

Dairy Products Technology (Dairy Technology)

Student Handbook for Class XII



CENTRAL BOARD OF SECONDARY EDUCATION, DELHI
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Preface

At present India is the world leader in milk production with an annual production of 127 million tonnes. About 50 percent of the milk is handled by the organized sector. Domestic market for value added products like butter, ice cream, cheese, dairy whiteners and spreads is growing at 8-10 percent per year. Despite the large infrastructure available for processing of milk, only 27% of the total milk produced is at present converted into value added products. Consumption of large quantities of liquid milk at the site of production and poor post-harvest handling and processing are among the reasons for low value addition of milk. With the launch of the National Dairy Plan, milk production in India is likely to increase over 4 to 5 percent annually in the next two decades. The increasing demands and the accompanying value addition present a great opportunity for the dairy industry to take up the production and marketing of various dairy products especially traditional products on an industrial scale. Accordingly the demand for professionals with formal education in dairy technology would be increasing.

The attempt of CBSE, to introduce Dairy Technology courses for Class XII is to encourage young minds to begin their career in dairying. In the present book, the composition, standards, methods and equipment used for manufacturing different dairy products viz. traditional Indian dairy products, western dairy products and dairy byproducts has been included. The objective of this book is to make understand the students the diversity of dairy products, their principles of manufacturing and legal standards prevalent in the country that govern marketing of these products.

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भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक '[सम्पूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य] बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए, तथा उन सब में, व्यक्ति की गरिमा और '[राष्ट्र की एकता और अखण्डता] सुनिश्चित करने वाली बंधुता बढ़ाने के लिए दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई० को एतद्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से), "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क मूल कर्तव्य

51 क. मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

- (क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;
- (ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;
- (ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;
- (घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;
- (ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;
- (च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परीक्षण करे;
- (छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;
- (ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;
- (झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;
- (ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ² [unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY TO OURSELVES THIS CONSTITUTION.**

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

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Dairy Products Technology

Theory

(Time 120 hrs)

S. No.	Chapter	Hours	Weightage (Marks)
1.	Chapter 1	25	12.5
2.	Chapter 2	20	10
3.	Chapter 3	20	10
4.	Chapter 4	25	12.5
5.	Chapter 5	20	10
6.	Chapter 6	10	5

Chapter-1

Composition, Standards, Manufacturing – Process and Equipment and Defects during Manufacturing and Storage of **Cream, Butter, Ghee, Khoa, Chhana and Paneer**

Cream

Objective

To learn the Production, Processing and Storage of Cream

Introduction

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

Definition

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

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

Classification

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

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

The various types of cream are:

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

Table 1.1: Chemical composition of cream

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

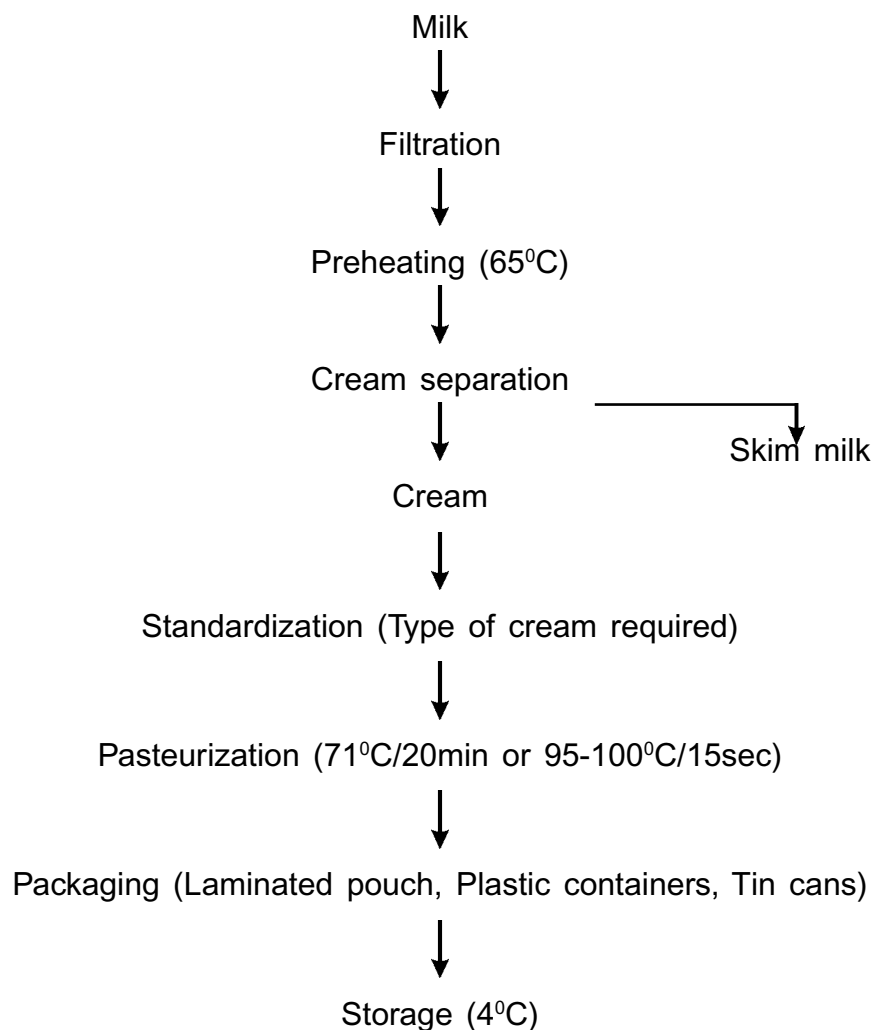
Production of Cream: The basic principle of cream separation, whether by gravity or centrifugal method, is based on the fact that milk fat is lighter than the skim milk portion.

At 16°C the average density of milk fat is 0.93 and skin milk 1.036. Hence when milk, which may be considered to be a mixture of fat (as cream) and skin milk, is subjected to either gravity or a centrifugal force (Fig. 1.1), the two components, viz. cream and skin milk, by virtue of their differing densities stratify from one another.

Centrifugal method is used commercially to separate cream from milk. When milk enters the rapidly revolving bowl of the cream separator, it is immediately subjected to a centrifugal force, which is 3000 to 1600 times greater than gravitational force. While both the fat and skim milk are subjected to the centrifugal force, the difference in density affects the heavier i.e. portion skim milk more intently and forced to the periphery while the fat portion moves towards the centre.

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

Fig. 1.1: Flow Diagram for the production of cream



Cream Neutralization (for butter- making)

Neutralization of sour cream for butter making refer to a partial reduction in acidity. Cream is neutralized to avoid excise fat loss in buttermilk that result from churning highly acid pasteurized cream, to guard against the production of an undesirable off- flavor in cream (which may result when high acid cream is pasteurized), to improve the keeping quality of butter made from high acid cream. Salted acid butter develops a fishy flavor during commercial storage at – 23°C to -29°C. Neutralizers commercially used are **Sodium bi carbonate** and **Calcium hydroxide**.

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

a- % Acidity of the cream

b- % desired acidity of the cream

Neutralization factor is as below

Sodium bi carbonate 1.1

Ca(OH)₂ 2.45+ 20% of Neutralizer

Standardization of Cream

This refers to the adjustment of the fat level in cream to the desired percentage, confirming to standard requirements. The fat percentage in cream is adjusted to the prescribed level by the addition of skim milk or cream. Desired level of fat in cream for butter making is 33 to 40 per cent. Standardization to both higher and lower level leads to higher fat loss in butter milk. Reduction of fat by adding water should be avoided as it interferes with ripening of cream and also results in butter with 'flat' or 'washed off' flavour.

Pasteurization of Cream

Cream is pasteurized at 71°C for 20 min in a batch process and 95 to 100°C for 15 sec in a HTST pasteurizer. Pasteurization is done mainly to destroy the pathoges, inactivate enzymes, eliminate gaseous tainting substances, and remove volatile off flavors.

Packaging and Storage

Table cream is packaged in retail packs in glass bottle, laminated pouches, plastic containers etc. and stored at 4-7°C and distributed as early as possible.

Activity

Take 100 ml milk in a glass and keep in undisturbed condition for 2h on uniform platform and observe for fat layer separation.

Review Questions

1. Write the importance of cream standardization
2. Write the importance of neutralization of cream
3. Standardize the cream having 60% fat to 45% fat using skim milk testing 0.8% fat. Calculate the amount of skim milk required and final quantity of standardized cream produced.

Butter

Objective

To learn the Manufacturing and Packaging of Butter

Introduction

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

Composition of Butter

Butter is principally composed of milk fat, moisture, salt and curd. It also contains small amount of lactose, acids, phospholipids, air, microorganisms, enzymes and vitamins. The proportion of principal constituents in butter is largely controlled by the method of manufacture and this in turn is chiefly regulated to conform to the standards of butter

prescribed by regulatory authorities such as codex and FSSAI. General composition of butter is given in table below (Table 1.2).

Table 1.2: Composition of butter

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

*0 percent salt indicates that butter is unsalted and it is not intended for direct consumption

Definition of Butter as per FSSR, 2011

Butter can be defined as the fatty product derived exclusively from milk of cow and/or buffalo or its products principally in the form of an emulsion of the type water-in-oil. The product may be with or without added common salt and starter cultures of harmless lactic acid and / or flavour producing bacteria. Table butter shall be obtained from pasteurised milk and/ or other milk products which have undergone adequate heat treatment to ensure microbial safety. It shall be free from animal body fat, vegetable oil, mineral oil and added flavour. It shall have pleasant taste and flavour free from off flavour and rancidity. It may contain food additives permitted in these Regulations as given in Table 1.3. It shall conform to the microbiological requirements prescribed in Table 1.4. Provided that where butter is sold or offered for sale without any indication as to whether it is table or desi butter, the standards of table butter shall apply.

Table 1.3: Food additives allowed in Butter

Sl. No.	Food additive	Permissible limit
1	Curcumin	100ppm
2	Beta carotene	100ppm
3	Carotene (Natural extract)	100ppm
4	Annatto extract on Bixin/ Nor bixin basis (50:50 ratio)	20ppm
5	Beta apo-8 carotenal	35ppm
6	Methyl ester of Beta apo-8 Carotenoic acid	35ppm
7	Sodium and Calcium hydroxide	2000 ppm
8	Sodium phosphate	GMP

Table 1.4: Microbiological standards of Butter

1	Total Plate Count Max	50,000/g
2	Coliform Count	50/g
3	E.Coli	Absent/g
4	Salmonella	Absent /25g
5	Staph aureus	50/g
6	Yeast and mold count	50/g
7	Listeria Monocytogenes	Absent/g
8	Sampling Guidelines	100g Sample and -18°C or lower storage temperature

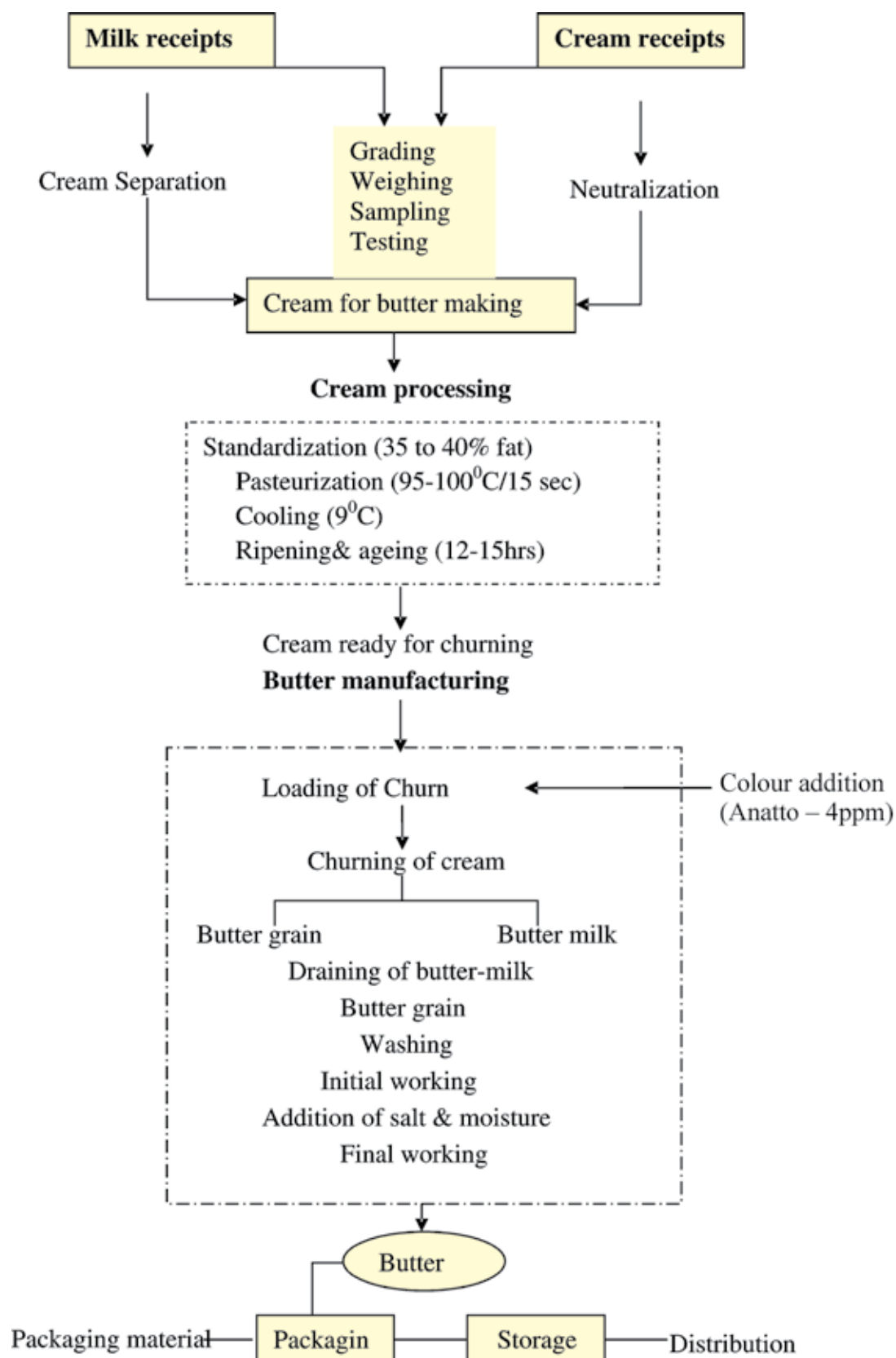
Production of Butter

Preparation of Cream

Commercial butter can be produced from both sweet as well as cultured cream. However, butter from sweet cream is most preferred as it results in sweet butter milk which has better economic value than sour buttermilk that results when sour/cultured cream is churned (Fig. 1.2). Cream should be neutralized to 0.06% lactic acid to produce butter for long storage and to 0.3% lactic acid to produce butter for early consumption. Then adjust the fat percentage of cream to 35 to 40% fat. Heat the neutralized and standardized cream to 95°C for 15 sec and cool it to 9°C.

Ripening: Ripening refers to the process of fermentation of cream with the help of suitable starter culture. This step can be eliminated if sweet-cream butter is desired. The main object of cream ripening is to produce butter with higher diacetyl content. Starter culture consisting of a mixture of both acid producing (*Streptococcus lactis*, *S.cremories*) and flavour producing (*S.diacetylactis*, *Leuconostoccitrovorum* and/or *Leuc. dextranicum*) organisms is added. Amount of starter added depends on several factors and usually ranges between 0.5-2.0 percent of the weight of the cream. After being thoroughly mixed, the cream is incubated at about 21°C till desired an acidity is reached. Cream is subsequently cooled to 5-10°C to arrest further acid development.

Fig. 1.2: Flow diagram for the manufacture of butter



Cream Processing

Aging: Cream is held at cool temperatures to crystallize the butterfat globules, ensuring proper churning and texture of the butter. In the aging tank, the cream is subjected to a program of controlled cooling designed to give the fat the required crystalline structure. As a rule, aging takes 12 - 15 hours. From the aging tank, the cream is pumped to the churn or continuous butter making machine via a plate heat exchanger which brings it to the requisite temperature.

Churning: Cream is agitated, and eventually butter granules form, grow larger, and coalesce. In the end, there are two phases left: a semisolid mass of butter, and the liquid left over, which is the buttermilk.

Draining and washing: In traditional churning, the machine stops when the grains have reached a certain size, whereupon the buttermilk is drained off. With the continuous butter maker the draining of the buttermilk is also continuous. After draining, the butter is worked to a continuous fat phase containing a finely dispersed water phase. It used to be common practice to wash the butter after churning to remove any residual buttermilk and milk solids but this is rarely done today. This washing process would ensure that all the butter milk is washed out of the butter. Otherwise the butter would not have good shelf life and go rancid.

Salting: Salt is used to improve the flavor and the shelf-life, as it acts as a preservative. Further, the butter is worked to improve its consistency. Salt used should be 99.5 to 99.8% sodium chloride and microbial count should be less than 10/g. Salt is added at the rate of 2 to 2.5%.

Working: The objective of working butter is to incorporate moisture and uniformly distribute added moisture and salt in butter. During this process remaining fat globules also break up and form a continuous phase, and moisture is finally distributed to retard bacterial growth in butter. It is safer to slightly over-work butter than to under-work. Under-worked butter may be leaky in body with large visible water droplets and may develop 'mottles' on standing.

Packing and storage: The butter is finally patted into shape and then wrapped in waxed paper and then stored in a cool place. As it cools, the butterfat crystallizes and the butter becomes firm. Whipped butter, made by whipping air or nitrogen gas into soft butter, is intended to spread more easily at refrigeration temperatures. Normally butter is stored at -23°C to -29°C.

Classification of Butter

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

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

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

II. Classification based on salt content

1. **Salted butter:** Butter to which salt has been added. It is added to improve flavour and keeping quality of butter.
2. **Unsalted butter:** This type of butter contains no salt. It is usually prepared for manufacturing other products such as ghee and butteroil.

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

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

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

1. **Pasteurized cream butter/ Pasteurized Table butter:** This is made usually from pasteurized sweet cream. Such butter usually has a milder flavour than that made from similar cream not pasteurized.
2. **Desi butter:** The butter obtained by traditional process of churning dahi or malai as practiced at domestic levels.

Activity

Prepare butter from dahi at your home. Take 1 kg milk, boil it for 3min and then cool it to 32°C. Add a spoon of previous day dahi and keep it undisturbed for 8-10h.

Review Questions

1. Give the FSSR 2011 standards for butter
2. Write the importance of salting
3. Why working is an important step in butter preparation?

Ghee

Objective

- To learn the Manufacturing Techniques, Packaging and Storage of Ghee
- To learn about the Different Standards and Grades of Ghee

Introduction

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

Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added. Ghee essentially consists of 99 to 99.5% milk fat (Table 1.5).

Table 1.5: Chemical composition of ghee

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

Methods of Preparation

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

There are five methods of ghee making:

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

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

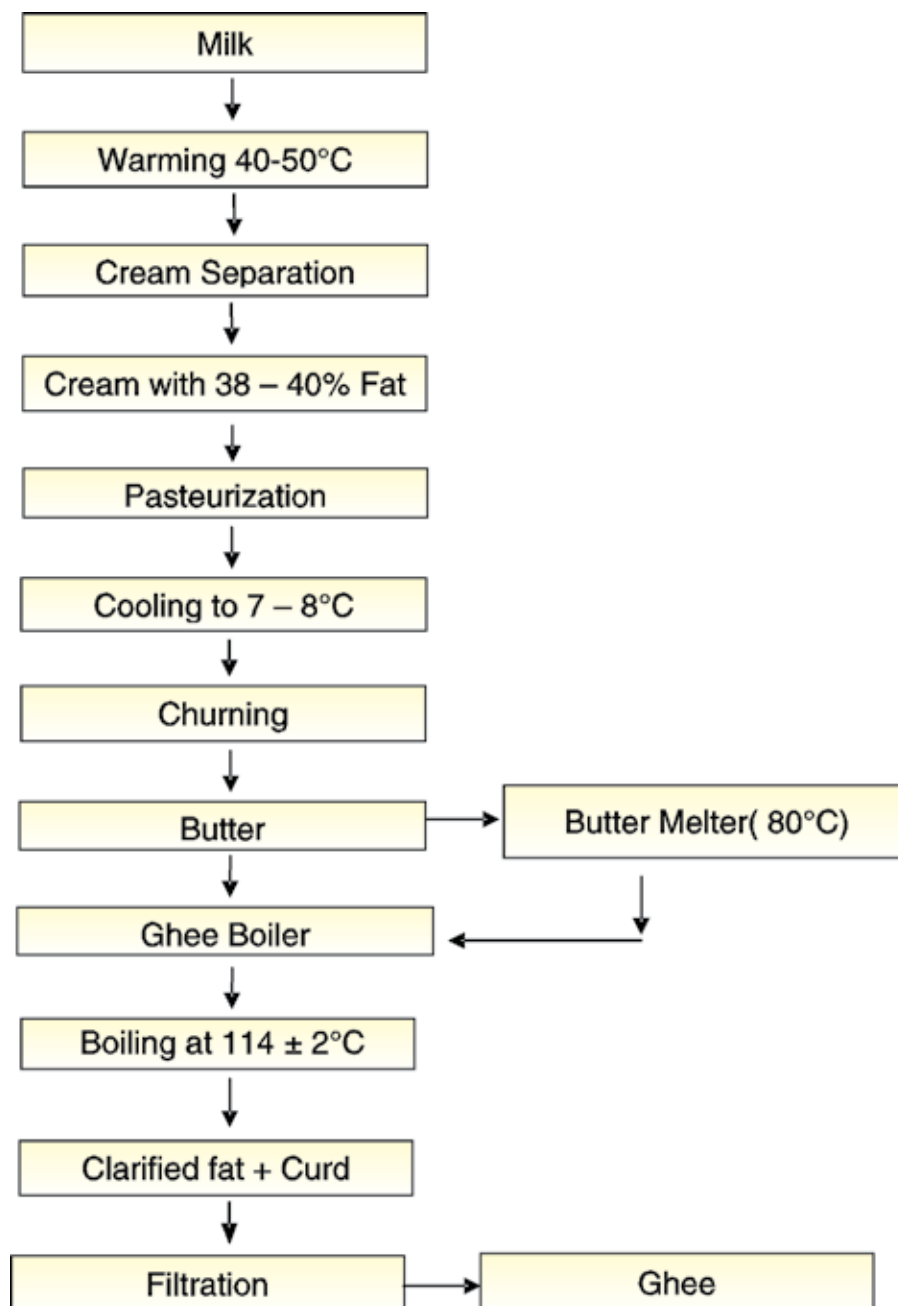
Desi Method

This was the practice from age-old days in rural areas where excessive milk will be cultured and kept for overnight for fermentation. The resultant curd was churned using hand driven wooden beaters to separate the milk fat in the form of desi butter. Some follow slightly different method wherein milk is heated continuously to about 80°C, the malai (creamy layer) that forms over the surface was collected manually. This malai is then churned to get the desi butter. After collection of desi butter over a period of time, this butter is melted in a metal pan or earthenware vessel on an open fire. Extent of frothing is an index to judge when to terminate heating. Heating must be stopped when sudden foaming appears and leave the contents undisturbed after heating. Curd particles starts settling down over a period of time and decant the clear fat carefully. In this method it is possible to achieve only 75 – 85% fat recovery.

Creamery Butter Method

Production of ghee from creamery butter method is depicted in fig. 1.3.

Fig. 1.3: Flow diagram for production of ghee from creamery butter method



This is the standard method adopted in most of the organized dairies. Unsalted or white butter is used as raw material. Butter mass or butter blocks are melted at 60°C to 80°C in butter melter. Molten butter is pumped into the ghee boiler, where final heating will be done using steam as heating medium. Increase the steam pressure to raise the

temperature. Scum which is forming on the top of the surface of the product is removed from time to time with the help of perforated ladle. At the moment of disappearance of effervescence and appearance of finer air bubbles on the surface of the fat along with browning of the curd particles indicates the end point. At this stage typical ghee aroma is produced. Final heating temperature is adjusted to about $114\pm 2^{\circ}\text{C}$. To get the cooked flavour, heating beyond this temperature is also being in practice. Ghee is filtered via oil filter into the settling tank.

AGMARK Ghee Specifications (Grade designation marks for ghee)

The grade designation mark shall consist of a label specifying the name of the commodity, grade designation and bearing a design consisting of an outline map of India with the word “AGMARK” and the figure of rising sun with the words produce of India and resembling the design as set out as follows.

Design of Label



1. Special Grade



2. General Grade



3. Standard Grade

Grade	Colour of Letter and Circular border
Special	Red
General	Green
Standard	Chocolate

- The labels shall be printed on the watermark paper of the Government of India and shall have a micro tint background bearing the words “Government of India” in olive green color
- Each label shall have printed thereon a serial number along with a letter or letters denoting the series, e.g. A054987.
- Each label shall have printed thereon the approximate weight content of the package on which it is affixed.

The word ‘Regional’ shall be printed on each label used on a package of the ghee not conforming to the normal physical and chemical constants specified in table 1.6 & 1.7.

Table 1.6: Physical & chemical constant for ghee

Parameters	Special Grade	General Grade	Standard Grade
Baudouin Test	Negative	Negative	Negative
Butyro-refractometer reading at 40°C	40.0– 43.0	40.0– 43.0	40.0– 43.0
Reichert Meissl value	Not less than 28.0	Not less than 28.0	Not less than 28.0
Polenske value	1.0 – 2.0	1.0 – 2.0	1.0 – 2.0
Moisture content	Not more than 0.3%	Not more than 0.3%	Not more than 0.3%
Percentage of Free Fatty Acid (as oleic acid)	Not more than 1.4	Not more than 2.5	Not more than 3.0

For cotton tracts areas such as part of Saurashtra region and Madhya Pradesh following standards are applicable.

Table 1.7: Physical & Chemical constant for ghee in cotton tract areas

Parameters	Special Grade	
	Winter	Summer
Baudouin Test	Negative	Negative
Butyro-refractometer reading at 40°C	41.5 – 44.0	42.5 – 45.0
Reichert Meissl value	Not less than 23.0	Not less than 21.0 [#]
Polenske value	0.5– 1.2	0.5 – 1.0
Moisture content	Not more than 0.3%	Not more than 0.3%
Percentage of Free Fatty Acid (as oleic acid)	Not more than 1.4	Not more than 2.5

General and Standard grade have percentage of free fatty acids (as % oleic acid) not exceeding 2.5 and 3.0, respectively. According to the law it is not compulsory for every trader and manufacturer, to get his produce certified under AGMARK symbol. Presently it is only a voluntary scheme of the Government.

Activity

Buy 200g table butter from the retail shop and try to produce ghee as mentioned in the creamery butter method

Review Questions

1. What is ghee?
2. Write the flow diagram for the manufacture of ghee by creamery butter method
3. Write the AGMARK standards for ghee

Khoa

Objective

To learn the Meaning, Varieties and Standards and Production of *Khoa*

Introduction

Among the indigenous milk products, *khoa* occupies first position as it form a base for number of sweet delicacies. *Khoa* is a popular product throughout India and is called by different names in different regions like *Khoya*, *Mawa*, *Kova*, *Palghova* etc.

Definition of *Khoa*

Khoa is a concentrated whole milk product obtained by open pan condensing of milk under atmospheric pressure.

According to **Food Safety and Standard regulations 2011**, KHOYA by whatever variety of names it is sold such as Pindi, Danedar, Dhap, Mawa or Kava means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination thereof by rapid drying. The milk fat content shall not be less than 30% on dry weight basis of finished product. It may contain citric acid not more than 0.1 per cent by weight. It shall be free from added starch, added sugar and added colouring matter.

Chemical Quality of *Khoa*

Wide variations exist in chemical quality of cow and buffalo milk *khoa* (Table 1.8).

Table 1.8: Chemical Composition of *Khoa*

Constituent %	Cow <i>Khoa</i>	Buffalo <i>Khoa</i>
Moisture	30.93	22.34
Total solids	69.07	77.66
Fat	22.00	32.20
Proteins	19.10	17.70
Lactose	24.10	23.70
Ash	3.72	3.71

The market samples of *khoa* show wide variations in chemical composition. Certain times, the market samples fail to meet the minimum legal standards. To provide minimum legal standards in *khoa*, the minimum fat content of 4.4% in cow's milk and 5.5% in buffalo milk should be maintained.

Varieties of Khoa

There are three distinct varieties of *khoa*. They differ in their composition, body and textural characteristics and end use (Table 1.9).

Pindi

This variety is identified as a circular ball of hemispherical pat with compact mass, homogenous and smooth texture. It shall not show any sign of fat leakage or presence of free water. It possesses pleasant cooked flavour and devoid of objectionable tastes like burnt, acidic etc. This variety of *khoa* is used in the manufacture of burfi, peda and other similar varieties of sweets.

Dhap

It is a raw (katcha) *khoa* characterized by loose but smooth texture and soft grains and sticky body. Dhap variety carries highest percentage of moisture over other varieties of *khoa*. This high moisture is necessary to provide adequate free water for soaking of maida and semolina (vermicelli) and for homogenous distribution of other ingredients in the preparation of smooth gulabjamoon balls. This variety of *khoa* is used in the manufacture of gulabjamoon, kalajamoon, pantooa, carrot halwa, etc.

Danedar

This is characterized by the granular texture with hard grains of different sizes and shapes embedded in viscous serum. Slightly sour milk is preferred in the manufacture of this variety as it yields granular texture. This variety of *khoa* is used in the manufacture of kalakand, milk cake, etc.

Table 1.9: BIS standards of *khoa*

Characteristics	Pindi	Danedar	Dhap
Total solids % by mass (min)	65.0	60.0	55.0
Fat % by mass (on dry matter basis) min	37.0	37.0	37.0
Total ash (% on dry matter basis)	6.0	6.0	6.0
Titrateable acidity % (max)	0.8	0.9	0.6
Coli form count /g (max)	90	90	90
Yeast and mould count /g (max)	50	50	50

Preparation of *Khoa*

Khoa is prepared by different methods depending on the location, quantity etc. *Khoa* is manufactured by the following four basic methods viz. traditional method, improved batch method, mechanized method and use of membrane technology.

Traditional Method

Generally buffalo milk is preferred for manufacture of *khoa* as it results in higher yield, smooth texture and soft body with sweet taste. Where buffalo milk is not available, cow milk is used for *khoa* making but it results in pasty body and slightly saltish taste in the product.

