairy products and gives an economic return. The dairy factories, which manufacture butter from sweet cream, do not follow the ripening step. Butter flavour can also be improved by the addition of starter distillate or synthetic flavour instead of ripening of cream. But it does not impart a characteristic permanent type of uniform butter flavour.

Cooling and Ageing: Butter- fat exists in both solid and liquid state in fat globules in cream. During pasteurization the solid fat is converted to liquid fat and thus the proportion of liquid fat increases. Cream containing more liquid fat does not churn properly. Therefore it is essential to cool the cream and store it at low temperature (5-10°C) for sometime so that partial re-solidification of the melted fat takes place. Cream is preferably cooled to 7-9°C in summer and 10-13°C in winter after pasteurization and held at this temperature for 15-16 hr or at least for 2-4 hr. High temperatures of cooling and ageing, though reduces the churning time it increases the loss of fat and produces soft- bodied butter. If the fat is not solidified properly, the losses of fat in butter-milk increases and the resulting butter will have a weak body. On the other hand, cooling cream to much lower temperature (less than 5°C) and holding it for longer duration makes the fat globules too hard to adhere together. Hence churning takes longer time and the resulting butter is too hard. Normally a cream, which has been properly cooled and aged takes about 35-45 min for churning (to produce butter grains). However, the conditions for cooling and ageing are selected to suit the requirements of the manufacturers.

The optimum temperatures of cooling and ageing depends on the following factors:

i) Composition of fat
ii) Size of fat globules
iii) Fat percentage in cream

iv) Acidity of cream

v) Period of ageing

vi) Temperature of churning

Churning: The objective of churning is to produce butter. The theory of churning has already been discussed in the Unit 4 in Section 4.6. During churning continuous agitation of cream destabilizes the oil-in-water type emulsion of cream, the emulsion breaks and butter grains are formed. The cream used for churning should possess good churn-ability. It means that it should produce sufficiently firm grains of butterfat easily and completely in optimum time (35-45 min). In short churn-ability of cream refers to the ease, completeness and duration of churning to produce sufficiently firm grains of butterfat, which can easily be washed. The following factors may cause delayed churning, high fat losses in buttermilk, excessive foam production, defective butter production, etc. and thus cause difficulties in churning of cream:

i) Excessive hardness of fat

ii) Small size fat globules

iii) Excessive thin cream

iv) Overloading of churn

v) Excessively low temperature of churning

vi) Abnormal cream

Loading the churn: Before the start of the operation the butter-churn, it should be properly washed and sanitized. The cooled and aged cream is then filled into it. The lumps, if any, should be mixed either by stirring or straining. The cream temperature should be 7-9°C in summer and 10-13°C in winter season. The quantity of cream in the churn should preferably be slightly below the rated capacity of churn.

Addition of colour: After the churn is loaded and butter colour is added to cream, the door of the churn is closed. Addition of colour results in a uniform yellow colour of butter throughout the year. Generally the quantity of added colour varies in the range of 0-250 ml per 100 kg of butter fat. The colour should be non-toxic, oil soluble, free from off-flavour, concentrated and permanent. Usually two types of colour are used, which include annatto colour and carotene colour. Annatto colour is a yellowish red extract of a colouring substance from the seeds of annatto plant in oil. It is grown in tropical countries like West Indies, Brazil, India, etc. The colour is extracted by dissolving the seeds in neutral oil such as caster oil, groundnut oil or sesame oil. Carotene colour is an extract from carrots and other carotene rich vegetables. The carotene colour is slightly greenish but is rich in vitamin A. Colour is also available from mineral sources, which are harmless, oil soluble, more concentrated and permanent and includes Yellow AB (Benzene-Azo-beta-napthyl-amine) and Yellow OB (Orthotoluene-Azo-beta napthyl-amine). But addition of these colours in butter is not permitted by PFA. Butter colour is always stored in opaque and airtight containers at about 18-25°C.

Operation of the churn: Initially churn is given few revolutions in about 5-10 min and then churn vent or air vent is opened once or twice. It permits air and the gases to escape. Churn is then stopped. The valve provided at the bottom of the churn is opened and sample of cream is drawn. The churn is again allowed to rotate until butter grains are formed. The temperature, throughout churning process; is maintained in the range of 7-13°C depending on the season. During the churning process the temperature of cream increases by 1-3°C and also foam is produced, emulsion breaks, grains of butter-fat are formed. This stage is known as breaking-stage. At this stage churn is stopped and break- water is added to control the temperature of the contents of the churn. The churning process is continued further,

until the smaller grains join together to form pea size grains. Usually the temperature of break-water is kept at or below 10°C depending upon the temperature reduction required.

Draining of buttermilk: On completion of the churning process, which normally takes about 35-45 min the churn is stopped and the butter-milk removed by opening the drain valve provided at bottom. It is essential to stop the churn in proper position so that the butter- milk is completely drained. Also a strainer is used to retain the smaller grains coming out with the buttermilk.

Washing: It helps to remove the loose buttermilk adhering to the butter grains, impart firmness and reduce the intensity of certain off-flavours. Removal of residual buttermilk in turn reduces the curd content in butter and improves the keeping quality. Water at a temperature of 1-2°C lower than the churning temperature of cream and in quantity equal to the amount of butter-milk drained is used for washing. After addition of wash water the churn is again rotated few revolution and then the water is drained out. Normally one washing is sufficient. Only good quality water, which is chemically and bacteriologically safe should be used.

Initial working: After draining the wash water, the churn is revolved few rotation so that the butter is kneaded to form a compact mass. The excess or loose moisture is also released and drained off.

Salting: The purpose of salting is to improve keeping quality, enhance taste and increase over-run in butter. There are three methods of salting butter, namely, dry salting, wet salting and brine salting.

Dry salting calculated amount of salt is sprinkled over the surface of butter in the churn during working. This is most common method of salting.

Wet salting method consists of wetting the calculated quantity of salt with minimum quantity of water and then sprinkling it over the butter during working.

Brine salting : It is suitable only for butter in which light salt is desired. In this case, salt is added in the form of a saturated brine solution.

Quantity of salt : The quantity of salt to be added varies in the range of 1.25-3.0%. It depends on the market requirements and legal standards. It is calculated as follows:

$$\text{Kg. of Salt} = \frac{\text{Rate of salting} \times 1.25 \times \text{Kg. of fat in churn}}{100}$$

The calculation is based on the assumption that 80 kg fat yields 100 kg butter. It means each kg of fat will yield 1.25 kg of butter. Hence is the factor 1.25.

The quality of salt should meet the standards prescribed by BIS, i.e., IS: 1845: 1961. It should be 99.5- 99.8% pure sodium chloride and the grains should pass through IS: 85 sieve (aperture 8424). The microbial count should be less than 10/g.

Moisture control: According to legal standard, the butter must not contain more than 16% moisture. Therefore, it is necessary to know the moisture content of butter in the churn. After addition of salt, butter churn is rotated until the butter develops dry appearance. A representative sample of butter is then taken with the help of a butter-trier and analyzed for its moisture content. Normally, it is less than the desired moisture content. So it requires addition of water. The required quantity of water is calculated as follows:

$$\text{Amount of water} = \frac{1.5 \times F\ (M - m)}{100}$$

Where,

F = Fat in churn (kg)
M = Desired moisture per cent in final butter
m = Initial moisture content in butter

The calculated amount of make-up water is added and the working is continued further until the additional water is thoroughly mixed with butter.

Working: It refers to kneading of butter at appropriate temperature to obtain a desired smooth texture. Modern churns produce a very close textured product because they work under vacuum. The purpose of working is:

i) To dissolve and uniformly distribute salt in butter;

ii) To uniformly incorporate added moisture;

iii) To break up the remaining intact fat globule membrane and form a continuous fat phase.

The working is continued until the butter attains a compact body and even distribution of salt and moisture. The temperature control throughout the working process is essential. Although overworking and under working both have damaging effect on body and texture of butter, it is always safe to slightly overwork the butter than under-work. Under-worked butter may have a leaky body, large visible water droplets and uneven colour. Working affects the colour of butter. It may produce slightly lighter coloured butter. It also increases the air content in butter. Increased air content is however un-desirable as it favours oxidative deterioration and microbial growth in butter. Therefore, working of butter under vacuum of 15-40 cm of mercury is preferred. Air content in butter worked without vacuum ranges between 3-7% by volume while in butter worked under vacuum it is only 1 ml/ 100g.

Removal of butter from churn: This is done either manually or by gravity or by mechanical means. Mechanical method requires soft butter and compressed air (3-5 psi) for removal. Butter from the churn is always taken out on a trolley provided with wheels to facilitate its movement to the storage room or packaging room. Continuous butter making machine may be set to discharge butter directly to the storage tanks or silo from where it moves to the packaging machine.

Check Your Progress 1

1) Differentiate between *Desi* and Creamery butter.

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2) Give the maximum limit of addition of salt to creamery butter.

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3) Give the qualities of colour added to butter.

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4) Name the colours used in butter.

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5) Give the optimum temperature for churning of cream.

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6) Explain ageing of cream.

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7) Describe ripening of cream.

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8) Give the optimum temperature for flavour producing organisms to grow in cream during ripening.

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9) Name the flavouring compound in butter.

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10) Explain the term double standardization.

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iii. Cooking Butter

It is a plain unsalted butter. The method of manufacture of cooking butter is same as that described for making creamery butter except for the salting step. It does not contain salt. Ripening of cream is also optional. Most of the cooking butter is used for ghee making or by the bakery industry. Ripening of cream produces curdy or acidic flavour in ghee, which may not be liked in all parts of the country. But the curdy flavour of ghee is preferred in northern parts of the country. Therefore,

in that region butter may be produced from ripened cream. Ripening of cream is done with a butter culture or a starter culture concentrate. Butter culture requires about 15 hr. of incubation time whereas starter culture concentrate produces the desired acidity only in 5 hr. But most of the dairy factories do not ripen the cream because of the following reasons:

a) Requirement for maintenance of starter culture

b) Requirement for storage space for incubation at controlled temperature

c) Problem in utilization of butter-milk

d) High energy requirement

e) Requirement of strict supervision

iv. Table Butter

This is the most common type of butter available in the market. The manufacturing procedure is the same as that followed for creamery butter. However the production of table butter requires utmost hygienic care until the butter is packaged and stored. The person who is handling the production must be aware of the legal requirements of table butter. The churn and other accessories must be thoroughly cleaned and sanitized before use. The water used for moisture control/adjustment must be of high chemical and bacterial standards.

v. Butter Structure

Good quality butter should taste fresh, clean and give dense appearance. The moisture content should be dispersed in fine droplets so that the butter looks dry and uniform in colour. The consistency of butter should be smooth, so that it is easy to spread and melts readily in the mouth.

The structure of good butter in which water droplets and air cells are dispersed in continuous fat phase is shown in Fig 5.3.

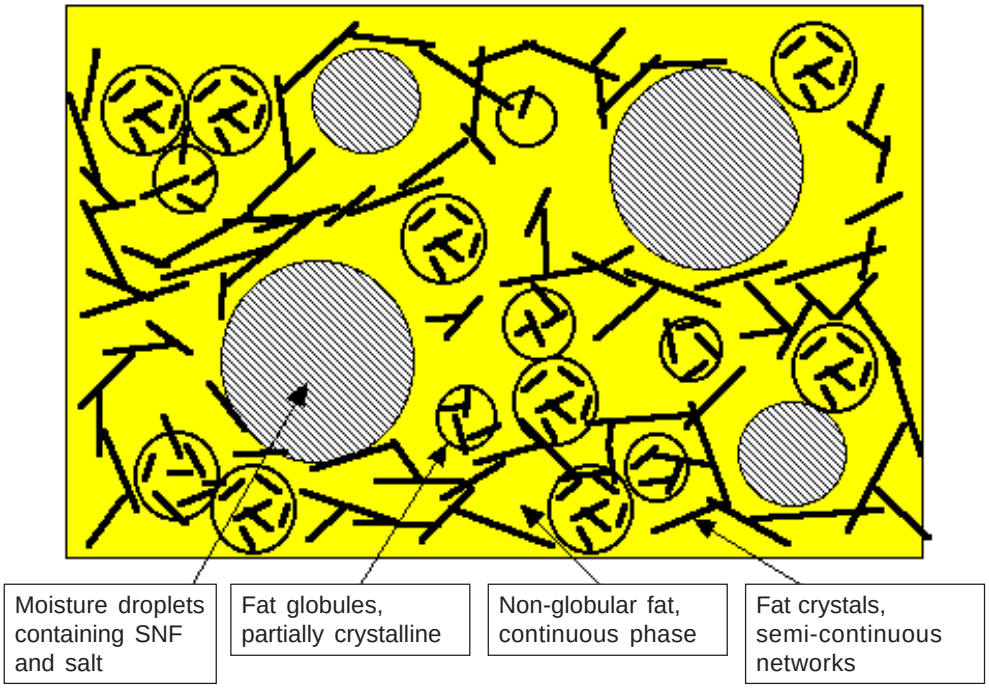

Fig. 5.3 Butter structure

Check Your Progress 2

1) Calculate the quantity of salt required for butter obtained from 300 kg of 40% fat cream. Butter contains 80% fat.

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2) Explain the air content in normal butter?

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3) Which butter is used for ghee making?

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4) Calculate the percentage of salt in moisture of table butter of standard composition.

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5.3 OVER-RUN

The weight of butter obtained from a given lot of cream is always more than the amount of fat present in cream. The amount of butter, which exceeds the amount of fat present in cream is called overrun. In other words, it may be defined as the increase in the amount of butter made from a given amount of fat. It is usually expressed as percentage overrun. The presence of moisture, curd, salt, air, etc., in butter increases the amount of butter. It is a source of profit to the manufacturer and also helps to check the efficiency of the working of the plant. There are several types of overrun which include

i) **Theoretical:** Theoretically, maximum obtainable overrun in butter is 25% because 80 kg fat yields 100 kg of butter as per PFA standard**.**

ii) **Compositional:** It is based on the composition of butter and varies according to the fat content in butter.

iii) **Factory:** It is calculated on the basis of total packed butter and total fat received in the factory for butter-making.

iv) **Churn:** This is calculated for a particular type of churn

The formula used for the calculation of Theoretical over-run is given below**:**

$$\text{Per cent Over-run (\% OR)} = \frac{B - F}{F}$$

Where,

B = Quantity of butter made (kg)
F = Fat in churn (kg)

Factors Influencing Over-run:

The following factors affect the over-run in butter:

2|21 Inaccuracy in weighing of milk, cream or butter;

- Inaccuracy in fat testing of the samples of milk, cream or butter;
- Fat losses in skim milk and butter milk;
- Fluctuation in fat content of butter;
- Weight allowance in butter packages;
- Handling losses.

5.4 YIELD OF BUTTER

The Yield of butter is calculated by the following formula:

$$\text{Yield (Y)} = \frac{F \times (100 + \%\ OR)}{100}$$

Where,

Y = Yield of butter
F = Fat content of cream (kg)
% OR = Per cent overrun in butter

5.5 BUTTER MILK

Buttermilk is an important by-product of creamery involved in butter production. There are three types of buttermilk produced in the country. These are:

i) **Sweet cream buttermilk:** It is obtained by churning of fresh/pasteurized cream with slight or no developed acidity.

ii) **Sour cream buttermilk:** It is obtained by churning of naturally sour milk or cream.

iii) **Desi buttermilk:** It is obtained by churning of *Dahi* for the manufacture of *Makkhan.* The chemical composition of buttermilk varies widely and depends on the amount of water added to cream for standardization. Addition of water decreases the total solids content of the resulting buttermilk. The chemical composition of buttermilk is given in Table 5.2

Table 5.2: Chemical composition of buttermilk

Constituents	Percent
Fat	0.5 - 0.6
Protein	3.75
Lactose	4.80
Ash	0.75
Total solids	9.5 – 9.8

The titratable acidity of sour cream buttermilk varies in the range of 0.15- 1.0% whereas that of sweet cream buttermilk varies in the range of 0.10- 0.14%. *Desi* butter milk, on an average contains only 4% total solids comprising 0.8% fat, 1.30% protein and remaining carbohydrates with an acidity of 1.2% L.A. Also, the colour may be brown due to prolonged heating of milk.

Sweet cream buttermilk may be used for standardization of milk, production of cultured buttermilk, *lassi* and in some of the Indian dairy products, like, *khoa*, *kheer*, etc. Sour buttermilk is not suitable for human consumption. Buttermilk from *desi* butter is used as a home-made refreshing beverage by the addition of some spices, like, cumin, coriander leaves, etc., or as such. It is also used for the preparation of some Indian culinary dishes such as *Kadhi.*

Fat Losses in Buttermilk

Although attempt is always made to recover total fat of cream in butter but some of the butterfat always goes in the buttermilk. Therefore, one should be aware of the factors, which influence the fat loss during churning. These factors include the following:

i) **Fat per cent of cream:** Although the fat per cent in butter milk resulting after churning of low fat cream is low, the total fat loss is more. This is because the quantity of buttermilk produced is more.

ii) **Size of fat globules:** Smaller size fat globules in cream are lost in buttermilk. Hence, increase the loss of fat in buttermilk.

iii) **Physical condition of fat:** Softer the fat at churning higher is the fat loss in buttermilk.

iv) **Ageing of cream:** Insufficient cooling and ageing result in less proportion of hard fat and cause higher loss of fat.

v) **Condition of churning:** Over-loading or under-loading or incomplete churning of cream causes more fat losses

5.6 CONTINUOUS BUTTER MAKING MACHINE

Among all the processes, Fritz process is commonly used. The machine working on the principle of Fritz process, consists of the following four sections.

a) Primary churning section

b) Secondary churning or separating section

c) Buttermilk drainage section

d) Salting and working section

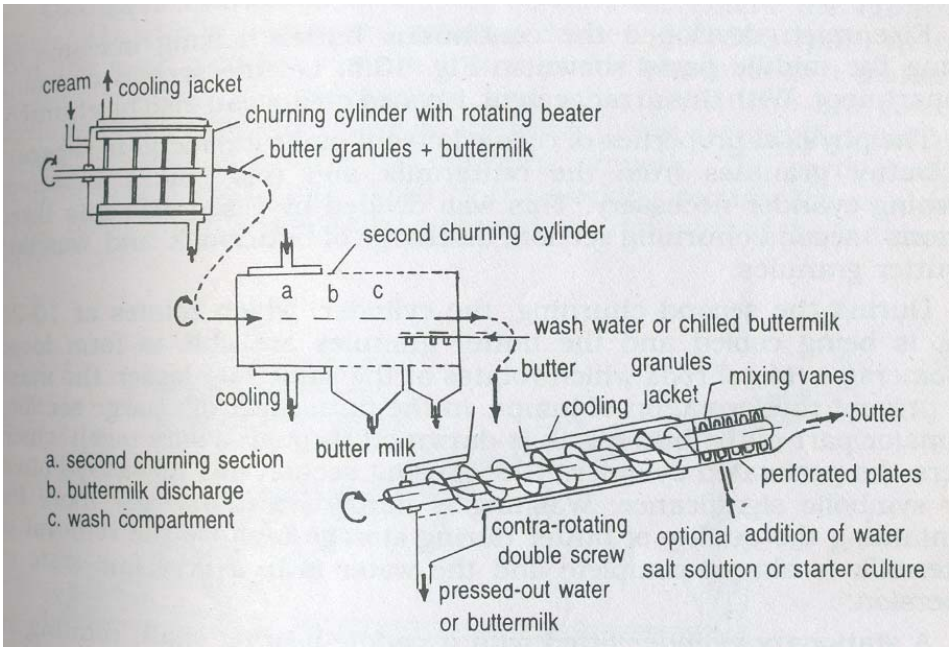

Fig. 5.4: Continuous butter making machine

Cream flows from the cream storage tank via a balance tank and is fed by means of a positive displacement pump to the rear of the primary churning section. Control of flow rate is essential to ensure proper churning, drainage of buttermilk, working and flow of butter to the packaging machine. The churning section consists of a horizontal cylinder with a rapidly rotating beater. The gap between the cylinder wall and the beater is only a few millimeters. The beater speed can be varied in the range of 0-1400 rpm. The residence time for cream in the section is only 1- 2 sec. In this very short time, small butter granules are formed but are not allowed to join

together to become bigger. The beater speed is adjusted accurately to yield butter grains of correct size. If the size is too small it causes difficulty in drainage of buttermilk. Fat loss in butter milk increases. On the other hand, if the size is too big it will entrap more buttermilk resulting in unsatisfactory drainage of buttermilk. The speed of beater is influenced by the following factors:

i) Flow rate of cream,

ii) Fat content of cream,

iii) Temperature of cream,

iv) Pre-treatment of cream, and

v) Viscosity of cream.

In the separating section, the butter grains receive a second churning effect to adjust their size for proper drainage of buttermilk with minimum fat loss. The outlet portion at the end of this section is fitted with a fine mess screen through which the buttermilk is removed. A washing device is also provided at the end of the section to facilitate washing of the grains.

After formation of proper grains of butter and initial draining of buttermilk, the grains pass into the working section. This section consists of two separate sub-sections in a Pasilac machine. This section is inclined and fitted with augers, which propel the grains forward, also squeeze some buttermilk and allow it to drain. At the end of this section there is a series of perforated plates and mixing vanes followed by a flow- regulating gate. The degree of opening of gate will affect the back-pressure on butter and thus affect the drainage of buttermilk from the butter. In addition the speed of the auger will either increase or decrease the residence time, which will affect buttermilk drainage.

In the salting section salt-water slurry (50:50) is injected between the first and second working plates in the section. A positive displacement pump is used to deliver accurate quantity of the salt slurry to the butter. Butter is then passed to a vacuum chamber where its air content is reduced from 6% to 1% and dropped onto augers in the second working section where it is pushed forward by the augers through another series of perforated plate. No buttermilk is separated in this second working section. After the final working, butter is pumped to the packaging machine by a positive pump. The entire system of butter manufacture can be computer controlled. In large manufacturing plants, butter is stored in a butter silo before packaging just to maintain some buffer stock. From the silo, it is pumped to the packaging system with the help of another positive pump.

Check Your Progress 3

1) State the normal fat loss in buttermilk.

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2) List the factors, which cause more losses of fat in buttermilk.

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3) Give the formula used for calculating over-run?