Filtered milk is taken in a thick wide mouth iron pan (karahi) and boiled on a brisk non – smoky fire. An iron scraper (kunti) is used for stirring the milk during boiling and also to scrape the milk films forming on the surface during boiling. A rapid stirring and scrapping is carried out throughout boiling to facilitate quick and rapid evaporation of water from milk and also to prevent scorching of milk film on surface. Due to continuous evaporation of water, the milk progressively thickens. Some researchers observed that at 2.8 fold concentration of cow milk and 2.5 fold concentration of buffalo milk, heat denaturation of milk proteins take place and the proteins will not go into solution again. As the concentration is progressing the product slowly tends to leave the sides of the pan and starts accumulating at the bottom and at this stage the pan has to be removed from the fire. The contents are worked up and allowed to cool and the residual heat in the product helps in further evaporation of moisture. At this stage, stirring and scraping is increased to obtain good quality product. If the milk is subjected to high heat treatment with less stirring and scraping at this stage results in dark colored *khoa* that does not fetch good market value as that of white or cream colored *khoa* which is more preferred for sweets making.

Production of Three Varieties of *Khoa*

Dhap

For preparing dhap variety of *khoa* the heating should be stopped at rabri stage (thick mass) and leaving the product without much working results in dhap variety of *khoa* which carry soft grains and high moisture content.

Pindi

For production of pindi variety of *khoa*, heating is continued after rabri stage and with the help of a wooden ladle the soft grains are crushed and the mass is worked out to a smooth textured product. After cooling, the *khoa* is moulded in to hemispherical molds to give its shape.

Danedar

Sour milk is preferred for production of *khoa*. Generally the milk that is left over after the preparation of other varieties of *khoa* is converted into danedar variety of *khoa*. Sometimes citric acid (0.05 to 0.1%) or sour whey is added to milk at boiling stage to get granular texture.

Improved Batch Method

A stainless steel double jacketed, steam heated pan or kettle is used to provide greater control on the heating process and to ensure a non smoky heating. Five liters of standardized cow milk with 4.5% fat or four liters of standardized buffalo milk with 5.5% fat is taken per batch and milk is brought to boil in the kettle. During boiling, bottom and the surfaces of the kettle are scraped and milk is stirred vigorously by a stainless steel stirrer to avoid burning of milk solids. About 2 kg/cm² pressure is used for boiling milk. When the milk attains a rabri stage, slow heating is necessary at this stage to prevent burning of solids on the surface, discoloration of the product, development of burnt flavour and hard body and coarse texture. The rate of stirring should be increased during last stages to obtain good quality product. As soon as the product shows signs of leaving the sides of the kettle and accumulating in the centre in a pat form, heating is stopped. It takes about 15-20 minutes to prepare a batch of *khoa* (1 kg approx) by this method.

As steam will not be available at village level the above method has its application only in dairies having steam production lines. However a village level *khoa* pan was developed to overcome the above problem. The set up consists of hemispherical mild steel pan joined to a cylindrical jacket. Water is taken in the jacket and heated by placing the whole unit over a Chulla. Steam is generated in the jacket and the pressure is indicated by a gauge. The milk is taken in the steel pan and heated by the steam and after losing the latent heat, returns to water phase. Water in liquid and vapour form exists in phase equilibrium at adjusted pressure because of the closed system. Good quality *khoa* can be prepared in the pan from 2.5 liters milk in 8 minutes.

Mechanized Processes for *Khoa* Production

Use of Roller Driers

A roller drying process was adopted in the preparation of *khoa*. Process variables such as steam pressure, flow rate and distance between rollers and scrappers were adjusted to get the desirable product. Vacuum concentrated milk with 50% T.S. was heated to 74 °C for 10 minutes to develop cooked flavour in *khoa*. Steam at a pressure of 25 -30 psi and roller speed of 17-19 rpm gives good results. It was concluded that satisfactory *khoa* can be prepared on drum driers using 50% T.S. vacuum concentrated milk. The concentrate is preheated to 101 to 103 °C for 10-12 minutes to develop cooked flavour and drums with steam pressure of 0.7 to 1 kg/cm² and a roller speed of 10 rpm.

Use of Scrapped Surface Heat Exchangers

Attempts have been made to use scrapped surface heat exchangers in the preparation of *khoa*. A mechanized scraped surface heat exchanger with a conical vat process is developed for the production of *khoa*. Forty kg concentrated or 80 kg whole milk can be taken per batch which takes about 14 minutes & 50 minutes respectively. Steam pressure used is 1.5 kg/cm². Product losses are high in this machine.

A Continuous *Khoa* Making Machine

A continuous *khoa* making machine was developed which consists of a preheating cylinder and two cascading pans. The preheater is a steam jacketed cylinder containing rotary scrapers which rotate at 120 rpm. The cascading pans are open steam jacketed pans provided with spring loaded reciprocating type scrapper knives operating at 30 strokes per minute. The milk is taken into the preheater and heated by steam at 3 kg/cm² pressure. Here the milk is concentrated to about 30 to 35 per cent of total solids within 10 to 12 minutes time. From the preheater, the milk enters the first cascading pan. Here the milk is further concentrated to about 50 to 55 per cent total solids within 7 to 8 minutes. The product then moves to the second cascading pan where its concentration is raised to the desired level i.e., 70-75 per cent in 6 to 7 minutes. The steam pressures maintained in the two pans are 2 kg/cm² and 1.5 kg/cm² respectively. 50 liters of milk can be converted into *khoa* within an hour time in this machine. The steam requirement is 50 kg per hour and electric power requirement is 4 KW per hour.

Use of Horizontal Heat Exchanger

A horizontal heat exchanger for *khoa* making was developed which consists of a hopper

to accommodate the foam and provide milk concentration under atmospheric pressure. In this model the steam jacket is subdivided into three parts to reduce the amount of heating as the product moves. The scraper speed is 40 rpm and the steam pressure maintained is 3 kg/cm² in the first compartment which is step wise reduced to 1.5 kg/cm² in the last compartment. The machine can convert 50 kg of milk into *khoa* per hour per batch. Later a continuous *khoa* making machine with three stage concentration was developed. The machine has three jacketed cylinders placed in a cascade arrangement. This facilitates easy transfer of milk from one cylinder into the other. The scraper speeds are 40, 55 and 69 rpm for the first, 2nd & 3rd stage respectively. The operating steam pressures used are 2.0 & 1.7 & 1.5 kg/cm² in respective stages. One roller is used in the last stage in place of scraper blade which kneads the *khoa* to improve its body and texture. The first stage raises the milk solids level from initial 15 to 25 percent, the second stage to 50 percent and the third stage to 70 percent. The machine converts 50 kg of milk into *khoa* per hour at the operating pressures, specified. However, the capacity depends on the milk flow rate, steam pressure, total solid concentration of feed and final moisture required in the product. It is claimed that use of concentrated milk improves the capacity of the machine.

Use of Inclined Scraped Surface Heat Exchanger

An inclined scraped surface heat exchange for continuous *khoa* making was developed. They used a scraper assembly which combines the functions of scraping and conveying. The SSHE has 3 jackets which operate at 1.0, 1.5 and 1.0 kg/cm³ respectively. Milk is pre-concentrated to 40 - 55% T.S and fed at the rate 60-80 lts/hr. Feed temperatures between 10 – 80°C can be employed. Rotor speed used is 40 to 80 rpm. The advantages claimed by this unit are:

- Increased solids content in feed improves the colour of *khoa* because of reduced residence times. It also improves the capacity of the machine.
- Increase in feed temperature enhances the capacity of the plant.
- By increasing rotor speed there will be significant increase in the heat transfer rate.
- Variation in steam pressure in separate sections of steam jacket results in change of heat transfer rate, colour and texture of *khoa* due to change in the temperature to which the milk constituents are subjected to different stages of *khoa* making.
- The man power requirements are less.

Contherm – Convap System

Attempts were made to prepare *khoa* on contherm- convap system which was developed by Alfa -Laval. This unit consists of two parts, a contherm for heating the feed to about 95 °C and convap (a SSHE) for concentrating milk to desired milk solids level. Concentrated milk with 35- 40%T.S. at the rate of 300-350 kg per hour can be fed to the machine. The steam pressures employed are 3 kg /cm² in contherm and 4 kg/cm² in convap.

Factors Affecting Quality of *Khoa*

Higher amount of free fat (>60%) will be released in buffalo milk *khoa* than cow milk *khoa*. Higher free fat content contributes to soft body and oily or greasy appearance to buffalo milk *khoa*. The quality of *khoa* depends on:

- Type of milk used in *khoa* preparation
- Chemical quality of milk
- Method of preparation
- Degree of heat treatment
- Manner of handling the product
- Packaging employed
- Duration, temperature and humidity of storage.

Due to compositional differences in cow and buffalo milks, the physical attributes of *khoa* will vary.

Activity

Prepare *Khoa* at home using 1kg milk

Review Questions

1. Write the FSSR 2011 standards for *Khoa*
2. Write the difference between Pindi and danedarkhoa
3. Write the flow diagram for the manufacture of *khoa*
4. List the factors affecting quality of *khoa*

Chhana

Objective

To learn the Product Description, Methods of Manufacture, Packaging and Storage of Chhana

Introduction

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

Food Safety and Standards Regulation, 2011 definition

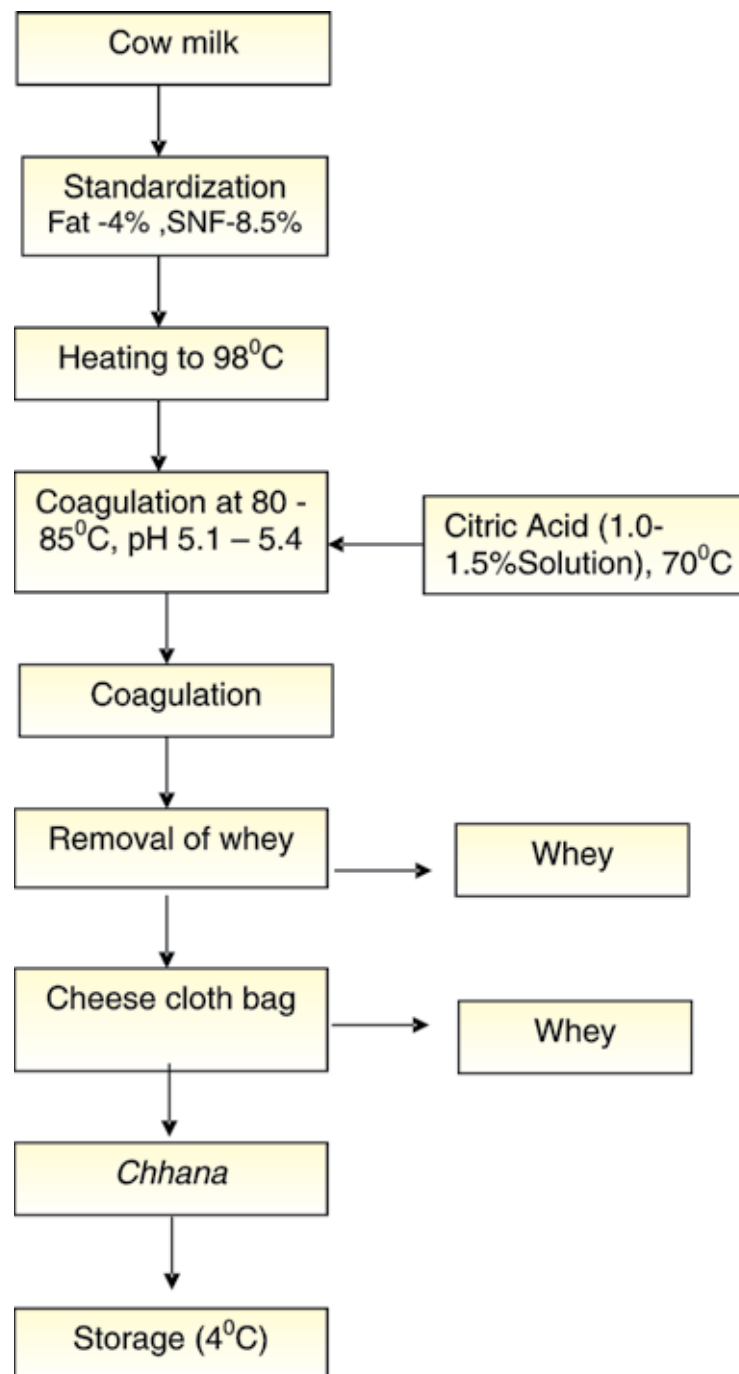
Chhana as a product obtained from cow or buffalo milk or combination thereof by precipitation with sour milk, lactic acid or citric acid. It should not contain more than 70% moisture, and its milk fat content should not be less than 50% on the dry matter basis. If skim milk is used, moisture should not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

Methods of Manufacturing

Traditional Method of Manufacture

Chhana has been prepared by boiling about 20-40 lts of cow milk in an iron Karahi. Acidic whey (previous day whey) added to boiling hot milk serve as coagulant with continuous stirring till the completion of coagulation. Contents then poured over a muslin cloth held over another vessel, whey will be collected in that vessel. Muslin cloth containing curd mass is hung to further drain out the whey.

Fig. 1.4: Flow diagram for Industrial production of *chhana* from cow milk



Method is similar to paneer making except pressing. SS vats and plate heat exchanger or steam jacketed kettle have been used for heating of milk and for storage of liquid milk at industrial production. Other process controls like temperatures of heating of milk, coagulation and coagulant are very precisely maintained as shown in flow diagram. Also SS strainers with cloth lining are used to filter the whey out of coagulum.

Mechanized System for Chhana Making

A prototype machine with a capacity to produce 40 kgs of *chhana*/hour has been developed at NDRI, Karnal. The production of *chhana* of commercial level is depicted in Fig. 1.4.

The standardized cow milk is pumped from the balance tank @ of 250 litres of milk/ hr to an injection chamber where culinary live steam (at 1 kgs/cm² pressure and at the rate of 65kgs/hr) is directly injected into the milk. The steam gets completely condensed in milk and the temperature is raised to 90-95°C. Thereafter the milk is brought in contact with sour whey, the quantity of which is regulated in proportion to the rate of milk flow. The mixture of whey and milk is circulated through a holding coil (8m X 10mm) to facilitate complete coagulation of milk. The coagulated product along with whey is then pumped into a double jacketed cooling tank, where it is cooled down to room temperature. Finally the product is taken to mechanical strainer, a double jacketed mechanical strainer, a double jacketed inclined sieve, where it is drained thoroughly. *Chhana* with 55-65% moisture is discharged through the outlet and collected in the container. Drained whey is transferred to a holding tank for souring for subsequent use.

Preparation of Chhana from Buffalo Milk

Introduction

In India about 53% of the total milk produced is from buffaloes. Dairy plants prefer to buy buffalo milk as it contains higher proportion of fat and T.S. (1.5 to 2.0) times more fat than cow milk. Because of many inherent differences in Physico-chemical make up of cow and buffalo milk several problems are encountered during processing of buffalo milk. Calcium content has direct correlation with hardness. The high calcium and casein (cow milk 2.42 - 2.7% casein and buffalo milk 2.6 - 3.38% casein) content in buffalo milk tender it unfit for preparation of most *chhana* based sweets. Few attempts have been made to produce *chhana* from buffalo milk

A mixture of buffalo milk and cow milk in the ratio of 1:3 yields *chhana* with soft body and smooth texture with features suitable for *rasogolla* and *sandesh* preparation.

Addition of mixture of sodium diphosphate (75g per 100lit.) and disodium phosphate (58g per 100lit.) followed by storing the hot milk for some time before precipitation produces a soft *chhana*. Sodium citrate converts some of the insoluble calcium into soluble salts in the BM and this helps in production of softer *chhana*.

Dilution of buffalo milk (standardized to 4% fat) with notable water @ 30% of milk after boiling and coagulating at 70°C using 0.5% citric solution produces *chhana* good for *sandesh* making.

Factors Influencing Quality of Chhana

Type of Milk

Cow milk produces *chhana* with moist surface, light yellow colour, soft body, smooth texture and mildly acidic flavour which is more suitable for sweets preparations than buffalo milk *chhana*. Buffalo milk gives hard body and coarse texture, white in colour and greasy surface. Sweets prepared from buffalo milk *chhana* are hard, coarse and less spongy. Colostrum milk produces too pasty *Chhana* with deeper yellow colour and unsuitable for *rossogolla*.

Quality of Milk

Fat level

Minimum 3.5 to 4% fat in cow and 5% fat in buffalo milk gives a satisfactory body and texture in *chhana*. Lower than 3.5% fat leads to hard body and coarse texture while higher fat level results in greasy surface

Acidity

Acidic milk produces *chhana* with sour smell and bitter taste hence unfit for sweet making. Addition of neutralizer to slightly acidic milk helps in getting *chhana* suitable for *sandesh* and not for *rasogolla*. Milk with 0.25-0.28% LA can be used by adding 0.2% Sodium Citrate followed by thorough washing of the coagulum.

Type, Strength and Quantity of Coagulant

Type

Organic acids, like citric acid, lactic acid or their salts (calcium lactate), tartaric acid, sour whey are normally used. Lactic acid produces granular *chhana* suitable for *rasogolla* making. Citric acid gives pasty texture suitable for *sandesh* making. However citric acid can also be used for making *chhana* suitable for *rasogolla*. Sour whey with (0.9% LA) can also be used for producing good quality *chhana*. Calcium lactate produces *chhana* with bright white colour, soft body and smooth texture and pleasant flavour and most suitable for *sandesh* making.

Strength

Low acid strength (0.5%) results in very soft body and smooth texture suitable for *rasogolla* but unsuitable for *sandesh* making. The optimum strength of coagulant should be between

1 to 2% citric or lactic acid to produce good quality *chhana* suitable for making both *rasogolla* and *sandesh*. However, Calcium lactate of 4% solution produces most satisfactory quality *chhana*.

Quantity

The quantity of coagulant required is dependent on the type of milk. Generally, 2 to 2.5 g of citric acid per kg of fresh milk and 2.5 to 3.9 gm of lactic acid and 6 to 12 gm of Calcium lactate per kg are required individually for complete coagulation.

Temperature of pH Coagulation

As the coagulation temperature decreases the moisture content of *chhana* increases resulting softer body and smooth texture, sticky *chhana* with slow whey drainage. Higher coagulation temperature imparts graininess and hardness to *chhana*. Optimum coagulation temperature of cow milk is 80 to 85°C and pH is 5.4 and that of buffalo milk is 70 to 80°C and pH is 5.7.

Speed of Stirring during Coagulation

Higher speed of stirring during coagulation reduces the moisture content on *chhana* and increases its hardness, whereas lower speed the reverse hold true (optimum speed is 40-50 rpm).

Method of Straining

Delayed straining produces a soft and smooth texture *chhana* than immediate straining. Delayed straining gives a higher proportion of moisture, yield, recovery of milk solids and lower hardness. Delayed straining is recommended for buffalo milk.

Yield of Chhana

Yield and quality of *chhana* depends on the type of milk, heat treatment given to milk prior to acidification, coagulation temperature, acidity of milk strength of coagulant and residence time of the coagulated *chhana*-whey mixture before separation of milk solids from whey.

Total solids present in milk especially fat and casein influence largely on yield of *chhana*. The yield of *chhana* from cow milk is 15 to 17% and from buffalo milk yield will be 21 to 23 %.

Shelf life of Chhana

Chhana is an extremely perishable food product due to its high moisture content. At room temperature it does not keep good longer than a day. Under refrigeration the shelf life can be extended up to six days. Since fresh *chhana* is preferred for making sweets of good quality much research efforts have not been made in extending the shelf life.

Packaging of Chhana

Most of the *chhana* will be used for making *chhana* based sweets, no special packaging materials were prescribed, as most of the time *chhana* will be sold in bulk. Polyethylene bags are widely used to pack the *chhana*. However, vegetable parchment paper, tin cans, cellulose film, LDPE, aluminum foil /LDPE laminates could also be used to pack the *chhana*.

Defects in Chhana

The various defects occurs in *chhana* are briefly explained in table 1.10, 1.11 & 1.12.

Table 1.10: Flavour defects

Defect	Causes	Prevention
Smoky	Use of smoky fire for boiling and simmering of milk	Use non smoky fire for boiling & simmering of milk
Sour	Use of excessive acidity milk. Use excessive amount of coagulating acid / sour-whey	Use optimum acidity milk, (preferably fresh milk) Use proper amount of coagulating acid / sour whey
Rancid	Fat hydrolysis due to lipase action during storage (at room temperature or above)	Store <i>chhana</i> at low temp (4 to 6°C)
Stale	Excessively long period of storage of <i>chhana</i> at low temp.(5-10°C)	Early utilization.

Table 1.11: Body & texture defects

Hard Body	Inadequate fat content in milk used for <i>chhana</i> production. Inadequate moisture content in <i>chhana</i> due to faulty production	Use optimum fat content in milk Maintain proper moisture content of <i>chhana</i> by adapting correct production technique
Course Texture	Use of excessive acidity milk. Inadequate fat content in milk Too-high temp. of coagulation Too-low pH. of coagulation	Use optimum acidity milk, (fresh milk) Keep optimum fat content in milk Coagulate at optimum. Temp. Coagulate at optimum pH

Table 1.12: Colour & appearance defects

Mouldy Surface	Long storage of <i>chhana</i> , especially in humid atmosphere Excessive moisture content in <i>chhana</i>	Pack the product immediately and reduce the exposure to air Maintain proper moisture content of <i>chhana</i>
Visible dirt / foreign matter	Incorrect or no clarification/filtration of milk Improper cleaning of utensils/equipments Dirty / windy surroundings during manufacture Transport of unpacked <i>chhana</i>	Follow the clarification/filtration with suitable filters Clean the utensils/equipments properly Manufacture <i>chhana</i> in hygienic place Pack the <i>chhana</i> in air tight containers and then transport

Activity

Take 1 kg milk, heat it near to boiling temperature, cool it to 70°C. Add the juice of freshly cut lemon while mixing very gently till clear greenish colored whey separates out. Takeout the curdmass in a thin cloth and hang it to drain the remaining whey.

Review Questions

1. Define Chhana as per FSSR 2011 standards
2. Briefly explain the factors affecting quality of Chhana
3. List the defect of Chhana

Paneer

Objective

To learn the product description, standards and methods of manufacture of *Paneer*

Introduction

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

Standards

FSSR, 2011 Standards

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

Table 1.13: Chemical & microbiological limit for paneer

Characteristics	BIS(IS:10484-1983, Reaffirmed 1999)
Moisture % Max	60
Milk fat % by mass (dry matter basis) min.	50
Titrateable acidity(as lactic acid), % by mass, max,	0.5
Total Plate Count	NMT50,000/g
Coliform count, per g, Max	90

Yeast and Mould count per g, Max	250
Total Plate Count	NMT 50,000/g
Coliforms	NMT 90/g
E.Coli	Absent in 1 g
Salmonella	Absent in 25g
Shigella	Absent in 25g
Staphylococcus aureus	NMT 100/g
Yeast and Mold count	NMT250/g
Anaerobic spore count	Absent in 1 g
Listeria monocytogens	Absent in 1 g

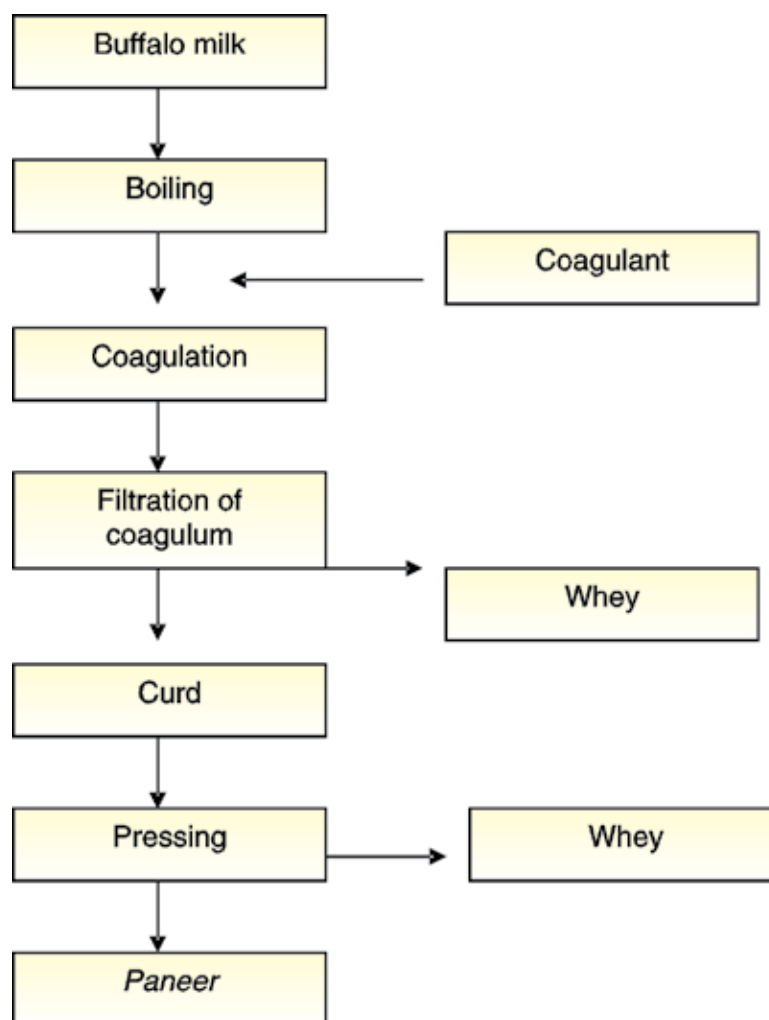
NMT = Not more than

Physico-Chemical Changes during Manufacturing

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

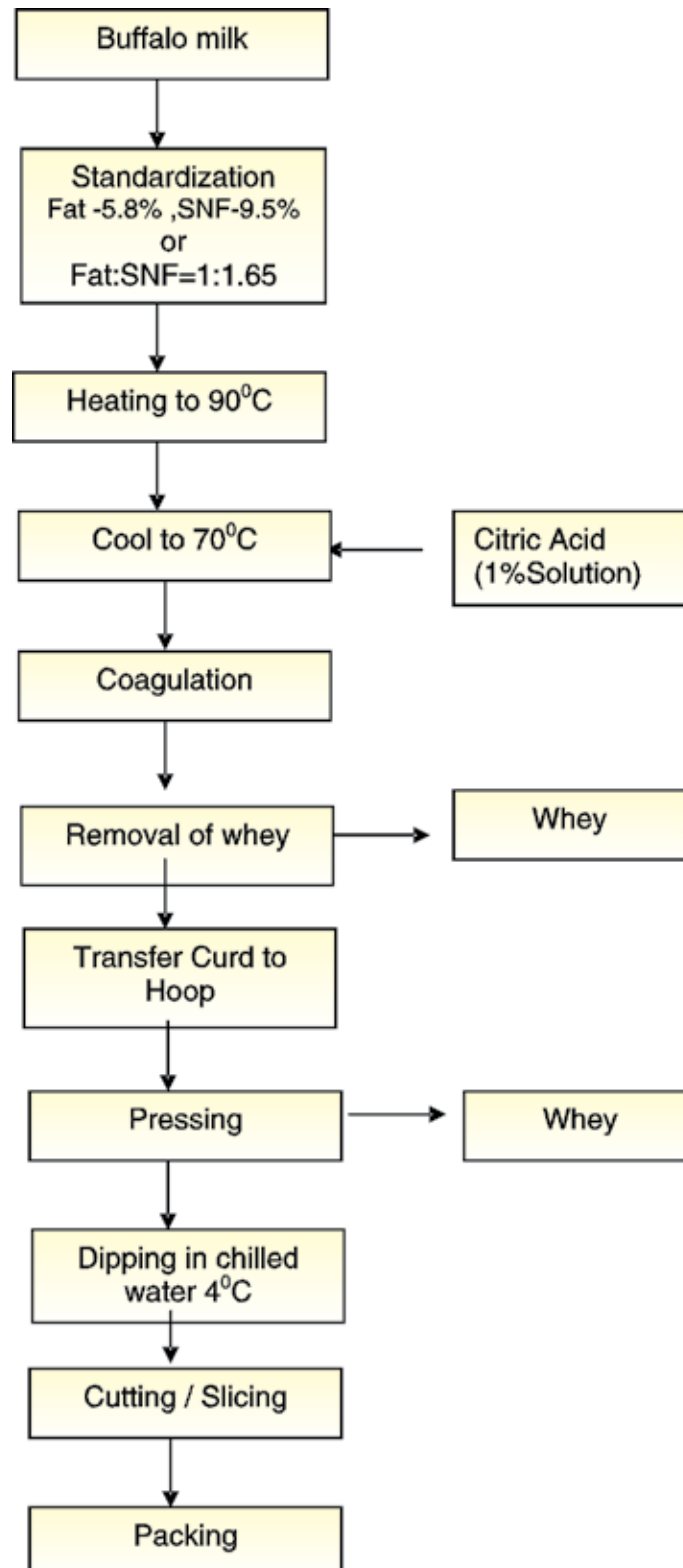
Method of Manufacture

Fig. 1.5: Traditional method of paneer manufacture



Buffalo milk is boiled in a suitable iron vessel and a small portion of this is then transferred to a smaller vessel (Fig. 1.5). The coagulant (usually sour whey) is added to the hot milk and stirred with a ladle till coagulation is completed. The contents of the vessel are emptied over a piece of coarse cloth to drain off whey. The whole process is repeated till all the milk is converted into *paneer*. The curd is collected after draining the whey and pressed to remove more whey. Finally, product is then washed with cold tap water.

Fig. 1.6: Method followed in the organized dairy plant



For commercial manufacture of paneer Buffalo milk is standardized to 5.8% fat having 9.5% SNF (standardize the buffalo milk to a fat: SNF ratio of 1:1.65) (Fig. 1.6). Milk is heated to 90°C without holding (or 82°C with 5 minutes holding) in a jacketed vat and cooled down to 70°C. Coagulation is done at about 70°C by slowly adding 1% hot (70°C) citric acid solution with constant stirring till a clean whey is separated at (pH 5.30 to 5.35) and coagulum is allowed to settle for 5 minutes then whey is drained off. The curd so obtained is filled into hoops lined with cloth. Pressure is applied on top of the hoop at a rate of 0.5 to 1kg/cm². The pressed blocks of *paneer* are removed from the hoops and immersed in chilled water for 2-3 hrs. The chilled *paneer* is then removed from water to drain out. Finally *paneer* blocks are wrapped in parchment paper / polyethylene bags and placed in cold room at about 5 to 10°C. (Indian Dairy Science 1992, 6 Review 6 K.V.S.S.Rao)

Paneer form Cow Milk

Cow milk yields an inferior product in terms of body and texture. It is criticized to be too soft, weak and fragile and unsuitable for frying and cooling. Buffalo milk contains considerably higher level of casein and minerals particularly calcium and phosphorous, which tends to produce hard and rubbery body while cow milk produces soft and mellow characteristics. By replacing one third of buffalo milk with cow milk a good quality *paneer* can be made. Buffalo milk *paneer* retains higher fat, protein and ash content and lactose as compared to cow milk *paneer*. To make *paneer* exclusively from cow milk certain modifications in the conventional procedure have to be made. Addition of calcium chloride at the rate of 0.08 to 0.1% to milk helps in getting a compact sliceable, firm and cohesive body and closely knit texture. A higher temperature of coagulation (85°-90°C) with optimum pH of coagulation of 5.20 to 5.25 keeps in producing good quality *paneer* from cow milk. However, at this pH of coagulation, moisture, yield and solids recovery are less.