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5.7 LET US SUM UP

Depending on the method of manufacture, butter can be classified as *desi*, creamery, cooking, table, etc. *Desi* butter is also known as *Makkhan* and made on cottage scale, by hand churning of dahi or *malai* in an earthen pot with a wooden laddle usually known as *mathani*. It is either consumed at household level or sold in the local market. Creamery butter is prepared by using a batch churn or continuous butter making machine from fresh cream obtained by centrifugal separation of milk in a dairy plant. Acidic cream having high acidity (0.06 - 0.08% L.A.) is neutralized using standard alkali, in order to obtain good quality butter with longer keeping quality. Generally, a portion of fat is lost in buttermilk while churning cream into butter. In order to reduce the losses, cream should be standardized to 35-40% fat. Pasteurization of cream aids in longer keeping quality of butter. Use of cream ripened with selected microorganisms produces butter with pleasant characteristic butter flavour and reduce fat losses in buttermilk. This is preferred mainly for unsalted butter. Addition of annatto and carotene is permitted in butter to enhance the uniformity in colour. Table butter contains salt and is used for direct consumption along with sandwiches. The level of salt can be maintained upto a level of 3% depending upon legal standard requirement. Cooking butter is the one, which is devoid of salt and is used mainly for cooking purpose and for conversion butter into ghee. The moisture level is controlled during working of butter in order to induce good spreadability and meet the legal standards. Increase in the amount of butter obtained from the known amount of fat is termed as 'over-run'.

Buttermilk is an important by-product of creamery involved in butter production. Depending on the nature of cream used, buttermilk can be classified as sweet cream buttermilk, sour cream buttermilk and *desi* buttermilk. Fat losses in buttermilk can be controlled by maintaining optimum fat level in cream, proper loading of churn and other processing parameters. In organized dairy industries, continuous butter making machines are employed for large scale manufacture of butter.

5.8 KEYWORDS

Neutralization : It is the process of partial reduction of acidity of cream, by using standard alkali in order to make it suitable for churning and produce good quality butter.

Standardization : It is the process of adjusting the fat content of cream to 35-40%, which is considered optimum for butter production.

Ageing : It is the process of storage of cream at low temperature at least for 2-4 hr for crystallization of liquid fat.

Ripening : It is the process of storage of cream at suitable temperature (21°C) after addition of starter culture like *Streptococcus lactis*, *Streptococcus cremoris*, *Streptococcus*

diacetilactis, Leuconostoc citrovorum or dextranicum for the development of acidity.

Salting : The purpose of salting is to improve keeping quality, enhance taste and increase over-run in butter. The methods of salting includes dry salting, wet salting and brine salting.

Yield : It refers to the quantity of butter obtained from a known of quantity of fat taken for churning.

Buttermilk : It is the by-product obtained during butter production. It is classified as sweet cream buttermilk, sour cream buttermilk and desi buttermilk.

5.9 SOME USEFUL BOOKS

De Sukumar (1980), Outlines of Dairy Technology, Oxford University Press, Delhi

Ahmed Tufail (1990), Dairy Plant Engineering and Management, Kitab Mahal Allahabad.

5.10 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points:

Check Your Progress 1

1) i. *Desi* butter is a home made freshly prepared butter obtained by hand churning of malai, *dahi* or cream. Creamery butter is an uniform quality butter made from cream by churning in a butter churn in a dairy plant.

2) i. It is 3.0%

3) i. On an average 20-25 ml colour per kg fat is added.

4) i. Annatto butter colour, Carotene colour

5) i. Optimum temperature for churning of cream is 7-10°C in summer season and 10-13°C in winter season.

6) i. Ageing of cream refers to its storage at low temperature at least for 2-4 hr for crystallization of liquid fat.

7) i. Ripening refers to storage of cream at suitable temperature (21°C) after addition of starter culture for the development of acidity.

8) i. 21°C

9) i. Diacetyl

10) i. Double neutralization refers to the neutralization high acidity in cream in two steps. First lime neutralizer is used to bring down the cream acidity to 0.3-0.4% and then soda neutralizer to bring down the acidity to desired level.

Check Your Progress 2

1) i. Calculate the quantity of salt required for butter obtained from 300 kg of 40% fat cream? Butter contains 80% fat.

Quantity of salt = Quantity of fat in churn x 1.25 x rate of salting /100

= 300 x 40 x 1.25 x 2 /100 x 100 = 3 kg.

2) i. It is in the range of 3-7% and 1ml/100g in butter worked without and with vacuum respectively.

3) i. Cooking or un-salted butter is used for ghee making.

4) i. It is 12.5% and 18.75% in butter containing 2% and 3% salt respectively in butter containing 16% moisture.

Check Your Progress 3

1) i. On an average it varies in the range 0f 0.2- 0.6%.

2) i. Type of milk, fat per cent in cream, size of fat globules, acidity of cream, physical condition of cream, ageing of cream and condition of churning

3) i. The formula used for the calculation of Theoretical overrun is given below:

$$\text{Per cent Over-run (\% OR)} = \frac{B - F}{F}$$

Where,

B = Quantity of butter made (kg)

F = Fat in churn (kg)

UNIT 6 PACKAGING, STORAGE AND COMMON DEFECTS IN BUTTER

Structure

6.0 OBJECTIVES

After the reading, we should be able to:

- specify requirements of packaging materials
- outline packaging forms
- state packaging machineries
- state methods of storage and distribution
- give reasons for common defects and their control measures

6.1 INTRODUCTION

Enclosing a product in a specially designed container for safe delivery to the end user is packaging. Packaging contains, protects and preserves the product. Packaging of product also informs about the product, sells the product and provides convenience to the consumer. Dairy products differ in their chemical composition and physical and rheological properties. Therefore they require packaging material with different characteristics. Most of the dairy products are highly perishable and are spoiled by external agents like moisture, light, gases, odours, biological agents, mechanical hazards, etc. The packaging material should possess barrier properties against all these agents to serve the purpose of packaging. In addition, the form of packaging should appeal and provide convenience of carrying, opening, re-closing etc., to the consumer besides meeting the protection requirements.

6.2 PACKAGING MATERIALS

Butter is a high fat product and contains about 80% fat, 15-16% moisture, 2-3% salt and 1.5% curd. The natural flavour of butter is unique but it is prone to oxidative deterioration. Therefore, a packaging material must protect the flavour of butter against spoilage. In presence of sunlight and metallic contamination, it develops flavour defect like rancidity. Also, butter absorbs the taste and odour of other

articles in the surroundings and develops defects. Therefore, preferred to use only such material in contact with butter, which has a low metallic content and provides adequate protection to flavour. In addition, it should also provide protection to its body & texture and colour & appearance against any deterioration. Microbial, enzymatic and chemical reactions also affect the quality of butter leading to its limited shelf life. Thus, it is obvious that the prevention or delay of certain reactions and the maintenance of the physical properties are necessary to store butter in a good condition for longer period. This can only be achieved by using an appropriate material for packaging of butter. Packaging material must be non-toxic, non-greasy, non-sticky and amenable to packaging systems. In addition, it should offer:

- Protection against external environments like light, humidity, gases and odours, etc.
- Protection against loss or gain of water vapour and moisture;
- Protection against contamination with yeast, mould and bacteria;
- Protection against mechanical damage (sufficient strength);
- Resistance to corrosion and de-lamination;
- Ease and safety of transport;
- Convenience to retailers and consumers;
- Convenience to identify the product;
- Appeal to the consumers.

Materials which offer these advantages include wood, parchment paper, flexible films and laminates, aluminium-foil, wax coated paper and paper-boards, tin plated cans, etc. are available for packaging of butter.

i. **Water vapour, gas and light transmitting materials**- Vegetable parchment is the common packaging material in this group, which is most commonly used for butter. It is impermeable to water and fat but it does not provide protection against water vapour, light, and oxygen. Vegetable parchment paper used should not have more than 9% moisture and excessive numbers of microscopic pinholes. The paper should be stored in a dust free place where the humidity ranges between 50-80% and above the ground on shelves. The place should be free from mould. For better results, sterile plasticized grade of vegetable parchment paper is used and is also suitable for use in high-speed packaging machines.

ii. **Water vapour tight, but light transmitting material (film) -** Examples of these materials are cellophane coated with wax or polyethylene. Tubs or cups made of poly-vinyl-chloride, polyethylene and polystyrene/poly-vinyledene-chloride laminate come under this group.

iii. **Water vapour, gas and light tight material (foil) -** Typical example of this group is Aluminium-foil laminated with parchment or imitation parchment and provided with protective coating of lacquer on the outer surface of the foil. In order to avoid de-lamination, two component lacquer laminated or polyethylene coated material instead of wax laminated material has been developed and used.

iv. **Large Packages-** In earlier days, butter was packaged in wooden barrels or boxes in 50 kg lots. With a view to better handling, easier storage, more efficient use of storage space and for reasons of economy, fibre-board boxes have been introduced which can generally hold 25 kg of butter. Before the box is filled it is lined with parchment or other suitable materials. Boxes may be filled directly from the churn using a butter pump or from the discharge line of a continuous butter-maker. It is, of course, also possible for the boxes to be filled manually from a butter trolley but it is more hygienic to use butter pump. The following factors should be considered while selecting material for butter boxes:

- Thickness and type of fibre-board,
- Water repellant properties,
- Basic weight of the material in g/sq. m.,
- Moisture absorption in a specified period at a predetermined relative humidity and temperature,
- The use of paper coating,
- Bursting strength,
- Compression strength,
- Design of the insert, top and bottom sheets.

Nowadays a large number of flexible packaging materials like films, foils and laminates, which meet the requirements are available. These films and laminates have the components such as Al. foil, polyethylene, cellophane, poly-vinylidene cellophane, polyester, polyamide, vegetable parchment, wax, adhesive, lacquer and hot melting and heat seal-able coating. Also, in order to offer protection against light multi-pack tub shaped containers, made from stackable plastic (polystyrene) trays with formed tubs (PVC) into which coated board segments can be inserted, are also available. Butter can also be packaged safely in Al. foil/parchment paper laminate. Such laminates are impermeable to air, gases, light and moisture. It also has sufficient mechanical strength and provides protection against microbial contamination. It is non-toxic, opaque and can make airtight containers. The packaging material consisting of aluminium and parchment or grease-proof material is usually produced from a thin aluminium foil (0.009 mm thick) which is treated on the surface with lacquer to afford protection against corrosion. The aluminium foil is laminated to parchment or 40/42 g greaseproof paper or other suitable materials. It is very important to avoid de-lamination of the material.

There is only limited market for butter packed in cups produced from Poly-vinyledene chloride or cardboard boxes with insert of parchment.

6.3 PACKAGING MACHINERY

The increased demand for pre-packed articles led to the introduction of modern packaging machines in dairy industry. Butter can be packaged either manually or machines. The manual packaging is slow and labour intensive while packaging by the machines is faster. There are two types of butter packaging machines. These are (a) semi-automatic and (b) fully automatic type. Use of machines for packaging of butter reduces losses and labour. Also the fully automatic machine delivers a pre-weighed quantity of butter in each individual package. It pats & moulds the butter, wraps it and then delivers to the packages. These machines can be set to deliver butter packets of different sizes such 5 g, 10 g, 25 g, 50g, 100 g, 250g and 500 g packs. Few well-known brands of fully automatic butter packaging machines are Kustner, Benhill (both German make) and SIG (Swiss make). In these machines the individually wrapped packs go to cartooning machines where they are packed in cardboard boxes for storage or further transportation. The butter packed in cardboard boxes are stored overnight at 5°C and then shifted to the butter storage room at -29°C.

6.4 PACKAGING FORMS

Butter may be packaged in various ways depending on the required form, weight unit and packaging material. Many forms of packages are in use. The common forms are listed below:

a) Wrapped blocks or rolls

b) Boxes

c) Cubes

d) Tubs

e) Tin cans

For bulk packages, corrugated or solid fibre board has almost completely replaced wood. Parchment is the common lining but plastic films and aluminium foils are used in some countries. The weight of contents in most countries is 25 kg.

Retail packages are mainly wrappers made from aluminium foil/ parchment laminate or parchment alone; the trend has been largely dictated by the design of automatic packaging machinery. Other types of packages are also used, for example, tubs holding 50-300 g for retail sale or 10-15 g for consumer portions. These are usually closed with heat sealed foil or laminate. There is small market for butter in collapsible tubs.

Check Your Progress 1

1) Describe the common packaging materials used for butter packaging.

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2) List the purpose of packaging butter.

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3) Name well known packaging machines used for butter.

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6.5 STORAGE OF BUTTER

Butter is essentially a perishable product. It should not be stored for a long period. However, when production exceeds the demand it becomes inevitable to store butter. Only butter made in hygienic conditions should be selected for storage. Good quality butter should keep good for 7 days at 20°C, 20 days at 10°C and 30 days in a refrigerator without significant decrease in quality. Storage for longer period (6 months) must be at –12 to –15°C to avoid loss of quality. During storage in deep freezer, salt crystals may develop at lower temperatures. However, the crystallized particles re-dissolve on thawing at ambient temperature.

During storage some changes in the quality of butter may occur particularly in salted-ripened butter. These changes may be physical, chemical or rheological. Butter may loose its weight and shrink due to the loss of moisture. Therefore, allowance must be provided to compensate for the possible evaporation losses of moisture while packaging butter. The loss of moisture depends on the following factors:

i) **Type of packaging material-** Use of moisture proof materials reduces losses.

ii) **Moisture in butter-**If the moisture present in butter is more in free form, then losses are more.

iii) **Size of pats-**The smaller size pats loose more moisture.

iv) **Temperature of storage-**Higher temperature causes more shrinkage losses.

v) **Relative humidity-**Higher the relative humidity of storage room lower is the loss of moisture. But higher humidity may favour mould growth and hence not desired.

vi) **Period of storage-** Longer the storage period higher is the loss in weight of butter.

The keeping quality of butter made from good quality cream under hygienic conditions depends upon its temperature of storage, degree of freedom from metallic contamination, exposure to light, salt content, curd content, acidity and air content. Higher contents of salt, acidity, curd, air and use of raw cream decreases the keeping quality. Also higher temperature of storage, exposure to light and metallic contamination reduce the shelf life of butter. Sweet cream and unsalted butter has the maximum shelf life while acid cream and salted ripened butter has the minimum storagability.

Butter is usually transported in a refrigerated transport system maintained at –23°C in bulk packages (i.e. secondary packing) to the whole-sellers. The temperature during the entire period of distribution should be preferably maintained at least in the range of – 18 to – 29°C. In retail shop, again it must be stored in deep-freezers at –18 to –20°C. It should only be taken out of the freezer at the time of delivering to the customer.

Check Your Progress 2

1) Give the storage temperature for butter.

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2) List the factors, which affect the loss of moisture in butter during storage.

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6.6 COMMON DEFECTS IN BUTTER AND THEIR CONTROL

Good quality butter should possess a mild, sweet, clean and pleasant flavour and a delicate aroma. The aroma of butter is due to the composite effect of flavour of milk fat and serum. The body & texture of butter should be evaluated at 7-13°C and it should be firm, smooth and waxy. It should look like a compact mass of closely-knit butter granules. Water droplets and air cells in proper amounts should be uniformly distributed and closely bound. Ideal butter should cut and spread easily and readily. There should not be any visible water droplets. The colour of butter may vary from light creamy white to dark creamy yellow or uniform light straw colour.

In case of decrease in quality it is difficult to determine which of the three factors,

like, chemical, microbial and enzymatic reactions is responsible. In general the development of defects can be checked by observing highest possible hygiene in the plant, using packaging material of hygienic quality, uniform distribution of moisture as fine droplets in butter, by proper working, avoiding exposure to light, humidity and external environment, avoiding contamination with metals and their salts, and microorganisms.

Defects in butter, however, may develop due to use of low- grade milk or cream and faulty method of production, packaging and storage. The common defects in butter, their causes of development and preventive suggestions are discussed below.

i. Flavour Defects—Causes and Prevention

Acid flavour: It is recognized by sour taste of butter on the tip of the tongue. It is caused by the use of acidic or under-neutralized cream for butter making. Contamination with bacteria, presence of water, air, light, enzymes and some metals can accelerate the defect. Use of fresh and sweet cream or properly neutralized cream may overcome the defect.

Alkaline or neutralized flavour: Use of over neutralized cream results in butter having flavour of neutralizer. This flavour defect can be eliminated by using optimum quantity of proper neutralizers.

Bitter flavour: It resembles the taste of quinine. It persists as a distinct lingering aftertaste even after the sample has been removed from the mouth. Use of Cream obtained from milk of cows/buffalo fed on some bitter weeds or from milk, which has not been heated enough to destroy lipase enzyme activity is the cause for development of the defect. The control measures include rejection of milk from milch animals fed on bitter weeds and heating of milk above 37°C to destroy lipase activity in milk and storage of cream at 5°C to check the growth of proteolytic bacteria and other organisms during storage of cream.

Cheesy flavour: The flavour of butter resembles that of the cheddar cheese. This is again the result of the growth of proteolytic microorganisms leading to breakdown of casein in cream. This can be eliminated by storing cream at 5°C to control the growth of proteolytic organisms.

Cooked flavour: This flavour is easily recognized but is less objectionable. It is caused by overheating of cream or milk at any stage of processing. Therefore following the recommended time-temperature combination for processing of milk or cream can eliminate the defect.

Feed flavour: It is similar to the smell of hay or silage. It results from the cream obtained from milk possessing this flavour defect. Therefore, grading of milk should be done carefully and such milk with this flavour defect should not be used for cream production. Vacreation process used for pasteurization may also help to control the defect.

Fishy flavour: Butter may develop a flavour and aroma similar to cod liver oil, fish-meal or codfish. It commonly develops in high acid salted butter in the presence of metals like copper and/ or iron. Use of sweet cream for butter making and avoiding possible source of metallic contamination are the preventive methods for the defect.

Flat flavour: Butter lacks characteristic buttery flavour. Butter, which, has low diacetyl content, low salt content and has been excessively washed may exhibit this flavour defect. Ripening of cream with butter culture to proper acidity, using correct amount of salt and giving optimum washing to butter are the suggested control measures.

Rancid flavour: It is a pungent and very undesirable flavour, caused by the hydrolysis of fat due to the action of lipase in milk or cream. It resembles decayed meat. Inactivation of lipase enzyme by giving proper heat treatment to milk and cream helps to control defect.

Oxidized/Metallic/Tallowy flavour: It resembles tallow. It is caused by oxidation of fat due to direct exposure of milk, cream or butter to sunlight and contamination with copper or iron. This defect can be prevented by storage of milk, cream and butter in opaque containers made of tinned or aluminium alloy, stainless steel, etc.

Stale flavour: Butter lacks freshness. This is caused by holding the butter for a long period at low temperature or for short period at high temperature. Use of cream stored for long period also results in this defect. Therefore, avoid storing cream or butter for longer period and use correct temperature of storage to control this defect.

Yeasty flavour: It is identified by the development of typical fruity, vinegar like aroma. It results from the use of old and yeasty cream for butter making. Use of fresh sweet cream and storage of butter in hygienic condition helps to eliminate this defect.

ii. Body and Texture Defects - Causes and Prevention

Crumbly or Brittle body: Lack of cohesiveness, dryness, rough surface and difficulty in slicing indicate crumbly body defect. It is caused by seasonal changes in the composition of fat, sudden chilling or under-working of butter. To overcome this problem, adequate working of butter, controlled cooling and ageing of cream, proper churning and washing of butter are the suggested measures.

Greasy body: Excessive smoothness and quick melting in the mouth indicate greasy consistency of butter. This defect is caused by over-working and high temperature of wash water. Corrective measures include adequate working and use of wash water at recommended temperature.

Gummy body: Butter does not melt readily in the mouth. It is caused by the presence of high melting triglycerides (solid fat) in high proportion in butter. This requires elimination of feeds containing high melting point fats to the milch animals to control the defect.

Leaky body: Butter showing moisture droplets when a sample is drawn indicates this defect. Under-working of butter, excessively high temperature of churning and wash water, over-working of butter, insufficient cooling and ageing of cream results in this kind of defect. The control measures include adequate working, optimum churning and use of correct temperatures at various stages of butter making.

Mealy body: Butter does not cut well and spread. Incorrect neutralization of high acid cream with lime and oiling-off of fat during butter making cause this defect. Use of correct neutralization procedure and neutralizers and avoiding oiling-off by using correct temperatures at processing steps can prevent the defect.

Spongy/Weak: This defect is indicated by quick melting of butter and its excessive softness. Inadequate ageing and cooling, high temperature of churning and high proportion of low melting fat in butter are the causes of development of the defect. Hence proper ageing and cooling of cream and churning at optimum temperature can prevent the defect.

Sticky body: Butter appears to be dry but sticks to the butter trier (the device used for drawing of butter sample). Overworking of butter causes this defect and therefore, requires controlled working under proper temperature.

Gritty body: Presence of undissolved salt particles indicates gritty body of butter. Proper salting method, use salt after grinding and avoiding long storage of butter can prevent this defect.

iii. Colour Defects - Causes and Prevention

Mottled colour: Mottled colour is indicated by the presence of spots of lighter and deeper shades of yellow colour in butter. It is caused by inadequate washing of butter grains, improper incorporation of salt and inadequate working of butter. The control measures include adequate washing, proper incorporation of salt and adequate working of butter

Streaky colour: Presence of distinct waves of different shades of yellow colour in butter indicates the defect. Streaky colour defect is caused due to un-even and incomplete working of two or more lots of butter. It can be controlled by properly and evenly working the butter.

Dull/pale colour: Over-working of butter may result in the development of a dull colour. Therefore, working should be optimum to control the defect.

Prime rose or high colour surface: This colour defect is indicated by deepening of colour of the exposed surface of butter. It requires proper packaging to cover the entire surface of butter to control this defect.

Mould discolouration: Growth of moulds on the surface of butter produces a range of colours. Proper packaging and storage of butter in rooms at controlled temperature and humidity are the means to control the defect.

Check Your Progress 3

1) Name some common flavour defects in butter.

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2) Describe the mottled colour defect in butter?

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3) Explain the difference between crumbly and gritty body defects?

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4) Describe the difference between oxidized and rancid flavour defects?

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6.7 LET US SUM UP

Natural flavour of butter is unique but is prone to microbial, enzymatic and chemical deteriorations due to its chemical composition. Butter is a high fat product, prone to oxidative deterioration. Therefore, care must be taken to package the product in suitable materials, which would protect the products from spoilage. The packaging material used for butter must be non-toxic, non-greasy, non-sticky, protect butter flavour and amenable to packaging systems besides being impermeable to gases, moisture and light. Butter can be packed both manually and by using machine. Packaging materials used for butter include a large number of flexible films, foils and laminates. These films and laminates have the components such as aluminium foil, polyethylene, cellophane, poly-vinylidene cellophane, polyester, polyamide, vegetable parchment wax, adhesive, lacquer and hot melting and heat seal-able coating. Also, a multi-pack tub shaped containers, made from a stackable plastic trays, which provides protection against light are available. The common packaging forms are wrapped blocks or rolls, boxes, cubes, tubs and tin cans etc. For bulk packages, corrugated or solid fibre board has almost completely replaced wood. Parchment is the common lining. Plastic films and aluminium foils are also used in some countries. Retail packages are mainly wrappers made from aluminium foil/ parchment laminate or parchment alone; the trend has been largely dictated by the design of automatic packaging machinery. There is small market for butter in collapsible tubs, which should be stored in a cold chain of temperature of –12 to –15°C. If proper care is not taken during manufacturing, packaging and storing of butter, it will lead to sensory defects in flavour, body & texture and colour parameters apart from chemical and microbial spoilage may develop.