Recent Developments in Paneer Manufacturing

Use of Ultra Filtration in Paneer Manufacturing

Ultrafiltration(UF) can be used for the manufacture of *paneer* which offer advantages like access to mechanization, uniform quality, improved shelf life increase yield and nutritionally better product. In this process milk after standardization and heating is passed through UF membrane where lactose, water and some minerals are removed as permeate.

The concentrated mass which has about 40% total solids is cold acidified to get the desired pH. Upto this point the product is flowable and can be easily dispersed into containers with automatic dispersing machines. The filled containers can then be subjected

to texturization by passing through microwave tunnels. The resulting product has typical characteristics of normal *paneer*. The yields increases by about 25% which is due to the retention of good quality whey proteins and slightly increase in moisture content (moisture about 70%) yield is about 25%.

In-package Long Life Paneer like Product

A fully mechanized process has been developed which yields a long shelf life *paneer* like product. In this process standardized buffalo milk is concentrated partly by vacuum concentration process and partly by UF to a T.S. content of 30%. Acidified using GDL – Gluco Delta Lactone. After packaging in metallized polyester pouches, the product is formed by texturizing process at 115°C for 5 min which permits concomitant sterilization. The yield of *paneer* is more due to retention of whey solids and the shelf life is 110, 80 & 47 days at 25, 35 and 45°C respectively.

Continuous Manufacture of Paneer

A continuous *paneer*-making system was developed at NDRI, Karnal by Agrawala et al. (2001). In this system, the unit operations involved in *paneer* making have been mechanized. The continuous *paneer* making machine is designed to manufacture 80 kg *paneer* per hour by employing twin-flanged apron conveyor cum filtering system for obtaining the desired moisture content and texture attributes

Yield

The yield of *paneer* is dependent on the fat and solid not fat content of the starting milk, as well as the moisture, fat and protein retained in the *paneer*. Co precipitation of casein and whey proteins is the simplest way of recovering whey proteins and thus increasing the yield of *paneer*. Heat treatment of milk to 90°C is necessary to achieve good yield. Generally a yield of 20-22 kgs of *paneer* from buffalo milk and 16-18 kg from cow milk

Factors Affecting Quality and Yield of Paneer

Type of Milk

Paneer prepared from buffalo milk will have desirable frying properties, body and texture as compared to cow milk. The cow milk *paneer* is too soft, weak and fragile and during cooking it tend to disintegrate. However cow milk and buffalo milk at 50:50 yields better product than cow milk. *Paneer* made from skim milk has chewy, rubbery and hard body.

Quality of Milk

To obtain *paneer* of good quality, the milk must be fresh and free from off flavour. Growth of psychotropic organisms should be minimized to restrict the off-flavour development. Acidic milk having a titratable acidity of more than 0.20% lactic acid yields a product of inferior quality. The milk with COB positive and low acidity (sweet curdling) is not suitable for *paneer* making. *Paneer* made from such milk has weak body and texture, more moisture, acidic smell and not safe for human consumption.

Type, Strength and Temperature of Coagulant

Product yield and moisture retention are directly influenced by the type and concentration of the acid and the mode of delivery and blending into the hot milk. Citric acid is generally used as a coagulant. Lemon or lime juice or vinegar imparts a typical flavour to the product. 1% solution of citric acid yields good quality of *paneer*. Sufficient acid is added gently but quickly blended with the milk (within 1 minute) to reach ideal pH of coagulation. Normally 1.8 to 2.0 kg citric acid is required for 1000L of milk coagulation. High acid concentration imparts acid flavour, hardness and causes greater solids loss. Whey cultured with *Lactobacillus acidophilus* at a level of 2% and incubated overnight at 37°C can be used as a substitute for citric acid.

Heat Treatment of Milk

This is one of the technological requirements of the process which affect the sensory and microbiological quality of *paneer*. The objective of heating the milk is to prepare the milk for rapid iso-electric precipitation, control the moisture content, develop typical body and texture, create conditions conducive to the destruction of pathogenic and other microflora present in milk and ensure safety as well as keeping quality of the final product. The milk is heated to 90°C without holding or 82°C for 5 minutes in order to maximize the total solids recovery. Whey proteins especially β -lactoglobulin and α -lactalbumin form a complex with κ -casein and retain with the curd thus increase the yield of the product. The high heat treatment imparts desirable cooked flavour by controlled liberation of sulphhydryl compounds.

Coagulation Temperature

It influences the moisture content of the *paneer*, an increase in temperature from 60°C to 86°C decreases the moisture in *paneer* from 59 to 49%. At 70°C, *paneer* has the best organoleptic and frying quality in terms of shape retention, softness and integrity.

pH of Coagulation

The optimum pH of coagulation of milk at 70°C is 5.30-5.35 for better product quality and maximum recovery of solids when made from buffalo milk. The moisture retention in *paneer* decreases with the fall in pH and consequently the yield also decreases. At pH more than 5.35 the *paneer* is very soft with fragile and crumbly body. Optimum pH when cow milk is used for *paneer* preparation is 5.2.

Packaging and Shelf Life

Polyethylene pouches, cryovac films, co-extruded laminates, retort pouches, are being used for *paneer* packing. Vacuum packaging of *paneer* in laminated pouches increases the shelf life to about 30 days at 6°C. *Paneer* packaged in laminate (EVA/EVA/PVDC/EVA) under vacuum and heat treated at 90°C for one minute increases the shelf life of up to 90 days under refrigeration. *Paneer* packed in tins along with water/ brine and sterilized in an autoclave at 15 PSI for 15 minutes lasts for 4 months. The product can be stored under frozen conditions (below 18°C) for more than one year without any deterioration in its quality. *Paneer* dipped in 5% brine solution lasts for about 22 days at 8-10°C. The salting at the time of dipping into chilled water can be used in extending the shelf life of *paneer*. Dipping in benzoic acid (1200 ppm) increases the shelf life of *paneer* to 40 days at refrigerated temperature and 20 days at 37°C. By adding sorbic acid to milk (0.15%) and subsequent wrapping of *paneer* in sorbic acid coated waxed paper the shelf life of *paneer* can be increased to 36 days at room temperature.

Activity

Prepare paneer as per the flow diagram given in the chapter using 1kg cow milk

Review Questions

1. Define paneer
2. Write the technical flow diagram for the preparation of paneer
3. Give the gross composition of paneer
4. List the defect of paneer

Chapter-2

Composition, Standards, Manufacturing – Process and Equipment and Defects during Manufacturing and Storage of **curd/dahi, yoghurt, chakka, shrikhand and cheese**

Dahi

Objective

To learn the Production, Packaging, Storage and Defects of Dahi

Introduction

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

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

Food safety and standards regulation (FSSR, 2011) defines: Dahi or curd means the product obtained from pasteurised or boiled milk by souring, natural or otherwise, by

a harmless lactic acid culture or other harmless bacterial culture may also be used in conjunction with lactic acid bacteria cultures for souring. Dahi may contain added cane sugar. Dahi shall have the same minimum percentage of milk fat and milk solids-not-fat as the milk from which it is prepared (Table 2.1).

Table 2.1: Chemical Composition of Dahi

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

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

Method of Preparation

Traditional Method

In traditional method of dahi preparation, milk is heated intensively to boil for 5 to 10 min and then it is cooled to room temperature. Thus boiled and cooled milk is added with previous day's curd or buttermilk, stirred and allowed undisturbed, to set, usually for overnight.

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

Industrial Method of Making Dahi

The commercial method for production of dahi is given in fig. 2.1.

Selection of Raw Material

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

Filtration/Clarification

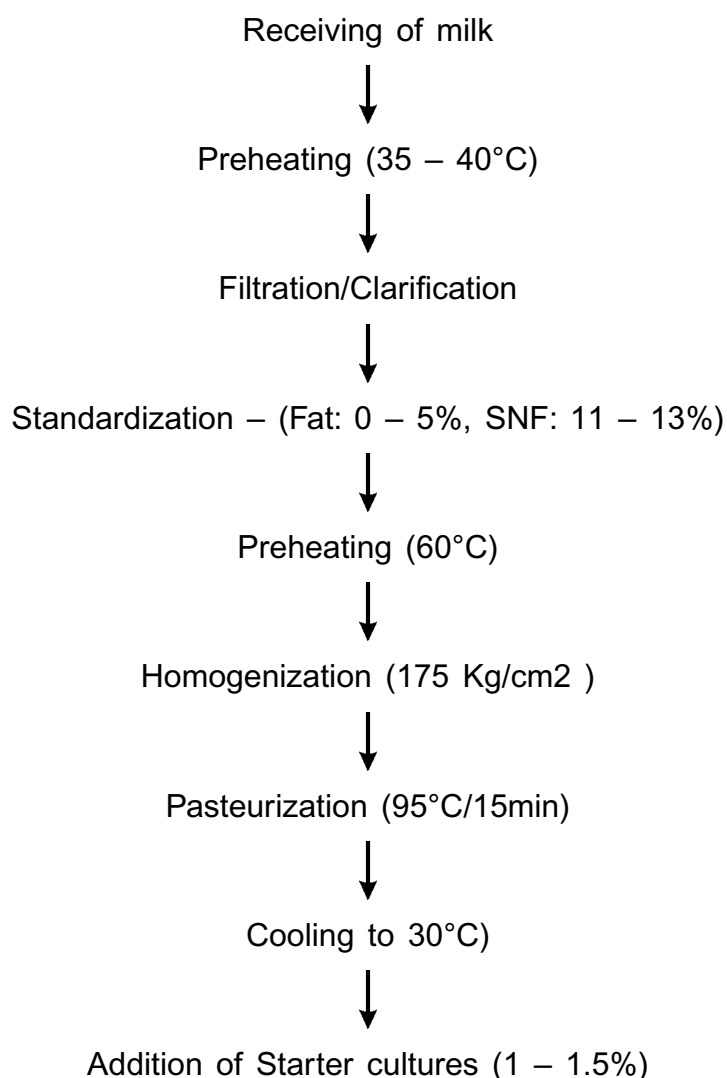
Fresh raw milk is heated to 35 to 40°C to aid clarification or filtration process then it is filtered to ensure the milk is free from extraneous matter.

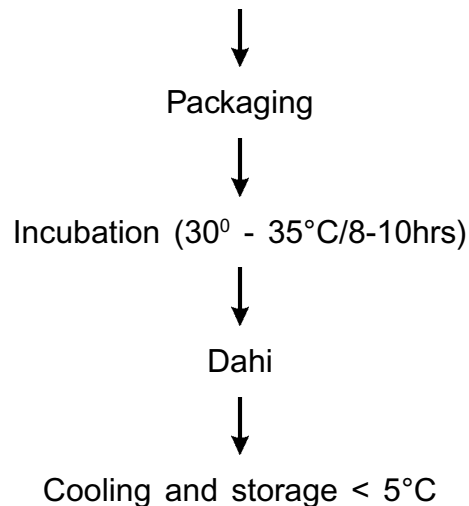
Standardization

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

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

Fig. 2.1: Flowchart for preparation of dahi at dairy industries





Homogenization

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

Heat Treatment

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

- Denatures and coagulates milk albumin and globulins which enhance the viscosity and produce custard like consistency
- Kills contaminating and competitive microbes
- Development of relatively sterile medium
- Removal of air form the medium – more conducive for the growth of culture bacteria
- Effective thermal breakdown of protein releasing peptones and sulfhydryl groups, this inturn provide nutrients to starter bacteria

Packaging and Fermentation

The heat treated product mix is cooled to 37°C and it is inoculated with specific dahi culture at the rate of 1 to 1.5%. Starter culture is the most crucial component in the production of high quality fermented milks. For the production of dahi mixed mesophilic cultures of *Lactococcus lactis* subsp *lactis*, *Lc. Lactis* subsp. *cremoris*, *Lc. Lactis* subsp *diacetylactis*, along with *Leuconostoc* species are grown together. Proper selection of culture strains decides the good quality product. Dairy cultures are available in various forms like freeze

dried, liquid and frozen forms. In India freeze dried cultures are generally used. After the product mix is inoculated with dahi culture it is thoroughly mixed and filled into plastic cups, sealed properly to avoid any contamination and spillage of the product. Thus packed product is arranged in cases or crates and transferred to incubation room maintained at 37°C. The product mix is incubated till the pH of the product reaches 4.4 to 4.5 and then it is cooled rapidly to less than 5°C by exposing the cups to high velocity cold air or by circulating chilled water.

Storage

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

Packaging of Dahi

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

Table 2.2: Defects in dahi

Sl No	Defect	Probable Cause	Remedy
1	Insufficient Flavour	Low citrate level in milk, Low diacetyl content	Add 0.02 – 0.05% Sodium citrate prior to the mix Cool rapidly after culturing
2	Oxidized flavor	Copper contamination Exposure to fluorescent light Exposure to sunlight	Avoid usage of copper utensils Protect product from direct exposure to Sunlight/ UV light
3	Yeast/cheesy	Contaminating yeast growth	Sanitation check
4	Rancid flavor	Lipolytic activity	Do not mix pasteurized and raw dairy ingredients prior to homogenization
5	Weak body	Insufficient heat treatment to the mix Too low milk SNF Sever agitation after fermentation	Heat treatment should be less than 85°C/30min Homogenize the dahi mix prior to homogenization Increase the MSNF content to 11% by adding Skim milk powder
6	Grainy texture	High acidity Improper dispersion of Skim milk powder	Rapidly cool the product to <5°C after attaining optimum acidity Use in line screen/filter

Common Quality Problems in Dahi

Several defects, that occurs in dahi due to various factors are shown in table 2.2.

Activity

Take 1 kg milk, heat it near to boiling temperature, and cool it to 32°C. Add a spoon full of previous day's dahi and keep it undisturbed for 8-10h. Observe for flavor, texture and taste.

Review Questions

1. Give the chemical composition of dahi
2. List the defects and preventing measures in dahi
3. Write the technical flow diagram for the manufacture of dahi

Chakka

Objective

To learn Product Description and Methods of Manufacture of Chakka

Product Description

Chakka is a fermented, intermediate dairy product obtained during the production of Shrikhand. Scientifically chakka can be described as strained dahi, in other words it is the curd mass obtained after removing whey from dahi, either by muslin cloth or basket centrifuge. Chakka is the base material for the production of shrikhand and shrikhandwadi.

FSSR, 2011 Definition for Chakka

Means a white to pale yellow semi-solid product of good texture and uniform consistency obtained by draining off the whey from the Yoghurt obtained by the lactic fermentation of cow's milk, buffalo's milk, skimmed milk and recombined or standardised milk which has been subjected to minimum heat treatment equivalent to that of pasteurisation. It shall have pleasant Yoghurt/Dahi like flavour. It shall not contain any ingredient foreign to milk. It shall be free from mouldness and free from signs of fat or water seepage or both. It shall be smooth and it shall not appear dry. It shall not contain extraneous colour and flavours. It shall conform to the requirements, given in table 2.3

Table 2.3: Chemical standards for chakka

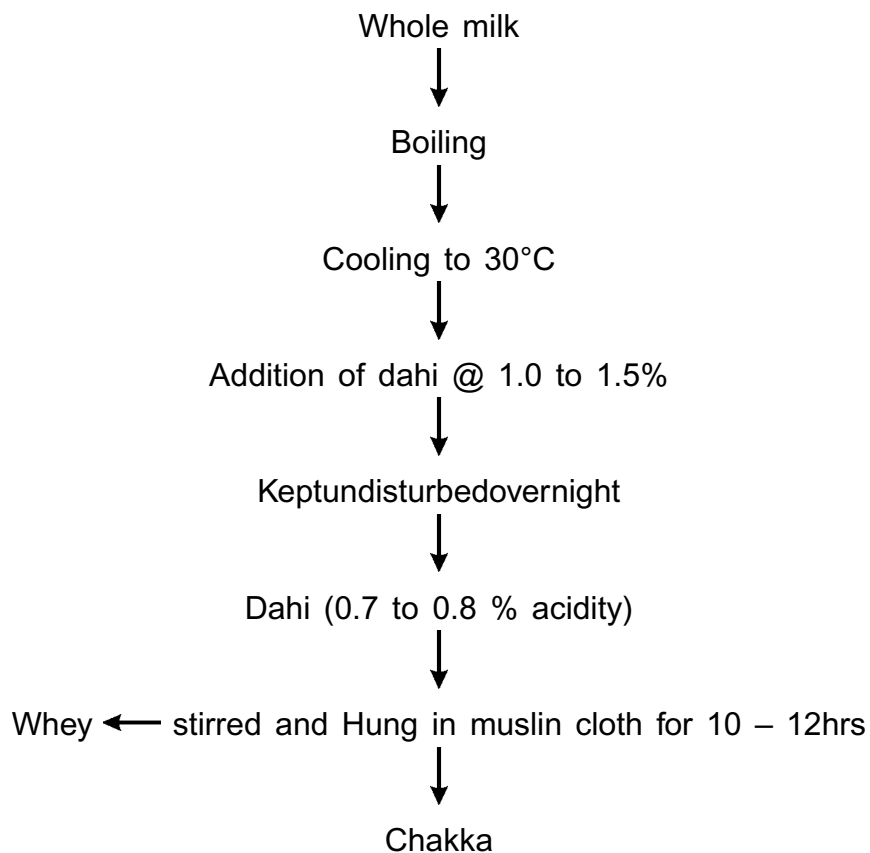
Sl. No.	Components	FSSR, 2011		
		Chakka	Skimmed Milk Chakka	Full cream Chakka
1	Totals Solids (% Min) on DM	30.0	20	28.0
2	Milk Fat % on DM	33.0 (Min)	5.0 (Max)	38.0 (Min)
3	Milk Protein % (Min) on DM	30	60	30.0
4	Titrateable Acidity (% LA) Max	2.5	2.5	2.5
5	Total Ash on DM (% Max)	3.5	5.0	3.5

Chakka when sold without any indication shall conform to the standards of Chakka.

Traditional Method of Making Chakka

In traditional method, cow milk or buffalo milk or mixed milk is boiled thoroughly and cooled to room temperature (30°C) Fig. 2.2. Previous day curd is added to this milk at the rate of 1 to 1.5 %. Milk is left undisturbed overnight at room temperature to set firmly. It is then stirred and hung in a muslin cloth for 10 to 12 hrs to drain off whey. The curd mass obtained after removal of whey is called as chakka.

Fig. 2.2: Flow diagram for traditional method of making chakka



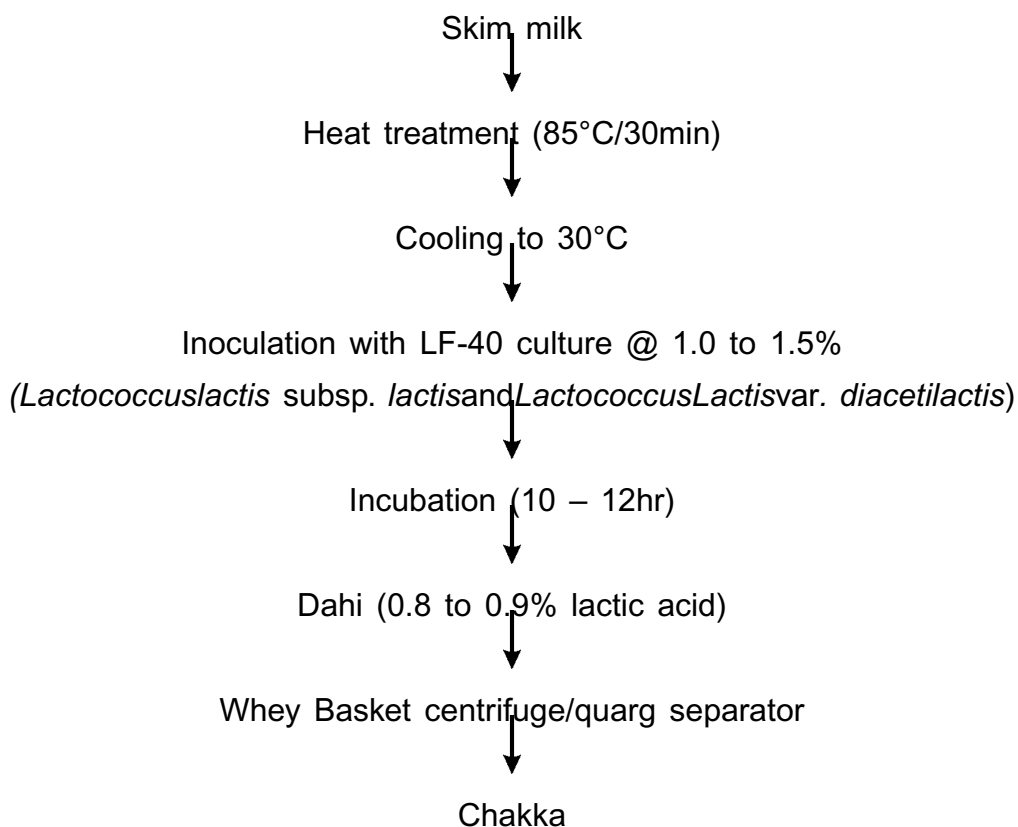
Industrial Production of Chakka

Skim milk is normally used in the commercial scale production of chakka (Fig. 2.3). Use of skim milk has got three fold advantages they are:

1. Low fat loss through whey
2. Faster moisture expulsion
3. Less moisture retention in the final product.

Fresh, good quality skim milk is received and heated to 85°C for 30min. High heat treatment kills the competitive microbes and create congenial environment for the culture bacteria. Heat treated milk is cooled to 30°C and inoculated with LF-40 culture containing *Lactococcus lactis* subsp. *lactis* and *Lactococcus Lactis* var. *diacetylactis* at the rate of 1.0 – 1.5%. Milk added with culture bacteria is incubated at 30°C for 10-12hrs. After the required acidity of 0.8 to 0.9% lactic acid is reached, the curd is taken into basket centrifuge or quarg separator to remove whey from the curd. Quarg separator is a special type of separator commonly used during the production of quarg cheese to remove whey from the curd. Use of quarg separator for removal of whey from curd is a recent innovation, it has increased the chakka production to 8 tonnes/day. Thus obtained curd mass/chakka is ready for further processing i.e. production of shrikhand.

Fig. 2.3: Flow diagram for traditional method of making chakka



Review Questions

1. Chakka is the intermediate product obtained during the production of
 - a) Chhana
 - b) Paneer
 - c) Shrikhand
 - d) Rasogolla

2. Skim milk is preferred in case of industrial production of chakka because
 - a) Reduction in fat loss through whey,
 - b) Faster moisture expulsion
 - c) Less moisture retention in the final product
 - d) All the above

3. As per BIS standards the fat content of whole milk chakka is
 - a) Min. 25 %
 - b) Max. 30% on dry matter basis
 - c) Min. 35%
 - d) Min. 33% on dry matter basis

4. As per PFA standards yeast and mold count of skim milk chakka
 - a) Max 10 cfu/g
 - b) Max 20 cfu/g
 - c) Max 30 fcu/g
 - d) Max 40 cfu/g

5. Acidity of chakka
 - a) 0.5% lactic acid
 - b) 0.8% lactic acid
 - c) 1.5% lactic acid
 - d) 2.5% lactic acid

ANSWERS

1.(c) 2.(d) 3.(d) 4.(a) 5.(d)

Shrikhand

Objective

To learn the Production, Packaging and Preservation of Shrikhand

Product Description

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

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

Food Safety and Standard Rules, 2011 Definition for Shrikhand

Shrikhand-means the product obtained from chakka or Skimmed Milk Chakka to which milk fat is added. It may contain fruits, nuts, sugar, cardamom, saffron and other spices. It shall not contain any added colouring and artificial flavouring substances. It shall conform to the following specifications (Table 2.4)

Table 2.4: FSSR, 2011 and BIS standards for shrikhand

Particulars	BIS	FSSR, 2011	
		Shrikhand	Full cream Shrikhand
Total solids (percent, by mass min.)	58.0	58.0	58.0
Milk fat (% on dry matter, min.)	8.5	8.5	10
Milk protein (% on dry matter, min.)	10.5	9.0	7.0
Titrateable acidity max.	1.4	1.4	1.4
Sucrose (% on dry matter max.)	72.5	72.5	72.5
Total ash (% on dry matter max.)	0.9	0.9	0.9
Coliform count cfu/gm max.	10	-	-
Yeast and mouldcfu/gm max	50	-	-

In fruit Shrikhand milk fat on dry matter basis should be not less than 7.0% and Milk protein on dry matter should be not less than 9.0%.

Traditional Method of Making Shrikhand

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

The yield of chakka produced traditionally is about 650g per 1000g of milk and yield of shrikhand is about 1.5 to 2.0kg per kg of chakka.

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

Industrial Production of Shrikhand

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

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

- Fat losses are eliminated

- Faster moisture expulsion
- Less moisture retention

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

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

Packaging of Shrikhand

As shrikhand is a semi solid product, heat sealable polystyrene cups of 100g to 1000g capacity are commonly used for packing shrikhand. However, small manufacturer sell the product in wax coated paper board boxes. High speed Form-fill-seal machines are also available to pack upto 6000 cups/hr.

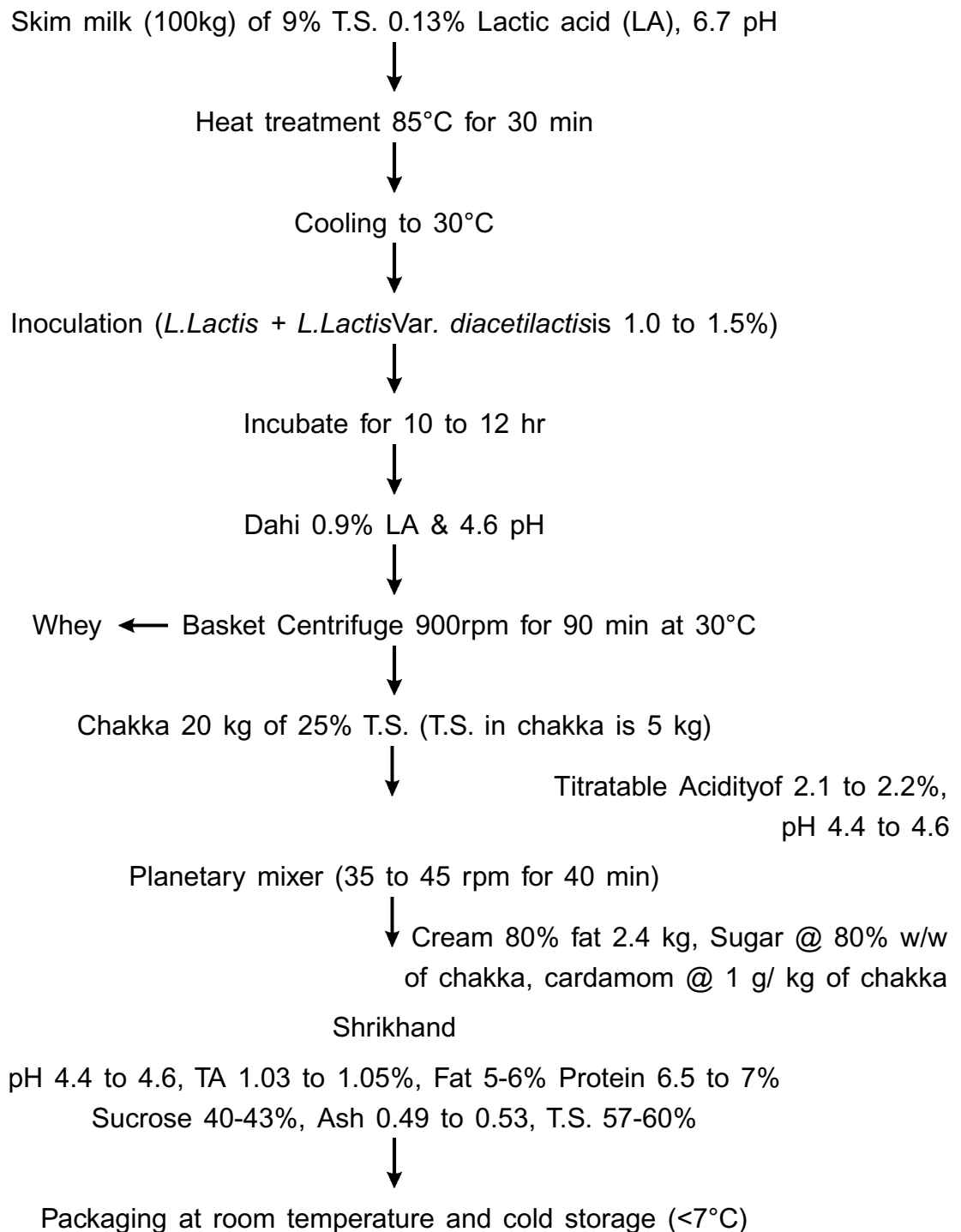
Shelf Life of Shrikhand

Due to both high acid and sugar levels, shrikhand has a fairly long shelf-life of 30-40 days at 8°C and 2-3 days at 30°C. The shelf-life depends largely on the initial level of contaminating Microorganisms particularly yeast and moulds. The shelf life of shrikhand can be increased by addition of potassium sorbate 0.05% or by thermization at 65°C for 10 minutes coupled with addition of 0.02% sorbic acid. For industrial purposes pasteurization of shrikhand at 65°C/10min and subsequent freezing can increase the shelf life upto 12 months at -18°C.

Innovations

- **Use of basket centrifuge or quarg separator for the production of Chakka** - use of basket centrifuge increased the curd production to 80kg/hr and quarg separator has got the capacity to produce 2,500kg of curd per hour. This permits to scale up the production upto 8tonnes/day and minimizes the batch to batch variation with

Fig. 2.4: Industrial method of shrikhand manufacture



respect to moisture and thereby quality of the product.

- Use of planetary mixer or Scraped surface heat exchanger for mixing chakka with sugar and other optional ingredients. These process not only produce homogenous mixture but also increases the production capacity to 40 to 500kgs per batch

- Starter culture – different combination of lactic strains have been developed to produce superior quality of shrikhand as listed below *Lactococcuslactis*, *Lactococcus lactic* var. *diacetylactis*, and *Leuconostoccremoris* in the ratio of 1:1:1, *S. Thermophilus* and *L. Bulgaricus* in the ratio of 1:1 LF-40 culture containing *Lactococcuslactis* subsp. *lactis* + *LactococcusLactis*Var. *diacetylactis* has received wide acceptance by many shrikhand manufacturers.
- Manufacture of shrikhand using UF-chakka
- Manufacture of fruit flavored shrikhand
- Manufacture of shrikhand using low calorie sweeteners. Ex. Raftilose

Activity

Using traditional method of shrikhand manufacture, at home try to manufacture shrikhand by taking 1kg Milk.

Review Questions

1. Base material for the production of shrikhand
 - a) Chhana
 - b) Chakka
 - c) Cream
 - d) Curd
2. As per PFA standards Milk fat content of shrikhand is
 - a) Min.8.5% on dry matter basis
 - b) Min.9.0% on dry matter basis
 - c) Min 9.0%
 - d) Min. 8.5%
3. In the manufacture of shrikhand basket centrifuge is used
 - a) For uniform mixing of ingredients
 - b) To remove whey from the curd
 - c) To improve body and texture of shrikhand
 - d) To minimize the fat loss

4. Innovation in the manufacture of shrikhand
 - a) Use of different combination of starter culture
 - b) Use of membrane processing for the production chakka
 - c) Use of low calorie sweeteners
 - d) All the above
5. Potassium sorbate could be used to improve the shelf life of shrikhand
 - a) True
 - b) False

ANSWERS

1. (d) 2.(d) 3.(b) 4.(d) 5.(b)

Cheese

Objective

To learn product description and method of manufacture of cheese.

Introduction

Cheese is one of the oldest foods of mankind. It is commonly believed that cheese evolved in the Fertile Crescent between the rivers Tigris and Euphrates in Iraq some 8000 years ago. It originated accidentally as a result of the activities of nomadic tribes. Since animal skin bags were a convenient way of storing liquids for nomadic people, these were used for storing surplus milk. Fermentation of the milk sugars in the warm climate prevailing would cause the milk to curdle in the bags. The swaying animals would have broken up the acid curd during journeys to produce curds and whey. The whey provided a refreshing drink on hot journeys, while the curds, preserved by the acid of fermentation and a handful of salt, became a source of high protein food supplementing the meager meat supply.

World Market for Cheese

Cheese continues to be a popular addition to every day diet, thanks to the high amount of protein, calcium, minerals and vitamins it contains. The consumption of cheese, over the years, has improved significantly across the world and subsequently the art of cheese making has now evolved into a lucrative business.

According to a report (Global Industry Analysts, 2010), though the economic recession has put a check on the cheese consumption pattern across the world, more importantly in the developing nations, the future outlook for global cheese market still remains bright with consumption of cheese projected to grow by more than 20% during 2008-2015. Purchasing decisions, being increasingly guided by price, cheaper yet healthy and wholesome foods are surfacing back into the spotlight. Consumers are additionally exhibiting shifting preferences from imported cheese brands to locally produced cheese. Post recession, the demand for organic cheese is slated to make a comeback, with manufacturers expected to expand their product offerings. Innovation and product diversification will be the most prominent market strategies for manufacturers and suppliers in the post recession period. The product mix is poised to change from traditional types of cheeses to new cheeses that suit the demand in developing dairy markets like China and India. The growing demand for dairy products that meet consumers changing diet and nutritional needs will result into strong growth for innovative and healthier cheese products, such as, lactose-free goat cheese products, and half-fat and reduced fat cheeses.

Definition

The word 'cheese' is derived from the Old English 'cese' which in turn was derived from the Latin 'caseus' which means correct or perfect thing. Cheese may be defined 'as the curd of milk separated from the whey and pressed into a solid mass'. This definition of cheese is satisfactory but too limited and vague from a technical standpoint. Therefore, a relatively complete definition is as follows:

Cheese is the curd or substance formed by the coagulation of milk of certain mammals by rennet or similar enzymes in the presence of lactic acid produced by added or adventitious microorganisms, from which part of the moisture has been removed by cutting, warming and pressing, which has been shaped in mould and then ripened (also unripened) by holding for sometime at suitable temperatures and humidity.

The expansion of the numbers of types of cheese makes a simple definition of cheese difficult. Thus the definition, the curd produced from milk by enzyme activity and subsequent separation of whey from the coagulum does not cover whey cheese, lactic cheese, cream cheese and some of the cheeses produced by newer techniques, viz. ultrafiltration and reverse osmosis. The definition is, therefore, not universally acceptable.

Cheese is the fresh or matured solid or semi-solid product obtained:

- a) By coagulating milk, skim milk or partly skimmed milk, whey, cream or butter milk or any combination of these materials, through the action of rennet or other suitable

coagulating agents and by partially draining the whey resulting from such coagulation, or

- b) By processing techniques involving coagulation of milk and/or materials obtained from milk (provided that the whey protein casein ratio does not exceed that of milk) and which give an end product which has similar physical, chemical or organoleptic characteristics as the product defined under (a).

According to the FSSR (2011), cheese means the ripened or unripened soft or semihard, hard and extra hard product, which may be coated with food grade waxes or polyfilm, and in which the whey protein/casein ratio does not exceed that of milk. Cheese is obtained by coagulating wholly or partly milk and/or products obtained from milk through the action of non-animal rennet or other suitable coagulating agents and by partially draining the whey resulting from such coagulation and/or processing techniques involving coagulation of milk and/or products obtained from milk which give a final product with similar physical, chemical and organoleptic characteristics. The product may contain starter cultures of harmless lactic acid and/or flavor producing bacteria and cultures of other harmless microorganisms, safe and suitable enzymes and sodium chloride. It may be in the form of blocks, slices, cut, shredded or grated cheese. FSSR (2011) has also defined cheese on the basis of ripening as follows:

- (i) Ripened cheese is cheese which is not ready for consumption shortly after manufacture but which must be held for some time at such temperature and under such other conditions as will result in necessary biochemical and physical changes characterizing the cheese in question.
- (ii) Mould ripened cheese is a ripened cheese in which the ripening has been accomplished primarily by the development of characteristic mould growth through the interior and/or on the surface of the cheese.
- (iii) Unripened cheese including fresh cheese is cheese which is ready for consumption shortly after manufacture.

Cheese or varieties of cheeses shall have pleasant taste and flavor free from off flavor and rancidity. It may contain permitted food additives and shall conform to the microbiological requirements prescribed in the regulation.

Classification of Cheese

Several schemes to classify cheese have been proposed to assist international trade and to provide compositional and nutritional information. The basis for such classification

include age, type of milk, country of origin, ripening process/agents, important compositional varieties, like moisture and fat, general appearance, texture and rheological qualities. However, none of the above schemes is complete in itself. There are about 2000 names of cheeses. It is very difficult to classify the different cheeses satisfactorily, in groups. There are probably only about 18 types of natural cheeses. These are: Cheddar, Gouda, Edam, Swiss, Brick, Herve, Camembert, Limburger, Parmesan, Provolone, Romano, Roquefort, Sapsago, Cottage, Neufchatel, Trappist, Cream and Whey cheeses. However, FSSR 2011 given certain standards for cheese (Table 2.5).

Such a grouping, though informative, is imperfect and incomplete. These can also be classified on the basis of their rheology, and according to the manner of ripening as shown below:

- 1) Very hard (grating) - Moisture < 35% on matured cheese and ripened by bacteria, e.g. Parmesan, Romano.
- 2) Hard - Moisture < 40%
 - a) Ripened by bacteria, without eyes: Cheddar
 - b) Ripened by bacteria, with eyes: Swiss
- 3) Semi-hard - Moisture 40-47%
 - a) Ripened principally by bacteria: Brick
 - b) Ripened by bacteria and surface microorganisms: Limburger
 - c) Ripened principally by blue mould:
 - i) External – Camembert
 - ii) Internal – Gorgonzola, Blue, Roquefort.
- 4) Soft - Moisture > 47%
 - a) Unripened – Cottage
 - b) Ripened – Neufchatel

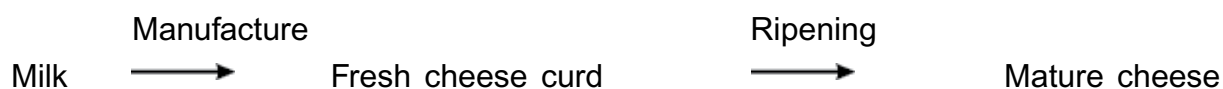
Outlines of Cheese Manufacture

Cheese manufacture involves the controlled syneresis of the rennet milk coagulum, the expulsion of moisture being affected by: i) acid development, the pH falling from 6.6 to about 5.0 as a result of lactic acid bacteria of the starter, chiefly *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris*, ii) warmth, the temperature being raised to about 31°C for renneting and to about 38°C for scalding the curd, and especially iii) repeated cutting of the curd and stirring (Fig. 2.5).

Table 2.5: Legal standards of cheese

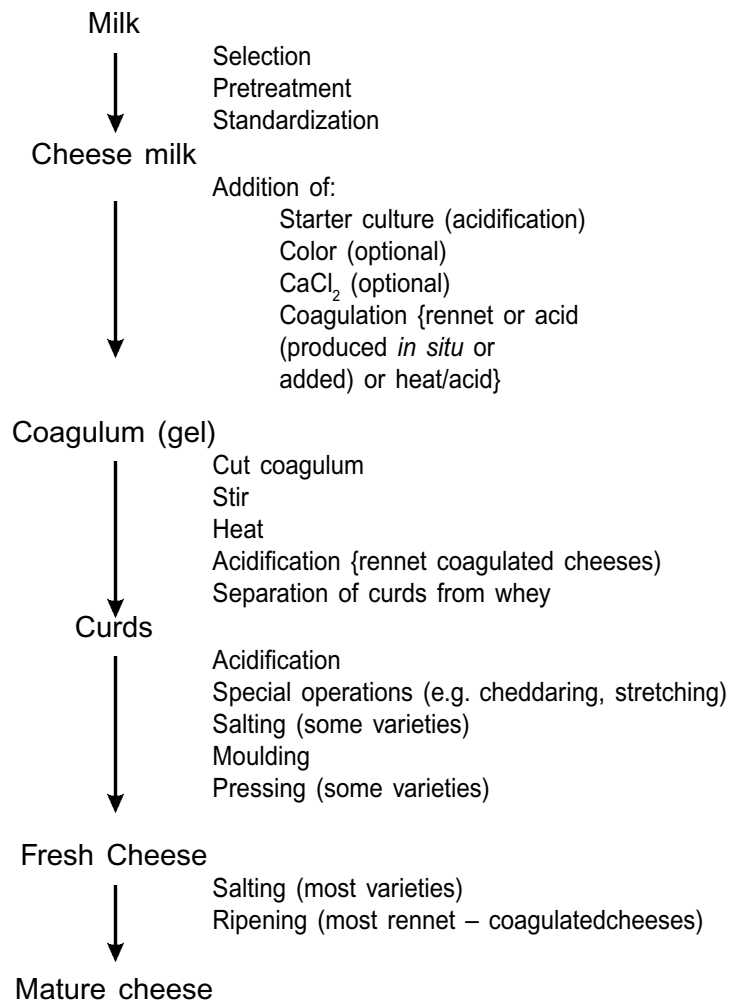
Type of cheese	Moisture, maximum	Milk Fat (on dry basis), minimum
Hard pressed cheese	39.0%	48.0%
Semi hard cheese	45.0%	40.0%
Semi soft cheese	52.0%	45.0%
Soft cheese	80.0%	20.0%
Extra hard cheese	36.0%	32.0%
Mozzarella cheese	60.0%	35.0%
Pizza cheese	54.0%	35.0%

Although some soft cheese varieties are consumed fresh, i.e. without a ripening period, the production of the vast majority of cheese varieties can be subdivided into two well-defined phases, manufacture and ripening.



The manufacturing phase might be defined as those operations performed during the first 24 h, although some of these operations, e.g. salting and dehydration, may continue over a longer period. Although the manufacturing protocol for individual varieties differ in detail, the basic steps are common to most varieties. These are acidification, coagulation, dehydration (cutting the coagulum, cooking, stirring, pressing salting and other operations that promote gel syneresis), shaping (moulding and pressing), and salting. During the dehydration process of cheese manufacture, the fat and casein in milk are concentrated between 6-12 fold, depending on the variety. The degree of dehydration is regulated by the extent and combination of the above five operations, in addition to the chemical composition of milk. In turn, the levels of moisture and salt, and pH and cheese microflora regulate and control the biochemical changes that occur during ripening and hence determine the flavor, aroma and texture of the finished product. Thus the nature and quality of the finished cheese are determined to a very large extent by the manufacturing steps. However, it is during the ripening phase that the characteristic flavor and texture of the individual cheese varieties develop.

Fig. 2.5: Flow diagram for cheese manufacture



Review Questions

1. Define various classes of cheese.
2. Give classification of cheese.
3. Describe the general procedure of making cheese.

Chapter-3

Composition, Standards, Manufacturing – Process and Equipment and Defects during Manufacturing and Storage of **softy, ice cream and kulfi**

Ice Cream and Frozen Desserts

Learning Objectives

- Definition of Ice cream and frozen desserts
- Ice cream standards
- Classification of ice cream
- Ice cream ingredients – Dairy and Non-dairy
- Manufacturing method of ice cream
- The concept of overrun in ice cream
- Freezing of ice cream
- Other frozen desserts



Introduction

Ice cream is a frozen dairy product prepared by freezing a mixture consisting of dairy and non-dairy components such as milk, cream, skim milk powder, sweeteners, stabilizer, emulsifier, fruits, nuts, colour and flavour. All ice cream ingredients are mixed in a specific order and processed to form ice cream mix and this mix is then frozen under rapid agitation with incorporation of air. This process forms semi frozen slush of ice cream which is then hardened to freeze it further.

Ice cream is a product that falls under the broad category of frozen desserts. Frozen desserts other than ice cream are frozen custard, frozen confections, frozen yoghurt, ice milk, sherbets, water ice and mellorine type products. There are many varieties of ice cream available which may differ in flavour, colour, form or ingredients.

Definition and Standards

According to Food Safety and Standards Regulation 2011, India, ice cream, *kulfi*, chocolate ice cream or softy ice cream means the product obtained by freezing a pasteurized mix prepared from milk and/or other products derived from milk with or without the addition of nutritive sweetening agents, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts and it may also contain bakery products such as cake or cookies as a separate layer and/or coating. It may be frozen hard or frozen to a soft consistency; it shall have pleasant taste and smell free from off flavour and rancidity. It may contain food additives permitted in this regulation and it should also conform to the microbiological standards laid by the regulation.

The product shall conform to the requirements given in Table 3.1.

Table 3.1: FSSAI standards for Ice cream

Requirement	Ice Cream	Medium Fat Ice Cream	Low Fat Ice Cream
Total Solid	Not less than 36.0 percent	Not less than 30.0 percent	Not less than 26.0 percent
Wt/Vol (g/l)	Not less than 525	Not less than 475	Not less than 475
Milk Fat	Not less than 10.0 percent	More than 2.5 percent but less than 10.0 percent	Not more than 2.5 percent
Milk Protein (Nx6.38)	Not less than 3.5 percent	Not less than 3.5 percent	Not less than 3.0 percent

(The Food Safety and Standards Regulation, 2011)

Frozen Dessert/Frozen Confection means the product obtained by freezing a pasteurized mix prepared with milk fat and/or edible vegetable oils and fat having a melting point of not more than 37°C in combination and milk protein alone or in combination/or vegetable protein products singly or in combination with the addition of nutritive sweetening agents e.g. sugar, dextrose, fructose, liquid glucose, dried liquid glucose, maltodextrin, high maltose corn syrup, honey, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts. The product may also contain bakery products such as cake or cookies as a separate layer or coating; it may be frozen hard or frozen to a soft consistency. It shall have pleasant taste and flavour free from off flavour and rancidity and may contain permitted food additives. It shall also conform to the microbiological requirements prescribed in the regulation. Total solids, weight /volume and other specifications for frozen desserts are same as for ice cream (The Food Safety and Standards Regulation, 2011).

Production

The ice-cream and frozen dessert market in India is estimated at approximately \$450 million in 2009-10. Growing at approximately 12-15 per cent, it is expected to cross \$900 million by 2014-15. The branded market is estimated at approximately \$200 million and is growing at 20-25 per cent. India has the right climate for Ice Cream consumption but has a very low per capita consumption, which is approximately 300 ml per annum as against the world average of 2.3 litres per annum (Table 3.2).

Table 3.2: Per capita consumption of ice cream in different parts of the world.

Country	Consumption (litres per capita)
Australia	17.9
New Zealand	15.8
United States	14.2
Finland	12.5
Canada	10.5
Italy	10.0
Norway	9.8
United Kingdom	8.6
Denmark	8.4
Chile	8.0
World	2.4
China	2.1
India	0.3

Classification

Depending upon the commercial practices followed, the following classifications are used for different groups of ice cream and frozen products.

Plain Ice Cream: An ice cream in which the total amount of the colour and flavouring ingredients is less than 5% of the volume of the unfrozen ice cream. Examples are vanilla, coffee, maple and caramel ice cream.

Chocolate: Ice cream flavoured with cocoa or chocolate.

Fruit: Fruit Ice cream is made by adding various fruits at the time of freezing with or without additional fruit flavouring or colour. The fruits may be fresh, frozen, canned or preserved.

Nut: Ice cream containing nut meats, such as almonds, pistachio or walnut, with or without additional flavouring or color.

Ice Milk / Milk Ice: A product similar to ice cream containing 2 -7% fats and 12-15% MSNF, sweetened, flavoured and frozen like ice cream.

Ices: Made of fruit juices, sugar and stabilizer with or without additional fruits, color, flavouring or water and frozen to the consistency of ice cream. Usually contains 28 – 30% sugar, 15-20% overrun, and no dairy products.

Sherbets: Sherbet is a product made of fruit juices, sugar, stabilizer, and milk products. It is similar to an ice, except milk, either whole, skim, condensed, or powdered, or ice cream mix, is used in place of all or part of the water used in ices, sherbet contains 1% to 2% milk fat.

Sorbets: The composition of sorbets is similar to that of ices. Sorbets have a high sugar and fruit and fruit juice content (30 and 30 -50% respectively). Stabilizer and egg white are also added, and the product has an overrun of 20% or less. Exotic flavours are often included in sorbets.

Mousse: Ice cream containing whipped cream, sugar, colour and flavouring, and frozen without further agitation. Sometimes condensed milk is added to give better consistency.

Bisque: It is made by the addition of grape, nuts, macaroons, sponge cake or other bakery products with appropriate flavourings.

Custards: custard is ice cream cooked to custard before freezing. Frozen custards are also known as French ice cream or French custard ice cream. It contains whole egg or egg yolk in such a proportion that the total egg yolk solids should not be less than 1.4% of the weight of the finished frozen custard or less than 1.12% for bulky flavoured products. Parfait is frozen custard with high fat content.

Cassata: This is made in a round mold, hinged so that it may be filled with ice cream and other frozen products. The confection is built up in layers of rich, variously flavoured ice cream, some with fruits, some with liqueurs, and sometimes with chocolate or nuts. Fingers or slices of sponge cake, sometimes soaked in liqueur, may be added. The cassata is frozen for several hours, and then turned out of the mold for serving.

Variegated or Rippled Ice Cream: Variegated ice cream is produced by injecting

approximately 10% of a prepared base into the ice cream. Most popular flavours of variegated ice cream are chocolate, butter scotch, straw berry, pineapple and caramel.

Novelties: An ice cream novelty is defined as a unique single-serve portion – controlled product. Novelties include special combinations of ice cream with flavour and confections, cup items, and fancy molded items. They are usually produced by either extrusion or molding, and examples include coated ice cream bars (e.g. Mars), Coated ice cream bars on a stick (e.g. Magnum), ice cream cake, and ice cream logs (e.g. Vienetta), ice cream sandwiches, popsicles and fudgesicles.

Fanciful-Name Ice Cream: These products usually do not contain a single characterizing flavour, but the flavour is due to the mixture of several flavouring ingredients. Two or more distinct flavours are present in the same package.

Mellorine Type Products: Mellorine is a product similar to ice cream in which the butter fat has been replaced by a suitable vegetable or animal fat.

Soft Serve Ice Cream: Soft serve ice cream is a type of frozen dessert that is similar to, but softer than the ice cream. These products are sold as drawn from the freezer without hardening. It is generally lower in milk fat (3.6%) than ice cream (10-18%) and produced at a temperature of about -4°C compared to ice cream, which is stored at -15°C.

Ice Cream Ingredients

The selection of ingredients is the most important factor in manufacture of good quality ice cream. Ice cream ingredients are divided into two groups namely:

- 1) Dairy ingredients
- 2) Non - dairy ingredients

Dairy ingredients are used as a source of milk fat and milk solid not fat (MSNF) required for imparting a characteristic richness and flavour to ice cream. These ingredients also contribute to smoothness of texture and resistance to melting. Various products used as a source of milk fat and milk SNF are summarized in table 2. Milk fat imparts richness and mellows the flavour of ice cream. It tends to retard the rate of whipping. It contributes to smoothness of texture and contributes to body and melting resistance of the product. It does not lower the freezing point of mix. Milk solid not fat is high in food value, inexpensive and enhances palatability of ice cream. It increases viscosity and resistance to melting, but also lowers the freezing point of ice cream mix. Lactose adds slightly to the sweet taste and minerals tend to have a slightly salty taste. Proteins help to make ice cream more compact and smooth.

Non-dairy ingredients comprise sweeteners, stabilizers, emulsifiers, color, flavor, fruits and nuts etc. There are various sources and types of these ingredients as listed in table 3. These ingredients have different role in manufacturing ice cream.

Table 3.3: List of ingredients used in ice cream manufacturing

Dairy Ingredients		
Sources of milk fat	Sources of milk SNF	Combined sources of fat and SNF
Butter	Skim milk powder	Cream
Anhydrous milk fat / butteroil	Whey protein concentrate	Sweetened condensed milk
	Whey powder	Whole milk
	Lactose powder	
Non-Dairy Ingredients		
Sweeteners	Natural	Sucrose, fructose, Glucose, Galactose, Maltose, Rhamnose, Lactose
	Artificial	Aspartame, Neotame, Sucralose, Saccharin, Acesulfame-K
Stabilizers	Gelatin, Guar Gum, Sodium alginate, Carboxy methyl cellulose, Pectin, etc.	
Emulsifiers	Monoglycerides and diglycerides, polysorbates, polyglycerol esters	
Others	Colour, flavour, fruits, nuts, chocolate and cocoa etc.	

Sweeteners

Sweeteners enhance palatability of ice cream. Generally, the desired sugar concentration in ice cream is 13-16%. Sweeteners also affect the freezing point of ice cream mix and thereby properties of the finished product as well. Sugars depress the freezing point of the mix and produce ice cream with smooth body and texture. This is the reason that an optimum quantity of sugar is required in ice cream. Too much sugar makes the product soft enough to handle and less amount of sugar makes is very hard. Since sugars are rich in calorie, artificial sweeteners (non-nutritive sweeteners) such as Aspartame, Neotame, Sucralose, Saccharin, Acesulfame-K etc. are used to replace sucrose in ice cream.

Stabilizers

The stabilizers are a group of compounds, usually polysaccharide in nature that is responsible for adding viscosity to the mix and the unfrozen phase of the ice cream. The

basic role of stabilizer is to reduce the amount of free water in the mix by binding it as “*water of hydration*” or by immobilizing it within a gel structure. Also it is the ability of small percentage of stabilizer to absorb and hold large amounts of bound water, which produces good body, smooth texture, slow melt down and heat shock resistance in the resultant product. Stabilizers can be divided into two main groups: the protein and the carbohydrate group. Gelatine and some milk proteins such as casein, albumin and globulin, all other stabilizers are carbohydrates.

Emulsifiers

An emulsifier is defined as a substance that reduces surface tension between oil–water or air–water interface, thus enhancing emulsification and increasing emulsion stability. An emulsifier consists of a water-loving hydrophilic head and an oil-loving hydrophobic tail. The hydrophilic head is directed to the aqueous phase and the hydrophobic tail to the oil phase. The emulsifier positions itself at the oil/water or air/water interface and, by reducing the surface tension, has a stabilising effect on the emulsion.

Most emulsifiers used in ice cream can be classified as i) fatty acid esters of glycerol and ii) ethoxylated esters of sorbitol. Blends of these two types are more common in use. Typical concentrations of these are 0.1-0.2 % fatty acid esters of glycerol and 0.02-0.04% of sorbitan esters. Other emulsifiers are sucrose esters, polyglycerol esters, propylene glycol esters and ethoxylated glyceride esters. When egg yolk solids are added in ice cream mix, lecithin present in egg yolk can also act as an emulsifier.

Emulsifiers improve whipping quality of ice cream mix, produce a dry and stiff ice cream, increase resistance to shrinkage and rapid meltdown, increase resistance to development of coarse or icy texture and provide smooth texture in the finished product.

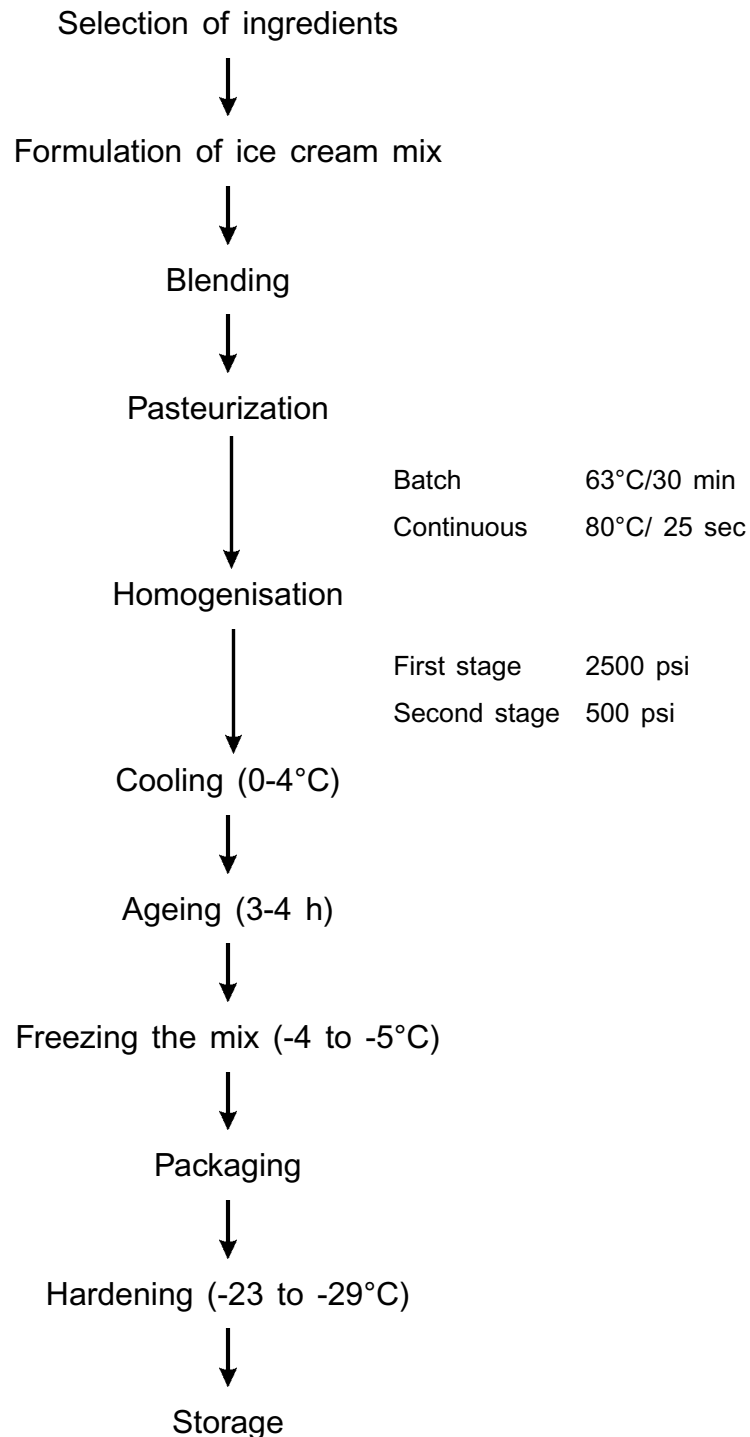
Method of Manufacturing Ice Cream

The method of ice cream making can be divided into two phases:

- 1) Ice cream mix preparation and
- 2) Freezing of ice cream mix.

For mix preparation, firstly all the ingredients are selected based on the composition, type and quality of ice cream desired. The selected ingredients are then proportioned, blended together, pasteurized, homogenized, cooled and then kept for ageing. Properly aged mix is then frozen in ice cream freezers, packaged in containers of desired size and kept for hardening. All these steps will be discussed in detail in the following section. Fig. 3.1 represents a brief outline of the process of ice cream making.

Fig 3.1: Flow diagram for ice cream processing



Selection of Ingredients

Selection of good quality ingredients is a pre requisite for making good quality ice cream. Ingredients for ice cream making can be divided into two groups' namely dairy ingredients and non-dairy ingredients. Dairy ingredients are the sources of fat and milk solid not fat

required for imparting a characteristic richness and flavour to ice cream. These ingredients also contribute to smoothness of texture and resistance to melting. Various sources of milk fat and SNF are milk, cream, unsalted butter, skim milk powder, sweetened condensed milk etc. Non-dairy ingredients include sweeteners, stabilizers, emulsifiers, eggs and egg product, flavours and colours etc. All these ingredients impart numerous functional properties to ice cream mix.

Formulation of Ice Cream Mix

For making good quality ice cream and also to conform to legal standards, composition of ice cream mix is decided and according to the desired composition, quantity of different dairy and non-dairy ingredients is calculated. There are various methods followed for calculating amount of ingredients viz.