6.8 KEYWORDS

Packaging machinery	:	It is the machine used for packaging of butter instead of manual packaging.
Packaging form	:	The shape of the container such as Wrapped blocks or rolls, boxes, cubes, tubs, tin cans, solid fibre board, etc., used for packaging of product.
Impermeability	:	Ability of the packaging material wherein to act as barrier for passage of moisture, fat, gases, light, etc.
Bitter flavour	:	It is a flavour defect in butter, which tastes like quinine. It persists as a distinct lingering aftertaste even after the sample has been removed from the mouth .
Crumbly texture	:	Refers to lack of cohesiveness and difficulty in slicing of butter.
Mottled colour	:	Refers the presence of spots of lighter and deeper shades of yellow colour in butter.
Mould discoloration	:	It is colour defect in butter caused due to the growth of moulds on the surface of butter producing a range of colors.

6.9 SOME USEFUL BOOKS

De Sukumar (1980), Outlines of Dairy Technology, Oxford University Press, Delhi.

6.10 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include the following points:

Check Your Progress 1

1. i. Nowadays a large number of flexible packaging materials like films, foils and laminates, which meet the requirement are available. These films and laminates have the components such as Al. foil, polyethylene, Cellophane, Poly-vinylidene cellophane, polyester, polyamide, vegetable parchment wax, adhesive, lacquer and hot melting and heat seal-able coating. Also, in order to offer protection against light a multi-pack tub shaped containers, made from a stack-able plastic (polystyrene) trays with formed tubs (PVC) into which coated board segments can be inserted, are also available.
2. i. Packaging contains, protects and preserves the products. Packaging of product also informs about the product, sells the product and provides convenience to the consumer.
3. i. Few well-known brands of fully automatic butter packaging machines are Kustner, Benhill (both German make) and SIG (Swiss make).

Check Your Progress 2

1. i. Storage for longer period (6 months) must be at –12 to –15°C to avoid loss of quality.
2. i. Type of packaging material, size of the pat, moisture content, storage temperature, relative humidity and period of storage.

Check Your Progress 3

1. i. Oxidized flavour, rancid flavour, stale flavour, acidic flavour etc.
2. i. It is indicated by the presence of spots of lighter and deeper shades of yellow colour in butter.
3. i. Presence of un-dissolved salt particles indicates gritty body of butter. Lack of cohesiveness, dryness, rough surface and difficulty in slicing indicate crumbly body defect. It is caused by seasonal changes in the composition of fat, sudden chilling or under-working of butter.
4. i. Oxidized flavour resembles tallow. It is caused by oxidation of fat due to direct exposure of milk, cream or butter to sunlight and contamination with copper or iron. Rancidity is a pungent and very undesirable flavour. It resembles decayed meat. It is caused by the hydrolysis of fat due to the action of lipase in milk or cream.

UNIT 7 DEFINITION, COMPOSITION AND STANDARDS OF GHEE AND BUTTER OIL

Structure

7.0 OBJECTIVES

After reading this unit, we should be able to:

- state the importance of ghee in India;
- define ghee and butter oil and explain their composition & nutritive value;
- describe the influence of different factors on composition and analytical constants of ghee;
- specify the various standards of ghee and butter oil;
- obtain 'Agmark' label for ghee.

7.1 INTRODUCTION

Ghee is one of the oldest and important traditional milk products of India. The origin of ghee making probably lies far beyond recorded history. The word itself emerges from the old Sanskrit *ghr*, which mean bright or to make bright. When sprinkled on fire fats like butterfat enhanced its brightness. This effect when combined with cause, butterfat was christened *ghrita* which evolved ghee. The mention of ghee along with many other Indian milk products is also found in the Vedas, the collections of Hindu hymns, since third century BC. Ghee has such a religious significance in India that no important religious or festive Hindu rite omits the use of ghee. It is used starting from the birth ceremony to the last funeral rite of Hindus.

Ghee production has also great economical significance in our country. About 24 million tonnes of the total milk produced in the country is utilized for the production of more than 1 million tonnes of ghee per annum, the value of which is about Rs.15000 crores. This is probably the only dairy product produced at all scales

starting from household level to very large organized dairies like AMUL.

Butter oil is a western dairy product and generally not prepared in our country because as such it has no established market. It is mostly imported and used for recombining purpose. In the subsequent discussion more emphasis is focused on ghee.

7.2 DEFINITION OF GHEE AND BUTTER OIL AND THEIR BENEFITS

Ghee: Ghee may be defined as heat clarified butterfat prepared from cow or buffalo or sheep or goat milk or their mixtures and having characteristic cooked or acidic flavour and grainy texture.

Butter oil: It may be defined as clarified butterfat and normally having bland or flat flavour. The grains are either absent or under developed in it.

i. Benefits of Making Ghee

The popularity and significance of ghee in India is owing to following features/ benefits:

- Established market
- Simple technology
- Low cost of production
- Longer keeping quality
- Refrigeration storage not required
- Butterfat, the most expensive constituent of milk, is preserved efficiently in form of ghee.
- It helps salvaging the sub-standard and surplus milk.

ii. Modes of Ghee Utilization

There are regional and seasonal variations in the modes of ghee utilization, which can be influenced by local food habits, price, number of festivals and image of the product as a nutritional supplement. A major part of ghee is utilized for culinary purposes. This may cover its extensive use for the direct dressing of food articles, such as unleavened breads, cooked rice and lentils (dhal), for flavouring, and as a cooking and frying medium. About 60-70% of total ghee in India is used for direct dressing, and almost 15-20% for the cooking and frying of foods. A significant quantity of ghee is used for confectioners and bakers. Innumerable Indian sweet meats based on milk solids, cereals, fruits and vegetables are cooked for preference in ghee. Sweets made from use of *desi* ghee are sold at premium price. Ghee is recognized as a sacred article, and approximately 5-7% is used in religious rites, such as the burning of ghee dips, lighting of the sacred fire in '*Yagnas*', preparation of sacred offerings and '*Prasadam*', and even for cremation of dead bodies. It is conjectured that '*Ahutis*' (burning of ghee in religious functions) purifies the air. The practice is considered environmentally safe. Other usages of ghee of minor significance include ladies' hair dressing, body massage of wrestlers, athletes and invalids, and in the formulation of indigenous pharmaceutical drugs. Ghee is also used for flavouring snuff by mixing and grinding to a very fine powder.

7.3 COMPOSITION OF GHEE AND BUTTER OIL

Composition of Ghee: Ghee and butter oil as given in definition, are essentially the isolated fats of milk, which constitutes about 99.5%. The other constituents of varied nature are present in solution in the fat. Moisture is always present because

it cannot be completely removed merely by boiling. All fats, including ghee, also dissolve gases present in the atmosphere, like nitrogen, oxygen and carbon dioxide. Some 0.5% of the material present in ghee is collectively known as unsponifiable matter, since on boiling with alkali, it is not converted into soap, and can be extracted with solvents like ether. This unsponifiable matter is a complex mixture of substances like sterols, vitamins and hydrocarbons, which though present in small amounts are of considerable significance. In addition to fat and unsponifiable matter, ghee also contain some other trace constituents. The presence and proportions of these trace compounds, like hydroperoxides, aldehydes, ketones, phospholipids, proteins, sugars and trace minerals, depend on the past history of ghee. The general composition of ghee obtained from cow and buffalo milks is given in the Table 7.1.

Table 7.1: Composition of ghee

Constituents	Average composition	
	Cow ghee	Buffalo ghee
1. Moisture	Not more than 0.5 per cent	
2. Milk Fat	99 to 99.5 per cent	
– Glycerides	98 per cent	
– Phospholipids	0.03 per cent	
– Cholesterol	0.50 per cent	
– Free fatty acids (as per cent oleic acid)	Not more than 2.8 percent	
– Carotene (μg/g)	3.7 to 7.4	—
– Vitamin A (IU/g)	19 – 34	17 – 38
– Tocopherol (μg/g)	26 – 48	18 – 37
3. Charred casein and salts of Ca, P, Cu, Fe etc.	Traces	

7.4 NUTRITIVE VALUE OF GHEE AND BUTTER OIL

Ghee and butter oil, being pure butterfat, are concentrated source of energy, supplying nine calories per gram as against four calories supplied by one gram each of pure source of either protein or carbohydrate.

Ghee particularly that prepared by traditional milk fermentation route, has good medicinal value. Ghee is a carrier of fat-soluble vitamins, A, D, E and K, which our body needs in very small quantities but cannot make for itself. These vitamins perform many essential functions. Similarly, the essential fatty acids, which cannot be synthesized in our body are also supplied by ghee. Ghee has been recognized as Indian medicine in *Ayurveda*. It is used in various disorders both externally as well as internally. There are about 55-60 medicated ghee types reported in *Ayurvedic* literature and they are used for treatment of various diseases. Medicated ghee is always prepared with selective fortification with herbs, so as to acquire all the required fat-soluble therapeutical components of the herbs. Some of the examples of medicated ghee are: *Arjima ghrit*, *Ashok ghrit*, *Dhanvantar ghrit*, *Amruta ghrit*, etc. Emerging scientific findings indicate that ghee contains several components such as conjugated linoleic acid (CLA), sphingomylein, butyric acid, myristic acid and vitamin A, which have potential to inhibit the development of cancer. In fact, ghee is the richest natural dietary source of CLA, which has shown to inhibit carcinogenesis of colour, mammary tissue, skin and fore stomach. CLA present in ghee is also known to have serum cholesterol lowering properties. Compared to

other fats and oils, milk fat (ghee) is easily digestible. The digestibility of ghee and butter oil is 99% while that of natural palm oil is 91%. Also ghee is rich in short and medium chain fatty acids, which are more easily absorbed than long chain fatty acids

Check Your Progress 1

1) Differentiate between ghee and butter oil and give reasons for making ghee.

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2) Write the major constituents of ghee and butter oil.

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3) Briefly explain the nutritional significance of ghee in our diet.

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7.5 ANALYTICAL CONSTANTS OF GHEE

The physico-chemical constants are important because they are used for characterization and differentiation of ghee. Some of the important analytical constants or standards of cow's and buffalo's ghee produced under standardized conditions are given in the table 7.2.

Table 7.2: Analytical constant of buffalo and cow ghee

Constants	Buffalo Ghee	Cow Ghee
Butyro-refractometer (BR) reading	42.0	42.3
Sponification value	230.1	227.3
Reichert-Miessel (RM) value	32.3	26.7
Polenske value	1.41	1.76
Iodine value	29.4	33.7
Kirschner value	28.52	22.16
Solidifying point (^oC)	16 – 28	15 – 23.5
Melting point (^oC)	32 – 43.5	28 – 41
Colour (yellow unit/g) (Tintometer)	0.8	8.8

7.6 FACTORS AFFECTING COMPOSITION AND ANALYTICAL CONSTANTS OF GHEE

Ghee, as defined earlier, is a pure heat clarified butterfat. In broad chemical definition, milk fat is referred to as triglyceride of fatty acids, containing varying

quantities of other substances. Milk fat contains about 500 fatty acids and fatty acid derivatives with 4 to 20 or more carbon atoms in their chain. The fatty acids usually contain an even number of carbon atoms, but they may be saturated or unsaturated. Nearly 80% of the cow and buffalo milk fats consists of only five fatty acids, namely palmatic, oleic, stearic, myristic and butyric. The polyunsaturated fatty acids of butterfat constitute about 3%.

The fatty acid composition of milk fat greatly influences the fat constants and rheological properties, such as melting and crystallization behaviour, that affect the texture of ghee. These fatty acids as such and by interaction with other milk constituents also influence the flavour of ghee. Excess amount of long chain saturated fatty acids, like palmatic and stearic acid and thus substantially high amount of high melting triglycerides make the ghee hard and develops good grains. The high proportion of low carbon atom saturated acids, for example, butyric and caproic acids and polyunsaturated fatty acids make the ghee softer with poor granularity.

The more prominent of the above factors that affect the lipid profile of milk fat and eventually the composition and analytical constants of ghee are discussed as below:

Effect of Species: The quality of ghee from cow milk and buffalo milk is different particularly in terms of colour and texture. This difference is attributed to the fatty acid profile and other constitutes of the two species, which are different. For example, yellow colour in cow ghee is due to carotene, which is absent in buffalo milk. The fatty acid composition of cow milk and buffalo milk fat is shown in the table 7.3.

Table 7.3: Fatty acid composition of cow and buffalo milk fat

Fatty acid	Buffalo milk fat (%)	Cow milk fat (%)
Butyric	4.4	3.2
Caporic	1.5	2.1
Caprylic	0.8	1.2
Capric	1.3	2.6
Lauric	1.8	2.8
Myristic	10.8	11.9
Palmitic	33.1	30.6
Stearic	12.0	10.1
Oleic	27.2	27.4
Linoleic	1.5	1.5
Linolenic	0.5	0.6

Since the long chain saturated fatty acids like palmatic and stearic are more in buffalo butterfat, buffalo ghee is harder with bigger grains than cow ghee. The other analytical constants of the cow ghee and buffalo ghee (table 7.2) are also different because of variance in their fatty acid composition.

Effect of Feed: The bulk constituents of the feed of ruminant milch animals are crude fibre, protein and fat, which together make up the total digestible nutrients. These are required not merely for maintenance of animal body but as a raw material for production of the constituents of milk.

(a) Proteins in the diet are the source of milk protein. Normally dietary proteins do not contribute to the synthesis of milk fat.

(b) Fats/oils and their cakes in the diet have most striking effect on the fatty acids composition and the analytical constants. Feeding whole cottonseed oil or cake increases the oleic acid content (and likewise iodine value) by about 10 units and a sharp increase, often to almost double the original values, occurs in stearic acid, bringing it upto even 20%. In compensation the contents of palmatic acid and of lower fatty acids taken as a whole are depressed almost to the same proportion. The dietary groundnut oil, hydrogenated groundnut oil, sesame oil, safflower oil, their seeds or cakes also increase the oleic acid and stearic acid and decrease the palmatic and lower fatty acids. The overall result is that ghee obtained from feeding of these seeds and cakes lower the RM value, polenske value and sponification value and increase of BR reading and iodine value, and such ghee are hard, granular and sometimes even waxy in appearance. Feeding of coconut cake increases lauric acid and myristic acid levels. Rape oil when feed to animal, elevates the oleic acid and depresses the palmatic acid content and thus decreases RM value and increases iodine value.

Feeding of carbohydrate materials, such as crude fibre, cellulose, starch and sugar also contribute in the synthesis of butterfat, especially in the built up of lower fatty acids. Feeding of animals on pasture grass or silage or under a regimen of green fodder produces butterfat with high proportion of lower fatty acids, such as butyric and caproic, which result in high RM value and Polenske value. This affect is commonly observed after the monsoon. Excessive feeding of green grass or fodder is stated to yield a soft butter of high iodine value, for which the highly unsaturated fatty acid may be responsible. Feeding large quantities of roots, which are rich in fibre and low in protein, yield butterfat of very low iodine value (about 30) and high RM value and Polenske value.

The dietary conditions of the animals also influence carotene, vitamin A and vitamin E constituents. Any carotene present in milk fat is, in fact, of dietary origin, while vitamin A arises either from dietary carotene or from reserves of vitamin A alcohol stored in the liver, which ultimately are also derived from ingested carotene or vitamin A. Hence the level of these materials in diet will influence their amounts secreted in milk fat. Feeding of more oil cakes and lowering of intake of green fodder generally lower the carotene and vitamin A content in butterfat. Similarly the a-tocopherol (also termed as vitamin E) in butterfat is of dietary origin. Therefore, its level is also dependent on the intake through feed.

Effect of Season: The season has indirect effect on the fatty acids and analytical constant of butterfat. The feeding regimen changes with the change in season. In monsoon there is more availability of green fodder and pasture feeding practice is also adopted. In the summer months, green fodders are not available, which are replaced by silage, dry straw and fibrous feeds. As discussed above the change in dietary conditions of the animals will alter the fatty acids composition and vitamins of butter fat.

Effect of Method of Preparation of Ghee: Adoption of any method for manufacture of ghee using good quality raw material generally does not alter the fatty acid profile and analytical constants. But the other lower constituents like carotene, vitamin A and E and phospholipids are affected by the method of manufacturing ghee. At each stage of processing during ghee making, such as cream separation, pasteurization, butter making, some loss of carotene and vitamin A takes place, hence more the steps involved in the method of ghee making lesser will be the percentage of these constituents. In case of indigenous method of ghee making higher recovery of vitamin A is achieved because large amount of fat soluble vitamin A is transferred to the fat phase during souring of whole milk into dahi and subsequently during churning of dahi into *makkhan*. Raising temperature to more than 125^{o}C during manufacture of ghee and storage of ghee for prolonged period drastically reduces the vitamin A content and almost completely destroy carotene

content. But, the method of manufacture of ghee has no bearing on the tocopherol content, which is in very close range when prepared by different methods. Also tocopherol in ghee is quite stable to heat. The total phospholipid content of creamery cow butter varies between 75-218 mg/100g, which is higher than the values of 61-67 mg/100 g found in cow *makkhan* (curd process butter) and 46 mg/100 g in buffalo *makkhan*. There is no loss of phospholipid on converting butter or *makkhan* into ghee.

Check Your Progress 2

1) Name the main analytical constants of ghee and butter oil. Write the significance of measuring these constants.

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2) What are the main differences between cow ghee and buffalo ghee?

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3) Briefly explain the role of feeds on the composition and analytical constants of butterfat.

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4) Which constituents of ghee and to what extent are influenced by the method of its manufacture?

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7.7 STANDARDS OF GHEE AND BUTTER OIL

For systematic marketing of ghee, quality control is a pre-requisite. Apart from the self-imposed discipline of quality control, there are several quality control agencies and legislative measures for quality assurance in our country. The important quality control agencies concerning ghee are:

- Prevention of Food Adulteration (PFA) Act, 1954.
- Bureau of Indian Standards (BIS)
- Directorate of Marketing and Inspection (AGMARK)
- Weights and Measures Authorities

The first organization, PFA checks the quality and it is mandatory for the product being marketed to conform to PFA requirements. The next two agencies, BIS and AGMARK are voluntary and assure the consumers a product of pre-tested quality and purity. Weights and Measures Authority ensures that the product is packed in correct size and consumers are assured of what they are legitimately eligible.

i. PFA Standards of Ghee

According to Prevention of Food Adulteration Act, (1954), as amended upto 2003, ghee is the pure clarified fat derived solely from milk or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added. Ghee shall not contain more than 0.5% moisture and the maximum permissible limit for Free Fatty Acids (FFA), as % oleic acid, is 3.0 irrespective of the state and union territory. The 'Baudouin Test' shall be negative. The details of other PFA requirements for different states and union territories are given in table 7.4.

Table 7.4: Standards of ghee under PFA rules

State/Union Territory	Butyro refractometer reading at 40^{C}C	Minimum Reichert Value
Arunachal Pradesh, Assam, Goa, Haryana (cotton tract areas), Himachal Pradesh, Jammu & Kashmir, Kerala, Maharashtra (other than cotton tract areas), Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Rajasthan (other than cotton tract areas), Tripura, Uttar Pradesh, Uttaranchal, Lakshadweep	40.0 – 43.0	26
Bihar, Haryana (other than cotton tract areas), Punjab, Sikkim, West Bengal (other than Bishnupur sub division areas), Chandigarh	40.0 – 43.0	28
Andhra Pradesh, Karnataka (areas other than Belgaum Distt.), Dadra and Nagar Haveli.	40.0 – 43.0	24
Cotton tract areas* of Gujarat, Madhya Pradesh and Maharashtra; Jodhpur Division of Rajasthan, Bishnupur sub division of West Bengal	41.5 – 45.0	21
Karnataka (Belgaum distt.), Madhya Pradesh (areas other than cotton tract) and Pondicherry	40.0 – 44.0	26
Gujarat (areas other than cotton tract)	40.0 – 43.5	24
Andaman & Nicobar	41.0 – 44.0	24
Delhi	40.5 – 43.0	28
Daman & Diu	40.0 – 43.5	24

* The cotton tract areas are those where cotton seeds are extensively feed to the animals and so notified by the state government concerned; Moisture not more than 0.5% and maximum FFA (as% of oleic acid) 3.0; Baudouin test shall be negative.

ii. PFA and BIS Standards of Butter oil

According to PFA Act (1954) as amended upto 2003, butter oil or anhydrous butter fat is a product exclusively obtained from butter or cream and resulting from the removal of practically the entire water and solids-not-fat contents. It may contain permitted anti-oxidants not exceeding 0.02% by weight except gallate, which shall not exceed 0.01% by weight. It shall conform to standards of quality laid down for ghee (Table 7.4) except that butyro refractometer reading, which shall be 40.0 – 44.0 at 40^{o}C. In case of imported butter oil, Reichert value shall not be less than 24. The standards of butter oil as laid down by BIS are shown in table 7.5.

Table 7.5: Requirements for butter oil as per BIS

S.No.	Characteristics	Requirements
i)	Milk fat, % by mass, min	99.5
ii)	Moisture, % by mass, max.	0.5
iii)	Butyro-refractometer reading (at 40°C)	40.0 – 44.0
iv)	Reichert-Meissel Value, min*	21, 24, 26, 28
v)	Free Fatty acids, % by mass (as leic acid), max.	0.3
vi)	Peroxide value, milli-equivalent of oxygen per kg of butter oil, max.	0.8
vii)	Coliform in 1 gm	nil

* Same RM values as for ghee for different states/UT (table 1.4). For imported butter oil the minimum RM value should be 24.

iii. AGMARK Standards of Ghee

'Agmark', derived from Agricultural Marketing, is the exclusive property of the Govt. of India and not a private trademark. The Agmark grading or certifications is for agricultural, livestock and horticultural commodities. These standards are voluntary and obtained by the producers/manufacturers or packers of ghee (or any other food commodity) to assure consumers that the product is of pre-tested quality and purity. The 'Agmark' standards of ghee are same throughout the country. Under Agmark, ghee is graded into three categories namely 'Special' (Agmark Red Label), 'General' (Green Label) and 'Standard'. The definition of quality for 'Standard grade' shall be same as laid down under PFA rules and amended from time to time. The Agmark standard for ghee are shown in table 7.6.