- Algebraic method
- Pearson square method
- Serum point method
- Computer developed formulations
- Formula tables/graphics method

Blending of Mix

Blending of all the ingredients is done in vat which is equipped with agitators and has provision for heating. All the liquid ingredients are first placed in the vat and agitation and heating is started. The dry ingredients like skim milk powder, stabilizer, sugar etc. are added to the vat before the temperature reaches 50°C. The temperature of adding dry ingredients also depends on the type of ingredients particularly stabilizer.

Pasteurization of Mix

Pasteurization is done to destroy all the pathogenic bacteria in the mix so as to render the final product safe for human consumption. In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and These methods are used based on the type of mix and the time required for calculations helps to hydrate some of the components (proteins, stabilizers). Both batch (69°C/30 min) and continuous (80°C/25 sec or 135-149°C for few sec) methods are used for mix pasteurization.

Advantages of pasteurization are:

- it renders the mix entirely free of pathogenic bacteria

- it helps in blending the ingredients of the mix
- it improves flavour
- it improves keeping quality
- it produces a more uniform product

Homogenization of Mix

Homogenization is an important step in cream for making permanent emulsion of fat. Two-stage homogenization is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt-down property of ice cream is also improved. Other than reducing fat globules size and forming emulsion, homogenization have some indirect advantages like it makes a smoother ice cream, results in better air stability and also increases resistance to melting.

Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes. If a two stage homogenizer is used, a pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage should be satisfactory under most conditions.

Cooling the Mix

Mix should be cooled immediately after homogenization to 0-5°C and held at the same temperature until used. Slow cooling of the mix increases viscosity and also results in ice cream that does not melt smoothly. Cooling to such a low temperature also retards growth of bacteria.

Ageing the Mix

The mix is then aged for at least four hours and usually overnight. Two important processes take place during ageing. First, the emulsifiers adsorb to the surface of the fat droplets, replacing some of the milk protein. Second, the fat inside the droplets begins to crystallize. Fig. 2 shows the adsorbed emulsifier at the surface of the fat globule and partially crystallized fat inside it. These two processes assist in incorporating and stabilizing air bubbles when the mix is frozen in the freezer. The ageing time, hence the extent of fat crystallization and emulsifier adsorption, depends on the nature of the mix. Overnight ageing is usually sufficient for all types of mixes.

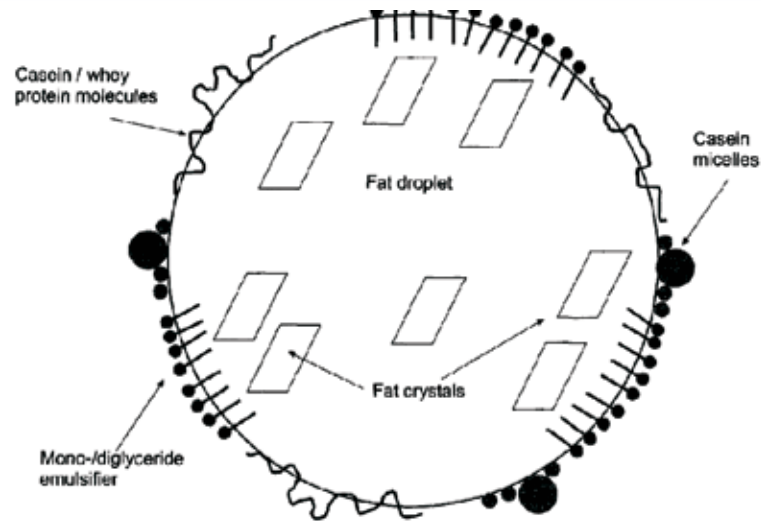


Fig. 3.2: Adsorption of milk proteins and emulsifiers at the surface of the fat droplet and crystallization of the fat

Freezing

Ice cream mix after cooling and ageing is frozen in ice cream freezers. These freezers can be of batch type or continuous. The ice-cream freezer converts mix into ice cream by simultaneously aerating, freezing and beating it, to generate the ice crystals, the air bubbles and the matrix. The freezer is a scraped-surface, tubular heat exchanger, which is jacketed with a boiling refrigerant such as ammonia or Freon (Fig. 3). Mix is pumped through this freezer and ice cream is drawn off within 30 seconds, (or 10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen. As shown in fig 3.3, there are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip the mix and incorporate

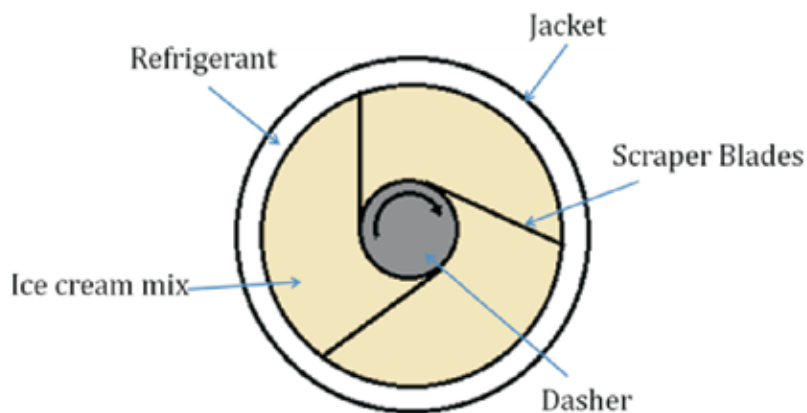


Fig. 3.3: Cross section of an ice cream freezer

air. Air is also incorporated to obtain the required over-run in the semi frozen mass during freezing process. This is achieved by supplying compressed air into the freezer.

As the ice cream is drawn from the freezers, particulate matter such as fruits, nuts, candy, cookies, etc. is added to the semi-frozen slurry which has a consistency similar to soft-serve ice cream. In fact, almost the only thing which differentiates hard frozen ice cream from soft-serve, is the fact that soft serve is drawn into cones at this point in the process rather than into packages for subsequent hardening.

Hardening

When ice cream is drawn from freezer, its consistency is such that it can be filled in containers like cups or in bulk packages. After filling into packs, it is necessary to lower the temperature of ice cream as quickly as possible. This is known as hardening. Hardening of ice cream is essential to stabilize the microstructure of the product after freezing and air incorporation.

Ice cream is hardened in a hardening tunnel, an enclosed chamber into which the ice cream passes on a conveyor belt from the freezer. Inside, cold air (typically - 30 °C to - 45 °C) is blown over the ice cream. The lower the air temperature and the faster the air flow, the faster heat is removed from the ice cream. Cold stores, which are typically about -25 °C, are not suitable for hardening because they are not cold enough and have still air, so they cannot cool the ice cream rapidly enough to minimize recrystallization. Hardened ice cream is then stored at temperature -23°C to -18°C so as to keep the structure stable.

Storage

The ice cream should be stored in a deep freezer at -18 to -23°C. It should not be allowed to melt for two reasons: first this would allow any bacteria in the ice cream to grow and spoil the product, and secondly the air in the ice cream escapes and it loses its texture to become solid ice when re-frozen. When the molten ice cream re-freezes, ice crystals formed are much larger than the crystals formed in freezers and the ice cream taste more 'gritty'.

Overrun: An Important Attribute of Ice Cream

As mentioned in the previous sections, ice cream mix is frozen with continuous agitation and aeration. This process incorporates a significant amount of air in the product which increases its volume but the weight remains constant. That is the reason that ice cream (finished product) is always measured in volume not in weight. The formulae for calculating overrun in ice cream are:

Percent overrun in ice cream

$$= \frac{\text{weight of ice cream mix of a fixed volume} - \text{weight of ice cream of the same volume}}{\text{weight of ice cream of the same volume}} * 100$$

Percent overrun in ice cream

$$= \frac{\text{Volume of ice cream of a fixed weight} - \text{Volume of ice cream mix of same weight}}{\text{Volume of ice cream mix of same weight}} * 100$$

For example, a 90 Kg (volume approx.80 litre) ice cream mix is frozen and 150 litre of ice cream is made. The overrun for the ice cream will be $\frac{(150-80)*100}{80} = 87.5\%$.

Other Frozen Desserts

Frozen Yoghurt

Frozen yoghurt is a type of frozen dessert wherein yoghurt is prepared first, it is mixed with ice cream mix in a definite proportion, sugar, fruits, colour and flavour and then the mix frozen in the same manner as ice cream is frozen. The resultant product is a frozen fermented product having consistency similar to ice cream. Frozen yogurt mix has a pH of 6.0 or titratable acidity of 0.30%. This titratable acidity is contributed both by yoghurt and ice cream mix. Most manufacturers use 10% of yogurt in their formulations. As a consequence, frozen yogurt tastes very similar to low fat/non-fat ice cream, with a hint of yogurt flavor at the end. This flavor attribute is preferred by the consumer because the perceived health attributes of yogurt bacteria are available along with the popular taste of low fat/non-fat ice cream.

Kulfi

Kulfi is a traditional frozen dairy product of India which is prepared by concentrating milk about two folds by continuous heating, addition of sugar, nuts etc., filling the mix in moulds and freezing in ice and salt mixture. The main differences in kulfi and ice cream are that the former is prepared by concentrating milk by heating and it has negligible overrun. Freezing of kulfi is not done with continuous agitation and aeration. It is frozen in static conditions in ice and salt mixture.

Soft Serve Ice Cream

Soft serve ice cream popularly known as softy is another variant of frozen desserts. Method of manufacture is similar to ice cream with the only difference that this product is not hardened before consumption. It is consumed just after drawing it from the freezer in soft condition. It has low overrun than ice cream.

Defects in Ice Cream

Ice cream defects can be classified as flavour defects, body and texture defects, melting quality characteristics, colour defects and shrinkage.

Various flavour defects in ice cream are given in Table 3.3.

Table 3.3: Flavour defects in icecream

Lack of flavour	Due to flavouring system used
Unnatural flavour	
Lacks sweetness or too sweet	Due to sweeteners used
Cooked flavour	Processing related defect
High acid	Ingredient related defect
Salty	
Oxidised	
Rancid	

Body and texture defect in ice cream may be due to faulty method of manufacturing, due to improper storage conditions or due to levels of various ingredients.

Coarse/Icy Texture: Due to the presence of ice crystals of bigger size that make them are noticeable when the ice cream is eaten. Optimum ice crystal size in ice cream ranges from 20-50 microns. This defect is caused by:

- Fluctuating temperatures during storage and distribution
- Insufficient total solids (high water content).
- Insufficient stabilizer or poor stabilizer.
- Insufficient aging of the mix
- Slow freezing because of mechanical condition of freezer.
- Slow hardening

Crumbly Body: A brittle or friable structure of ice cream is characterized as crumbly defect. This is caused by:

- High overrun
- Low stabilizer or emulsifier
- Low total solids

Fluffy Texture: A spongy characteristic caused by:

- Incorporation of large amount of air.
- Low total solids.
- Low stabilizer content.

Gummy Body: This defect is the opposite of crumbly in that it imparts a pasty body. It is caused by:

- Too low overrun.
- Too much stabilizer

Sandy texture: It is caused by lactose crystals, which do not dissolve readily and produce a rough or gritty sensation in the mouth. This can be distinguished from “iciness” because the lactose crystals do not melt in mouth. This defect can be prevented by many of the same factors that inhibit iciness such as:

- hardening the ice cream quickly
- maintaining low storage room temperature
- preventing temperature fluctuations

Weak Body: Ice cream lacks “chewiness” and melts quickly into a watery liquid. Such ice cream gives impression of lacking richness. It is caused by:

- Low total solids.
- High overrun.
- Insufficient stabilizer

Melting Quality Characteristics

Curdy Melt-Down: This is the defect caused by fat or protein destabilization. This may be due to:

- High acidity that causes protein coagulation
- Salt balance (protein coagulation).
- High homogenizing pressures (fat coagulation).

Does not melt: Ice cream with this type of defect retains its shape even after 15-20 min. It may be caused by:

- Over emulsification.
- Excessive fat destabilization

Wheying off: It is characterised by the appearance of watery fluid with curd particles. The common cause is protein destabilization or phase separation.

Summary

Ice cream is a type of frozen dessert in which milk or milk products can be the only source of fat and protein. Other ingredients are also used in ice cream such as sweeteners, emulsifiers and stabilizers. These are required for various functional properties of ice cream. Technology of ice cream needs understanding of various unit operations such as pasteurization, homogenization, aging, freezing and hardening. All these operations are described in this chapter with an aim to sensitize the students about the technology of ice cream.

Despite the fact that ice cream is a highly nutritive product, consumption of ice cream in India is far below the world's average per capita ice cream consumption.

Activities

- Collect five different brands of ice creams or frozen desserts available in the market.
- Observe their compositions and figure out the differences.

Review Questions

1. What is the difference between ice cream and frozen desserts?
2. What is the role of stabilizers and emulsifiers in ice cream?
3. What are the ingredients used in ice cream making? How are they classified?
4. What is frozen yoghurt?
5. Define ice cream with standards laid by FSSAI, 2011.

Chapter-4

Composition, Standards, Manufacturing – Process and Equipment and Defects during Manufacturing and Storage of **Concentrated milks - Condensed milk, Evaporated milk, Milk Powder - Skim milk, Whole milk, Whitener**

Condensed and Evaporated Milk

Learning Objectives

After reading this chapter you will be able to understand:

- what are condensed and evaporated milks
- what are the types of evaporators
- the manufacturing process of condensed milk and evaporated milk
- how the condensed and evaporated milks are packaged
- the possible defects in condensed and evaporated milks during their storage and their causes

Introduction

Liquid milk and some byproducts of dairy industry like whey and buttermilk contains more than 80% water. Removal of a part of water from these liquid milk and byproducts has the benefits of; convenience in handling, increase their usefulness in food manufacture, reduce their shipping weight, increasing their shelf-life and reduce the expenditure of energy while drying them to make the process more economical.

Condensed Milk

Condensed milk is the product obtained by evaporating a part of the water of whole milk, or fully or partly skimmed milk with or without the addition of sugar. Sweetened condensed whole milk and sweetened condensed skim milk have sugar added as preservative.

However, in the dairy industry, the term condensed milk is commonly used when referring to sweetened condensed whole milk.

Evaporated milk is the product obtained by evaporating a part of the water from milk (whole or skimmed) and subsequently sterilizing that concentrated milk.

The ratio of concentration of milk solids is about 1:2.5 for full cream (whole milk) products and 1:3 for sweetened condensed skim milk.

Water may be removed from the milk by evaporation (in an open pan at atmospheric pressure or under vacuum), partial freezing or by reverse osmosis. Concentration of milk under vacuum is based on the physical law that the boiling point of a liquid is lowered when it is exposed to a pressure below the atmospheric pressure. Because of this reason evaporation of milk under vacuum is widely used in the dairy industry. Advantages of vacuum evaporation of milk include economy of operation, rapidity of evaporation and protection of milk against heat damages like protein denaturation, vitamin losses and cooked flavour development. Food Safety and Standards Regulations (2011) for sweetened condensed milk and evaporated milk are given in Table 4.1.

Table 4.1: FSSR (2011) standards for evaporated and sweetened condensed and evaporated milk products

Product	Milk fat (w/w)	Milk solids (w/w)
Evaporated milk	Not less than 8 %	Not less than 26%
Evaporated skimmed milk	Not more than 1%	Not less than 20%
Evaporated partly skimmed milk	Not less than 1% and not more than 8%	Not less than 20%
Evaporated high fat milk	Not less than 15%	Not less than 27%
Sweetened condensed milk	Not less than 9 %	Not less than 31%
Sweetened condensed skimmed milk	Not more than 1%	Not less than 26%
Sweetened condensed partly skimmed milk	Not less than 3% and not more than 9%	Not less than 28%
Sweetened condensed high fat milk	Not less than 16%	Not less than 30%

Note: Milk protein in milk solids not fat should not be less than 34% w/w

Evaporation Unit and Classification of Evaporators

An evaporation unit (Fig. 4.1) chiefly consists of: a vacuum evaporator operating as heat exchanger, a separator for the separation of vapour and concentrate, a condenser for the vapour and equipment for the production of a vacuum and the removal of the concentrate.

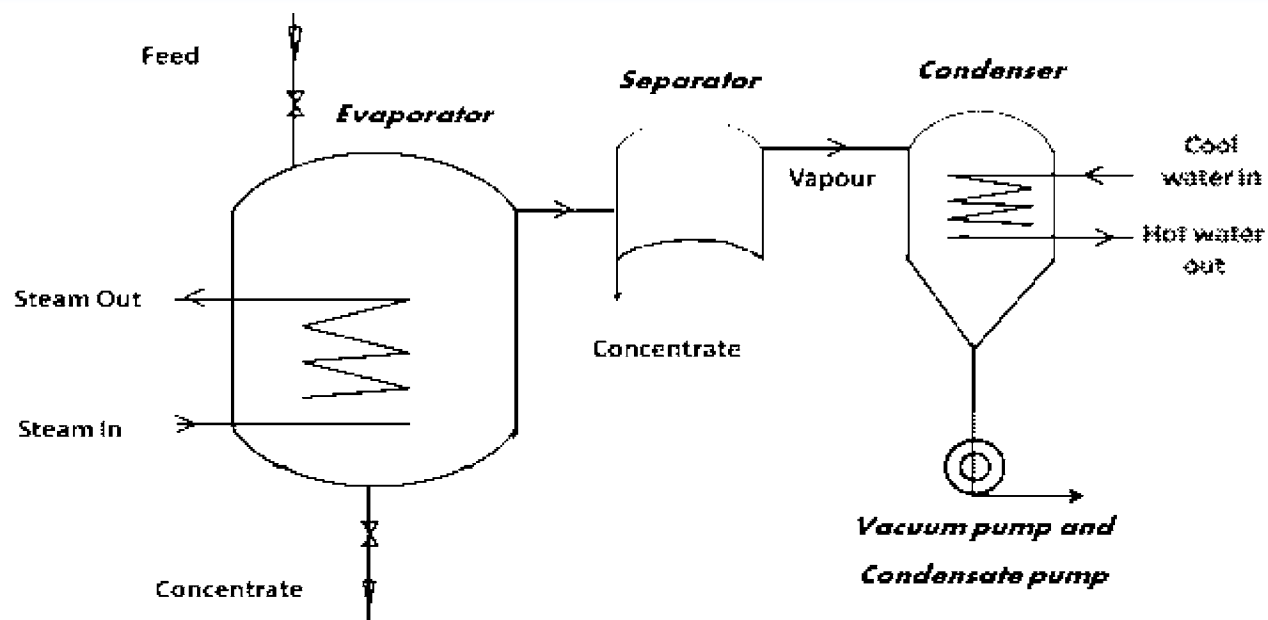


Fig. 4.1: Principle parts of an evaporation unit

Description of a Batch Type Evaporator or Vacuum Pan

The main components of a batch type evaporator or vacuum pan (Fig 2) are described below:

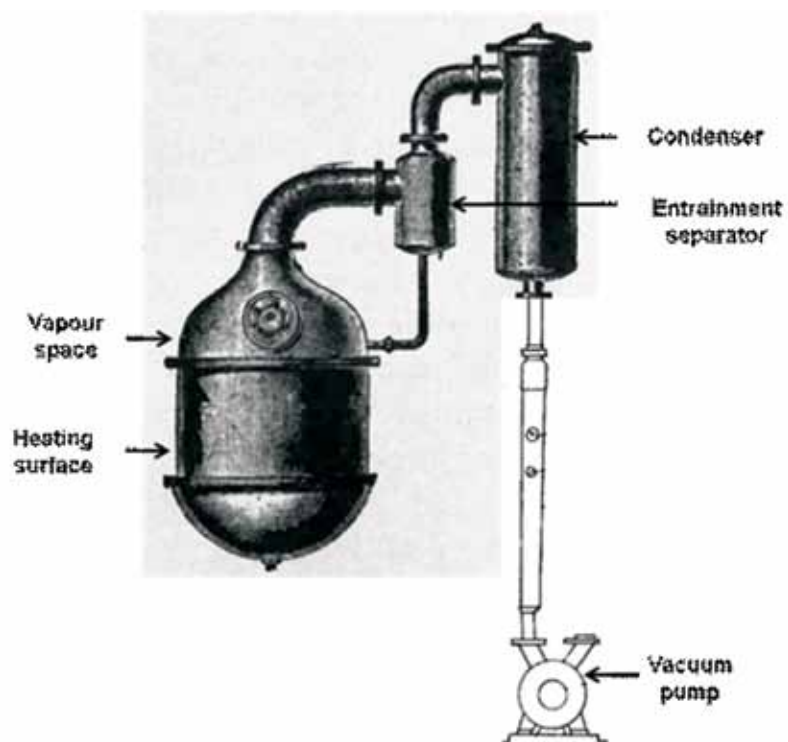


Fig. 4.2: Schematic of a vacuum pan

Heating surface: This is the surface area available for the heating of liquid. This determines the evaporative capacity of the vacuum pan (Fig. 4.2). Design of heating surface varies with the type of product to be obtained and /or type of evaporator intended for the evaporation of liquid. It is provided with either a steam jacket, or a series of steam coils, or both; or with product tubes enclosed in a steam chest or calandria; or a series of plates with low pressure steam and product in alternate plates, etc.

Vapour space: This refers to that portion of the body of the pan which extends above the level of milk. The walls of the vapour space are equipped with a manhole, thermometer, vacuum gauge, vacuum break, observation glass and illumination glasses with lights. The milk intake pipe also enters here from the forewarmer and discharges hot fresh milk into the pan.

Entrainment separator: During boiling of milk in the evaporator, the vapours produced may carry the milk solids to the condenser which not only causes product losses but also reduces efficiency of the condensers. Entrainment separator reclaims the particles of milk that pass from the vacuum pan to the condenser along with the high velocity vapour currents. The latest designs of efficient entrainment separators are capable of reducing entrainment losses to less than one per cent.

Vapour condenser: In the condenser, milk vapour is condensed for maintaining the desired vacuum and the entrained air and non-condensable gases are cooled to have a smooth pan operation. The condensers may be either surface or spray types. The spray condenser of the counter current type is generally used in milk condensery. The counter current condenser makes highly efficient use of the water supply, makes possible the advantageous use of a water- cooling tower or spray pond, and is particularly recommended in the tropics.

The amount of cooling water required in the condenser is determined by the temperature of the water supply, the pan operating temperature and the temperature of the condenser water discharge. On an average, it requires 20 kg of cooling water to remove the vapours of 1 kg of water contained in milk, in the tropics. It is desirable to use potable water in the condenser because it may get into the vacuum pan sometimes.

Vacuum producing equipment: During evaporation of milk, the vapours released in the vacuum pan will increase the pressure in the surroundings which lead to the increase in the boiling point of liquid. This will increase the energy inputs and also causes product damage. Vacuum producing equipment produces and maintain vacuum in the plant by removing continuously non-condensable gases and air. Vacuum pumps or steam ejectors are employed for this purpose. The vacuum pumps employed can be of two types, viz.,

the wet type and the dry type. The wet type vacuum pump, besides the non-condensable gases, pumps out the condensed vapours whereas; the dry type handles only the air and non-condensable gases. Steam ejectors are used when high vacuum (above 610 mm or 24 inches Hg) is required.

Classification of Evaporators

Evaporator development began in 1850's and has resulted in many shapes, sizes and types of units. Evaporators may be classified mainly based on (i) method of circulation of product: forced, natural; (ii) direction flow of film of product: rising film, falling film; (iii) number of evaporator bodies employed: single effect, double effect or multi effect. Falling film evaporators are currently the most suitable means for concentrating large amounts of milk for various purposes; (iv) continuity of operation: batch, continuous. The description of a few well-known evaporators with their particulars is briefly given below:

Circulation or vertical tube evaporators: Tubes carrying the steam internally are placed vertically in the bottom of the cylindrical evaporator, chamber. It is popularly known as Calandria evaporator. As a single pass through the tube heat exchanger is usually not sufficient to achieve the required degree of concentration, the product is returned by means of the circulation tube. Cleaning and inspection is easy.

Horizontal tube evaporators: In certain conditions, if, for, example, there is limited vertical space for installation, the tubular heat exchanger can be used as a horizontal evaporator. To ensure that both the top and the bottom tubes are covered with liquid, the evaporator must be operated in a flooded condition, i.e. the feed inlet must be positioned above the uppermost tube. Steam enters a chest on one end of the tubes, moves through the tubes and the condensate is removed from the chest at the opposite end while the vapour is removed from the top of the cylindrical chamber.

Plate evaporators: The plate evaporator is characterized by a large heat exchange surface occupying a relatively small space. Like the plate heat exchanger, it is constructed from profiled plates with the condensing steam used as heating medium and the evaporating product passing between alternate pairs. The capacity of a plate evaporator can be altered by changing the number of plates.

Forced circulation evaporators: When highly viscous products are to be evaporated, the forces which normally move the liquid along are not sufficient to transport the product satisfactorily. Centrifugal or positive pumps are used for forced circulation of viscous

liquids. The operation is only economical if the product has been pre-concentrated on a simpler evaporator.

Falling film evaporators: The heat exchange surface in a falling film evaporator consists of a bundle of tubes down which the product flows. Depending on the design, the tubes are 4-10 m long and have a diameter of 25-80 mm. The falling film evaporator has become of great importance to the dairy industry. The relatively short contact times and the possibility of accurate temperature control ensure mild evaporating conditions.

Multiple effect evaporators: The vapour produced through evaporation in the vacuum pan contains considerable latent heat. The vapour from the vacuum pan may be used in much the same way to heat another vacuum pan as steam is used to heat the unit. Thus, two or more effects can be utilized in the evaporator to provide a method of utilizing the useful heat in the vapour and to improve the economy of the operation. A common multiple effect evaporator is the triple effect system. Each effect can consist of any of the types of several units discussed previously. The vapour removed from the first effect at a high temperature moves to the heating coils of the second effect which is at a lower temperature. Likewise, the vapour removed from the second effect is directed to the heating coils or tubes of the third effect, at a still lower temperature. The temperature must decrease in the direction of flow so that the heat will flow from the vapour to the Product. The major advantage of the multiple effect evaporator is that it requires less steam per kg of water

Processing, Packaging and Storage of Sweetened Condensed Milk

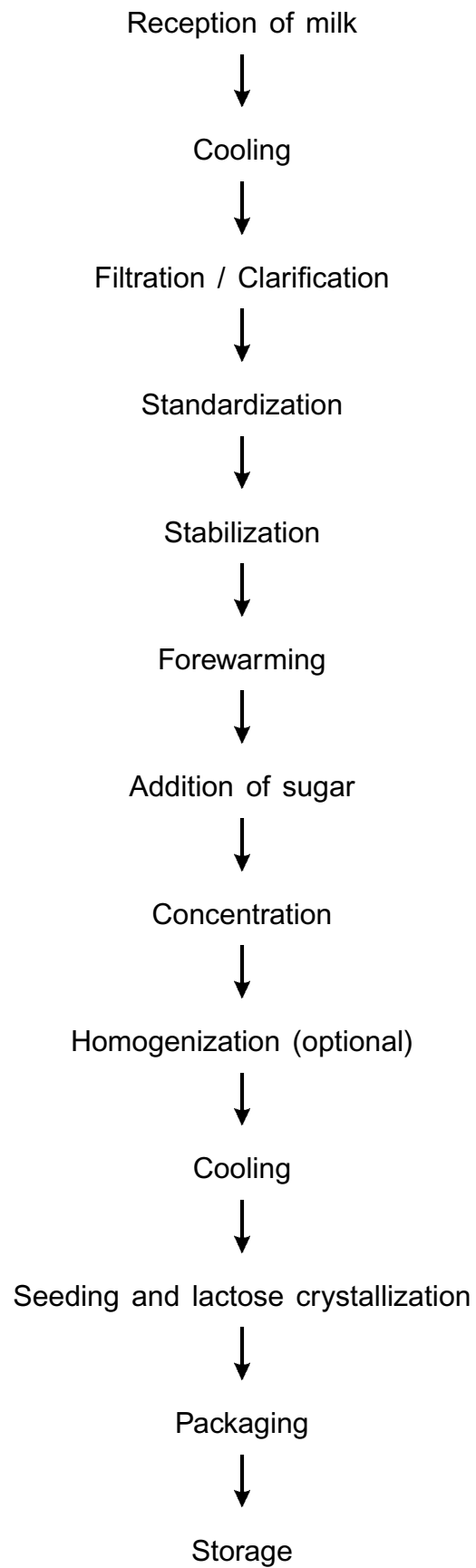
Condensed milk is made from either cow or buffalo milk or a mixture of both. Condensed whole milk products are sold in cans for retail sale while sweetened condensed skimmed milk is bulk packed in drums or barrels for use in confectionary, bakery, etc.

Manufacture of Sweetened Condensed Milk

This is one of the earliest products commercially introduced and is made from standardized whole milk with sugar acting as a preservative. For each kilogram of milk, approximately 0.4 kg of product is obtained with removal of 0.8 kg of water. The product can be readily reconstituted by the addition of water, 1 kg of product giving 2.5 kg of sweetened reconstituted milk. The processing steps involved in the production of sweetened condensed whole milk are indicated in Fig. 4.3.

Reception of milk: Milk intended for use in preparation of condensed milk should be clean, sweet, free from off-flavours and odours, and reasonably free from extraneous matter. No

Fig. 4.3. Flow diagram for the preparation of condensed milk



abnormal milk should be accepted. Platform tests like Alcohol and Clot-on-boiling (COB) tests must be carried out to check the heat stability of the milk which determines its acceptance for condensing.

Cooling: After receiving at platform, the raw milk should be immediately cooled to 5°C or below to retard the deteriorative changes due to bacterial growth.

Clarification/filtration: Filtration is carried out to remove the coarse particles, visible dust or dirt from the raw milk. Clarification is done to remove tiny feed particles, leucocytes and blood cells, etc. from milk. Generally Clarification/filtration is carried out before or after standardization.

Standardization: Standardization milk to a required fat and SNF ratio (1:2.44) is generally done to conform to legal standards in the finished product. The standardization of raw milk is usually done by the addition of skimmed milk or cream.

Stabilization: Heat stability i.e. the extent of heat treatment that the milk can with stand without undergoing coagulation is regarded as its heat stability. Milk salts, mainly the ratio of calcium and magnesium to citrates and phosphates influences the heat stability of milk. Since, milk undergoes extensive heat treatment during condensed and evaporated milk manufacture, it is necessary to maintain the correct ratio of salt balance i.e. 0.7:1.0 in milk. Excess of calcium and magnesium salts over the desired ratio leads to heat instability and improper forewarming of milk which leads to thickening and gelation in the product during storage. Hence, the excess calcium and magnesium content in milk should be corrected by the addition of trisodium citrate or disodium phosphate which is known as stabilization. Stabilization of salts is necessary in the processing of buffalo milk into SCM, because of the high calcium content of buffalo milk.