Table 7.6: AGMARK standards of ghee

Test	Values		
	All India	Regional	
		Winter	Summer
B.R. Reading (40°C)	40 – 43	41.5 – 44.0	42.5 – 45.0
RM value (not less than)	28.0	23.0	21.0
Poleske Value	1.0 – 2.0	0.5 – 1.2	0.5 – 1.0
Free fatty acids (% oleic)	a) Special Grade (Agmark red label) not more than 1.4		
	b) General grade (Green label) not more than 2.5		
Moisture (%)	Not more than 0.3		
Baudouin test	Negative		
Phytosterol acetate test	Negative		

7.8 GRADING OF GHEE

Agmark grading scheme was initiated by the Agricultural Marketing Department in 1938 under the Agricultural Produce (Grading and marketing) Act of 1937 and revised from time to time. The parties (ghee packers) desirous of packing ghee under Agmark is considered by the Joint Agricultural Marketing Advisor, Nagpur for issue of certificate of authorization on receipt of a written request from the ghee

packer. It is followed by a recommendation by the State Agricultural Marketing Department on inspection report about the equipment refining facilities, laboratory and qualified chemists.

i. Procedure for using Agmark Label

The ghee packer or the party who intends to use Agmark grade first of all undertakes preliminary screening of raw material for the general characteristics (organoleptic tests) and butyro-refractometer reading, Baudouin test and acid value before purchase of raw material. On passing the preliminary examinations, refining of *Kachha* ghee or butter or cream is done adopting the recommended temperature and conditions. Refined ghee is transferred to settling tank for separation of residue at the bottom.

A sample of each lot of freshly made ghee from settling tank (also from the dairy plants, which want to sale ghee under Agmark label) is drawn by the respective chemist and divided into 3 parts. One part is analyzed by the chemist himself at the laboratory of refinery or dairy plant. The second part is sent for check analysis to one of the control laboratory maintained by the agricultural marketing department. These laboratories are: The Central Laboratory, Kanpur, and the Subsidiary Control Laboratory, Rajkot (Gujarat). The third part is sealed and maintained with the ghee packer/producer for future reference.

After drawing the samples, ghee is filled in new tin cans, which have been previously marked with the following particulars:

- Name of the authorized packer
- Place of packing
- Date of packing
- Melt/ batch number

Ghee filled in tins should remain in the custody of chemist till the labels are fixed on them. Agmark labels are printed under security condition on watermark paper bearing the words “Government of India” in microtint to avoid counterfeiting. These are affixed on the tins with a special adhesive supplied by the Agricultural Marketing Advisor to the Govt. of India.

ii. Quality control check

If the control laboratory finds that a melt sample does not conform to the specifications, immediate intimation is sent to the authorized packer and the chemist to remove the Agmark Label from all the tins filled with the melt/batch in question, and ghee rejected from Agmark grading.

A check on the quality and purity of ghee is also exercised by frequent inspection of the grading stations/refineries by the state and central marketing staff. Samples of graded ghee are collected from the grading centers and consuming markets (both retail and wholesale) through specially authorized officers. If on analysis, sample is found to be below specifications, the entire melt/batch is declared mis-graded and the packer has to arrange for the removal of Agmark label from the tins pertaining to that batch.

Check Your Progress 3

1) Name the quality control agencies that exist in our country for quality assurance of food products, including ghee.

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2) Write the definition of ghee and butter oil as per the PFA.

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3) What do you understand by cotton tract areas? Which analytical constants of ghee are most affected in cotton tract regions?

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4) Name the categories of ghee graded under "Agmark". Which tests are conducted for preliminary screening of raw material for Agmark grading?

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7.9 LET US SUM UP

Ghee, a heat clarified butterfat, is very important and perhaps oldest Indian traditional milk product. The origin of ghee making in India is probably lies far beyond recorded history. There is sufficient evidence that ghee has been used extensively for dietary and religious purposes since Vedic Times (3000-2000 BC). More than one million tonnes of ghee is produced per annum in our country, the value of which is about Rs. 15000 crores. Some of the specific benefits of making ghee are: simple technology, longer keeping quality and no refrigeration storage required, established market and several applications.

Butter oil is also a pure clarified butterfat, but of western origin. Where flavour of ghee is pleasantly cooked or slightly acidic or curdy, butter oil has bland or flat flavour. Butterfat, either in form of ghee or butter oil, when added to any food product, increases its palatability, which cannot be duplicated by other fats/oils. Ghee and butter oil contain about 99.5% milk fat and are rich source of fat-soluble vitamins A, D, E and K. In India, ghee prepared by traditional milk fermentation method has great medicinal value and contains constituents, like conjugated linoleic acid, sphingomylein and vitamin A, which have potential to inhibit the cancer. Many types of medicated ghee are prepared by blending with it some selective herbs for curing both external and internal disorders in our body. For marketing pure ghee many analytical constants have been suggested by quality control agencies. Some of these are butyro refractomer reading, Reichert value, Polenske value and Iodine value. These values and composition of ghee are affected by many factors, such as species of animals, fatty acid composition, stage of lactation, feeding practices and method of manufacture of ghee.

The important quality control agencies and legislative measures for quality assurance of ghee in our country are: Prevention of Food Adulteration (PFA) rules, Bureau of Indian Standards (BIS), and Directorate of Agricultural Marketing (AGMARK). The PFA standards are mandatory for marketing of ghee and butter oil, whereas the BIS and Agmark standards are voluntary and adopted to assure the consumers a product of purity and pre-tested quality.

7.10 KEY WORDS

Colostrum : The first milk from the mother after birth of the young mammal.

Fibre : Usually referred to as a crude fibre, this is coarse woody cell walls of mature plants and constitutes the feed ration of animals. This material is partly digestible by the ruminants. It is composed chiefly of insoluble carbohydrates, such as cellulose and hemicellulose.

Iodine number : It is the number of grams of iodine absorbed by 100 grams of fat under specified conditions. This constant is measure of the unsaturated linkages present in a fat. The value for this constant is more for other oils/fat in comparison with ghee.

Medicated ghee : Ghee prepared with selective fortification of herbs either during manufacture of ghee or subsequently for treatment of various diseases.

Polenske value : This value is the number of ml of 0.1 N alkali solution required to neutralize the volatile and insoluble fatty acids distilled from 5 grams of fat under specified conditions. Polenske value measures the caprylic and capric acids, which are steam volatile and largely insoluble in water.

Refractive index : Measurement of degree of bending of light waves passing through a liquid (ghee at 40^{o}C) or transparent solid. The refractive index value of ghee is less than vegetable fats and other oils.

Reichert Meissel : This value is the number of ml of 0.1 N alkali solution required to neutralize the volatile of soluble fatty acids distilled from 5 grams of the fat under specified conditions. RM value is primarily a measure of butyric acid and higher in ghee than other fats/oils.

Ruminant : Cud chewing animal, having four distinct compartments of stomach.

Sponification number : It is the number of milligrams of KOH required to sponify one gram of fat. This constant is an indication of the average molecular weight of the fatty acids.

7.11 SOME USEFUL BOOKS

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Aneja, R.P., Mathur, B.N., Chandan, R.C. and Banerjee, A.K. (2002). Technology of Indian Milk Products, A Dairy India Publications, Delhi.

De, S. (1980). Outlines of Dairy Technology, Oxford University Press, Delhi.

Rangappa, K.S. and Acharya, K.T. (1974). Indian Dairy Products, Asia Publishing House, New Delhi.

7.12 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Your answer should include the following points:

Check Your Progress 1

1) i. Ghee is a heat-clarified butterfat. It has a typical pleasant flavour, either slightly to mildly cooked or slight acidic or curdy, depending on the method used. Granularity in ghee is also better than butter oil. The flavour of butter oil is rather flat or bland because it is prepared under vacuum where very high heat treatment is not used.

   ii. Ghee is more popular in India because it has commercial as well as religious significance. Indians have developed taste for ghee from their childhood. Surplus fat is best stored under tropical Indian conditions in form of ghee

   iii. About 28% of total milk produced in India is utilized for manufacture of ghee.

   iv. The reasons for converting milk into ghee are: simple technology, low cost of production, established market, longer keeping quality, refrigeration storage not required, many religious uses, sub-standards and surplus milk can be utilized.

2) i. Major constituent of ghee and butter oil is milk fat which constitute more than 99%, out of which triglyceride are about 98%. Other constituents are: phospholipids, cholesterol, free fatty acids, carotene and vitamin A & E. The moisture content is less than 0.5%. Ghee also contains some trace compounds, such as charred casein, ketones, aldehydes, etc.

3) i. Ghee is a concentrated source of energy and supplies 9.0 calories/g.

   ii. It has medicinal value.

   iii. Ghee is a carrier of fat-soluble vitamins, particularly vitamin A and E.

   iv. Essential fatty acids in our body are also supplied by ghee.

   v. Ghee, particularly desi ghee is a richest natural dietary source of conjugated linoleic acid.

Check Your Progress 2

1) i. Main analytical constant of ghee and butter oil are Butyro- refractometer reading, Reichert-eissel value, Polenske value, Iodine value, solidifying and melting points.

   ii. These vales are important for characterization of ghee

   iii. The values of these constants of butterfat are different than vegetable fats/oils and animal fats values and this can be used to check adulteration.

2) i. Cow ghee has yellow colour due to presence of carotene but buffalo ghee is white with greenish tinge.

   ii. RM value and solidifying & melting points of buffalo ghee are higher than cow ghee.

   iii. Buffalo ghee is harder than cow ghee because of larger proportion of long chain saturated fatty acids, palmatic and stearic.

3) i. Feeds affect the fatty acid composition, carotene contents, vitamin A and tocopherol of ghee.

   ii. Use of higher amounts of cotton, groundnut, sesame, mustard/rape and safflower oil or seeds or their cakes in feed increase the levels of oleic and stearic fatty acids and decrease the proportion of palmatic acid and

lower chain fatty acids, thereby decreasing the Reichert value and increasing iodine value.

iii. Feeding of animals on pasture, green fodder or silage produces ghee with higher proportion of lower fatty acids or soft fat. Such ghee has high Reichert and Polenske value.

4) i. The analytical constant are not altered by the method of manufacture of ghee.

ii. At each stage of manufacture, some loss of carotene and vitamin A takes place. Hence more the steps involved, as in case of creamery butter method, the higher will be the losses of these constituent.

iii. Higher vitamin A content in ghee prepared by indigenous method where soured milk is converted into *makkhan*.

iv. Total phospholipid in creamery butter method is more than indigenous method.

Check Your Progress 3

1) i. Prevention of Food Adulteration Rules (PFA).

ii. Bureau of Indian Standards (BIS)

iii. Agricultural Marketing Standards (Agmark).

iv. Weight and Measures agency.

2) i. *Ghee:* It is a pure clarified fat derived solely from milk or desi (cooking) butter or from cream to which no coloring matter has been added. It shall contain not more than 0.5% moisture and not more than 3% free fatty acid (as oleic acid) The Boudouin test shall be negative. The BR reading shall be in the range of 40-44 and RM value 21, 24, 26 or 28 depending on the state or union territory. *Butter oil*; also called as anhydrous butterfat, is a product exclusively obtained from butter or cream resulting from entire removal of practically entire water and SNF contents. It may also contain permitted antioxidant not exceeding 0.02% by weight (gallate shall not exceed 0.01%). The other standards are same as for ghee, given above.

3) i. Cotton tract areas are those areas where cottonseeds or cakes are extensively fed to the animals. The state government concerned notifies these.

ii. Reichert value is most affected in cotton tract area, which reduces to about 21.

4) i. Under Agmark ghee is graded into three categories i.e. Special grade (FFA not more than 1.4%), General grade (FFA not more than 2.5%) and Standard grade (same standard as for PFA).

ii. Preliminary screening tests conducted on raw materials for Agmark grading of ghee are: BR Reading, Baudouin test, organoleptic test and some other tests in case of doubt.

UNIT 8 PRINCIPLES AND METHODS OF MANUFACTURE OF GHEE AND BUTTER OIL

Structure

8.0 OBJECTIVES

After reading this unit, we should be able to:

- state the principle involved in the manufacture of ghee and butter oil.
- outline different methods of preparation of ghee and butter oil.
- evaluate the efficiency and applicability of different method of ghee making
- set up a ghee-refining unit.

8.1 INTRODUCTION

We know the importance of ghee in our diet and its nutritive value. Now, we should also be able to differentiate between ghee and butter oil. Butterfat is the most expensive constituent of milk and you know ghee is essentially constituted of butterfat. All efforts are made to minimize losses of butterfat while making ghee and butter oil. Another important aspect is to maintain the organoleptic and analytical properties of butterfat to an acceptable level in the final product. Also the technological and economic viability of the method used cannot be underestimated. To achieve these objectives, it is highly essential to adopt a most appropriate method for preparation of ghee and for butter oil. There are different methods of manufacturing ghee. In this unit we shall discuss all these methods along with their merits and demerits.

8.2 PRINCIPLE OF MANUFACTURE OF GHEE

The principle of manufacturing ghee basically involves following three steps:

a) **Concentration of lipid phase :** Butterfat in milk is present in form of fat globules, which are properly emulsified by fat globule membrane and dispersed

in serum phase. For efficient separation of butterfat from the continuous phase (serum), it has to be concentrated inform of cream or malai. Further concentration of butter fat is possible by converting it into a continuous phase as in case of butter. The purpose of concentrating butterfat in a discontinuous (cream) or continuous phase (butter) is to reduce the amount of water and SNF contents in the raw material and facilitate ghee preparation.

Sometimes, some intermediate operations such as fermentation of milk prior to concentration of lipid phase or of cream to emanate desired acidic flavour is also adopted.

b) **Heat clarification of cream or butter :** Removes practically all the moisture and to generate typical flavour and granulation, and

c) **Removal of residue from the heat clarified butter fat :** To meet the legal requirements and also to improve the storageability.

8.3 METHODS OF MANUFACTURE OF GHEE

Different methods are used for the preparation of ghee. The adoption of a particular method is mainly dependent on the scale of production. The classification and description of these methods is given as below:

1 Indigenous (*Desi*) method
2 Direct cream method
3 Creamery butter method
4 Pre-stratification method
5 Continuous method

The flow diagram of the above methods has been schematically shown in Fig. 8.1.

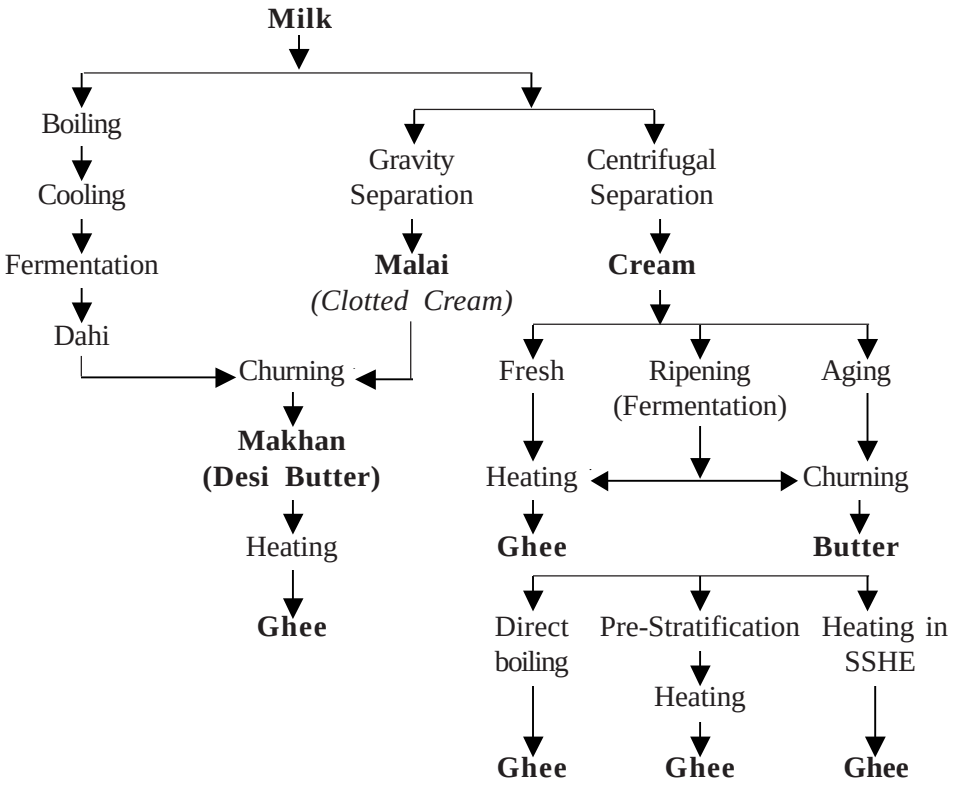

Fig. 8.1 Flow diagram of manufacturing ghee by different methods

i. Indigenous (*Desi*) method

It is an age-old process and largely adopted in rural areas/villages and also at urban household levels because of simplicity in equipment and technique. This traditional

method of making ghee contributes about 80% of the total ghee produced in the country. This method usually involves two routes, (1) lactic acid fermentation of raw or heated milk is followed by churning of curd into *makkhan* (butter) and (2) separation of *malai* (clotted cream) from the boiled milk and its churning into butter. *Dahi* or buttermilk of previous day is used as starter culture for fermentation of milk. Churning of curd or *malai* is done with hand wooden churn. Now-a-days electrically operated butter churns are available and used by many housewives or *makkhan* producers. *Makkhan* is stored at room temperature for days together and when sufficient quantity accumulated, it is converted into ghee. For this purpose, *makkhan* is heated in a earthen pot (now-a-days metal, particularly steel or aluminum containers are also used) on slow fire. The scum gathered on the top of melted butter is continuously removed with perforated ladle. The heating is discontinued on complete removal of scum and froth and getting clear fat (ghee). There are several limitations in this process which are mentioned here:

- The quality of ghee is highly inconsistent in terms of chemical and sensory quality.
- Method is incompatible to large-scale production.
- Recovery of fat is low.
- Acidity is high and hence keeping quality is low.
- Manufacture and storage of ghee is done in undesirable containers.
- Ghee residue being acidic in nature cannot be used.

The indigenous method is not adopted by organized dairies. Most of the ghee produced by this method is either consumed for household purpose or serves as a base material for the blending operations at ghee grading and packing centers functioning under Agricultural Marketing and Grading (AGMARK) scheme in India. To overcome the problems associated with *desi* method an improved indigenous method has been suggested which is as follows:

- Always pre-filter/strain milk before use.
- Give suitable heat treatment, preferably boiling the milk before making *dahi*.
- Cool milk to room temperature (22-30^{o}C) and then add starter culture for *dahi* preparation. The setting of *dahi* should be done under controlled conditions. Incubate milk till *dahi* is set and desired acidity (0.80 per cent) is developed. It normally requires about 16-18 hrs in winter and 8-10 hrs in summer.
- Churn *dahi* by electrically driven beater or butter churn.
- Use cold water during churning in summer months to minimize the fat losses in buttermilk (*lassi*), thereby improving the fat recovery in ghee.
- Make ghee preferably from fresh *makkhan* or store *makkhan* in a refrigerator if it is to be converted into ghee after a long period. Don’t store makkhan or ghee in earthenware or copper or iron containers.
- Heat *makkhan* (butter) at sufficiently high (more than 100^{o}C) temperature for ghee making.
- Strain ghee properly so as to make it completely free from residue.

ii. Direct Cream Method

The small dairies use a technologically improved method for ghee making which involves the separation of cream from milk by centrifugation. This process omits the need for production of butter because cream is directly converted into ghee. The fresh cream or refined cream or even washed cream is heated in a heating kettle to evaporate moisture. The kettle may be an ordinary kettle heated by gas or a steam heated double jacketed kettle made up of stainless steel. The choice of kettle is made on the scale of operation. A steam heated jacketed ghee kettle is fitted with an agitator, steam control valve, pressure and temperature gauges and a movable, hollow, stainless steel tube centrally bored for emptying out the contents

(Fig. 8.2). Alternatively provision can be made for a tilting device on the ghee kettle to decant off the product. High fat cream is heated continuously in the kettle with intermittent agitation to avoid burning at initial stage. At last stage temperature should be controlled between 105-110°C. Heating is discontinued as soon as brownish froth appears on the surface and colour of the ghee residue turns to golden yellow or light brown. At this stage ghee is left undisturbed in the kettle so that residue settles at the bottom. Ghee is allowed to cool to about 60°C and then filtered properly. In case a oil separator is used for removing residue, then ghee is directly passed through the centrifugal separator. The use of plastic cream or washed cream with about 75-80% fat is recommended for minimizing both fat loss and steam consumption. The final product will have a less intense cooked flavour when low SNF (solids not fat) cream is used.

Fig. 8.2: Industrial steam jacketed kettle for manufacture of ghee

Advantages

- Butter churn and butter storage facilities are not required, therefore, less initial costs are needed.
- No refrigeration facility required for preparation and storage of butter.
- Recovery of fat on basis of total butterfat is higher than indigenous methods because of elimination of butter making step.
- The keeping quality of ghee is better.

Disadvantages

- Direct cream method requires a long heating time to remove the moisture.
- A high content of serum solids in the cream may also produce a highly caramelized flavour in the ghee.
- This method leads to about 4-6% loss of total butterfat in the ghee residue or during handling operations, depending upon the fat percentage in the cream. However, excessive fat from ghee residue may be recovered.
- Energy consumption in comparison with creamery butter method is higher.

Check Your Progress 1

1) Write the steps on which the principle of ghee manufacture is based. Name the methods used for concentration of lipid phase for ghee making.

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2) Name the different methods of manufacturing ghee. Which of these is most primitive?

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3) Write the major steps involved in manufacture of ghee by indigenous method and direct cream method.

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4) What are the limitations of indigenous method of ghee making and how these can be improved?

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iii. Creamery Butter Method

This is the standard method adopted by organized dairies. In this method unsalted creamery butter or white butter or cooking butter is used a raw material for ghee making. A typical plant assembly for the creamery butter method comprises the following units. (1) a cream separator (2) butter churn (3) butter melting outfits (4) steam-jacketed, stainless steel ghee kettle with agitator and process controls (5) ghee filtration devices, such as disc filters or oil clarifier (6) storage tanks for cream, butter and ghee (7) pumps and pipelines interconnecting these facilities (8) crystallization tanks and (9) product filling and packaging lines.

First, the butter mass is melted at 60^{o}C. The molten butter is pumped into the ghee boiler. Alternatively, solid butter may also be transferred manually to ghee kettle. The steam pressure is increased slowly to raise the temperature of butter to 90^{o}C. This temperature remains constant as long as the moisture is being driven off. The scum, which collects on the top surface of the product may be removed from time to time with the help of a perforated ladle. The temperature gradually rises and the heating at the last stage is carefully controlled. The end-point shows the disappearance of effervescence, appearance of finer air bubbles on the surface of fat, and browning of the curd particles. At this stage, the typical ghee aroma is also produced. The final temperature of clarification is adjusted less than 110^{o}C. Heating beyond this temperature will generate a marked ‘cooked’ flavour. The ghee is then pumped, via an oil filter or clarifier, into crystallization tank, which are cooled by re-circulating water at 60^{o}C. The ghee is then packed in suitable containers.

Advantages

- This method produces ghee of highly consistent quality.
- Quantity of ghee residue is very less, hence less fat losses.
- Less space is required for storage of cooking butter, the raw material for this method.
- Energy requirement are lower than direct cream and indigenous methods.
- Longer keeping quality than indigenous method

Disadvantages

- The flavour of ghee prepared by creamery butter method is criticized to be either flat/bland or cooked, particularly to the consumers who are habitual of using village ghee made by traditional method.
- The granulation in ghee is also poor as compared with the earlier discussed method.

iv. Pre-stratification Method

The ghee boiler in pre-stratification method is slightly modified. A faucet is provided at lower end (almost at side of bottom) of the boiler to remove most of the buttermilk (moisture and SNF). In this method, white butter is heated at a temperature of about 80°C and left undisturbed for about 30 minutes at this temperature. The melted butter stratifies into three layers, viz., a top layer of floating denatured curd particles, a centre layer of fat, and a bottom layer of buttermilk. This separation of butter into layers is called as pre-stratification. The bottom layer of buttermilk contains 60-70 per cent of milk solids-no-fat and also over 80 per cent of moisture originally present in the butter. The buttermilk is mechanically removed without disturbing the top and middle layers. Afterwards, the temperature of remaining two upper layers is raised to the usual clarifying temperature of about 110°C and ghee prepared as discussed above for creamery butter method.

Advantages

- Economy in fuel consumption to an extent of 60 per cent as compared with direct clarification.
- The acidity of ghee is less, which results into longer keeping quality.
- Exposure to high temperature for lesser time.
- The amount of residue formation is reduced.

Disadvantages

- It is essentially a batch method unsuitable for continuous production of ghee.
- The flavour of ghee is very mild or rather flat.

v. Continuous Method

The batch methods for making ghee discussed earlier are highly suitable for small and medium scale production of ghee. With the increase in demand and scope for export of ghee, some very large organized dairies prefer to adopt a continuous ghee making methods. Some of the problems associated with the current batch methods of ghee making are:

- Unsuitable for large-scale production.
- High-energy consumption.
- Excessive strain and fatigue on the operators.
- Product exposed to the environment.
- Cleaning of equipment is done manually.

All the limitations of the conventional batch methods given above are obviated by continuous ghee making plants. These systems work on the basis of two principles, viz. (a) moisture evaporation from cream/butter using thin film scraped surface heat exchanger (TSSHE) and (b) de-emulsification of cream using high speed clarifixator and oil concentrator followed by moisture evaporation. The design, function and special feature of continuous ghee making units are discussed below:

TSSHE for continuous ghee making: Fig. 8.3 shows the schematic of TSSHE continuous ghee making unit. The white or cooking butter from continuous butter

melter is pumped in balance tank where it is kept agitated by means of agitator to maintain the homogeneity of molten butter. Then the butter is pumped to the TSSHE. The flow rate of molten butter is indicated by a rotameter and controlled with a value provided on the inlet line. The centrifugal action of the rotor blade make the molten butter spread uniformly in form of a film on the heating surface of the SSHE. Steam is admitted at regulated rate into the jacket of SSHE. The rate of evaporation of water from the butter film is very fast due to turbulence caused by the action of rotating blade. The speed of rotor blade is controlled by a motor drive. The vapour is removed through the outlet provided at the top of the SSHE and can be used for heating the butter in balance tank, thus economizing the steam consumption. The temperatures of molten butter and ghee are indicated by thermometers and adjusted by controlled steam supply with valves. Ghee is collected continuously in the ghee tank. The residue is separated from ghee by the oil clarifier. Residue free ghee is finally transferred to packaging line/tank.

Fig. 8.3: TSSHE Continuous Ghee Making System

Cream de-emulsification method*: This* method of continuous ghee making is based on the principle of de-emulsification of fat in cream from oil-in-water phase to water-in-oil phase. In this process milk is separated into cream of 40% fat using a centrifugal cream separator. This cream is converted into plastic cream of 80% fat in a clarifixator and then further concentrated in a concentrator, which work under centrifugal force. The de-emulsification of fat is done mechanically in the clarifixator and concentrator. Scraped surface heat exchanger is used to generate flavour and remove most of the moisture from fat concentrate. The traces of moisture left in ghee are removed in a vapour separator and the ghee residue removed by a oil clarifier. The flow diagram of the process is shown in fig. 8.4 below.

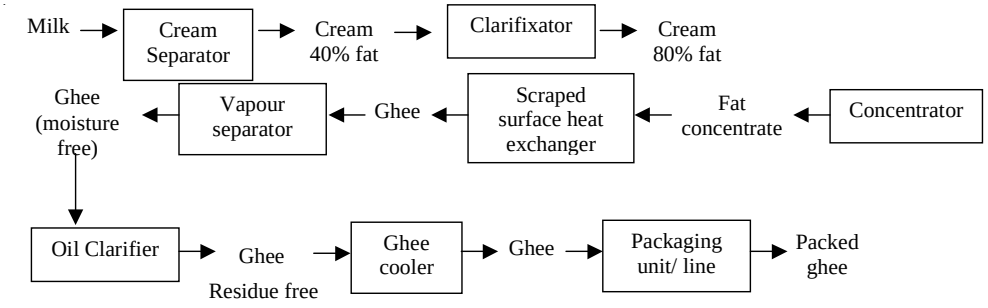

Fig. 8.4: Flow diagram of Ghee manufacture by Cream de-emulsification method

8.4 COMPARISON OF DIFFERENT METHODS

The important merits and limitations of each method of ghee making have already been discussed. The comparison of these methods on the basis of fat recovery and energy consumption, the most vital parameters for gauging efficiency of method is made here (Table 8.1).

Table 8.1 Comparison of different methods of making ghee

Method of ghee preparation	Fat recovery (%)	Items of fat loss*	Energy consumption (kCal/kg of ghee)
Indigenous method			
- Traditional	80	i) Ghee residue ii) Lassi	1700
- Improved	85	i) Ghee residue ii) Lassi	1500
Direct cream method			
- 40 to 50% fat	85	i) Skim milk ii) Ghee residue	1325
- 65 to 85% fat	95	i) Skim milk ii) Ghee residue	850
Creamery butter method	92	i) Skim milk ii) Butter milk iii) Ghee residue	525
Pre-stratification	92	i) Skim milk ii) Butter milk iii) Ghee residue	400
Continuous method	92	i) Skim milk ii) Butter milk iii) Ghee residue	325

Check Your Progress 2

1) Which method is most commonly used for manufacture of ghee by organized dairies? What are its main advantages?

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2) What do you understand by pre-stratification? Discuss the main benefits of adopting this method for making ghee.

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3) Which principles are involved in continuous manufacture of ghee? Write the benefits of continuous methods of making ghee over the batch methods.

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4) Comments on the recovery of fat in ghee prepared by different methods. What are the main points/items of fat losses during ghee making?

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8.5 METHODS OF MANUFACTURE OF BUTTER OIL

The following methods are used for manufacture of butter oil.

- Evaporation under vacuum.
- Decantation of molten butter.
- Centrifugal separation of butterfat followed by vacuum drying.
- Direct from cream by de-emulsification and centrifugation.

First three methods make use of butter as raw material.

i. Evaporation of Butter under Vacuum

This is a batch process and carried out normally under vacuum. Molten butter is taken in a vacuum pan and boiled under vacuum until moisture is completely removed. SNF (residue) is subsequently removed by physical or mechanical methods. Neither the efficiency of the process nor product quality are satisfactory in this method.

ii. Decantation

It is like pre-stratification method of ghee making, i.e. butter is heated to about 80°C, left undisturbed for some time. This results in the formation of three layers, viz. top scum, middle fat and bottom serum. The top layer and bottom layers are discarded and middle fat layer is separated and used as Butter oil. Fat recovery is less, hence method is uneconomical, especially when employed on a large scale.

iii. Centrifugal Separation followed by Vacuum Drying

This is a continuous method and produces a product of high quality. Invariably butter oil is prepared by this method. Flow diagram of centrifugal separation followed by vacuum drying method is given in Fig. 8.5.

Fig. 8.5: Flow Diagram of Butter Oil Plant

Butter (unsalted) is dumped in the butter melter, which is a vertical jacketed stainless steel tank fitted with an agitator. Hard butter is cut into small pieces before heating. Then steam valve is opened and agitator is started. The temperature of water in tipping tank is adjusted to 77 – 79°C with the help of steam and hot water is allowed to pass through the oil separator. Subsequently molten butter is allowed to go to tipping tank and oil separator. The rate of flow is so adjusted that there is no overflowing. The melt is separated into oil and serum.

The oil flows into the float controlled balance tank and from there into the vacuum pan due to suction. Here it is heated at 56-63°C under a vacuum of 56-62 cm Hg. All the moisture is removed from all the oil at this stage. At the end of operation, the vacuum is released and butter oil allowed to flow by gravity into the receiving kettle for subsequent cooling, packaging and storage.

iv. Directly from Cream by De-emulsification and Centrifugal Separation

The process utilizes the principle of de-emulsification of cream used in various continuous butter making processes. De-emulsified fat may then be melted and clarified by centrifuging and vacuum heating.

8.6 SETTING UP OF A GHEE REFINERY

Refinery is the place where refining of ghee is done. Refining as applicable to ghee is to improve its flavour, colour and appearance by adopting physical processes of heating and clarification of raw material and not by any chemical process. Normally raw (*Kachcha*) ghee or butter or cream collected from small producers is the raw material for refining.

i. Refining Facilities and Equipment

Building: Ghee refinery building should be spacious, having proper lighting and ventilation, and facilities for employees comfort and hygiene.

Ghee collection vessels: These are normally cylindrical vessels with handles and lids, used exclusively for weighing ghee. The capacity of the vessels is 100 and 200 litres.

Water bath: Water bath is used at several ghee refineries for melting the remnants of ghee adhering to the sides of the tins after emptying the *Kachcha* ghee in the heating pan. It shall be a shallow vessel with a flat bottom or a tray made up of mild steel.

***Heating pans* (*Karahis*/kettles)**: *Karahis* are used for heating butter, *Kachcha* ghee or cream. They shall be constructed with hemi-spherical, dished or conical bottom. The joints in the kettle shall be welded and finished smooth. Double jacketed tie table kettles with provision of heating by steam are preferred over *Karahis*.

Stirrers and scoops: Rods, preferably of stainless steel or aluminum alloy with flattened end on one side and wooden handle on other side shall be used for stirring butter/kachcha ghee/cream to prevent charring of casein and facilitate escape of moisture. For large size heating pans mechanical agitator may be used. The scum that rises on the top may be scooped out with metallic scoops.

Strainer: Before ghee is transferred from the heating pan to the settling tank, it shall be strained through a detachable strainer having an aperture width of not more than 14 mm. The strainer shall preferably be made of stainless steel.

Transfer device: Ghee shall preferably be transferred from the heating kettle through a stainless steel pipe and a stainless steel pumping arrangement.

Settling tank: A settling tank should be of the capacity in range of 500 to 6000 litres depending on the requirement. It shall be preferably of the cylindrical type with a conical or dished bottom with suitable arrangement for mounting. The interior corners shall be rounded off facilitating cleaning and complete drainage. The lid shall be in two or more parts and of overlapping type. A central outlet at the bottom of settling tank or a side outlet at a suitable height should be provided for completely draining the tank.

A centrifugal clarifier may also be used for clarification of ghee and the clarified ghee may be led to a tank similar to settling tank from where it can be drawn for filling into containers/packaging unit.

Heating source: The method of heating butter or *kachcha* ghee or cream depends on the scale of refining process. Small to medium sized refineries should built a furnace on which heating pans may be mounted. The furnace may be of the single pan or multiple pan type and made of firebrick and fire clay plaster. The fuel for such furnace may be smoke free wood or charcoal. Modern refineries with large capacity make use of steam heating for which necessary facilities, such as boiler, generator, etc. have to be installed.

Filling, sealing and seaming arrangements: Proper arrangement for filling of ghee, depending on the type of packaging system, sealing and seaming of the containers should be made.

Packing room: In the packing room, ghee is filled into tins, cooled for granulation, sealed and labelled. The room should be well ventilated and lighted and shall be insect proof and rodent free. The floor should be maintained dry and clean, and drippings while filling ghee shall not be allowed to spread on the floor.

ii. Method of Refining

Refining practices differ in different parts of the country but the basic principle and practices involved are the same. In some parts of the southern states, butter is generally the starting material for processing whereas in the northern and western parts of the country, it is *kachcha* ghee, which contains considerable amount of buttermilk and suspended solids, such as casein. The heating of butter of *kachcha* ghee is done in *karahis*/kettles to a certain temperature depending on the regions. The heating temperature in range of 110-115^{o}C (sometimes even upto 130^{o}C) is maintained for the consumers in the southern states so that mild to strong cooked flavour may be induced in ghee. On the other hand *kachcha* ghee is heated only to about 70^{o} to 80^{o}C to developed slight acidic to strong curdy flavour for the consumers of northern and western states depending on their preferences. The ghee so produced is transferred to settling tank, where kept undisturbed for 4-12 hours depending on the season. The clarified ghee is filled into tins adopting a suitable system.

iii. Reception of Raw Materials for Refining and Grading

All the butter, *kachcha* ghee or cream received at the refinery should be subjected to preliminary screening before it is accepted or rejected. Preliminary screening generally consists of only following three tests.

- Organoleptic examination.
- Butyro-refrectometer reading at 40^{o}C and
- Baudouin test.

In doubtful cases, the samples may be subjected to further tests, such as determination of Reichart value and polenske values, and free fatty acid content.

Check Your Progress 3

1) What are the uses of butter oil? List the various methods used for preparation of butter oil.

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2) Which is the most commonly used method of manufacturing butter oil? Write its flow diagram.

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3) What do you understand by ghee refinery? List the important facilities and equipment required for setting up a ghee refinery.

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8.7 LET US SUM UP

The principle of manufacture of ghee involves three step a) concentration of lipid phase by either centrifugal or gravity separation of milk into cream or cream and their churning into butter; b) heating of lipid rich phase to remove moisture and generate flavour, and c) removal of residue from pure ghee. Based on this principle five different methods are adopted to manufacture ghee in our country. These methods are: Indigenous (*desi*) method, Direct cream method, Creamery butter method, Pre-stratification method and Continuous method. Indigenous method is most important because 90% of ghee is produced by this method. It is adopted on a small scale in rural areas. Milk is converted into curd followed by its churning into *makkhan* and finally heating to obtain ghee. High fat cream (60-80%) is preferred in direct cream method. Creamery butter method is commonly used by organized sector in which cooking butter is boiled to get ghee. Pre-stratification method is highly energy efficient method, because by stratifying melted butter into three layers, a major portion of buttermilk is removed from it, thereby drastically reducing the heating time. The large organized dairies prefer to adopt continuous method owing to several benefits.

Most of the steps involved in the manufacture of butter oil are same as in case continuous ghee making except that moisture from fat rich source (cream or butter) is removed by heating under vacuum. Since very high heat treatment is not used for its preparation, the flavour of butter oil is mild or bland. The most common method of making butter oil involves concentration of fat in term of cream or butter, its de-emulsification and heating under vacuum to remove moisture.

8.8 KEY WORDS

Buttermilk : By product of butter containing all the milk solids similar to skim milk.

Churning : Agitation of curd or cream by either a agitator/ stirrer or in a rotating container (Churn) to destablize the fat emulsion for obtaining fat in continuous phase and moisture in discontinued phase.

Clarifixator : A centrifuge based on very high centrifugal force used for de-emulsification of fat emulsion.

Cooking butter : Plain butter containing neither colour nor salt, and used for making ghee.

Cream : The portion of milk in which fat has been concentrated either by gravitational or centrifugal separation.

De-emulsification : Destabilization (breaking) of fat globule membrane and converting lipid phase from 'oil-in-water' phase to 'water-in-oil' phase.

Emulsion : Emulsion are dispersed system, usually of two immiscible liquids when the outer phase consists of lipids and inner of water, as in case of butter, it is considered as an 'water-in-oil' type emulsion. In this emulsion fat is in continuous phase and water in discontinuous i.e. in form of fine droplets. The other type is oil-in-water in which outer phase is serum and inner is fat.

Ghee clarifier : A centrifugal machine used for obtaining pure ghee by removing all ghee residue or sediment.

Ghee residue : The brown curd (MSNF) portion left out when pure butter fat (ghee) separated. It is a by-product of ghee and contains fat, charred proteins, lactose and minerals.

Makkhan : Butter prepared by indigenous (desi) method, i.e by fermentation of milk into curd/*dahi* followed by churning.

Malai : Also called as clotted cream. This is also a fat rich portion obtained by gravitation from hot milk. When hot milk is left undisturbed, formation of a skin layer on the interface of milk and air take place. This is called malai.

Rotameter : A device used to measure the flow of fluids.

Scum : A mixture of curd particles and air normally accumulate on the surface when butter is melted.

Seaming : It is sealing or closing of lids on cans by double seamer.

Vacuum pan : A stainless steel pan fitted with steam heating coils to heat the fluids. Moisture is removed in this pan by boiling the fluid under vacuum. It is thus used for condensing of milk and other fluid foods.

8.9 SOME USEFUL BOOKS

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Rangappa, K.S. and Acharya, K.T. (1974). Indian Dairy Products, Asia Publishing House, New Delhi.

8.10 ANSWERS TO CHECK YOUR PRGRESS

Your answer should include the following points:

Check Your Progress 1

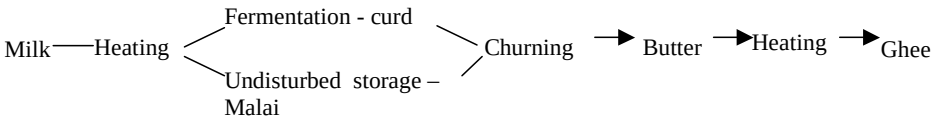
1) i. Manufacture of ghee is based on three principles, namely
   a. concentration of lipid phase
   b. heat clarification to remove moisture and
   c. removal of residue.

   ii. Methods of concentrating lipid phase for making ghee are
   a. Gravitational separation – malai
   b. Centrifugal separation – cream
   c. Churning – makkhan

2) i. Different method of ghee making are i) Indigenous (desi) method; ii) Direct cream method; iii) Creamery butter method; iv) Pre-stratification method and iv) Continuous method.

   ii. The most primitive method is *desi* method.

3) i. Fermentation - curd



   ii. Direct cream method involves separation of cream, preferably high fat (60-80%) by using a centrifugal cream separator, heating of cream at about 110°C to obtain ghee and removal of residue from ghee.

4) i. The limitations are:
   - Inconsistent quality of ghee in terms of organoleptic and chemical quality such as moisture, acidity, curd content, etc.
   - Recovery of fat is low.
   - Cannot be adopted for large scale production.
   - Keeping quality is low.
   - Ghee residue cannot be used.
   - Packing not done properly.

   ii. The limitations could be taken care by adopting improved practices such as:
   - Always pre-filter/strain milk before use.
   - Give suitable heat treatment, preferably boiling the milk before making *dahi*.
   - Cool milk to room temperature (22-30°C) and then add starter culture for *dahi* preparation. The setting of *dahi* should be done under controlled conditions. Incubate milk till *dahi* is set and desired acidity (0.80 per cent) is developed. It normally requires about 16-18 hrs in winter and 8-10 hrs in summer.
   - Churn *dahi* by electrically driven beater or butter churn.
   - Use cold water during churning in summer months to minimize the fat losses in buttermilk (*lassi*), thereby improving the fat recovery in ghee.

- Make ghee preferably from fresh *makkhan* or store *makkhan* in a refrigerator if it is to be converted into ghee after a long period. Don't store makkhan or ghee in earthenware or copper or iron containers.
- Heat *makkhan* (butter) at sufficiently high (more than 100°C) temperature for ghee making.
- Strain ghee properly so as to make it completely free from residue.

Check Your Progress 2

1) i. Creamery butter method is invariably used for manufacture of ghee by organized dairies.

   ii. The benefits of this method are: i) produces ghee of highly consistent quality; ii) quantity of ghee residue is less, hence fat losses are less; iii) less space is required for storage of cooking butter, the raw material for this method; iv) energy requirements are less than direct creamery and indigenous methods; and v) better keeping quality.

2) i. Melting of butter at about 80°C and undisturbed holding for 30 minutes results into three different layers of scum (top), butter fat (middle) and butter milk (bottom).This process of separating ingredients of butter is called as pre-stratification.

   ii. The benefits of pre-stratification method for making ghee are: i) lowest energy consumption; ii) longer keeping quality and iii) exposure to high temperature for less time.

3) i. Two types of continuous ghee making plants have been developed based on following two principles.

   - Use of thin film scraped surface heat exchanger for removal of moisture from cream or butter.
   - De-emulification of fat from oil-in-water phase to water-in-oil phase followed by fat concentration and moisture removal and generation of flavour in a scraped surface heat exchanger.

   ii. Advantages of continuous ghee making method are: i) large scale production possible; ii) low energy requirement; iii) labour requirement is very less; iv) product do not expose to environment and v) CIP (cleaning-in-place) possible.

4) i. Highest recovery of fat (about 95%) is possible in direct cream method, provided plastic cream is used. The recovery in creamery butter, pre-stratification and continuous method is almost similar (90-92%). Lowest recovery of fat in desi and direct cream (low fat) methods (80-84%).

   ii. The main points of fat losses in different methods are:

   - Desi method – buttermilk (lassi), ghee residue
   - Direct cream method— skim milk and ghee residue
   - Creamery butter method skim milk, buttermilk, ghee residue
   - Pre-stratification method skim milk, buttermilk and ghee residue
   - Continuous method skim milk, buttermilk ghee residue

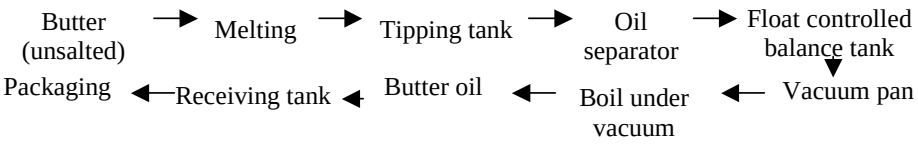
Check Your Progress 3

1) i. Butter oil is used for recombination purposes and as a source of fat in many food products, such as ice-cream.

   ii. Various methods that can be used for making butter oil are: i) evaporation under vacuum; ii) decantation; iii) centrifugal separation followed by vacuum drying and iv) de-emulsification of cream and centrifugation.