Forewarming: Forewarming helps in controlling the age thickening and gelation of the product during storage. It also helps in bacterial destruction and in feeding milk to the vacuum pan at a high enough temperature so as not to depress the boiling. The exact temperature-time of heating is so controlled as to provide optimum viscosity in the manufactured product without inducing excessive thickening or thinning during storage. Forewarming at 115 to 118°C by flash heating is recommended for condensed milks manufacture.

Addition of sugar: Sugar acts as a preservative in sweetened condensed milk. There are different methods of sugar addition; however, addition of sugar as 65 to 70 per cent syrup in water to the partly concentrated milk in the vacuum pan when the total solids are about 30 to 31 per cent is preferred. The syrup is heat treated to 85-90°C with a holding of 20-30 minutes to destroy yeast, mould and bacteria, filtered and drawn into the vacuum

pan. Sugar is added at an amount that the sugar ratio ($\% \text{ sugar} \times 100 / \% \text{ sugar} - \% \text{ water}$) in the final product should be 60-64.5. After the addition of sugar, the concentration is further continued until the desired total solids (74- 75 per cent) are reached as tested by specific gravity or refractometer and the product is pumped to the cooling vat. It is necessary that all pipelines, pumps and vats should be thoroughly sanitized since any bacterial contamination after forewarming of the milk will persist in the product.

Concentration: The forewarmed milk is concentrated under vacuum in a pre-sterilized vacuum pan, until the required total solids are attained. The product should cover the heating tubes before steam intake so as to prevent scorching. The product should be maintained at a uniform level by controlling the rate of fresh product intake. Excessively rapid boiling is avoided as it is likely to increase entrainment losses. In order to stop the evaporator, the following steps should be taken in the sequence given: turn off steam; turn off water to- the condenser; stop the vacuum pump; and open the vacuum relief. The Baume Hydrometer test is most commonly used for density tests of pan samples in order to know the right time for striking the batch. This term indicates that the correct concentration as determined by the density tests has been reached.

Homogenization: Homogenization process is optional for condensed milk preparation and is performed before the product is cooled. Homogenization render a uniform fat emulsion and reduces fat separation to a minimum during storage. Homogenization is carried out at a total pressure of 2500 psi (2000 psi in the first stage and 500 psi in the second stage).

Cooling: Prompt cooling is desirable to delay the tendency of age-thickening, discoloration and to have a finished product with a smooth texture and free from any objectionable sugar deposit.

Crystallization: This is a very important step intended to induce micro mass crystallization of lactose which will be in a supersaturated stage in the product when it is pumped to the cooling vat. This is done by the addition of a slurry of finely ground (1-2 micron size), pre-sterilized lactose in condensed milk from the same batch. This process is known as seeding and 200-300 gms of lactose are used for 1000 kg of product. The temperature of seeding depends on lactose concentration in the product and is usually between 29-31°C. After seeding, the product is held at this temperature for one to three hours with slow agitation to complete the lactose crystallization, followed by cooling to 14-16°C; and pumped to storage and filling. Improper lactose crystallization gives the defects of mealiness (roughness) or sandiness in the final product depending on the size of lactose crystals.

Canning: The product is packaged for retail consumer market in pre-sterilized tin plate cans under aseptic conditions in automatic filling and sealing machines. The tins roll off

from the filling room for labelling either on the machine or manually, followed by casing and storage.

Storage: The sweetened condensed milk does not require refrigerated storage, although for long shelf-life, particularly in tropical countries, storage at 10-15°C under controlled humidity conditions (to avoid rusting of the cans) is recommended.

Defects in Sweetened Condensed Milk

Microbial growth and physico-chemical changes leads to defects in the sweetened condensed milk during storage. Buttons, gas production and thickening are some of the common microbiological defects that occur due to the growth of mold, yeast and bacterial, respectively. The physico-chemical changes cause defects like discoloration and browning, stale or cooked flavours, age thickening and gelation which can be retarded by low temperature storage. Other defects like fat separation, thinning, sediment and sandiness can be controlled by proper forewarming and lactose crystallization conditions at manufacture.

Processing, Packaging and Storage of Evaporated Milk

Evaporated milk is a commercially sterile product and does not contain sugar. A flow diagram for its manufacture is given in Fig. 4.4.

Reception of milk - Evaporation: The processing steps from reception of milk to evaporation are similar to the sweetened condensed milk manufacture, except that no sugar is added and concentration is usually done in a multiple effect evaporator.

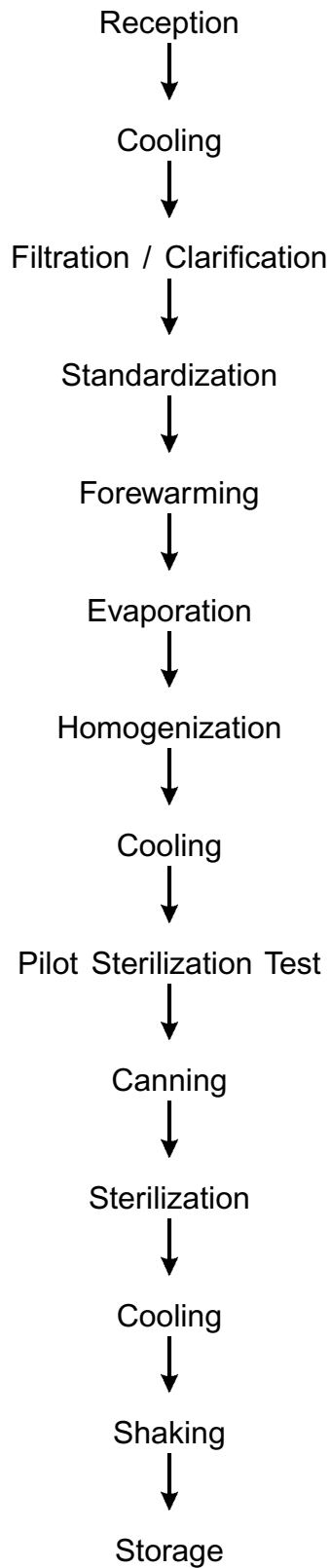
Clarification of milk is preferable to filtration and the main purpose of forewarming is to improve the heat stability of milk and ensure a medium viscosity in the finished product. Forewarming during the manufacture of evaporated milk is not relied upon for destruction of micro-organisms and inactivation of enzymes, which is taken care of by sterilization.

Homogenization: Unlike, in case of sweetened condensed milk, homogenization of the concentrated milk is an essential step to prevent fat separation in the evaporated milk manufacture during its storage. Two-stage homogenization is generally recommended, 2000 psi in the first stage and 500 psi in the second.

Cooling: The concentrated homogenized milk is cooled to 8-10°C to retard the deteriorative changes due to bacterial growth. The cooled product is held in large storage tanks for re-standardization of fat and total solids.

Pilot sterilization test: Since the concentrated milk is subjected to high heat treatment

Fig. 4.4: Flow Diagram for Preparation of Evaporated Milk



during sterilization, it is difficult to predict correctly the behaviour of the product during sterilization. Hence, each batch is tested by pilot sterilization test. This is done by packaging the product in small 125-150 ml cans and sterilizing at 116-118°C for 15-16 minutes followed by rapid cooling. The cans are then opened and examined for colour smoothness and viscosity. If flakes are observed, stabilization of the concentrated milk needs to be done with trisodium citrate or polyphosphates or a combination of both. The quality of sterilized product is tested again before canning. The calculated amount of stabilizer should be added to the evaporated milk in the form of a solution, using just enough water to dissolve it.

Canning: The concentrated milk is packaged in clean dry cans leaving a head space of 0.5 to 0.7 cm in the automatic filling machine. The temperature of the evaporated milk when filling in to the cans should be around 5°C.

Sterilization: Leaky cans are eliminated by passing them through a hot water bath and if there are pin holes air escapes out as bubbles and such tins are removed. The filled cans are sterilized either in a batch or continuous sterilizer. Agitation of the product by rotating the cans in the sterilizer is preferred during sterilization to give uniform heating and acceptable viscosity to the product. A successful sterilizing routine consists of a coming up time between 15-20 minutes, a holding temperature of 116-118°C, a holding time of not less than 15 minutes and a cooling time of not more than 15 minutes.

Cooling: Immediately after the holding time is over, the evaporated milk is cooled within 15 minutes to 27-32°C. Delayed cooling may cause the cans to bulge.

Shaking: The purpose of shaking is to mechanically break down any mass which may have formed during sterilization to a smooth homogeneous consistency. A shaking period of 15 seconds to two minutes is usually sufficient. Excessive shaking should be avoided as it decreases the viscosity.

Storage: A storage temperature of 5 to 16°C is generally used. Commercial evaporated milk remains acceptable up to two years when stored below 16°C but deteriorates rapidly at 21°C or above. Inversion of the cans during storage helps minimize fat separation.

Defects in Evaporated Milk

The defects occurring in the evaporated milk are similar to those occurring in sweetened condensed milk although microbiological defects do not occur usually unless the tins are leaky or heat treatment is insufficient. The physico-chemical defects that occur are flavour defects like cooked, stale, oxidized flavours and excessive browning, sediment, age- thickening and fat separation.

Review Questions

1. What is the importance of forewarming milk for the manufacture of: (a) Condensed milk? (b) Evaporated milk?
2. Enumerate the different kinds of evaporators used for concentration of milk.
3. Differentiate between condensed milk and evaporated milk.
4. Give the processing steps involved in the manufacture of sweetened condensed milk.
5. How is the sugar ratio calculated?
6. What are the common defects in: (a) Sweetened condensed milk? (b) Evaporated milk?

Milk Powders

Learning Objectives

After reading this chapter you will be able to understand:

- what is dried milk and advantages of drying milk
- how the spray dryers are classified
- the drying operations in a spray dryer
- the manufacturing process of whole milk powder and skim milk powder
- the drying operations in a roller dryer
- the packaging requirements of whole milk and skim milk powders

Introduction

Drying is a method of preservation by which products are changed to a form which is light and capable of being stored at room temperature. Dried milk products play a significant role in storage since their biological value can be retained for a long period of time under relatively simple storage conditions. Long storage stability is however, obtained only if the product is packed in a water vapour, air and light impermeable material. Dried milk accounts for a substantial portion of the milk products made, the major one being skimmed milk powder.

The objectives of drying milk are summarized below:

- To remove the moisture so as to reduce bulk, thereby effecting a saving in storage space and packaging costs
- To reduce the cost of transportation
- To improve the storage life of the product
- To provide a product with versatile uses in many food manufacturing operations
- To conserve the natural properties of the original raw material to the maximum possible extent

Definition and Legal Standards

Table 4.2: FSSR standards for whole milk powder and skimmed milk powder

Product	Moisture (w/w)	Milk fat (w/w)	Titrateable acidity*	Insolubility index	Total ash**
Whole milk powder	Not more than 4%	Not less than 26%	Not more than 18%	Not more than 2 ml	Not more than 7.3%
Partly skimmed milk powder	Not more than 5%	Not less than 1.5% and not more than 26%	Not more than 18%	Not more than 2 ml	Not more than 8.2%
Skimmed milk powder	Not more than 5%	Not more than 1.5%	Not more than 18%	Not more than 2 ml	Not more than 8.2%

* ml of 0.1N NaOH per 10 gm of solids not fat; **on dry weight basis; Milk protein in milk solids not fat should not be less than 34%

Dried milk or milk powder is the product obtained by the removal of water from milk by heat or other suitable means to produce a solid containing five per cent or less moisture. The dried product obtained from whole milk is called whole milk powder (WMP) and that from skim milk is known as skim milk powder (SMP) or non-fat dry milk (NFDM). Table 4.2 presents the FSSR (2011) standards for WMP and SMP.

Processing, Packaging and Storage of Dried Milk

The manufacturing technique for dried milk essentially consists of forewarming, concentration under vacuum and drying. In view of the large quantum of heat to which the milk is subjected, the heat stability of milk, whether it is cow milk or buffalo milk, becomes an important consideration. Salt balance and acidity of milk are important factors. The equipment for

processing of dried milk (non-fat or full-fat) consists of equipment for reception, cooling, storage, separation, pasteurization and or forewarming, concentration of milk (usually multiple effect evaporator), filtration, pre-heating of concentrated milk, drying (spray or roller) with powder collection equipment, sifting and packaging. The two most important methods of drying used today are spray drying and roller drying.

Spray Drying of Milk

The use of spray driers has increased in recent years and it is the most important method of drying milk and milk products (Fig. 4.5). While drying, the aim is to dry products as quickly as possible and at low temperatures. By spraying a stream of hot air, liquid products can be dried within a few seconds. The extremely large amount of surface area presented by the droplets causes rapid evaporation of the moisture and provides a powder with high solubility. The, vaporization temperature of the droplets lies between 40 and 50°C if the hot air inlet temperatures are between 150 and 220°C. The whole process of spraying and drying is carried out in a spray drier. The drying functions include: moving the air, cleaning the air, heating the air, atomizing the liquid, mixing the liquid in a hot stream of air, removing the dry material from the air, additional drying of the product, cooling the product, pulverizing and sizing the product.

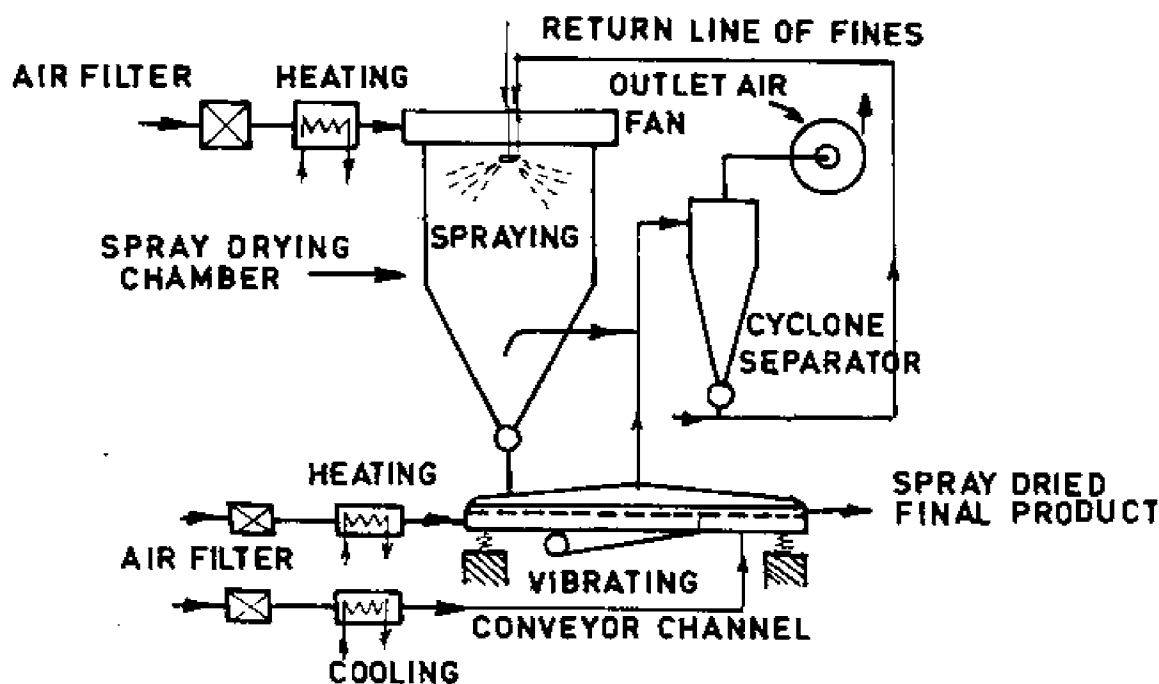


Fig. 4.5: Schematic of a spray dryer used for milk powder manufacture

Classification of Spray Driers

Spray driers may be classified according to:

- Method of atomizing spray material: (a) high pressure nozzles, (b) two fluid nozzle and (c) centrifugal discs
- Method of furnishing heat: (a) steam, (b) gas, (c) fuel oil, and (d) electricity
- Method of heating air: (a) direct (gas or fuel oil), and (b) indirect (using heat exchanger plate or coils)
- Position of drying chamber: (a) vertical, and (b) horizontal
- Number of drying chambers: (a) one drying chamber, and (b) two drying chambers -main and secondary
- Direction of air flow in relation to product flow: (a) counter current, (b) parallel, and (c) right angle
- Pressure in drier: (a) atmospheric (usually a very slight pressure), and (b) vacuum
- Method of separation of powder from air: (a) cyclone, (b) multi- cyclone, and (c) bag filter etc
- Shape of drying chamber: (a) silo or cylindrical, (b) box-like, (c) square cross-section, and (d) tear drop

Spray Drier Operations

Heating air: Air for drying is filtered and heated before it passes through the atomized product. Filtering is normally done by mechanical means. Air may be heated with an indirect heater, such as steam; a direct fired indirect heater which burns the fuel with the heat transferred across the metal surface to the air or with a direct-fired unit in which the products of combustion enter the drier. Most spray driers have been of the indirect type but many new installations are made with direct-fired units. Radiators with steam at 50 to 100 psi have been quite common as a means of heating. The air is heated to about 150-260°C for drying milk and milk products; the outlet air exhausted from the drying chamber usually ranges from 100-105°C. The relative humidity of the drying air is also quite low e.g. three to four per cent.

Air flow: The air must be properly and uniformly directed into and through the drying chamber otherwise, the heat in the air will not be utilized efficiently and a partially dried product may accumulate on the inside edge of the drier. Air straightening vanes are used at bends in the ducts to direct the air into the drying chamber and to; reduce the pressure drops.

Atomization: The purpose of atomization is to obtain many small particles with a large surface area, preferably uniform in size generally ranging from 50-180 μm in diameter. Uniform particles provide: (a) superior instantizing product (b) reduced product losses (c) less over and under drying and (d) more efficient drying. The large surface area provides easy transfer of heat to the droplet and transfer of moisture away from the droplet.

There are three major methods of atomizing: pressure nozzle, centrifugal disc and compressed air.

- a) *Pressure nozzle:* A high pressure pump such as a three-or-five piston homogenizer pump is used for generating pressures from 1500 to 5000 psi. The milk is forced under high pressure through a small orifice and is atomized instantly. The higher the pressure or smaller the orifice, the finer the particle size of the mist, and vice-versa.
- b) *Centrifugal spinning discs:* The device consists of a radial vaned disc through which the product moves. The speed, at which the disc revolves, varies from 19000 to 30000 rpm for discs with usual diameters. The disc atomizer permits considerable variation in capacity and is particularly useful for viscous materials and for materials in suspension.
- c) *Compressed air:* Atomization is produced by passing compressed air or steam over an opening leading to the liquid usually a pipe. The unit operates similar to a perfume sprayer. This two- nozzle system, wherein the second material is air or steam is inexpensive in initial cost but extensive to operate.

Separation of air and powder: The moist air leaving the drier carries with it some dried product which needs to be separated for better yield and preventing air pollution. This may be achieved either inside the drier or outside it. The relatively large particles, which may constitute approximately 80 per cent or more of the yield respond to the force of gravity and get deposited on the sides or drop to the floor of the chamber. The milk fines become entrained in the air currents and are recovered by mechanical means.

Recovery of fines: There are principally three types of devices in use for recovery of fines:

- a) *Filter bag:* It consists of a series of filters of cotton or wool of very fine weave. The air is drawn through these bags and deposits the entrained milk particles in their meshes. Losses range from 0.2 to 0.5 per cent.
- b) *Liquid dust collector:* The incoming fresh milk is pumped in a closed tank and the exhaust air escaping from the drying chamber is made to pass through this tank. The

milk dust in the spent air from the drying chamber gets deposited in the incoming fresh milk.

- c) *Cyclone separator:* The cyclone separator is most commonly used for removing the dry product from the air. Air at a high velocity moves into a cylinder or cone which has a much larger cross section than the entering duct. The velocity of the air is decreased in the cone, thus permitting the settling of the solids. Cyclones can be used individually or in combination to provide multi-cyclone units.
- d) *Cooling the powder:* The dried product should be removed from the drier as quickly as possible after it is produced, to minimize the effect of heat damage on the product. Prolonged exposure to heat causes staleness in non-fat dry milk and increase in free fat content of whole milk powder.

Salient Features of SMP Production

Skim milk is pre-heated to a temperature of 85°C for 20 minutes when the powder is intended for the bakery trade (high heat SMP). Low temperature treatment is required for the manufacture of low heat SMP. The skim milk is then condensed usually in a multiple effect evaporator to total solids of 42-48 per cent. The condensed product is passed through a filter before pumping to the spray drier with or without re-heating. Feeding of cold concentrate to the drier results in powder sticking to the chamber and hence the concentrate is heated to about 74°C. Spray drying is carried out at an inlet air temperature of 180-230°C and an outlet air temperature of 70-95°C to get powder with two to five per cent residual moisture. The air outlet temperature is the factor that controls the final moisture content of the powder. The powder coming from the cyclone and the chamber is preferably cooled to 30°C to avoid clumping due to coalescing and sintering as well as undesirable browning of the powder.

Salient Features of WMP Production

A high quality dried WMP requires high quality raw milk containing as little as possible of copper and iron. Adjustment of the fat content of the milk to 3.2 to 3.5 per cent results in the usual standard fat content of the powder (26 per cent). Milk is preferably clarified to remove leucocytes and other extraneous matter and homogenized at a pressure of 2500 psi in the first stage and at a temperature of 63-74°C. Homogenization prevents the clumping of fat globules during reconstitution and improves the keeping quality. Different considerations prevail in choosing pre-heating temperatures. Low pre-heating temperatures minimize the development of cooked flavour in the product but also do not destroy the enzymes which promote hydrolytic rancidity in the product during storage. By using high

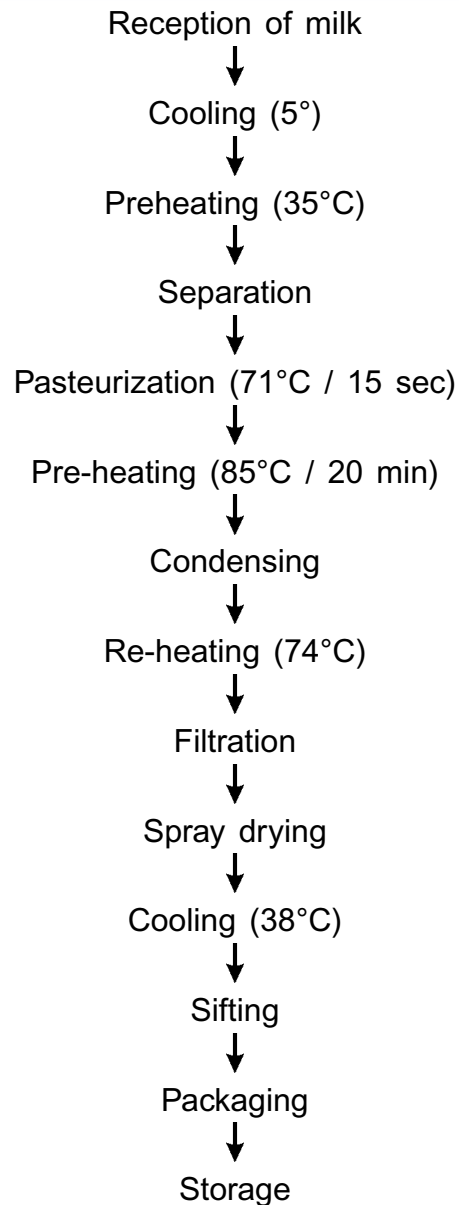


Fig. 4.6(a): Manufacture of SMP

heat treatment (in the range of 80-93°C for 15 to 30 minutes), sulphydryl compounds with reducing properties are formed which extend the keeping quality due to their anti-oxidative action. Pre-heating is followed by concentration and spray drying. To reduce the heat damage during drying and yet obtain the desired moisture, a low exhaust air temperature is preferred. It is essential that the powder be cooled to 30°C to avoid flavour and textural defects. Fig. 4.6(a) and Fig. 4.6(b) delineate the steps involved in the preparation of skim milk powder and whole milk powder by the spray drying process, respectively.

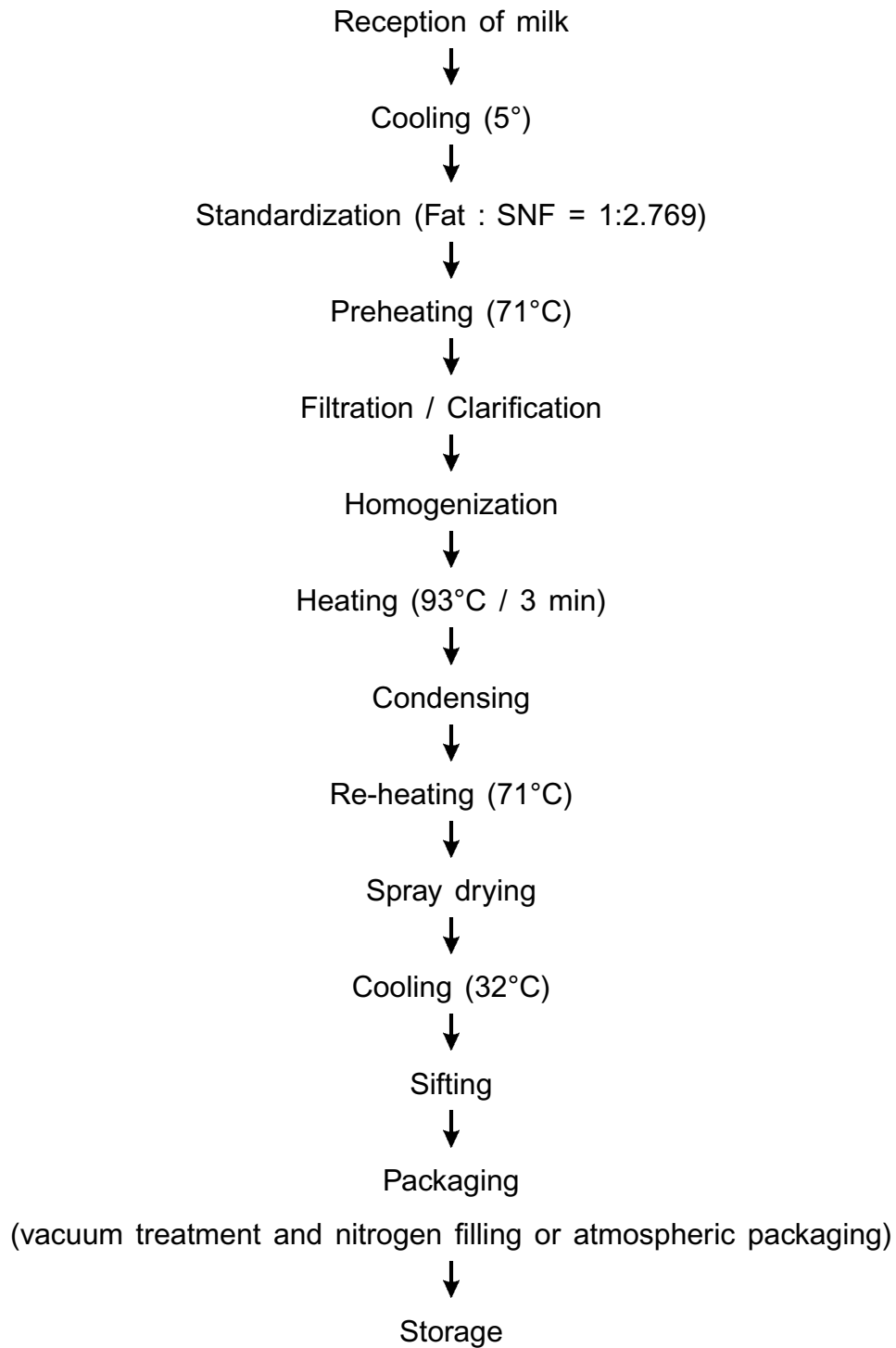


Fig. 4.6(b): Manufacture of WMP

Roller Drying

The roller drying process is becoming comparatively obsolete because of the inherent disadvantages like low solubility of powder, cooked flavour and smaller capacity. However,

the roller-dried powder finds special application in the manufacture of confectionery, baby foods, ice-cream, milk sweets, etc.

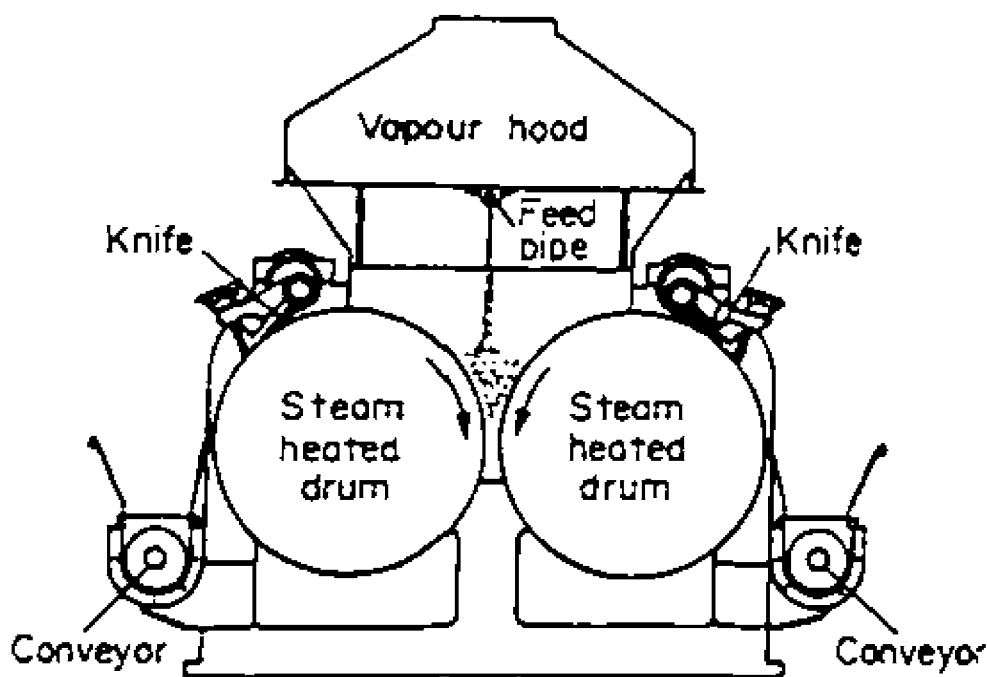


Fig. 4.7: Schematic of a roller dryer

The product to be dried is spread as a thin film on to the smooth surface of a continuously rotating hot drum roller or cylinder, and the film of the dried product is continuously scrapped off by a stationary knife, located opposite the point of application of milk. The film has to be ground to obtain powder.

Roller Drying Operation

The product may be placed in its natural form or pre-condensed in a vacuum pant evaporator before it is fed to the drum drier. The pre-heated product is pumped into the reservoir between the upper portion of the rotating drums (14-19 rpm) to provide a thin layer over the turning drums (Fig. 4.7). The drums are heated internally by steam usually at 4.2 to 4.9 kg/sq.cm (60-70 psi) with suitable arrangements for steam intake and a condensate outlet. The cylinders are mounted parallel to each other about 0.5 to 0.75 mm apart. One drum can be moved to provide the desired clearance between the drums. The drums should be properly aligned and the surface must be kept free of rust and pits. The doctor blade, which is made of spring steel is mounted on strong blade holders and pressed against the drum at an angle of 15 to 30°. The knife should be sharp and reground frequently. The film of dry milk forms a continuous sheet from the knife to

the auger trough, which is about level with the bottom of the drum. The auger for each drum discharges the product into the elevators, then to a grinder which pulverizes the product, after which it is sifted, packed and stored. Water vapour above the drier has a lower density than the air surrounding the unit and hence rises upwards. A hood is placed over the drums for the vapours to escape.

Salient Features of Roller Drying of Milk

The skim milk is pasteurized or pre-heated to preferably 80°C with or without holding before condensation to 20-22 per cent total solids. Beyond a total solids concentration of 25 per cent difficulties arise in drying. The capacity of the drier and final moisture content are controlled by the pressure of steam inside the drums, the speed of the drum, the temperature of the inlet milk, the level of milk between the drums, the total solids and viscosity of concentrated milk and the gap between the drums. The product is in contact with the drum for three seconds or less at a temperature of about 150°C depending on the steam pressure. Scorched and burnt particles are to be expected in roller drying.

Instantization

If reconstitution or re-wetting of the dried product is reached very quickly then the product is said to have instant properties. A process which imparts good re-wetting properties to a dry product is, therefore called instantization. Such properties can usually be produced by agglomeration of the small powder particles to give granules of 1-3 mm. In a granular particle, water can be drawn by capillary forces all the way into the interior before an impenetrable gel layer is formed. The salient features of the instantizing process are:

- Wetting of the surface of the particles with steam, atomized water, or a mixture of both
- Agglomeration, which occurs because the particles collide with each other due to turbulence, and adhere to each other to form clusters
- Re-drying with hot filtered air
- Cooling
- Sizing to eliminate very large agglomerates and very small particles
- Sifting and packaging

Packaging of SMP

The requirements of a container for packing dry milk are that it should be impervious

to moisture (and oxygen for full fat dried milk), light and insects; should have sufficient mechanical strength to stand wear and tear during normal handling; should be relatively easy to fill, seal, handle and empty; and should be reasonably priced. For retail packaging, it should be capable of easy reclosure. For retail use, the product is packed in cartons, polyethylene bags or plastic bottles. For bulk, it is packed in polyethylene bags of at least 3 mil thickness inside a 4 or 6 ply kraft paper bag. The outer kraft bag is closed by putting 3 or 3.5 stitches per inch.

Packaging of WMP

Because of the susceptibility of whole milk and other high fat powders to oxidation and flavour deterioration, gas or vacuum packaging techniques are employed to inhibit the rate of oxidation. In order to have a satisfactory shelf-life of say six months, the oxygen content in the headspace of the container should be less than two per cent. Oxygen desorption is a slow process due to the entrapped air. Double gas packing is the preferred procedure for consumer packs. The normal procedure consists of making a hole of 1-2 mm dia, removing the air rapidly in a vacuum chamber to a vacuum of 730 mm of Hg or more in about 60 seconds time, holding under this vacuum for 2 to 5 minutes and releasing nitrogen until the pressure comes up to 0.03 to 0.06 kg/sq.cm and sealing the vent hole.

Review Questions

1. What are the FSSR (2011) standards for whole milk powder, skim milk powder and partially skimmed milk powder?
2. How are the spray driers classified?
3. What do you understand by instantization of powder and how is it done?
4. Why is whole milk powder gas-packed and how?
5. How is roller drying of milk carried out?
6. What are the objectives of drying milk?

Dairy Whitener

Learning Objectives

After reading this chapter you will be able to understand:

- what is dairy whitener and its uses
- how the dairy whitener is manufactured
- what are the functions of main ingredients used in dairy whitener manufacture
- what are the legal standards for dairy whitener
- what are the packaging requirements of a dairy whitener

Introduction

Tea and coffee are the most popular beverage all over the world. In India, people prefer to drink tea made with the addition of milk and spices known as *chai*. *Chai* is consumed daily in almost all homes, offered to guests, consumed in high amounts in domestic and official surroundings. Without the aid of refrigeration facility it is difficult to get the milk all the times for the purpose of *chai*/coffee making.

Dairy whitener is widely used as a substitute for fresh milk, cream or evaporated milk in tea and coffee. Dairy whitener is produced in fluid, condensed and dried forms and differs widely in their formulation. Dairy whitener production has gone up during the last two decades because of its acceptability as a convenient, shelf stable and ready to reconstitute product. In India, Dairy plants having condensing and drying units are mostly diversifying to the production of dairy whiteners with normal, medium and low fat contents.

Manufacture of Dairy Whitener

The blend of condensed milk (skim/partly skimmed/full fat), sugar and stabilizer is pasteurized, preheated at 74°C, and dried. In case of full fat and partly skimmed milks, the milk is homogenized prior to concentration and the preheating temperature should be high as 82°C for 5 min. homogenization. If there is fat in the blend, the blend must be added with emulsifier to avoid the fat separation during processing. Dairy whiteners usually instantized to improve their solubility.

Lately ultrafiltered milk retentates have been investigated as a base for the formulation of dairy whiteners. The formulation of dairy whitener using ultrafiltered skim milk and buttermilk

retentates as a base has many advantages like reduction in product cost, enhanced nutritional properties due to increased concentration of proteins during ultrafiltration process.

Functions of Major Ingredients of Dairy Whiteners

Protein provides whitening power, imparts body, has feathering resistance, and improves flavor. Fat imparts whitening power, body, and viscosity to the product. The whitening effect produced in coffee, primarily as a result of light reflected from the surface of the fat globules. Sugar imparts sweet taste and improves body. It also reduces freezing points of the emulsion and contributes to the caloric value. Stabilizing salts like phosphates and citrates improve the colloidal solubility of proteins. The disodium or dipotassium salts of phosphoric acid are most commonly used, although other sodium and potassium phosphates are suitable. Table 4.3 gives the Bureau of Indian Standards (IS 12299: 1998) for Dairy whiteners.

Table 4.3: BIS (IS 12299: 1998) standards for Dairy whitener

Characteristic	Requirement (% w/w)
Moisture, Max	4.0
Milk solid (non-fat), Min	57.0
Total ash (on dry basis), Max	5.5
Milk fat, Min	20.0
Acid insoluble ash, Max	0.1
Total added sugar (as sucrose), Max	18.0
Insolubility Index, Max	1.5 ml*

* measured in ml not in %w/w

Packaging of Dairy Whitener

As per BIS standards (IS 12299: 1998), for bulk packaging, the product may be packed in quantities of 25 kg in bags of food grade polyethylene of minimum thickness 0.05 mm. The bags should be properly closed by tying with a string or a rubber band and shall be subsequently encased in sacks or multi-walled kraft paper, such as crepe kraft paper bags of not less than 80 g/m² grade lined with Hessian cloth having a mass of 270 g / m² and having two inner layers of plain kraft paper of not less than 80 g/m² grade.

For retail packing, the product shall be packed in nitrogen or in a mixture of nitrogen and carbon dioxide gas. The product shall be packed in clean and sound metal containers or in a food grade flexible pack made from a film or combination of any of the substrate made of board, paper, polyethylene, polyester metallized film or aluminium foil in such a way so as to protect it from deterioration. In the case of the plastic material, only food grade plastic shall be used.

Review Questions

1. What function does protein performs in dairy whitener?
2. What function does fat performs in dairy whitener?
3. What are the two commonly used stabilizers in the manufacture of dairy whitener?
4. What are the packaging requirements for retail packaging of dairy whitener?
5. What are the BIS standards for dairy whitener?
6. What are the benefits of using ultrafiltered milk retentates in the manufacture of dairy whitener?

Chapter-5

Composition, Standards, Manufacturing - Process and Equipment and Defects during Manufacturing and Storage of **Dairy Byproducts** (Skim milk, casein, caseinate, whey concentrate, powder, lactose and ghee residue)

Learning Objectives

After learning this chapter, the students will be able to:

- Understand the benefits of byproduct utilization
- List out various dairy byproducts
- Understand what is skim milk and its composition
- Understand what is whey and what are its constituents
- Describe the manufacturing process of caseinates
- Describe the manufacturing process of whey protein concentrate
- Describe the manufacturing process of lactose
- Understand what is ghee residue

Introduction to Dairy Byproducts

A byproduct may be defined as a product of commercial value produced during the manufacture of a main product. During the processing and conversion of milk into various milk products some byproducts are also generated. Skim milk, buttermilk, ghee residue and whey are the main dairy byproducts. Separation of milk for obtaining cream results in skim milk, separation of butter from cream results in buttermilk, ghee residue is that fraction of cream or butter that is left out when they are converted into ghee. Whey is the watery portion obtained during the manufacture of cheese, casein, *paneer*, *chhana*, and

shrikhand. Sometimes these dairy byproducts are also called as dairy co-products. It has always been realized that effective utilization of byproducts is an essential prerequisite to profitable dairying. Utilization of dairy byproducts improves plant economy, makes valuable nutrients available for humans and reduces environmental pollution originating from dairy waste.

Skim milk is produced by separation of cream from milk in dairy processing. Skim milk is rich in solid not fat (SNF) content and is used for standardization of milk, preparation of skim milk powder and coffee whitener. It is regarded as a byproduct only when it is either not economically utilized or has to be utilized for the manufacture of derived byproducts like casein in small quantities. Casein and caseinates are prepared from skim milk and used in food preparations, specialized foods and in non-food uses such as in the manufacture of plastics, etc.

Whey, the greenish translucent liquid is obtained during the manufacture of cheese, casein, *chhana*, *paneer*, *chakka* and co-precipitates and has been viewed until recently as one of the major disposal problems of the dairy industry. Depending on the type of source whey is called as cheese whey, paneer whey, etc. The chemical quality of whey slightly differs depending on the source. Due to the presence of significant amount of organic matter (6-7% total solids) in the form of protein, lactose, fat, minerals and water-soluble vitamins, its disposal causes environmental pollution. The biological oxygen demand of whey is very high (40,000 mg/kg or more), constituting a major economic burden to be disposed of as a waste material. However, whey being a source of precious nutrients like lactose, whey proteins, minerals and vitamins, some economical prepositions has been evolved to utilize it. Utilization of this by-product in the human food chain is now being predominantly favoured due to the economic opportunities provided by the milk nutrients contained in whey. It is the base material for manufacture of not only nutritional products like whey protein concentrates (WPC) and lactose, but also the base for manufacture of whey drinks and dietetic beverages.

Lactose production from whey can be economically feasible only when it is produced on large scale. Generally, sweet whey is preferred because of its high lactose and low ash content. In case of acid whey, neutralisation is necessary. This will change the whey characteristics and also increase the cost of manufacture. Lactose can be produced by using ultrafiltration (UF) permeate as a raw material, but UF permeate, particularly the acid whey permeate, has a very high calcium content. Removal of approximately 50% calcium is necessary to avoid difficulties during evaporation, which makes the process costly.

Buttermilk is produced when butter is made by churning cream (sweet cream) or whole milk curd. Sweet cream buttermilk that is produced in organized sector is preferred for

processing and utilization in different products. Buttermilk obtained from curd or cultured cream (cream incorporated with microorganisms) is called as cultured buttermilk.

Gheeresidue is brownish sediment obtained by filtration of ghee after heat clarification. Major portion of gheeresidue in countries like India is obtained in small quantities, particularly from the scattered small scale household production of *desi* ghee in villages, which remains unutilized. Gheeresidue from ghee produced at organized sector or at commercial level can be utilized for the manufacture of chocolate *burfi*, samosa filling, etc.

Skim Milk

Skim milk is a by-product obtained during the manufacture of cream. It is rich in solid not fat content and has high nutritional value. This milk is also referred as non-fat, fat free or defatted milk. Skim milk and cream are the products of whole milk separation through a cream separator (Fig. 5.1). The principle of cream separation is shown in Fig. 5.2. As per the Food Safety and Standards Rules(FSSR) (2011), skimmed milk means the product prepared from milk from which almost all the milk fat has been removed mechanically and it should have not more than 0.5% milk fat and minimum 8.7% milk Solids-not-fat (SNF). A fat content in skim milk below 0.1% is desirable. Buffalo skim milk contains higher total solids i.e. about 10.7% including higher lactose and protein mainly casein content as compared to cow skim milk having about 9.3% total solids. Typical chemical composition of skim milk is shown in the following Table 5.1.



Fig. 5.1: Hand operated Cream Separator

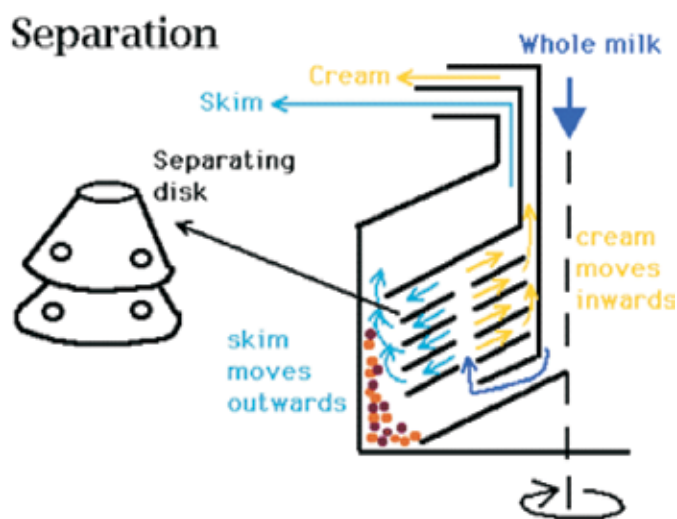


Fig. 5.2: Principle of cream separation

Table 5.1: Chemical composition of skim milk obtained from cow and buffalo milk

Component (%)	Cow milk	Buffalo milk
Water	90.7	89.3
Total solids	9.3	10.7
Fat	0.1	0.1
Lactose	50	5.3
Protein	3.3	4.3
Casein	2.6	3.5
Whey protein	0.7	0.8
Non-protein nitrogenous matter	0.2	0.2
Minerals	0.7	0.8

Physico-chemical Properties of Skim Milk

Density

The density of milk is a resultant of the densities of its components. The density of a given specimen of milk is determined by its percentage composition, by its temperature and processing treatments. Specific gravity of skim milk at 15.5°C is 1.036.

Viscosity

The viscosity of the milk depends on the temperature and on the amount and state of dispersion of the solid components. Representative values at 20°C for skim milk is 1.5 centiPoise (cP). Caseinate micelles are the most important contributors to the viscosity. There is decline of viscosity from 5 to 30°C, reflecting a decrease in voluminosity of the caseinate micelles. Above 30°C, the decrease is less marked until about 65°C, where the whey proteins begin to be denatured.

Surface and interfacial tension

The area of contact between two phases is called “interface”, or especially if one of the phases is gaseous, the “surface”. Properties of interfaces and surfaces are determined by the number, kind and orientation of molecules located in them. Surface tension of skim milk at 20°C is 51 dynes per cm.

Electrical conductivity

Electrical conductivity of milk is mainly due to sodium, potassium and chlorides present in milk. The fat globules of milk reduce the conductivity by occupying volume and by impeding the mobility of ions. Thus, the conductivity of the whole milk is less than that of skim milk by about 10%. The production of acid by bacterial action increases the conductivity of milk. Temperature control is important in the measurement of electrical conductivity.

Refracting index

Refracting index of a substance is defined as the ratio of the speed of light in a vacuum to its speed in that substance. One consequence of refraction is to change the direction of a light ray as it enter or leave the substance. Measurement of this bending gives a direct measure of refractive index. Refractive index of skim milk falls in the range of 1.344-1.348.

Solubility

Between pH 3.5 and 5.5, caseins are very insoluble which restricts its use in low pH foods.

Heat stability

Skim milk normally withstands heating at 140°C for 20 min, while concentrated skim milk (20% TS) is usually stable at 120°C for 20 min. Heat induced interaction between *betalactoglobulin* and *kappacasein* plays a major role in determining the heat stability and rennet clotting behaviour of milk.

Heat capacity and thermal conductivity

The heat capacity of a substance is the quantity of heat required to raise the unit temperature of a unit mass. It is usually expressed in terms of cal/g-°C. Thermal conductivity is the rate of heat transfer by conduction through unit thickness across unit area of substance for a unit difference of temperature. Skim milk exhibits a small but definite linear increase in heat capacity between 0 and 50°C from about 0.933 to 0.954 cal/g-°C. There is a marked decrease in heat capacity as the total solids contents of the sample are increased.

Casein and Caseinates

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

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

Casein may be classified based on the use or based on the type of coagulant used. Based on the use, as already mentioned, it is classified into edible and non-edible casein. Based on the type of coagulant used it is classified into acid casein and rennet casein. Acid casein can be further classified into direct acidified(with mineral acids) casein such as hydrochloric acid casein, sulphuric acid casein, etc., lactic casein produced by growth of lactic starter culture and rennet casein, obtained by using rennet as the coagulant. The general requirements of non-animal rennet casein and acid casein as specified by the FSSR (2011) are given in Table 5.2. The product should also meet the microbiological requirements specified by the FSSR.

Table 5.2: The FSSR (2011) requirements of different edible caseins

Requirements	Non-animal rennet casein	Acid casein	Caseinate
Moisture	Not more than 12.0 per cent, m/m	Not more than 12.0 per cent, m/m	Not more than 8.0 per cent, m/m
Milk fat	Not more than 2.0 per cent, m/m	Not more than 2.0 per cent, m/m	Not more than 2.0 per cent, m/m
Milk protein (N x 6.38) on dry basis	Not less than 84.0 per cent, m/m	Not less than 90.0 per cent, m/m	Not less than 88.0 per cent, m/m
Casein in protein	Not less than 95.0 per cent, m/m	Not less than 95.0 per cent, m/m	Not less than 95.0 per cent, m/m
Ash including P ₂ O ₅	Not less than 7.5 per cent, m/m	Not less than 2.5 per cent, m/m	----
Lactose	Not more than 1.0 per cent, m/m	Not more than 1.0 per cent, m/m	Not more than 1.0 per cent, m/m
Free fatty acid		Not more than 0.27 per cent	----
pH value in 10% solution	----	----	Not more than 8.0

Method of Manufacture of Acid Casein

The flow diagram for the manufacture of acid casein is depicted in Fig. 5.3. The major steps involved in the manufacture of acid casein are described below:

Receiving of milk: Good quality skim milk is always an essential requirement for the manufacture of casein. In case whole milk is available for the manufacture of casein it has to be separated and skim milk is to be obtained.

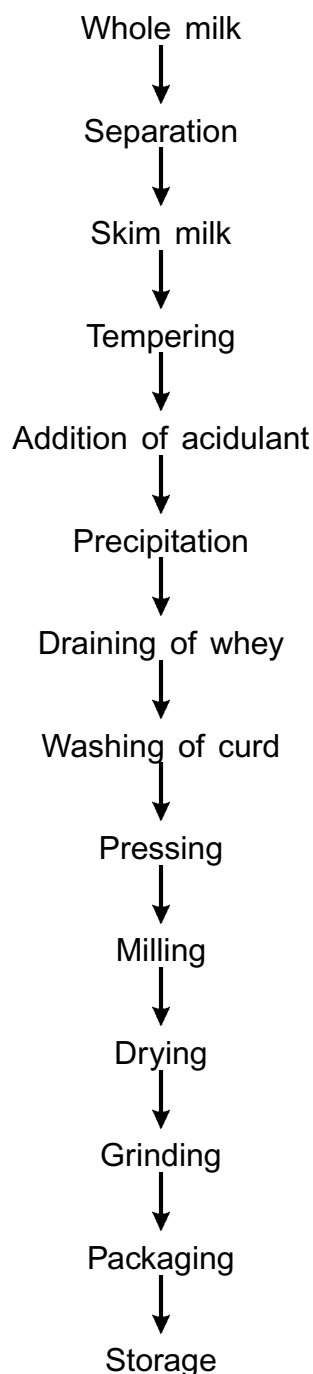


Fig. 5.3: Flow diagram for the preparation of acid casein

Table 5.3: Effect of temperature of precipitation on quality of casein curd.

Temperature of precipitation	Quality of casein curd
Less than 35°C	Soft and fine curd, slow to settle and difficult to wash
35 to 38°C	Coarse, provided it is not stirred too quickly, quick to settle and easy to wash
More than 38°C	Chewing-gum texture (i.e. stringy, lumpy and coarse)

Tempering: Tempering is the process of adjusting the temperature of skim milk for precipitation. The temperature should be carefully controlled during precipitation, since the casein curd is sensitive to heat. The double jacketed vat is usually used for this purpose. The effect of the temperature on the character of curd is given in Table 5.3.

Precipitation: Casein exists in milk as a calcium-caseinate-phosphate complex. At about pH 5.3, the casein begins to precipitate from the solution and at the isoelectric point of casein, about 4.7 pH, the maximum precipitation occurs. If the pH is too high (above 4.8) in the coagulum, then the resultant curd is likely to be large, sticky and rubbery due to high calcium content and difficulty to wash thoroughly. It will tend to have a dark colour. The casein may have a high calcium and ash content, high viscosity and poor solubility. On the other hand, if the pH of the coagulum is too low (pH 4.4 or less), then the resultant curd will be fine and losses during washing and separation will be high. The casein will then have a high acidity. In this case, the pH of the coagulum is preferably increased by adding fresh skim milk (about 5 litres of fresh skim milk is required to raise the pH of 100 litres of coagulum by 0.1 pH unit).

Draining and washing: The longer the casein curd stands in the whey, the more difficult it become to remove the impurities like whey proteins, lactose, salts and acid. Hence, the whey is removed promptly. The first step in this regard is to allow the curd to settle and then push it back from the outlet end of the vat. Next, the outlet strainer is fixed in position and another cloth-lined strainer hung at the discharge end of the gate to recover small curd particles. Then the whey is drained off promptly. As soon as the whey ceases to run freely, wash-water is added in quantities approximately equal to the amount of the whey removed. The wash-water is made acidic (pH 4.1) especially for the first washing. The curd is well-stirred in the wash-water, but care is taken not to break it into fine particles. It is then allowed to settle and the wash-water drained is drained as did in earlier occasions. At least two washings are required. As a rule of thumb, the amount of wash-water required to adequately wash casein curd in the vat is approximately 0.7 litres per one kg of skim milk. All the whey and wash-water contain some fine particles of casein curd called “casein fines”, which can be removed from the whey or wash-water

by suitable means (using centrifugal self-desludging centrifuge or decanter, hydrocyclones and rotary sieves) for the recovery of fines.

Pressing: At the stage immediately prior to drying some form of mechanical expulsion of water from the curd is necessary so that the cost of evaporating the remaining water in the curd is minimized. The wet curd is pressed to remove as much water as possible by using any of the following methods: dewatering in cheese hoops, pressing in canvas bags, roller press, moving belt press, screw press and centrifugal dewatering. Normally it is not possible to reduce the moisture level in the pressed curd to less than 55 per cent.

Milling and spreading: After being pressed, the curd is milled to produce particles of a uniform size and surface for drying. If it is not milled it dries unevenly. The pressed curd should be promptly milled and dried, in order to prevent spoilage by mould and bacteria. Milling should be of the shredding variety. The milled curd should be evenly spread over standard perforated trays with a fixed amount of curd to ensure adequate drying.

Drying: Drying is the process of removal of water from casein curd to below 8 per cent. It is essential to control the temperature and humidity of the inlet air correctly if the curd is to be efficiently dried. Once started, drying should not be interrupted till the moisture content has been reduced to less than 8 per cent. The inlet air temperature may range from 70 to 77°C while the outlet air temperature should be between 52 and 57°C in order to avoid the risk of discolouring the casein and impairing its solubility.

Grinding: After proper cooling, casein is ground. Warm casein becomes plastic in a grinder and sticks to it. The fineness of grinding depends on the requirement of the user. Uniformity in the size of the ground casein is ensured by passing it through the screens of a particular mesh size.

Packaging and storage: The dried casein, whether finely ground or partially ground, is normally packaged either in jute bags lined with closely woven cloth or in heavy 3-ply paper bags with polyethylene liners. The filled packages of casein should be closed air-tight and transferred to a clean, dry storage room. Wide variations in the storage room cause casein to “sweat and mould”. If stored in a damp atmosphere, it will absorb water and deteriorate. For long storage, it is best to store casein in a basement away from the sun.

Yield: The yield of casein is roughly equal to the percentage of casein in the skim milk and may vary from 2.8 to 3.2 per cent, depending on whether it is cow or buffalo skim milk.

Method of Manufacture of Non-animal Rennet Casein

Rennet is a protein which acts as a coagulating agent in milk due to the presence of rennin enzyme in it. It is obtained from the young calf's fourth stomach (abomasum). Because of the religious sentiments of many vegetarian people, its use is discouraged in India. However, there are many rennet substitutes such as those obtained from microorganisms (microbial rennet) or other enzymes which can be used in place of animal rennet. Non-animal rennet casein essentially uses rennet substitutes in the manufacturing process. Similar to acid casein preparation, for the preparation of non-animal rennet casein, high quality fresh, sweet skim milk is essential. Skim milk is heated in a jacketed vat up to 30°C. Sufficient quantities of rennet and calcium chloride are added to the skim milk to give a setting time of 20-30 minutes. The rennet should previously have been diluted with 15-20 times its weight in water (about 1.82 per cent v/v). Calcium chloride is usually used at the rate of 1 per cent. The coagulum is agitated for 2-5 minutes after coagulation begins but before the coagulum reaches a solid clot, so as to produce curd particles of an optimum size for further processing. Simultaneously with agitation, the temperature of the curd is raised to 54-66°C. the curd is cooked at this temperature for about 30 minutes. After cooking, the curd is processed in the same manner as for acid caseins.

Method of Manufacture of Sodium Caseinate

Caseinates, the soluble form of casein, may be prepared from freshly precipitated acid casein curd or from dry acid casein by reaction with dilute solution of alkali such as sodium, potassium, calcium or ammonium hydroxide. Sodium caseinate is the most commonly used water soluble form of casein and is used in wide range of processed food products as a source of protein, and for their physico-chemical, nutritional and functional properties. Irrespective of the starting material used, the manufacture of sodium caseinate consists of formation of a casein suspension, solubilization of casein using sodium hydroxide and drying the sodium caseinate produced (Fig. 5.4). The major steps involved in the preparation of sodium caseinate are described below:

Casein suspension and solubilization: The fresh casein curd passed from a de-watering device (about 45% solids) is minced and the finely-divided curd is mixed with water at 40°C to give a solid content of 25-30% solids. If dried casein is used, it is ground and held in water for some time so that it absorbs water and becomes soft. Casein suspension is then passed through the colloidal mill. The temperature of the emerging slurry, which may have the consistency of 'toothpaste', should be below 45°C, since it has been observed that milled curd can re-agglomerate at higher temperatures. The main difficulties experienced in the conversion of acid casein to sodium caseinate are: (a) very high

viscosity of sodium caseinate solutions of moderate concentration, which limits the solids content for spray drying to 20% (b) formation of a relatively impervious, jelly-like, viscous coating on the surface of casein particles which impedes their dissolution on addition of alkali. To overcome the former difficulty, it is essential that the pH and temperature are controlled during conversion as these influence viscosity, while the latter can be overcome by reducing the particle size by passing a curd-water mixture through a colloid mill prior to addition of alkali.

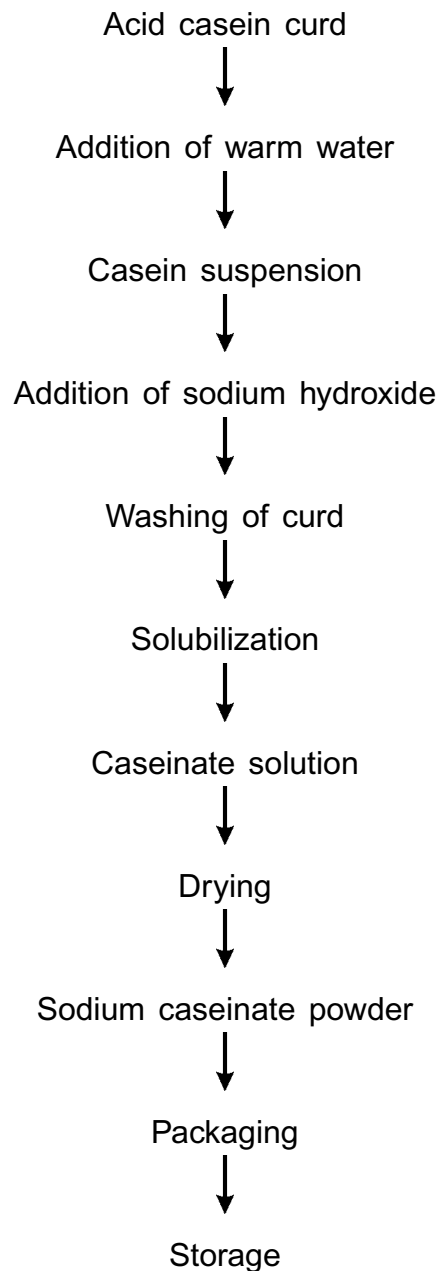


Fig. 5.4: Flow diagram for the preparation of sodium caseinate

Addition of alkali and pH control: Sodium hydroxide solution (2.5 M) is pumped into the casein slurry at about 45°C. The quantity of sodium hydroxide required is generally 1.7-2.2 per cent by weight of the casein solids. Other alkalis such as sodium bicarbonate or sodium phosphates may be used, but the amounts required and their cost is both greater than those of sodium hydroxide. The addition of the dilute alkali must be carefully controlled with the aim of reaching a final caseinate pH of 6.6-7.0.