2) i. The most commonly adopted method is centrifugal separation followed by vacuum drying.

ii. Flow diagram of this method is:



3) i. Refinery is a factory/unit where the flavour and colour & appearance of *kachcha* ghee are improved by adopting physical methods.

ii. The facilities required in a refinery are: i) Refinery building including packaging room, toilets etc. ii) ghee collection vessels iii) heating pans/ kettles iv) water bath v) stirrers and strainers vi) settling tank vii) heating source and viii) filling, sealing and seaming machine.

UNIT 9 PACKAGING, STORAGE, KEEPING QUALITY EXTENSION AND ADULTERATION OF GHEE

Structure

9.0 OBJECTIVES

After reading this unit, we should be able to:

- Select suitable packaging material for ghee and butter oil.
- Identify the nature of spoilage (defects) in ghee and butter oil during storage.
- Increase the keeping quality of ghee by using different techniques.
- Detect adulteration of ghee with vegetable fats and oils.

9.1 INTRODUCTION

In the preceding units, we discussed that ghee is the most expensive dairy product, almost three times costlier than vegetable fats. It has several health benefits and many food applications. Above all, ghee is known for its typical aroma and creamy taste which can not be duplicated by any other fat or oil. The palatability of any food to which ghee is added increases to a very high preference level. These benefits can only be availed if ghee of good quality is prepared, packaged and protected from adulteration and spoilage. We shall discuss these aspects in this unit. The information on butter oil is also provided wherever relevant and necessary.

9.2 PACKAGING OF GHEE AND BUTTER OIL

i. Packaging Requirements

While selecting the packaging material for ghee, it should be carefully observed that

- the material does not react with ghee
- it is non-toxic and non-tainting
- easily available at low cost
- should have good resistance to rough handling

- does not allow tempering of ghee, and
- it prevents or delay spoilage of ghee.

With a view to select suitable packages for ghee, it is essential to know the method of handling, nature of spoilage, storage conditions and consumers' requirements/ choices. Ghee is prepared at a temperature of around 110°C at which most of the microorganisms and enzymes (lipase in particular) are eliminated and moisture content is left less than 0.5%; hence there is no microbial spoilage of ghee during storage. However, upon prolonged storage, ghee and butter oil undergo lipid deterioration resulting into either hydrolytic rancidity or oxidative rancidity defects. The selection of right type of packaging material can play a vital role in delaying the onset of these defects in ghee. The packaging materials being used for ghee and butter oil and that having great potential are discussed here.

ii. Packaging Materials

Tin plate containers: Majority of dairies in public as well as private sector are using lacquered or even un-lacquered tin cans of different sizes (250g to 15 kgs) for bulk and retail packaging of ghee. Some dairies sell loose ghee to local consumers through their sale depots or stores, where the possibilities of adulteration are fairly high. The advantages of using tin cans are manifold:

They protect the product against tampering.

Being sturdy, they can be transported to distant places without much damage and wastage during transport.

The oxygen content in ghee can be reduced in case of tin cans by either hot filling or minimizing the headspace thereby preventing/delaying the oxidized flavour defects.

Ghee packaged in tin cans normally has better developed grains.

The only draw back of tin cans is their high cost and involvement of foreign exchange.

It is very essential that tin cans be properly lacquered because rusted cans are liable to accelerate the lipid deterioration. BIS specifications for different sizes of tin plate containers are available for packaging of ghee.

Glass bottles: Though glass bottles provide excellent protection, they do not react with the food material and can be used for high-speed operations, but are not in much use for bulk or large size packaging of ghee because of their fragility and high weight. Since ghee is a expensive commodity and all consumers can not afford to buy large size packs, some of the ghee producers have started packaging ghee in glass bottles for retailers in sizes of 100g to 500g.

Semi-rigid containers**:** Of late, semi-rigid plastic containers are replacing tin plate containers. These are mainly made from high density polyethylene (HDPE). The advantages of using these containers are a) they provide a moderately long shelf life (not as long as tin cans), 2) are lightweight, economical and transport-worthy. These are of several types viz., blow moulded HDPE (high density polyethylene), PET (polyethylene terephthalate) bottles, PVC (poly vinyl chloride) bottles, and recently introduced bag-in-box systems, lines cartons and tetra packs. Blow moulded HDPE are, available in form of bottles (200, 400g), jars (1 kg and 2 kg), and jerry cans (2kg, 5 kg, and 15 kg). PET bottles have excellent clarity, are odour free and have gas barrier properties. All these semi-rigid containers have good scope for packaging of ghee and butter oil.

Flexible films/pouches: Flexible pouch may be made from laminates or multi layer films of different composition. The pouch may be in the form of pillow pouch or as stand-up pouches. Limited quantities of ghee are today packed in flexible pouches upto 1 kg. The most attractive feature of packaging ghee in flexible pouches is that they are cheapest than any other packaging system. The selection of laminate or a multi layer film is governed primarily by the compatibility of the contact layer, heat-sealing ability and heat-seal strength and shelf life required. The indigenously available flexible materials, which have very good values for the above, mentioned properties are HDPE, polypropelene, Al foil, Nylon 6, PVC, Saran, Polyester and numerous laminates of flexible films. Sachets made from a laminate of PVDC/ PVC Al foil/PP (polyvinyliedene chloride/aluminium foil/polypropylene) are suitable for long-term storage of butter oil and ghee.

iii. Filling and Sealing

While filling ghee and butter oil utmost care is taken to reduce the oxygen content in it. This can be achieved by

a) Filling containers up to brim, i.e. with minimum headspace.

b) Hot filling of ghee (preferably at 60^{o}C) reduces the level of dissolved oxygen by its continuous expulsion.

c) Application of vacuum packaging wherever possible or packaging in an inert atmosphere.

Check Your Progress 1

1) Which considerations are important while selecting packaging material for ghee and butter oil?

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2) Name the most commonly used packaging material for bulk packaging of ghee and butter oil. What are its benefits?

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3) Which cheaper packaging material do you suggest for retail packaging of ghee? Which properties you will look into while selecting such material?

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4) What precautions should be taken to minimize the level of oxygen in packaged ghee?

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9.3 STORAGE AND DEFECTS OF GHEE AND BUTTER OIL

The storage temperature of ghee in India ranges from 5 to 38°C depending upon the season of the year and region. Higher temperature of storage (> 30°C) accelerates chemical, particularly oxidative deterioration, whereas, the low storage temperature (< 10°C) though delays the chemical spoilage, it impairs the texture of ghee. At low temperature, ghee becomes greasy and pasty. Best temperature for storage of ghee and butter oil is between 20-30°C. The various defects normally encountered in ghee and their causes are discussed as below:

Acidic: Slight to moderate acidity in ghee, as produced by *desi* or indigenous method is highly desirable but too much acidity is considered as a defect. Use of raw materials, viz. milk, cream or cooking butter with high acidity along with high initial moisture in ghee is responsible for development of high acidity. This is not a very serious flavour defect.

Curdy: This flavour (referred as defect when pronounced intensity) can be found when cream or butter is undercooked during ghee preparation and all the SNF content (curd) not completely removed. *Kachcha* ghee prepared under rural conditions by heating *makkhan* or butter at low fire normally contains curdy and acidic flavour. Sometimes curdy defect resembles to acidic ghee. Ghee packers normally collect the *kachcha* ghee having either acidic or curdy flavour and convert it into good ghee by further heat processing.

Smoky: Use of smoky fire, such as of wood/animal dung, for making ghee is responsible for smoky flavour defect in ghee. Storage of ghee under smoky environment may also be responsible for absorption of this flavour. The intensity of this defect, however, decreases on storage.

Burnt: Heating of butterfat, particularly at the last stage of preparation, at a very high temperature (normally at about 125°C and above) is responsible for development of burnt flavour defect in ghee.

Flat or lacking: When there is no flavour in ghee it is criticized as bland or flat or lacking. Butter oil has typically this type of flavour. The use of butter having very low curd content, or maintaining low temperature of heating under vacuum are responsible of producing ghee with flat flavour. This type of ghee, though not completely rejected, but receives lower preferences by consumers.

Rancidity: This is the most serious defect of ghee. It is of two types, viz. hydrolytic and oxidative rancidity. Normally this defect develops in ghee during storage, but in case the raw material used for ghee making is rancid, the freshly prepared ghee will also have this defect. Rancidity in ghee is caused by the formulation of volatile compounds, which exhibit unpleasant odours even when present in small quantities. The nutritive value of ghee is also adversely affected due to rancidity in ghee. Milk fat hydrolysis is faster in liquid state than in solid state. Because of more solid fat in buffalo milk its rate of fat hydrolysis is slower than cow milk fat. Therefore, the cow ghee is more prone to developing rancid flavour during storage.

Hydrolytic rancidity: The fat splitting enzyme, lipoprotein lipase found in milk fat globule membrane, is responsible for hydrolysis of milk fat and production of lower molecular weight fatty acids (butyric, caproic and caprylic). These fatty acids, particularly butyric, impart rancid off flavour in ghee. During manufacture of ghee a very high heat treatment is employed which inactivates the lipase enzyme. Therefore, the hydrolytic rancidity, in ghee is not of much problem, provided raw material of good quality (having no rancidity) is used. Rancid flavour defect is found more commonly in butter oil.

Oxidative rancidity: Oxidation of butterfat (ghee) is a more common problem and caused by oxidation of poly-unsaturated fatty acids in presence of oxygen. The reaction of oxygen with poly-unsaturated fatty acids involves free radical initiation, propagation and termination. In ghee and butter oil the chain reaction is catalyzed by heat, light, ionization reaction and trace metals (copper and iron), etc. The end products of lipid auto-oxidation are ketones, aldehydes, alcohols, hydrocarbons, acids, epoxides, etc.

Greasy texture: Good quality ghee should have well developed and uniformly dispersed ghee grains. Improper storage of ghee, particularly frequent thermal shocks, destroys the granularity of ghee and causes greasiness. Prolonged storage of ghee under refrigeration also leads to developing greasy texture in ghee.

Note: Amongst the above-discussed defects, acidic, curdy, smoky and burnt are normally not encountered in butter oil, whereas flat or lacking is not a common defect of ghee.

9.4 MARKET QUALITY OF GHEE AND REGIONAL PREFERENCES

The organoleptic quality and physico-chemical properties of ghee offered for sale in the market are referred to as its market quality. The organoleptic quality includes colour, flavour and body and texture of ghee and is the index of consumers' acceptability and the market sale including price. The physico-chemical constants are the legal requirements (PFA rules) and are mandatory as far as marketing of ghee is concerned. The physico-chemical constants are affected by many factors and have been discussed in the unit 7. The desirable marketable attributes of good quality ghee are discussed here.

i. Colour

The colour of cow ghee varies from deep yellow to straw yellow while that of buffalo is white with a characteristic greenish tinge. Yellow colour of cow ghee is attributed to carotene, which is affected by many factors. The greenish tinge in buffalo ghee is attributable to bilirubin and biliverdin.

ii. Flavour

Ghee is greatly valued in our country for its characteristic flavour, which varies from region to region. It is mainly dependent on method of preparation. The flavour of butterfat, as observed in case of fresh butter oil is termed as bland. The typical ghee flavour may be due to a combination of diacetyl, carbonyls, free fatty acids, lactones, alcohols and other compounds generated due to fermentation and/or heating. The more pleasant flavour of ghee preferred by majority of Indian buyers is that produced by *desi* method. The flavour of ghee produced by all other methods is comparatively bland or cooked and less preferred in comparison to *desi* ghee.

iii. Granulation

The texture of ghee is an important quality attribute as far as consumer acceptability is concerned. Good quality ghee should have medium sized grains uniformly distributed throughout the lot. Granularity in ghee is considered by the average Indian buyer to be an index of purity in addition to the quality. Since butterfat is a mixture of triglycerides containing several types of fatty acids, the crystallization behaviour of ghee is very complex. There are several factors that contribute to the crystallization of butterfat and consequently to the grain formation of ghee. Proper control of these result in producing desirable texture in ghee.

Factors affecting granularity in ghee

Inherent factors: These include the type of milk, feeds and fodders, season, region,

etc. The presence of larger proportion of higher melting saturated fatty acids, especially palmitic and stearic results into large size grains, whereas low melting fatty acids and unsaturated fats either produce very small grains or no grains in ghee. All those factors that change the fatty acids profile in milk affect the granulation in ghee. Size of grains in buffalo ghee is larger (0.31 mm) than that of cow (0.24 mm) mainly because of higher proportion of long chain saturated fatty acids in the former. Feeding more of green fodder or on pasture produce higher amount of soft fats, whereas, feeding higher amount of dry feeds and cottonseeds impart bigger sized hard grains/crystals in ghee.

Temperature of clarification: Higher temperature of clarification gives better grain size as well as more number of grains.

Method of preparation: The desi method produces ghee with larger size uniform grains in comparison with industrial methods wherein creamery butter is used as a raw material.

Rate of cooling: It has been observed that heating ghee to 60-100^{o}C, followed by rapid cooling yields small grains in ghee. However, if ghee is gradually cooled to a temperature at about 1^{o}C above the crystallization point of ghee (cow ghee 29^{o}C and buffalo ghee 31^{o}C), bigger size grains are produced.

Storage temperature: Fluctuation in storage temperature deteriorates the grain distribution in ghee. Size and quality of grains in better at 28^{o}C than at storage temperature of higher than 35^{o}C.

Seeding: Seeding of ghee with grains of previous batch (1-2%) act as nuclei and develop desirable grains in ghee. The grains shape in this process is needle like as compared to that of spherical found in normal grains formation (without seeding) process.

iv. Regional Preferences for Ghee

Though ghee is consumed in all parts of India, the preference of consumers in different regions, in terms of flavour and texture, are not similar. These preferences are shown below in Table 9.1.

Table 9.1 Regional preference for ghee flavour and texture

Region	Flavour preference	Texture preference
Northern	Slight acidic; mildy curdy	Fine to medium size grains
Western	Mildy curdy, strong curdy in Saurashtra region	Coarse grains of 0.3 to 0.6 mm size.
Southern	Mildy to highly cooked aromatic, higher level of free fatty acids with herbs flavour in Tamil Nadu and Karnataka	Medium (Tamil Nadu) to large size grains (Andhra Pradesh & Karnataka)
Eastern	Mildy to definitely cooked	Medium grains

Check your Progress 2

1) What do you understand by market quality of ghee? Name the compounds responsible for flavour of ghee.

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2) Why granulation in ghee is important? Write the factors that affect granulation in ghee.

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3) Explain the meaning of regional preference for ghee. Which flavour in ghee is most preferred in which regions?

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9.5 KEEPING QUALITY OF GHEE AND BUTTER OIL

Ghee is expected to have the keeping quality of about 9 months on storage at about 21°C when packaged in rust free lacquered tin containers. The spoilage of ghee and butter oil results into:

- Production of objection off-flavour, thereby loosing the consumers' acceptability
- Adversely affect its nutritive value on account of
  - Loss of unsaturated (essential) fatty acids, and
  - Destruction of fat-soluble vitamins and carotene
- Formation of toxic products due to auto oxidation
- Loss of attractive colour

i. Factors affecting keeping quality

It is highly essential to identify the factors that influence the keeping quality of ghee and butter oil so that they can be effectively controlled during production and storage. Some of these factors are listed as below.

- Initial moisture content in ghee and butter oil
- Initial acidity in the products
- Amount of residue/sediment
- Oxygen content in packaged products
- Copper, iron and other catalytic salts
- Method and type of packaging
- Storage temperature
- Exposure to light

Under practical situation the moisture content in ghee and butter oil is about 0.2% (the extreme limit can be 0.5%) when properly processed. The higher moisture content is responsible for faster hydrolysis of fat and other deteriorations. Similarly higher initial acidity, oxygen content and presence of catalytic salts, which accelerate the fat oxidation, always increase the rate of spoilage of anhydrous milk fat. The spoilage of these butterfat products is also directly proportional to the storage temperature and prolonged exposure to direct sunlight.

ii. Extension of keeping quality of ghee and butter oil

The following approaches can be used:

Use of good quality raw material: Raw material used for the manufacture of

ghee and butter oil should be of good quality. Any off flavour, such as acidic, oxidized, and rancid present in raw material shall be carried over to the final product. The raw material should also be checked for the presence of copper and iron, which should not be more than permissible limits.

Method of manufacture of ghee: Ghee prepared by desi method has higher moisture and higher acidity and thus lower keeping quality. If ghee is to be stored for longer time than this method should be avoided. The sulphydryl and phospholipid contents have antioxidant properties in ghee and butter oil. Those methods, which releases higher amounts of these natural antioxidant components should be adopted. Heating butterfat with higher amounts of solids-not-fat, as in case of direct cream method, at higher temperature of clarification will produce more sulphydryl and thus better shelf life. Probably due to this reason the keeping quality of ghee is more than butter oil.

The pre-stratification method produces ghee with higher amounts of phospholipids because its loss in ghee residue is minimum. Also the extraction of phospholipids from ghee residue and addition @ 1 percent to the ghee enhance its keeping quality.

Addition of antioxidants: The antioxidants are added universally to anhydrous butterfat and high fat food products. There are two sources of antioxidants, namely synthetic and natural.

Synthetic antioxidants: These include

- Gallates (ethyl, propyl and octyl),
- Butylated hydroxy anisol (BHA)
- Butylated hydroxy toluene (BHT)
- Tertiary butyl hydro quinone (TBHQ), and many more.

PFA rules do not allow any synthetic antioxidant in ghee whereas permits the addition of gallates upto a level 0.01% and BHA & BHT upto 0.02% in butter oil .

Naturally occurring antioxidants: There are many plants and herbs, which have antioxidant properties and may be added particularly to ghee for extending the keeping quality. Some of the examples of such natural sources are as below:

– The seeds of soybean and safflower are rich source of phospholipids. Their addition to ghee and butter oil at 0.5% level during boiling may delay the oxidative rancidity.

– Juices of Amla (*Phyllanthus amblica*) at level of 1.25% in ghee can retard the fat oxidation possibly due to high content of ascorbic acid and gallate in amla.

– It has been found that addition of betel and curry leaves (at rate of 1% of ghee) during heat clarification of butterfat improves not only the oxidative stability but also colour and flavour of ghee. The antioxidant properties of these plants are attributed to their phenolic compounds, predominately hydroxy charicol. The betel and curry leaves also contain carotene and ascorbic acid, which have tendency to undergo oxidation by consuming all free oxygen that may be present in the head space of the ghee container.

Packaging and storage conditions: As discussed in preceding section of this unit (9.2.2), tin cans are best to protect ghee against oxidative spoilage. The reason being that hot filling of ghee is possible in tin cans, which will exclude most of the oxygen from the product and also enable to replace oxygen with nitrogen gas. The headspace in such containers can also be minimized. Ghee should not be exposed to direct sunlight or irradiation. It should preferably be stored at about 22^{o}C.

9.6 ADULTERATION OF GHEE

The market price of ghee is almost 3 times more than the price of edible vegetable oils/fats. The supply of ghee is also far short of its demand. These gaps between price and availability leads to several malpractices. Adulteration of ghee is more common malpractice in India because it will fetch more profit to the traders and also result into increased supply. Two types of adulterants are used in ghee:

i) Vegetable oils/fats, and

ii) Animal body fat

The adulteration of ghee can start at the stage of milk itself. Water emulsion of coconut, groundnut and other cheap oils are added to milk or cream. On souring and churning, these transfer to butter, and thus on boiling of butter or cream pass on to ghee.

i. Adulteration with vegetable oils/fats

The analytical constants of ghee, as discussed in the unit 7, cover a very wide range, permitting fairly high degree of adulteration while still keeping the constants within normal limits. The feeding of various oil cakes or oilseeds and even starvation (under feeding) can also alter the individual analytical characteristics of ghee as to bring perfectly genuine (pure) samples under suspicion of adulteration. Those vegetable oils/fats whose analytical constants are close to ghee and butter oil cannot be detected visually are preferred for adulteration. Coconut oil approaches closest to ghee as far as analytical characteristics (high polenske value and low sponification value, iodine value and butyro refractometer reading). In respect of physical resemblance, hydrogenated fats (edible vanaspati), particularly groundnut, is most preferred. Its melting point is slightly below 37^{o}C, has solid to semisolid consistency and even the characteristic granular appearance of ghee.

Realizing the problem of adulteration of ghee with vegetable oils/fats, the introduction of an easily detectable 'marker' in vanaspati has been made compulsory by the Vegetable Oil Products Control Order, which is under the control of Ministry of Food and Agriculture, Govt. of India. According to this order, vanaspati shall contain raw or refined sesame (til) oil not less than 5% by weight. The Baudouin colour test enables vanaspati containing sesame oil to be detected in adulterated ghee.

ii. Adulteration with animal body fat

Adulteration of ghee with animal body fat is not so common as with vegetable oil/fats. Tallow or other animal body fats obtained from slaughter houses are mixed with ghee in different proportions. The animal body fat being hard cannot be detected visually. The chemical characteristics of ghee adulterated with animal body fat falls within normal range of pure ghee, hence their detection is difficult. Further, it is found that ghee prepared from buffaloes fed with cotton seeds acquire analytical constants similar to those samples adulterated with animal body fat.

iii. Detection of adulterants in ghee

Several tests have been developed from time to time to detect adulteration of ghee with vegetable oils/fats and animal body fat. Under the PFA rules the Baudouin test, which should be negative is mandatory, whereas Agmark standards recommends that Baudouin test and Phytosterol Acetate test should be negative. There is no reliable simple method, which can distinguish genuine ghee from ghee containing as high as 20-30% animal body fats.

The Baudouin test for sesame oil consists essentially in treating the fat with concentrated hydrochloric acid and adding to the extract a 2% solution of freshly distilled furfural in 95% ethyl alcohol. Development of a permanent pink colour indicates the presence of sesame oil (alternatively vanaspati) in ghee. This test can detect upto 3% sesame oil in ghee.

The Phytosterol acetate test also detects the adulteration of ghee with vegetable oils. Ghee is an animal fat and contains cholesterol while all vegetable oils contain sterols of other types which are together termed phytosterol. This test will not detect the presence of animal body fat, such as tallow's and lards in ghee, since these also contain cholesterol. The acetate of these sterols have characteristic melting point. Admixture of phytosterol acetate with that of cholesterol sharply raises the melting points of the latter, permitting detection of vegetable oil in ghee. The sterols are obtained from ghee by crystallization from ethanol of the isolated unsponifiable matter. These sterols are then precipitated from ethanol solution as digitonides using digitonin. On boiling with acetic anhydride the corresponding acetates are obtained, and their melting points are determined. The average melting point of sterol acetate from ghee is about 114.6°C (range 112.7° to 116.4°C) whereas of vegetables fats always more than 125°C. If the observed melting point of a test sample is 117°C or higher, phytosterol from vegetable fat is assumed to be present and test is positive.

Recently many advanced and sensitive techniques, such as thin layer-chromatography, paper chromatography and gas liquid chromatography have been developed for detection of ghee adulteration, but these are expensive and time consuming.

Check Your Progress 3

1) What is the expected shelf life of ghee and butter oil? Write the nature of spoilage in these products during storage.

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2) Define keeping quality. What are the factors that affect keeping quality of ghee and butter oil?

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3) Discuss the role of antioxidant in extending keeping quality of ghee and butter oil. Which antioxidants are permitted in ghee and butter oil and at what level?

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4) Name the adulterants most commonly used in ghee. Which tests should be used to detach these adulterants?

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9.7 LET US SUM UP

The market of a brand of ghee is based on its overall quality, which the consumers receive. The organoleptic quality viz. colour, flavour and granularity, as well as physico-chemical constants of ghee are important parameters as far as its consumer

acceptance and purity are concerned. All attempts are, therefore, made to maintain the quality and purity of ghee until it reaches to the users. In this context, the first step is proper packaging of ghee. The packaging material should be such that it is tamper proof, does not affect the quality of ghee and properly protect the product from spoilage and rough handling. Various types of packaging materials used for ghee and butter oil are: tin cans, glass bottles, semi-rigid containers and flexible pouches. Tin cans, though most expensive, offer many advantages, hence used by many dairies for retail and bulk packaging. For retail packaging upto one kg, flexible pouches made up of different laminates are preferred because of least cost. While filling ghee and butter oil in containers all care should be taken to minimize oxygen content in the product as well as in headspace. The sealing/seaming of package must be perfect to avoid leakage.

Ghee and butter oil are stored at room temperature (21^{o}C is considered the most desirable). Higher temperature of storage accelerates the spoilage of these products whereas refrigeration storage makes ghee and butter oil greasy. Several defects such as acidic/curdy, burnt, smoky, bland, rancid and oxidized are found in ghee and butter oil. Some of these defects are common such as hydrolytic rancidity and oxidation and more serious. In fact, oxidation of fat is most common defect of ghee and butter oil and normally occurs during storage. It is due to oxidation of unsaturated fatty acids in the presence of oxygen and the reaction is catalyzed by catalytic salts. The breakdown products of oxidation deteriorates flavour, colour and nutritive value of ghee and butter oil. The use of two antioxidants, namely BHA and gallates are permitted by PFA rules in butter oil but none can be added to ghee. Some natural occurring antioxidants such as ascorbic acid, phospholipids, vitamin E, etc. can be added to ghee.

Ghee is an expensive commodity. So its adulteration with cheaper vegetable fats/ oils and animal body fat is another serious malpractice in our country. Baudouin test is mandatory as per PFA to detect adulteration of ghee with vegetable fat and the AGMARK grade recommends the use of Baudouin and Phytosterol acetate tests to detect presence of vegetable oils.

9.8 KEY WORDS

Anti-oxidant : Any substance (chemical or natural) when added to food, retard or minimize the oxidation of fat.

Auto-oxidation : A self-catalyzed oxidation reaction that occurs spontaneously in the food and once starts it will continue.

Hydrolysis : A chemical reaction in which water reacts with another substance and gives decomposition or other products.

Ionization : The process of adding an electron to, or removing an electron from, an atom or molecule so as to give a net charge.

Irradiation : Exposure of material to radiations specially ultraviolet rays, which convert ergosterol into vitamin D, destroys bacteria, bleaches fat and catalyze the oxidation of unsaturated fatty acids.

Keeping quality : Defined as the period between manufacture and retail purchase of a food product during which the product is of satisfactory quality.

Lacquered : Coating of tin cans with a substance made of

resin (e.g. epoxy phenolic resin), or similar material to prevent rusting.

Oxidation : A process involving addition of oxygen, loss of hydrogen; also a reaction involving loss of electron.

Palatability : Acceptability of a food, influencing the amount to be eaten.

Preservative : Any substance that prevents decomposition, fermentation, spoilage and decay of food products.

9.9 SOME USEFUL BOOKS

Anantakrishnan, C.P. and Srinivasan, M.R. (1964). Milk Products of India, ICAR Publications.

Aneja, R.P., Mathur, B.N., Chandan, R.C. and Banerjee, A.K. (2002). Technology of Indian Milk Products, A Dairy India Publications, Delhi.

De, S. (1980). Outlines of Dairy Technology, Oxford University Press, New Delhi.

Rangappa, K.S. and Acharya, K.T. (1974). Indian Dairy Products, Asia Publishing House, New Delhi.

9.10 ANSWERS TO CHECK YOUR PRGRESS

Your answer should include the following points:

Check Your Progress 1

1) i. Since ghee is an expensive dairy product, due considerations should be made while selecting packaging material.

ii. The type of packaging material should also be decided keeping in mind whether ghee is packaged for retail or bulk marketing

The packaging material should have following properties:

- non-reactive to ghee
- non-toxic and non-tainting
- easily available at low cost
- must properly protect the product from tampering, sunlight, oxygen transmission, etc.
- should withstand rough handling

2) i. Lacquered tin cans of normally 15 kgs size are most widely used for packaging of ghee and butter oil for bulk marketing.

ii. The benefits of packaging ghee in tin cans are:

- They are sturdy, so can be transported to distance places and with stand rough handling.
- Protect the product against tampering,
- Completely impermeable to oxygen and moisture gain and loss.
- Oxygen content in product can be reduced to minimum, also inert or nitrogen gas packaging is possible
- Shelf life is more
- Granulation is better in ghee packaged in tin cans.

3) i. Flexible pouches made up of laminates of multi layer films are very suitable for retail packaging of ghee upto 1 kg size.

ii. A laminate of polyvinylidene chloride/Al. foil/ poly propylene is highly suitable for long term storage of ghee and butter oil.

4) i. The following preventive steps can be taken during packaging to minimize oxygen content in ghee and butter oil.

- Leave minimum headspace
- Hot filling of ghee
- Packaging under vacuum or inert environment

Check Your Progress 2

1) i. The organoleptic quality and physico-chemical constants, which are important for sale of ghee from consumers' point of view and from legal requirements, respectively are termed as market quality.

ii. The flavour of ghee is bouquet of many compounds generated due to fermentation and/or heating, namely diacetyl, carbonyls, free fatty acids, lactones, alcohols, etc..

2) i. Granulation in ghee is important from consumer point of view. Granularity in ghee is considered by an Indian buyer as an index of purity and quality.

Following factors affect the granularity in ghee:

- Inherent factors i.e. fatty acid profile and all those factors that affect it.
- Method of preparation.
- Temperature of clarification.
- Rate of cooling.
- Storage temperature.
- Seeding

3) i. Consumers of different region prefer different types of ghee in respect of flavour and texture. This is called as regional preference for ghee.

- Northern region – Slightly acidic to mildly curdy ghee is preferred.
- Western region – Mildly curdy; strong curdy in Saurashtra region (Gujarat).
- Southern region – Mildly to highly cooked.
- Eastern – Mildly to definitely cooked.

Check Your Progress 3

1) i. Ghee of good quality is expected to have a keeping quality of 9 months at 21°C. In case of butter oil the shelf life is slightly shorter (by about one month). The keeping quality decreases proportionally to temperature increase.

ii. Spoilage of ghee during storage causes following changes:

- Decrease of nutritive value due to loss of essential fatty acids, fat soluble vitamins and carotene.
- Production of objectionable off-flavours (such as rancid, oxidized).
- Formation of toxic substances.
- Loss of attractive colour.

2) i. The keeping qualify of ghee or butter oil is defined as the period between manufacture and its retail purchase during which the product is of acceptable quality.

ii. There are numerous factors that effect the keeping quality of ghee and butter oil. Some of these are:

- Initial quality of products in terms of moisture and acidity.
- Oxygen content in headspace and in the packaged products.
- Presence of copper and iron salts.
- Method of manufacture and packaging.
- Storage temperature.
- Exposure to sunlight.

3) i. Antioxidants play a significant role in retarding the lipid oxidation reaction in ghee and butter oil. The main role of an antioxidant is termination or delaying free radical chain reaction by acting as hydrogen or electron donor to free radicals, which result in the formation of more stable products. This group of antioxidant is called as primary antioxidant.

ii. The other group i.e. synergistic antioxidant, utilize the available free oxygen in a good system and thus retard the initiation of lipid oxidation. In ghee no synthetic antioxidant is permitted as per PFA. But some plants/herbs having antioxidant substances such as curry and betel leaves, safflower and soybean oils (0.5% level) and juice of amla can be added. BHA @ 0.02% and gallates (propyl, ethyl etc.) @ 0.01% antioxidants, may be added to butter oil as per PFA rules.

4) i. Ghee is normally adulterated with either vegetable fats/oils or animal body fat (tallow or lard).

ii. Baudouin test and phytosterol acetate test are used for detection of vegetable oils/fats in ghee.

iii. Detection of animal body fat upto a level of 20-30% is difficult to be detected by a chemical method.

UNIT 10 LOW-FAT SPREADS

Structure

10.0 OBJECTIVES

After reading this unit you should be able to:

- define a low-fat spread;
- enumerate different types of spreads;
- specify ingredients required for spread-making;
- give methods of manufacturing spreads;
- indicate factors affectly quality of low-fat spreads.

10.1 INTRODUCTION

The current generation of dairy products contains those that have been functionally improved by enhanced formulation of the conventional products. The functionality

may be based on physiological or health considerations, or may have physical implications relating to convenience of use. This new type of products is deriving impetus from the consumer focus on health and well-being as well as convenience. New products formulation/development may also be governed by the consumer's needs and desires such as extended shelf life, low cost, added flavour/texture appeal and other sensory quality improvements. Demand for special foods on account of dietary reasons is also increasing, more so because of the implication of high-fat dairy products like cream, butter, ghee, etc. in health problems. Butter is one of the important dietary dairy products in India as well as countries advanced in dairying. However, in recent years consumption of butter in most advanced countries has declined because of the following reasons:

- Very poor spredability at temperatures below 15^0 C
- High cost
- High saturated fatty acids content
- High cholesterol content
- High caloric value
- Suspected role in heart diseases and medical recommendations aimed at promoting the consumption of more unsaturated fat.

Consumer awareness and the resulting demand for new products which have solutions to the problems associated with butter consumption has opened space for dairy manufacturers to introduce 'modern' products. This has led to emergence of new categories of dairy products including "low fat spreads".

A 'spread' (or 'table spread') may be defined as a product, semi-solid in nature, characterized by adequate 'stand-up' ability (i.e. capacity to support its own weight) and yet be 'spreadable' on a bread slice or toast with moderate effort. Such a 'plastic' product usually has a wide 'plasticity range' i.e. it will retain its form or shape at normal ambient temperature (or, room temperature) and also be pliable enough 'directly out of refrigerator', refrigeration being the commonly required storage condition for such products.

A 'low-fat spread', as the term indicates is a spread with a fat content appreciably lower than the normal one (which is 80% in conventional table butter). Although the fat content may vary over a wide range low-fat spreads often contain about half the fat content of butter or margarine (a butter-like product obtained essentially from vegetable oils/fats) i.e. approx. 40%. Such spreads may be obtained solely from milk fat ('dairy' spreads) or from vegetable fats and oils ('non-dairy' spreads) or a blend of the two ('mixed' or 'blended" spreads). A 'cheese spread' is also a dairy spread, but is not a 'fat spread' as it is rich more in non-fat solids than in fat, and is characterized by a 'cheese' flavour and an 'oil-in-water' (O/W) emulsion (where fat is dispersed as droplets in a continuous aqueous or water phase carrying the non-fat solids). Most low-fat spreads (fat content, more than 15%), whether 'dairy' or 'non-dairy' type, are 'water-in-oil' (W/O) emulsion, though 'very-low-fat' spreads may be of O/w type. The first low-fat spread was developed and marketed in UK during 1968.

Low-fat dairy spreads are variously designated as 'half butter', 'half-fat butter', 'low-calorie spread', 'reduced-fat butter', 'low-fat butter' etc. Low-fat spread in which caloric reduction is less than 33% are sometimes termed as 'reduced-calorie' spread.

10.2 DEFINITION OF A FAT SPREAD

According to PFA, a 'fat spread' means a product in the form of a water-in-oil emulsion of an aqueous phase and a fat phase of edible oils and fats excluding

animal body fats. It may be a 'milk-fat' spread (fat content, exclusively milk fat), 'mixed-fat' spread (based on a mixture of milk fat and one or more of hydrogenated or un-hydrogenated refined edible vegetable oils or interesterfied fat), or a 'vegetable fat' spread. A fat spread may contain edible common salt not exceeding 2% by weight in the aqueous phase; milk solids-not-fat, lactic acid, butyric acid, valeric acid, cinnamon oil and ethyl butyrate as flavouring agent up to 0.08% by weight; diacetyl may be added as flavouring agent not exceeding 4.0 ppm; permitted emulsifiers and stabilizers; permitted antioxidants (BHA or TBHQ) not exceeding 0.02% of the fat content of the spread; permitted class II preservatives, namely sorbic acid and its sodium, potassium and calcium salts (calculated as sorbic acid), or benzoic acid and its sodium and potassium salts (calculated as benzoic acid), singly or in combination, not ex-ceeding 1000 ppm by weight; and sequestering agents. It may contain annatto and/or caro-tene as colouring agents. It shall contain starch not less than 100 ppm and not more than 150 ppm. It shall be free from mineral oil and wax. Vegetable fat spread shall contain raw or refined sesame oil (*Til* oil) in sufficient quantity so that when separated fat is mixed with refined groundnut oil in the proportion of 20:80, the red colour produced by Baudouin test shall not be lighter than 2.5 red units in 1 cm cell on the Lovibond scale.

It shall also conform to the following standards:

i) Fat - Not more than 80% and not less than 40% by weight.

ii) Moisture - Not more than 56% and not less than 16% by weight.

iii) Melting point of ex-tracted fat (capillary slip method) in case of vegetable fat spread - Not more than 37^0C.

iv) Unsaponifiable matter of extracted fat

   a) In case of milk-fat and mixed-fat spreads - Not more than 1.0 % by weight.

   b) In case of vegetable fat spread - Not more than 1.5%

v) Acid value of extracted fat - Not more than 0.5.

The vegetable fat spread shall contain not less than 25 IU synthetic vitamin A per gram at the time of packaging and shall show a positive test for vitamin A, when tested by antimony trichloride (Carr-Price reagents as per IS 5886-1970).

10.3 CLASSIFICATION OF FAT SPREADS

In general, spreads are classified on the basis of the *origin or type of fat* and *level of fat*. The European Community Commission (ECC) classified fat spreads into different categories on the basis of fat level as shown in (Table 10.1). ECC permits the use of animal body fats as wells as marine oils, and designates 3 types of spreads with 6 different fat levels. Codex specifications for fat spreads are under revision along these lines. AGMARK identifies two grades of fat spreads (milk-fat spreads, mixed-fat spreads and vegetable-fat spreads): 'Medium-fat' (60.1 – 80.0% fat and 16.0 – 36.0% moisture) and 'Low-fat' (40.0 – 60.0% fat and 36.1 – 56.0% moisture).

Table 10.1: ECC classification of fat spreads (Tentative)

Fat %	Type of the fat component		
	Milk fat	**Non-milk fat**	**Blends**
	Exclusively milk fat	Any animal or vegetable fats; milk fat not more than 3%.	Any animal or vegetable fats; milk fat between 10 and 80% of total fat.
80-90	Butter	Margarine	Blend
> 62 - < 80	Dairy Spread	Fat spread	Blended spread
60 – 62	Reduced-fat butter/ three-quarter butter	Reduced-fat margarine/ three-quarter margarine	Reduced-fat blend/ three-quarter fat blend
> 41 - < 60	Reduced-fat dairy spread	Reduced-fat spread	Reduced-fat blend
39 – 41	Low-fat butter/half fat butter	Low-fat margarine/ half fat margarine	Low-fat blend/ half fat blend
< 39	Low-fat dairy spread	Low-fat spread	Low-fat blended spread

10.4 SALIENT FEATURES OF LOW-FAT SPREADS

In addition to its low fat content, spreadability and organoleptic quality are two important properties of a low-fat spread.

i. Spreadability

One of the most important properties of spreads from the consumer's viewpoint is spreadability. It is desirable that product should be spreadable at refrigeration temperature i.e. 5^0C. To attain such a state of plasticity in a product, there are three essential requirements:

- There must be two phases, solid and liquid.
- The solid phase must be so finely dispersed that the crystal mass is held together by lateral cohesive forces.
- There must be a proper proportion between the solid and liquid phases. If the spread is deficient in solids, not enough crystal will be present to hold the liquid oil. This is noted when product oozes out oil. If the solids content is too high, the interlocking crystals, coupled with insufficient liquid, will cause a brittle texture (breaking into pieces).

ii. Organoleptic properties

The organoleptic attributes of the spread are influenced by (besides the flavour of the raw materials used):

- Melting profile of the fat.
- Lightness of the emul-sion.
- Storage condition of the finished product.

The other important oral quality aspect called "coolness" is the coldness felt on the tongue, when fat crystals melt at nearly the same temperature, absorbing heat during dispersion in the mouth. The droplet size (in an O/W spread) also affects oral properties of the aqueous phase and it should be uniformly small. A mar-garine

in which about 95% of the droplets has a diameter of 1-5 micrometers and 4% of 5-10 micrometers and 1% of 10 - 20 micrometers is described as 'light on the palate'.

Check Your Progress 1

1) Define 'Dairy Spreads'.

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2) What do you understand by a 'Low fat spread' (LFS)?

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3) State the advantages offered by an LFS over the conventional table butter.

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4) Classify spreads on the basis of origin of fat.

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5) What is spreadability?

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6) State the essential requirements for the desirable plasticity/ spreadability in a low fat spread.

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10.5 INGREDIENTS OF LOW-FAT SPREADS

The technology of low-fat spread manufacture has two salient aspects: Selection of ingredients, and processing. The important constituents of spreads are fat, (milk) proteins, stabilizers, emulsifiers, emulsifying salts, acidulants, common salt, colouring and flavouring materials, vitamins, preservatives/ antioxidants, etc. Each ingredient has specific importance in production of a good-quality spread.

i. Fats and Oils

Fat is a major ingredient of a low-fat spread. The main functions of fat are:

- To provide structure, texture and taste including creaminess.
- To act as a carrier of flavour and vitamins
- To serve as a source of energy and essential fatty acids.

The physical properties of spreads, namely, spredability, firmness, plasticity and thixotropy are mainly determined by the ratio of liquid to solid fat content. For low-fat *dairy spreads*, sources of milk fat include cream, butter and butteroil of ghee. A somewhat better product in terms of body and texture characteristics can be obtained with the use of cream in place of butter for spread manufacture. To obtain 40 % fat in the finished product, cream having 65-67 % fat content is necessary. Since cream contributes substantial amount of milk solids-not-fat (MSNF), quantity of additional protein/MSMF required is generally less with cream based spreads. Cultured cream imparts butter flavour and desirable spredability to the spread. It also imparts a softer texture to the spread. Use of butter gives less oiling off and a pleasing, characteristic butter flavour as compared to butteroil. It gives firmer body than cream. Equal quantity of butter and 40% fat pasteurized cream can be used as a source of milk fat in a 60% dairy spread. Use of butteroil simplifies compositional control because the gross composition of butteroil is reasonably constant, being almost 100 % fat. The use of butteroil is recommended in case of unavailability of butter, as it offers ease in tempering and re-pasteurization just prior to use in spread-making, which help in improving the bacteriological quality of the product. However, butteroil has a tendency to yield product with more oiling off and less tight structure than that with butter. Spreads with a stable emulsion can be prepared using 35 to 40% fat. Low-fat dairy spread with milk fat content below 35% may have a weak body and inferior spredability in addition to poor flavour.

Fats sources other than milk fat include vegetable oils such as corn, safflower, sunflower, soybean, and groundnut oils. These oils used in combination or singly, are usually subjected to partial hydrogenation prior to use. Health considerations favour use of monounsaturated (oleic-acid) fats/ oils such as groundnut (or, peanut), sesame and canola (rapeseed) oils. Olive oil would be the most desirable but it is rather expensive. At present most spreads available in the North American and European markets contain 17-33% saturated fat, 22-50% mono-unsaturated fat and 26-45% polyunsaturated fat.

The fat phase of non-dairy spreads comprises unhydrogenated and partially hydrogenated oils. However, hydrogenated fat is regarded as an unhealthy fat because of its ‘trans’ fatty acids (e.g., elaidic acid) content. In view of this ‘interesterified’ fat with the desired plasticity but without trans fatty acids has been found more desirable.

Another health-related feature of newer spreads is fat containing omega-3 fatty acids which is found in appreciable concentrations (6-10%) in fish oils, walnut oil, mustard (or, rapeseed) oil and soybean oil. Phytosterol (plant sterols) added as an additive and/ or in the form of oils containing the same (e.g. rice-bran oil) is also considered to make low-fat spreads more heart healthy.

ii. Protein Products

Milk proteins are generally added to dairy and non-dairy spreads for their organoleptic, functional and nutritional properties. They impart a creamy taste contribute viscosity and water holding capacity to the aqueous phase, thereby improving emulsion stability during processing and storage. The main sources of proteins are skim milk, buttermilk, caseinate and whey solids. Use of ripened cheese in fat spreads would not only provide easily digestible protein but also help in imparting *cheese flavour* to the product. Skim milk and butter milk are used as such or in a concentrated or dried form.

Condensed skim milk produces spread with a firm body and least wheying off. Skim milk powder (SMP) also yields a product with good body and water retention properties. Spread prepared using calcium-reduced SMP has a very strong water binding characteristic. Use of sodium caseinate imparts a soft body to the spread without causing wheying off. The caseinate can be used for both moisture retention and emulsion stability. However, use of excess (e.g. 1.5%) sodium caseinate imparts a 'gluey' taste to the product.

Milk protein concentrate derived from skim milk or buttermilk by ultrafiltration (UF) can be used to ensure formation of desired structure and binding of water. Buttermilk protein together with the butteroil gives a butter-like flavour to the product. In comparison to SMP, butter milk powder is superior in terms of both taste and emulsifying ability.

Use of whey solids in spreads may cause a problem of lactose crystal formation. Cheddar cheese whey powder promotes softness in the product and excludes free whey during thawing. Use of whey protein concentrate (WPC) prepared by UF also improves the body of the product with the least wheying off.

Among vegetable protein products, soy protein isolates have been frequently used in manufacture of spreads because of high water holding capacity and high protein quality. It can be also used in the form of protein-lipid concentrate so as to utilize the polyunsaturated soy oils as well.

The proportion of fat and MSNF influences the quality of a spread. An increase in fat/SNF ratio results in increased wheying off and decreased body strength. Milk protein in the form of MSNF can be used at the level of 5-15 %.

iii. Emulsifiers and Emulsifying Salts

In order to get a stable emulsion, various emulsifiers are also employed in spread-making. Emulsifiers yield a softer and more easily spreadable product with a stable emulsion. It improves the mouth-feel of the product. Various emulsifiers are used in spreads, e.g., monoglycerides (MG) of saturated and unsaturated fatty acids, egg yolk solids, lecithin, combination of lecithin and MG, hydrophobic compounds such as methylated silicon oxide, etc. The level of emulsifiers in spreads may vary from 0.1 to 0.6 %.

Chelating or sequestering agents (i.e. chemicals that bind calcium and magnesium), also known as 'emulsifying salts' include tri-sodium citrate, di-sodium phosphate, etc. These are used either singly or in combination usually at the rate of 1 to 4 % to improve the emulsification by proteins, and enhance the texture of spread, especially of the O/W type.

iv. Stabilizers

A low-fat spread with a moisture content of 30-50% has a tendency to wheying off (or, syneresis), and exhibits poor body and consistency in absence of suitable stabilizers. The high water-holding ability of stabilizers plays an important role in improving body and texture of products. They yield an emulsion that gives good melt-down in the mouth and consequently, rapid flavour release with a satisfying cooling effect. Various stabilizers such as gelatin, carboxymethylcellulose (CMC), starch, modified starch, sodium alginate, xanthan gum, carrageenan, pectin, gum acacia, etc. can be used individually or in combination at the rate of 0.1 to 0.5 %.

v. Plasticizers

Plasticizers like glycerol, sorbitol, glycol, etc may be used in spreadable products to improve their pliability or plasticity. They also depress the water activity of the aqueous phase. This may help in extending the shelf life of the product. Addition

of glycerol and sorbitol at the rate of 0.5-1.0 % in low fat spreads improves the mouth-feel and spreadability.

vi. Acidulants

Spreads, in general, have low a storage stability owing to their high moisture content. Acidification of the product helps in extending the shelf life as well as enhancing the flavour. The pH may be reduced to 4.8 to 6.0 with the use of different acidulants such as citric acid, lactic acid, ascorbic acid, and phosphoric acid. Addition of lactic acid improves the body and imparts a slightly tart flavour to the spread. Very low pH would, however, cause more wheying off. Best body and least syneresis can be obtained with pH from 5.7 to 5.9 in most spreads.

vii. Colouring matter

In order to make the spread visually attractive, two types of colour, namely anatto and b-carotene are added. O/W -type spreads require water-soluble annatto colour (anatto cheese colour), whereas W/O spreads require oil soluble anatto colour (anatto butter colour). Use of b-carotene enhances not only the nutritive value but also the oxidative stability of the product. Anatto colour can be used in low-fat spreads at the rate of up to 0.3%. Butter annatto is usually added to the fatty phase.

viii. Flavouring Agents

A spread without added flavouring often tastes rather bland. Hence, it is necessary that external flavourings are added. Use of butter starter distillate, synthetic butter flavour, diacetyl, phenols, ä-lactones, etc. have generally been found to effectively simulate the desired butter flavour. Diacetyl (0.5 – 2 ppm) is the most frequently used flavouring. A suitable dairy culture (starter) can be used @ 1% in spreads to give a mild, ripened flavour, acceptable to most people. Cultured buttermilk solids have an advantage of imparting a diacetyl aroma to the spread.

ix. Common salt

Sodium chloride or table salt is usually added to spreads. It provides taste and palatability to the spread and also retards the growth of bacteria, thereby acting as a preservative. Generally, the salt content in low-fat spreads varies from 0.25 to 2 %. Cheese-flavoured spreads involve the use of cheese flavour concentrate, aged Cheddar cheese, or blue cheese. Addition of melted cheese as a protein ingredient as well as flavouring material can yield a low fat spread with high overall quality. Other flavourings like herbs, garlic, chocolate, vanilla, honey, nuts, etc. can be used to enhance the acceptability of low-fat spreads.

x. Preservatives

In general, high-moisture foods such as spreads have low stability against microbial spoilage. In order to inhibit the growth of spoilage organisms including yeasts and molds, various preservatives may be added besides following an appropriate heat treatment. Sorbic acid and its salts, nisin, propionates, benzoic acid, sodium benzoate, etc. can be added upto 0.1 % to extend the shelf-life of spreads.

xi. Other additives

Other additives like anti-oxidants, vitamins, sweeteners, etc. are sometimes incorporated into low-fat spreads. Use of certain antioxidants like nordihydroguaratic acid (NDGA), hydrophobic metal oxide or methylated silicon dioxide, and alcohol etc. have been suggested to prevent oxidation of fat during storage. Spreads are often fortified with vitamins to enhance their nutritional value. These vitamins include ascorbic acid, vitamin A (3000 IU / 100 g) and Vitamin D (300 IU / 100 g).

Check your Progress 2

1) State the function of fat in the low-fat spreads.

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2) What are the sources of fat and protein used in low -fat spreads?

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3) State the significance of salt and preservatives in a low-fat spread.

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4) Explain the importance of emulsifiers in spread-making.

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10.6 PRINCIPLE AND METHOD OF MANUFACTURE

As compared to conventional butter (80% fat), low-fat dairy spreads have much reduced concentration of fat and correspondingly increased level of non-fat constituents viz. water and non-fat milk solids. This altered composition, together with additives, imparts the desired spreadability to the product. In case of non-dairy and mixed spreads blending of liquid and solid fats and the use of other ingredients results in the required plasticity properties. Further, the emulsification and fat-crystallization processes in spread-making ensure the desired body and texture characteristics. Thus, the formulation and processing of spreads generally determine the final product characteristics such as appearance, spreadability and keeping quality.

Processing basically comprises preparation of aqueous and fat phases and their mixing, emulsification, cooling/crystallization, working, filling, packaging and setting. Heat treatment is given to the separate phases prior to blending and/or to the blended mix. As there is a wide range of spread formulations and these could be either an O/W or W/O type emulsion, the processing protocol will largely depend on the type and level of ingredients to be used as well as the kind of emulsion desired. Accordingly, for most O/W type spreads homogenization of a hot spread mix using a pressure homogenizer or a colloid mill or a similar device followed by cooling and fat crystallization, whereas in order to obtain a W/O type spread the finishing steps are usually cooling, crystallization, working and pre-packaging or post-packaging setting. Thus, spread processing is specific to the finished-product formulation. An example of the spread-manufacturing method is shown in Fig. 10.1.

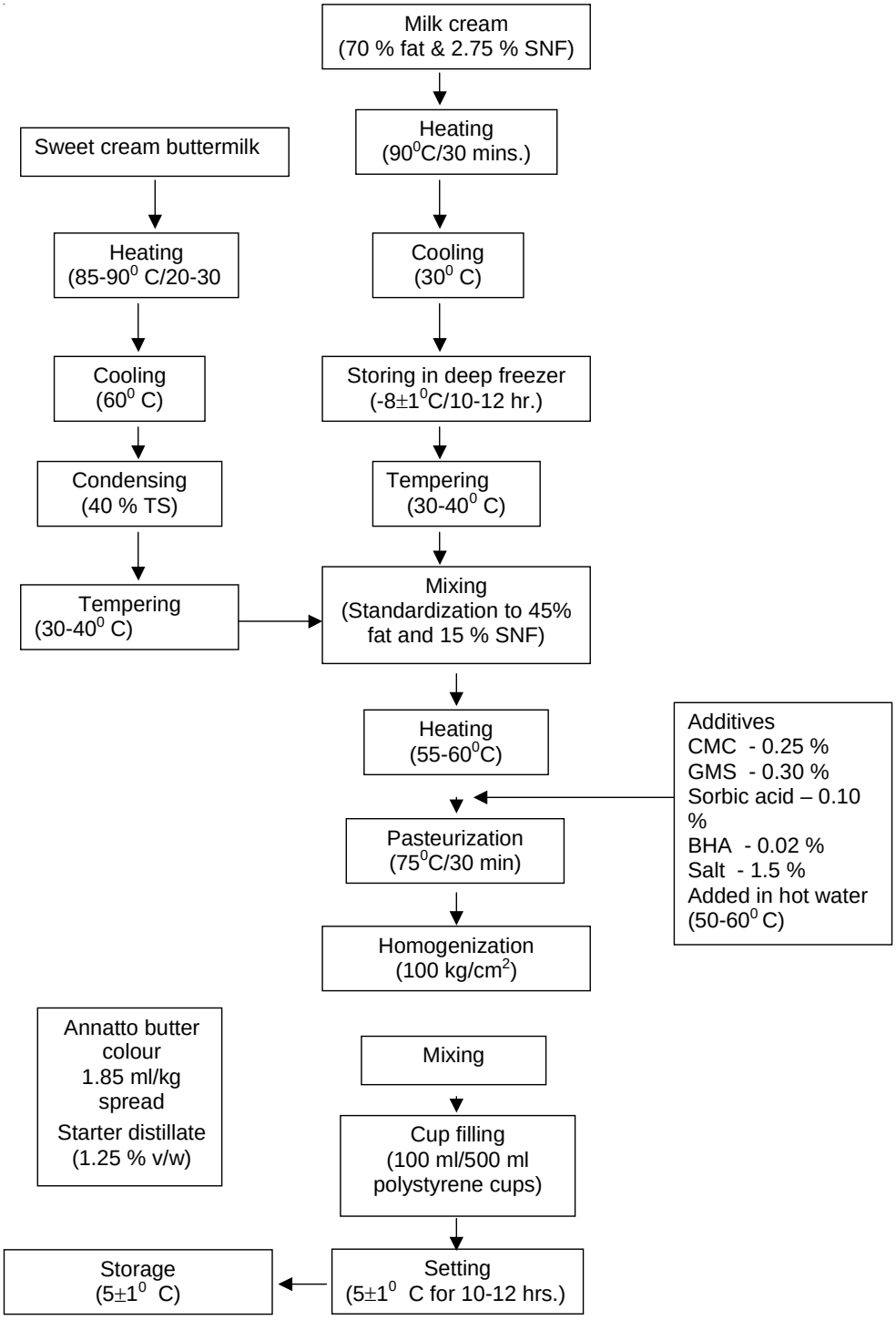

Figure 10.1: Schematic Diagram of Manufacture of Low Fat Butter Spread

i. Preparation of the Aqueous Phase

Aqueous phase preparation involves dissolving/dispersing of water soluble ingredients namely, protein product, stabilizer, salt, etc. in water or the aqueous medium to be used. Blending temperature between 40-80°C is generally used for faster dispersion and solubilization of ingredients. Cultured buttermilk or synthetic flavour or starter distillate should be incorporated at the end of heating to minimize loss of volatile flavour. Treatments like pasteurization (75-95°C for up to 30 min) and cooling are commonly followed for the aqueous phase before addition/blending it into the fat phase.

ii. Preparation of the Fat Phase

Preparation of the fat phase involves melting of fat and mixing it with fat soluble vitamins and colour. Pretreatments of the fat phase depend upon the source or form of fat. Low-fat or medium-fat cream is often pasteurized as is the aqueous

phase before being concentrated into a high-fat cream, if so desired, and cooled/ precrystallized for blending with the aqueous phase. Phase inversion (O/W to W/ O) may also be followed depending on the formulation. This can be achieved by using a continuous butter-maker or a 'transmutator' (worm cooler).

Butter- or Butteroil-based processes involve tempering (preferably to the emulsification temperature e.g. 21°C) before converting it into a spread. In a continuous method for low-fat spread-making, butter (80% fat) requires vacuum working, deaeration and warming before blending with the aqueous phase.

In case of non-dairy or mixed-fat spreads, partial hydrogenation or interesterification of vegetable oils or their blends followed by refining, bleaching, deodorization, etc. is commonly practiced in preparation of the fat phase.

iii. Blending and Emulsification

Separately prepared aqueous and fatty phases are often blended to form a 'pre-emulsion'. Such a premix may be subjected to heat treatment if the individual phases were not so treated. The heat treatment is then followed by cooling, crystallization, etc. Sometimes one phase, usually the pasteurized and cooled aqueous phase, may be continuously introduced into the pre-treated fatty phase during cooling or crystallization, thus combining the blending and emulsification steps.

Emulsification is carried out by means of a suitable agitating device such as a mixer or a churn, which may involve shearing action with or without simultaneous cooling. It ensures adequate distribution of the dispersed or discontinuous phase into the continuous phase.

Homogenization, an emulsification method, particularly suitable for O/W-type spreads, is carried out after pasteurization / heating of the spread base mix. Two most important parameters of homogenization are temperature and pressure. Generally, a single-stage pressure of 5-36 MPa (50-360 bar) is used. In two-stage homogenization, the pressure used is 7-18 MPa (70-180 bar) in the first stage and 3-5 MPa (30-50 bar) in the second. In general, homogenization of the spread mix is carried out at a temperature employed for pasteurization/heating. However, the temperature may range from 25° to 85°C. Homogenization can also be used for achieving phase inversion in spread-making. Emulsification can also be brought about by churning of cream either in a batch or continuous churn. Churning is often done at 14-16°C.

iv. Cooling, Crystallization and Working

Scraped surface coolers are used to achieve the water-in-oil emulsion. Such equipment also known by various generic names such as 'Votator', 'Kombinator' or 'Perfector' are cylindrical devices with a rotor/scraper housed in a double–walled tube provided with an evaporating refrigerant. These multifunctional units are used for carrying out cooling, crystallization and working. Solidification of fat into the desired crystal size and type is important for a smooth, plastic spread. The process of working ideally disperses the fat crystals throughout the emulsion and if the process is carried out satisfactorily, the product will be plastic and spreadable; if not, it will be greasy.

10.7 PACKAGING AND STORAGE

Water- and grease-resistant as well as air-tight containers are required for packaging of a spread. Various kinds of packaging materials namely, plastic cups or tubs, plastic-coated cartons, plastic-coated paper packs, polyethylene-lined paper-board containers, parchment paper, coloured glass containers, etc. are used. The packaged

product is allowed to 'set' before distribution. Setting is the phenomenon where the spread is usually kept at a low temperature for several hours to get the desired consistency. Crystallization of fat during setting helps in attainment of final body characteristics. Setting temperatures govern the rheological properties of the product. Setting conditions vary from 0°C to 15°C for 4 hours to 48 hours.

Low-fat spreads, as mentioned earlier, have a relatively short shelf life (7-90 days at 4^0 C to 30^0 C). However, most fat spreads keep well for several weeks under refrigeration. The shelf life of the product is affected by various factors, namely, type of emulsion and serum dispersion, moisture content, processing treatment, type of ingredients, salt content, packaging material, storage temperature, pH of the product and use of preservative.

Check Your Progress 3

1) State the basic principle involved in manufacture of low fat spreads.

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2) Briefly describe the procedure for preparation of aqueous and fat phases for spread manufacture.

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3) What are the different methods of emulsification used in spread-making?

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4) Give the importance of setting the product.

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5) What is the shelf life of low fat spreads?

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6) State the factors influencing the shelf life of spreads.

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10.8 LET US SUM UP

A low-fat dairy spread is a product with lower fat content and higher moisture content as compared to conventional butter or margarine. It has a low caloric value and depending on the formulation, several health attributes such as low or no cholesterol content, low saturated fatty acid content, etc. It is characterized by a very good spreadability at refrigeration temperature. The manufacturing process involves the selection of ingredients (i.e. source of fat, protein, stabilizer, emulsifier, plasticizer, acidulant, preservative, etc.), preparation of aqueous and fat phases, blending, emulsification, cooling, crystallization, packaging and setting. The product may be either oil-in-water or water-in-oil type emulsion depending upon the method of manufacture as well as proportion of aqueous and fat phases. The shelf life of the product can be enhanced with the use of preservatives as well as controlling packaging and storage conditions. The product has shelf life of upto 7-90 days under different storage conditions.

10.9 KEY WORDS

Chelating agent : A calcium-binding chemical employed to enhance the emulsifying property of proteins such as casein.

Dairy Spread : A fat spread whose fat content is derived entirely from milk.

Emulsification : The process of formation of an emulsion by bringing together an aqueous phase and an oil/ fat phase and effecting a stable dispersion of one into the other.

Emulsifier : A chemical assisting in formation and stabilization of an emulsion.

Oil-in-water emulsion : An emulsion wherein fat is present in the form of globules in a continuous water-containing (or, aqueous) phase.

Plasticizer : A compound such as glycerol which, when used in a spread, helps in improving its spreadability

Setting : The process of holding a cooled emulsion (in spread-making) at a low temperature so as to bring about fat crystallization/ solidification to the desired extent and thereby improve the plasticity of the product.

Spread : A semi-solid fat-based product with a plastic consistency enabling it to have a stand-up property and yet be spreadable even at refrigeration temperature.

Spreadability : Ability of a product to be spread into a thin layer on bread slice (or, toast) with a moderate effort.

Stabilizer : A water-holding compound used to minimize wheying off of a high-moisture spread and improve its body and texture.

Water-in-oil emulsion : An emulsion in which water is dispersed as fine droplets in a continuous fat phase.

10.10 SOME USEFUL BOOKS/ REFERENCES

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10.11 ANSWERS TO CHECK YOUR PRGRESS

Your answer should include the following points:

Check Your Progress 1

1) Dairy spreads are defined as the products containing dairy ingredients with a fat content usually less than that of table butter. No ingredients other than those of milk origin are used.

2) A low –fat spread (LFS) is a product, which contains less fat than butter and margarine. Usually it contains 39-41 % fat and is called a half-fat butter whereas those in which calorie reduction is less than 33 % are termed as Reduced-Calorie spreads.

3) LFS has the following advantages over conventional butter:
   i. Very good spreadability at refrigeration temperature (i.e. $<15^0$C)
   ii. Low cost
   iii. Lower fat content and lower caloric value as compared to butter and margarine.

4) The spreads are classified on the basis of origin of fat as under:
   i. Dairy spreads containing exclusively milk fat
   ii. Blended spreads which are blends of fat containing minimum 10% milk fat
   iii. Non-dairy spreads which are blends of fats of mostly non-dairy origin.

5) Spreadability is the ability of a spread to be easily spread into a layer on a bread/ toast. It is one of the most important properties for spreads from the consumer's viewpoint. It is desirable that the product should be spreadable at refrigeration temperature i.e. 5^0C.

6) There are three essential requirements to attain the desirable plasticity/ spreadability in a low fat spread:
   i. There must be two phases, solid and liquid.
   ii. The solid phase must be so finely dispersed that the crystal mass is held together by lateral cohesive forces.
   iii. There must be a proper proportion between the solid and liquid phases.

Check Your Progress 2

1) The major functions of fat in low fat spreads are:
   i. To provide structure, energy and taste including creaminess.
   ii. To act as a carrier of flavour and vitamins
   iii. To serve as a source of essential fatty acids..
2) For low fat spreads, sources of milk fat include cream, butter and butter oil. Non-milk fat sources include corn, safflower, sunflower, soybean, and groundnut oils. The main sources of proteins are skim milk, buttermilk, caseinate and whey solids; ripened cheese would provide protein and cheese flavour to the product.
3) Sodium chloride or table salt usually added to a spread not only provides taste and palatability to the spread but also retards the growth of bacteria, thereby acting as a preservative. Preservatives used in spreads inhibit the growth of spoilage organisms and thus help in extending the shelf life of the high-moisture product.
4) Fat spreads are emulsions of either water-in-oil (W/O) type or oil-in-water (O/W) type, the former being more common. Emulsifiers help in uniform dispersion of the dispersed phase in the continuous phase. In a stable W/O spread fine distribution of aqueous droplets in the fat phase gives the desired textural properties, reduced wheying off or 'weeping' and enhanced shelf life.

Check Your Progress 3

1) The basic principle involved in the manufacture of spread comprises compositional manipulation in terms of increased moisture and non-fat solids, incorporation of additives such as emulsifiers, stabilizers etc., and modified fat composition, so as to obtain, upon cooling, crystallization and working, a smooth-textured, plastic (pliable semi-solid) emulsion.
2) Aqueous phase preparation involves dispersing of water-soluble dairy and non-dairy ingredients namely milk protein, stabilizers, salt, etc. in water or liquid milk component at 40-80^{o}C, flavouring being incorporated after heating. Similarly, preparation of the fat phase comprises melting of fat, blending of fats/ oils if desired and adding fat-soluble vitamins and colour. Pretreatment of the fat phase depends upon the source of fat. Separately prepared aqueous and fatty phases are suitably tempered and blended in order to produce a pre-emulsion followed by emulsification, cooling, crystallization, working, and setting before or after packaging.
3) Emulsification is an important process to get a stable product during handling as well as storage. It can be carried out by blending, shearing action, churning, etc. with or without simultaneous cooling, using different kinds of mixers.
4) Setting is the process where the spread is usually kept at a low temperature for several hours to get the desired consistency. Crystallization of fat during setting helps in attainment of final body characteristics. Setting temperatures govern the rheological properties of the product.
5) Low-fat spreads, being high in moisture, have a relatively short shelf life varying from a few days at to a few weeks at storage temperatures of 4^{0} C to 30^{0} C.
6) The shelf life of spreads is affected by various factors namely, the type of emulsion and serum dispersion in water-in-oil products, moisture content, processing treatment, salt content, packaging material, storage temperature, pH of the product, and use of preservative.

10.12 SOME MORE QUESTIONS TO CHECK YOUR PROGRESS

1. How is the desired spreadability is obtained in a fat spread?
2. How does the type of emulsion affect the shelf life of a low-fat spread?
3. What is the purpose of using an acidulant in a fat spread?
4. How does a plasticizer affect the spread quality?
5. What kind of a packaging is suitable for spreads?