Drying of sodium caseinate solution: The homogeneous sodium caseinate solution is usually spray dried in a stream of hot air. In order to ensure efficient atomization of the sodium caseinate solution, it must have a constant viscosity as it is fed to the drier. It is common practice to minimise the viscosity by preheating the solution to a temperature of 90-95°C just prior to spray drying. However, care should be taken to minimise the time for which the caseinate solution is at high temperature. The total solid content of the solution destined for spray drying ranges between 20 and 25 per cent. At about 20% solid concentration of the sodium caseinate solution, approximately 4 kg of water need to be evaporated to produce 1 kg of powder. The low solids content of the feed solution produces a spray-dried powder with a low bulk density. The moisture content of spray-dried sodium caseinate should be less than 5 per cent for satisfactory storage.

Alternatively to reduce cost, increase processing rate during caseinate manufacture and control the properties of the resulting powders, include: production of roller dried sodium caseinate by feeding a mixture of curd (50-65% moisture) and an alkaline sodium salt (Na_2CO_3 or NaHCO_3) onto the drying drum of a roller drier. Sodium caseinate with good flavour and a high bulk density could be produced by using the roller drier at relatively low steam pressure (i.e. low drying temperature).

Calcium Caseinate

Next to sodium caseinate, calcium caseinate is common and finds use in both pharmaceutical preparations and as a food ingredient. The specifications for this product vary with its end use, but they frequently include a limitation of the calcium content to within the range of 1.0-1.5%. Calcium caseinates are much less soluble and have poorer functional attributes than sodium caseinate. In contrast translucent, viscous, straw-coloured sodium caseinate, calcium caseinate forms micelles in water, producing an intensely white, opaque, 'milky' solution of relatively low viscosity.

Whey and Whey Protein Concentrate

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

Table 5.4: Composition of whey from different sources

Constituents (%)	Cheddar Cheese	Acid Casein	Rennet Casein	Chhana and Paneer
Total Solids	6.7	6.9	6.7	6.4
Fat	0.3	0.1	0.1	0.5
Protein	0.9	1.0	1.0	0.4
Lactose	4.9	5.1	5.1	5.0
Ash	0.6	0.7	0.5	0.5
Titrateable acidity	0.2	0.4	0.4	0.4

Table 5.5: Classification of whey based on acidity

Classification	Titrateable acidity	pH
Sweet whey	Less than 0.20 %	5.8 – 6.6
Medium acid whey	0.20 to 0.40 %	5.0 – 5.8
Acid whey	More than 0.40%	Less than 5.0

There is wide variation in composition of the whey depending on milk supply and the process involved in the production (Table 5.4). In general, whey produced from rennet-coagulated cheeses and casein is sweet whey, whereas the production of acid casein and fresh acid cheeses, such as Ricotta or Cottage cheese, yields acid whey. When we use rennet, most part of calcium and phosphorus of the casein complex remain with the curd. The ash content of the whey is, therefore, less than when the coagulating agent is acid, which transfers part of the phosphorus and most of the calcium to the whey. Production of *chhana* and *paneer* yields medium acid whey. Based on acidity, whey can be conveniently classed into three groups namely sweet whey, medium acid whey and acid whey (Table 5.5).

Physical Properties of Whey

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

Whey Powder

Conversion of whey to whey powder is the one of the options to preserve whey solids. Whey powder is essentially produced by the same method as other milk powders. Composition of whey can be modified by removal of lactose and minerals to give whey protein products of 15 to 40 percent protein on dry matter basis. The material that remains after lactose has been crystallized and separated from concentrated whey is known as delactosed whey powder, which contains about 25 percent protein. Delactosed whey powder has a high mineral concentration (up to 25 percent). Whey powder when subjected to electrodialysis results in demineralized whey powder. Whey powder production consists of three main operations: evaporation, crystallization, and drying. During evaporation whey is concentrated to 42 to 60 percent total solids. Lactose crystallization is necessary prior to drying of whey because lactose is amorphous and sticky in nature. This causes problems during drying. Hence, lactose is converted into crystalline β -hydrate form. When dried conventionally without lactose crystallization, whey concentrates yield powder that are very hygroscopic and the manufacturer runs the risk of the powder caking on storage,

or even in the drier. In addition, the efficiency of the drying is reduced, since it is not possible to concentrate whey to solids content greater than 42 to 45 percent total solids for a non-crystalline product. The advantage of lactose crystallization lies both in energy savings and in improved powder properties.

Drying of Whey

Whey can be transformed into powder by using different drying techniques, with the final product quality depending on applied technology. Roller drying or drum drying of whey is simple and much less expensive technique than other methods. But its harsh heat treatment effects reduce the quality of whey powders. Also, whey powder obtained by the roller drying method is very hygroscopic since most of the lactose is in amorphous form. It has a dark colour caused by the Maillardbrowning reactions due to reaction between proteins and lactose. Hence, spray drying is extensively used either in single stage, two-stage and even three-stage drying for the production of whey powders. The moisture content of whey powder ranges between 3.5 to 5 percent. Characteristics essential to powder quality are powder hygroscopicity and caking tendency. Since 100 percent lactose crystallization cannot be achieved, the target in whey powder production is to gain the largest possible portion of lactose in crystalline form, such as 90 to 95 percent α -lactose monohydrate.

In single-stage drying, the product is dried to its final moisture content in the spray-drying chamber alone. Usually liquid whey is concentrated by evaporating moisture in it to achieve total solids content of about 45 to 60 percent. The concentrated whey is pumped into the spray drying chamber through a centrifugal (rotating) atomizer. The inlet air temperature varies from 150 to 200°C while the outlet air temperature is about 85°C. As a general rule, outlet air temperature should be as low as possible, but high enough to prevent the powder from sticking and leaving a deposit (fouling) in the spraying chamber. Air, evaporated materials, and powder fines are directed through the system of cyclones, where powder particles are separated from the mixture of hot air and dried solids. Whey powder thus obtained is cooled with cold air and pneumatically transported to sifting and packaging equipment. Powder obtained in such a way is very hygroscopic, with a high caking tendency.

The principle of two-stage drying is a combination of spray drying as the first-stage drying and fluid bed drying at the second stage. Final drying in the integrated fluid bed dryer ensures that the desired residual moisture is achieved. After final drying, the powder is cooled in a pneumatic cooling and conveying duct. The installations can be operated with both nozzle and centrifugal atomizers. By two-stage drying, it has been possible to obtain good quality powders and increased drying economy. The three-stage dryer involves transfer

of the second drying stage into the base of the spray drying chamber and having the final drying and cooling conducted in the third stage located outside the drying chamber. It consists of a main drying chamber, static integrated bed chamber and vibro-fluidized bed chamber. Primary drying of the droplets takes place in the main chamber as they fall from the atomizer to the base of the chamber. The second drying stage takes place as drying air is sucked through the powder layer. The moisture content of the powder falling on the integrated bed is 12 to 20 percent depending upon the type of product. This second drying stage reduces the moisture content to 8 to 10 percent. The third and last drying stage takes place in the vibro-fluidized bed dryer where the moisture contents of the powder reduces to 3 to 5 percent.

Whey Protein Recovery from Whey

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

Heat Precipitation Process

Whey proteins may be precipitated (and thereby rendered insoluble in water) by heating whey at acid or near-neutral pH. In order to precipitate whey proteins, acid whey must be heated to at least 90°C and maintained at that temperature for at least 10 min to achieve maximum yields. For sweet whey, good yields can be obtained by heating at pH between 6.0 and 6.5. However, such whey protein contains higher mineral concentrations. Mineral concentrations can be reduced when the pH is adjusted to 4.6 prior to protein removal. Precipitated proteins are removed by settling, followed by washing and dried. In modern plants, high speed centrifuges such as clarifiers and decanters are used for separations that follow washing. The precipitate thus obtained is dried using various drying techniques to obtain whey protein powders.

Molecular Separation Process

The aim of manufacture of whey protein products is to separate proteins from whey in such a form that they remain, as far as possible, fully undenatured and thus retain their functionality. Molecular separation processes aid in producing whey proteins in undenatured form. Ultrafiltration (UF) is a molecule separation process where components of a liquid are separated based on their difference in size. It is low energy consuming process and is being widely used in the dairy industry to recover whey proteins. The dairy industry typically uses membranes with a molecular weight cut off of 10,000 daltons. Thus, any component smaller than 10,000 daltons will be part of the permeate fraction. Ultrafiltration retains in the liquid product any insoluble material or solutes larger than about 20,000 Da molecular weight. Such retained liquid with materials in it is termed as **retentate**. The rest of the whey stream passes through the membrane, driven by the applied pressure and is called **permeate**. UF of whey enables the whey protein to be separated from the lactose, mineral and other water-soluble low-molecular-weight species (Fig. 5.5).

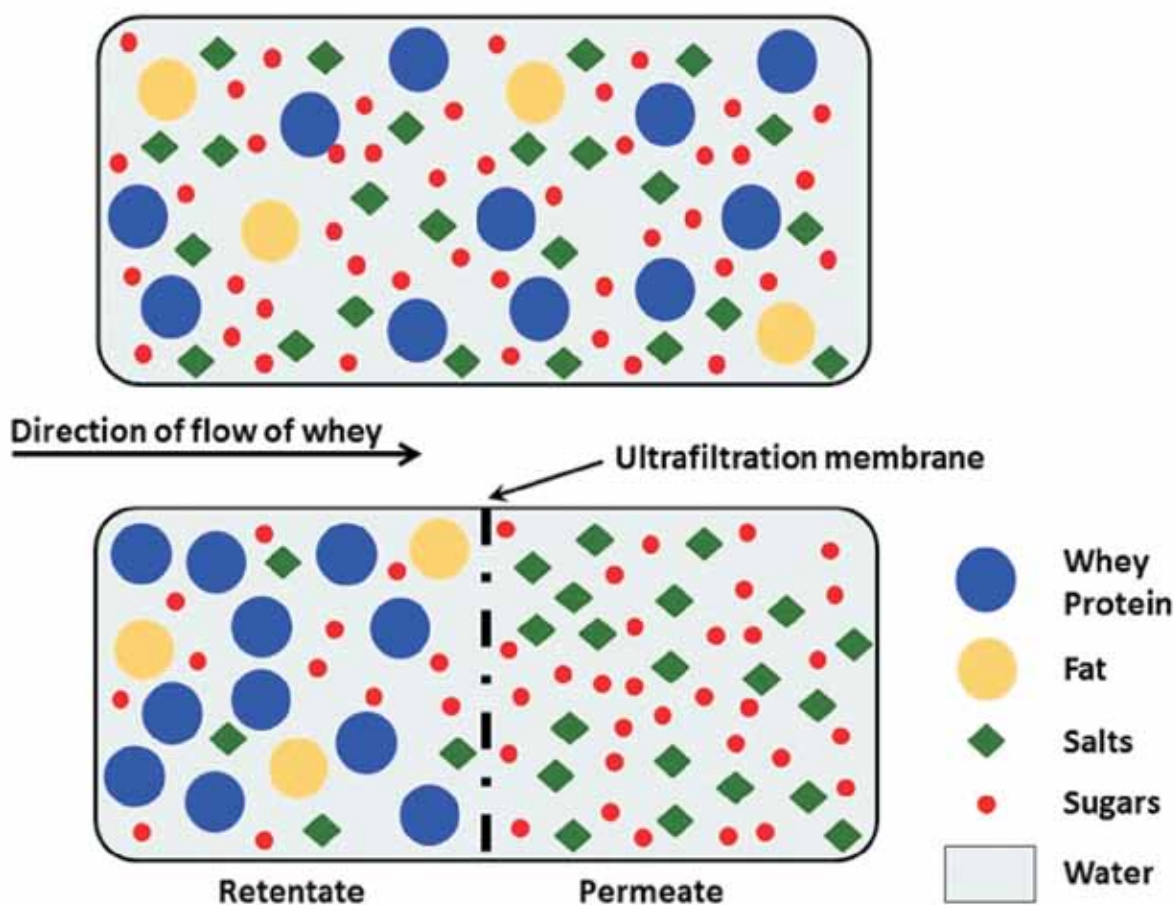


Fig. 5.5: Principle of ultrafiltration process of whey

UF is a major means of producing WPC throughout the world. With this process, 90 to 95 percent of the proteins in the whey are recovered. WPC is commonly characterised by its protein content on dry basis (e.g. WPC-80 has 80 percent protein on dry basis). In order to achieve higher protein values (up to 90 percent of dry matter), one or more diafiltration steps may follow. The process of addition of water to the retentate is called as **diafiltration**. Diafiltration reduces the viscosity and concentration of lactose, ash, and NPN in the retentate. A typical commercial scale UF plant is shown in Fig. 5.6.



Fig. 5.6: A commercial scale Ultrafiltration unit.
(Courtesy: NDRI, Karnal)

Manufacture of Whey Protein Concentrates using UF

One of the prerequisite to UF process is to minimize fouling (deposition of minerals especially calcium) of the UF membranes by either sequestering of calcium, demineralization, heating plus calcium precipitation or pH adjustment, replacement of calcium with sodium, clarification and filtration. Hence, whey, regardless of type, usually must be filtered or

centrifuged to remove suspended cheese or casein particles and for cheese whey, to remove fat also. Manufacturing process of whey protein concentrate (WPC) involves separation for fat and fines from whey followed by pasteurization and cooling to 55°C. Holding of whey at a temperature higher than the UF temperature (60-70°C) causes the precipitation of calcium phosphate to take place in the balance tank itself. However, there is much less tendency for the precipitation of calcium phosphate in the membrane system. Whey is then pumped into UF plant, from which WPC is produced (retentate) based on the principle as shown in Fig.5. Also a protein depleted permeate (the stream which passes through the semi permeable membrane) is produced. The protein content of the retentate stream will depend on the volume of permeate removed from the whey. Due to the UF treatment, the total solids concentration in the retentate increases up to 25 percent. As the protein content increases, the fat content increases and lactose, moisture, and ash contents decrease. The membranes not only retain the protein, but also the fat. On the other hand, in this process lactose and minerals are lost in the permeate resulting in their proportional decrease in the remaining solids. With diafiltration, the protein purity of the product improves significantly. The UF retentate, thus obtained is evaporated to 25 to 40 percent solids using an evaporator and subjected to spray drying for obtaining WPC powder. The resulting powder may be blended to ensure good product uniformity, and then bagged. Low-temperature processing is necessary for the manufacture of WPC because of the heat sensitivity of the product.

Manufacture of Lactose

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

Manufacturing Process of Lactose

Lactose is separated from whey by the simple process of concentration and crystallization. The whey is pre-treated or clarified for the removal of impurities viz. whey proteins, salts and acids and other impurities (dust, dirt, microbes) from whey, primarily for two reasons: (i) to reduce the viscosity of the concentrated whey so as to make the separation of lactose crystals possible, and (ii) to increase the purity of the recovered lactose. The lactose crystals are then removed from the concentrate in a centrifuge, while most of the whey proteins and salt pass on to the remaining liquid called the **mother liquor**. Degree to which the proteins and salts are removed from whey prior to concentration and crystallisation, determines the purity of lactose. The general flow diagram for the process of manufacture of lactose is given in Fig. 5.7.

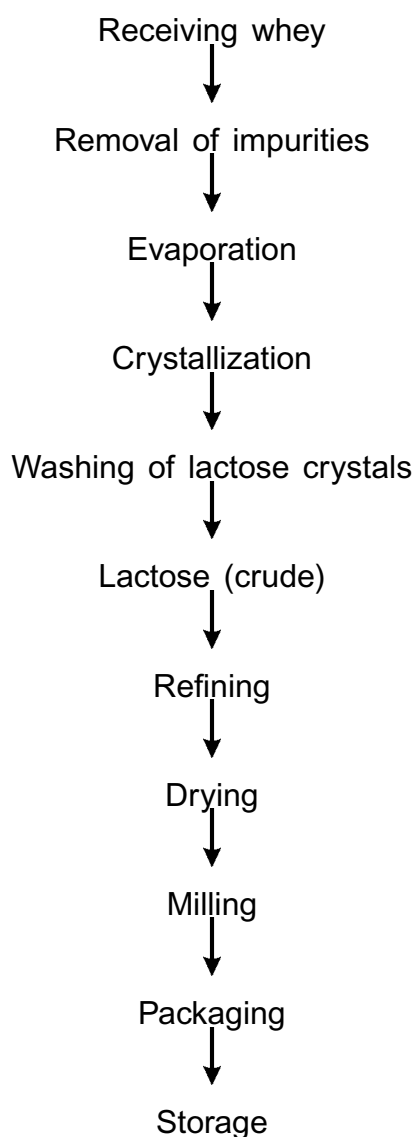


Fig. 5.7: Flow diagram for the manufacture of lactose

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

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

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

The lactose crystals can be harvested either in a basket centrifuge batch-wise or in a continuous decanter attached with a screw conveyor. Wash water is introduced into the centrifuge during the separation of lactose crystals to assist in the removal of the remaining

impurities. The use of 10 percent wash water can reduce the ash level of the lactose by more than 66 percent. The obtained lactose crystals are refined and dried to a final moisture content of 1.5 to 2.0 percent. The dried lactose crystals usually have a size of 40 μm . The BIS specifications for lactose are given in Table 5.6.

Table 5.6. Bureau of Indian Standards (BIS) Specification for Lactose

Characteristic	Requirement
Lactose (% on dry basis) min.	99.0
Moisture (%), max.	
For lactose, monohydrate	5.5
For lactose, anhydrous	1.0
pH (of 10 percent solution)	4.0 – 6.5
Sulphated ash (% on dry basis), max.	0.2
Nitrogen (%), max.	0.05
Lead (ppm), max.	2.0
Arsenic (ppm), max.	1.0
Specific rotation	52.0 – 52.6
<i>E. coli</i> , per 0.1 g	Absent
<i>Salmonella</i> , per 0.1 g	Absent

Ghee-Residue

Ghee-residue is the by-product of ghee manufacturing industry. It is partially charred (burnt) light to dark brown and moist residue that is obtained on the cloth strainer after the ghee is filtered. During the manufacture of ghee, the solids not fat (SNF) present in cream or butter appears in the form of small particles known as ghee-residue. It is obtained after molten ghee has been either strained out with bag filters or muslin cloth or separated by continuous centrifugal clarifiers (Fig. 5.8). The yield of ghee-residue varies with the method of preparation of ghee. This is due to the variation in the non-fatty serum constituents of the different raw materials used for the preparation of ghee. Ghee is manufactured by various methods viz. direct creamery method, creamery butter method and *desi* butter method. The average yield of ghee-residue is maximum in direct creamery method (12 percent) followed by about 3.7 percent yield in creamery butter and *desi*(home-made) butter method.

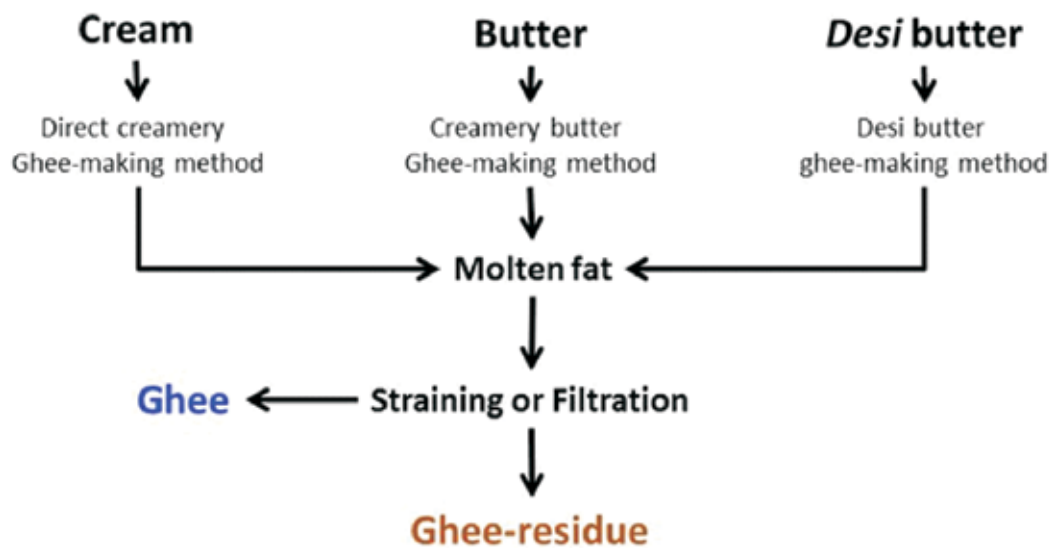


Fig. 5.8: Flow diagram for the preparation of ghee-residue

Properties of Ghee-Residue

Depending on the intensity of the heat treatment used during the ghee manufacture, colour of ghee-residue may vary from light to dark brown. It has smooth to granular texture with glossy exterior due to the presence of excessive free fat. There are considerable variations in the chemical composition of ghee-residue depending upon the method of preparation of ghee. Approximately ghee-residue contains 32 to 70 percent fat, 12 to 39 percent protein, 8 to 30 percent moisture, 2 to 14 percent lactose and 1 to 8 percent ash.

The lipids of ghee-residue have lesser lower chain fatty acids and total saturated fatty acids and more of unsaturated fatty acids in comparison to those of ghee. Irrespective of the method of preparation, poly unsaturated fatty acids (PUFA) content of ghee-residue lipids is higher than those of corresponding ghee. Ghee-residue is rich in phospholipids (1 to 9 percent) and the levels are much higher than those in ghee (0.004 to 0.08 percent). The free sulphhydryl content of ghee-residue (2.90) is much higher than that of ghee (0.02 $\mu\text{m/g}$). These substances are liberated from protein during heat treatment and because of their polar nature are mostly retained in the ghee-residue. Whey proteins, especially β -lactoglobulin are the main source for these sulphhydryl compounds. Main sugars in ghee-residue obtained from ghee (120°C) are lactose, galactose, glucose and others. As the period of heating is increased, the lactose content of ghee-residue decreases with a corresponding increase in galactose and glucose content.

Ghee residue is also a rich and natural source of flavour compounds viz. free fatty acids (FFA), carbonyls and lactones. The level of FFA, carbonyls and lactones in ghee-residue

are 11, 10 and 132 times, respectively those in ghee. Ghee-residue is a rich source of natural antioxidants. It is rich in phospholipids and nitrogenous compounds, which contribute towards its antioxidant properties. Other constituents discharging the same function include free amino acid and reducing substances like free sulphydryls from denatured proteins and free sugars from lactose. The antioxidant properties of ghee-residue are affected by method of preparation. The overall antioxidant properties are due to both lipid and non-lipid constituents. In lipid constituent of ghee-residue, phospholipids show the maximum antioxidant activity followed by *l*-tocopherol and vitamin A. Creamery butter ghee-residue has the maximum antioxidant properties followed by *desi* butter and direct creamery ghee-residues.

Recovery and Processing of Ghee-residue

In dairy plants, attempts are made to recover as much ghee as possible from ghee-residue. Two methods of recovery of ghee from ghee-residue are commonly adopted: (i) pressure technique and (ii) centrifugal process. Pressure technique is simple, efficient, more practical, economical and requires no electricity or sophisticated equipment. It consists of subjecting the heated ghee-residue (65-70°C) to a limited pressure in hand screw or hydraulic press. This method gives a yield of about 45 percent (extraction efficiency of about 67 percent). Centrifugation process consists of heating ghee-residue in water (65°C) due to which fat entrapped within the residue matrix melts and oozes out, and can be collected as the top layer above soak water. Ghee is subsequently recovered by centrifuging the water-fat phase. The method yields 25 percent ghee (46 percent efficiency). Alternatively the released fat at the surface of water is recovered by solidification by cooling either by adding ice/cold water or leaving it in a cold store (5-10°C) over night.

Ghee-residue has soft and smooth body, but gets progressively hardened during storage. The change in the textural characteristics is much faster particularly during the first 15 days and by the end of a month it becomes hard and gritty. In order to eliminate the undesirable characteristics it is necessary to process it so as to yield a soft and smooth texture essential for edible preparations. Before subjecting the residue to any-treatment, lumps are broken and then pulverized by passing through 40 mesh sieve. A number of processing treatments are possible for ghee-residue such as (i) loosely tying residue in the form of a bundle and cooking in boiling water for 30 min, (ii) cooking the residue in boiling (1 percent) sodium bicarbonate solution for 30 min, (iii) washing of residue with 50 percent ethyl alcohol followed by cooking in boiling water for 30 minutes (iv) washing of residue with 50 percent ethyl alcohol followed by boiling in sodium bicarbonate (1 percent) solution, (v) autoclaving the residues. All the treatments make the processed residue soft and smooth. It was reported that the changes brought about in the constituents of the

residue remained same. Washing of ghee residue with 50 percent ethyl alcohol followed by cooking in baking soda was reported to be the best as far as removal of excess fat from the residue was concerned. Autoclaving of this residue after incorporating 2 percent vinegar lowered the moisture content and improved the texture of the product. Keeping quality of all types of GR clarified at 120°C is 3 months. Its shelf life can be further extended to more than 4 months by pressing it in cake form.

Applications of Ghee-residue

Ghee-residue can be used in the preparation of confections, preparation of candy, preparation of chocolate, preparation of edible pastes, preparation of burfi-type sweet, preparation of bakery products and broiler/animal feeds.

Activities

The following activities are suggested for better understanding of the dairy byproducts discussed in this chapter:

- Visit a dairy plant to know about cream separation and resulting cream and skim milk
- Visit a cheese making or paneer making unit to know more about whey
- Your mothers may be making ghee at home on domestic scale. Evaluate the quality of ghee-residue obtained from such method.
- Visit a super market and find out what kind of dairy and food products contain casein or caseinates or whey protein concentrates as additives in them.

Review Questions

1. Define dairy byproduct.
2. What is whey?
3. As per the FSSR (2011), what are the specifications of milk fat and SNF of skim milk?
4. What are the important contributors to the viscosity of skim milk?
5. What is rennet?
6. What is the isoelectric pH of casein?
7. What are the differences between rennet casein and acid casein?
8. As per the FSSR (2011), what is the minimum percentage of milk protein in non-animal rennet casein and acid caseins?

9. With the help of a neat flow diagram, describe acid casein manufacturing process.
10. What is the effect of temperature of precipitation on the quality of casein?
11. What is the yield of casein per 100 kg of skim milk?
12. What are caseinates?
13. With the help of a neat flow diagram, describe the manufacturing process of sodium caseinate.
14. What are the differences between sodium and calcium caseinates?
15. What is the approximate amount of whey generated during cheese manufacture?
16. Which type of whey has lowest total solids among cheddar cheese whey, acid casein whey and paneer whey?
17. What are the differences between sweet whey and acid whey?
18. What is whey powder?
19. Why is lactose crystallization necessary prior to drying during whey powder manufacture?
20. Describe the manufacture method of whey powder.
21. What is the protein content of whey protein concentrates?
22. What are the commonly employed methods to recover whey proteins from whey?
23. What is principle of ultrafiltration?
24. What is Diafiltration?
25. What are the different forms of lactose?
26. What is mother liquor?
27. Describe the process of lactose manufacture with the help of a neat flow diagram.
28. What are the specifications of lactose as per BIS?
29. What is ghee-residue?
30. Which method of ghee-making yields highest amount of ghee-residue?
31. What are the properties of ghee-residue?
32. Describe the process of ghee-residue recovery.

Chapter-6

Sensory Evaluation of Milk and Milk Products

Objective

To check organoleptic properties of milk and milk products.

Introduction

Whenever we go to market to buy any food item we prefer to purchase it according to our expected quality. For example if we go to buy a loaf of bread, we usually smell, press or pat it to decide its freshness. While buying sweets we first look their colour and appearance and sometimes taste it at the shop itself to decide its deliciousness. Similarly during buying green vegetables we also look whether it is lush green and fresh or not. If it is wilted we don't buy it. If we look closely while deciding the quality of the food in these cases we use any of our five senses that is either eye, tongue, nose, skin and ear or a combination of them. The process of determining the quality of any food by using any or a combination of our five senses is known as sensory evaluation. There are other processes to judge food products quality like determining its composition in terms of its fat, protein, carbohydrate and vitamin content to determine its nutritional quality. Similarly microbiological quality of any food reveals whether it is free from any disease causing micro organisms or not. However, even if a food is highly nutritious and microbiologically safe, people will not consume it if it is not taste or sometimes looks good also. This is because human being consumes only that type of food which is delicious and provides them enjoyment while eating. Thus the quality of any food that is decided by sensory evaluation mostly becomes the primary deciding factor for its acceptability. Among all the processes of determining the quality of foods sensory evaluation is the oldest because it does not require anything other than the five senses which every human possesses.

Definition of Sensory Evaluation

Sensory evaluation may be defined as a scientific method used to evoke, measure, analyze and interpret results of those characteristics of foods perceived through five senses of sight, smell, taste, touch and hearing.

What is the Importance of Sensory Evaluation?

The sensory evaluation is very important in product evaluation on account of following advantages:

1. It is relatively simple analytical process.
2. Employing sensory evaluation techniques quality attributes like colour, appearance, flavour etc are measured in objective (quantifiable) manner. The use of chemical and microbiological methods for examining quality of milk and milk products are time consuming, complicated and expensive.
3. It directly determines the eating quality of milk products that cannot be done by other analytical techniques.
4. Sensory evaluation helps to ensure that consumers get a defect free product that provides them great enjoyment while eating.

Where Sensory Evaluation is Applied in a Dairy?

In recent years, the competition among the dairy product manufacturing companies has tremendously increased. The companies are making very fast changes in their existing product in terms of ingredients, composition, packaging etc. mainly to reduce cost. They are developing new products to grab larger market share. In these situations, sensory evaluation playing a much greater role than earlier. Usually sensory evaluation is used in the following situations.

1. **Inspection of raw materials:** The main raw material for dairy industry is milk. Any defect in quality of milk related to colour, appearance, aroma and taste can be quickly detected on the reception dock by the senses of smell, taste and sight. This is very important to achieve final product of good quality as from inferior quality raw material good quality final product could never be produced. The other raw materials that are required to produce milk products such as, sugar, stabilizers, emulsifiers, ingredients used to impart flavour and colour to foods and other additives are also examined using sensory evaluation.
2. **New product development or improvement of existing product:** According to a survey more than 90% of the new products launched in the market result into failure mainly because of poor sensory attributes and rejection by the consumers. The adoption of appropriate sensory methods during new product development is thus very important.

3. **Cost reduction:** Cost is an important consideration for selection of the product by consumers. Dairy product manufactures always try to reduce the cost by either using low cost ingredients or adopting new production techniques. The use of low cost or alternative production technologies may adversely influence the sensory characteristics of the product and may not find good acceptability. Hence after applying any modification sensory evaluation of the final product is always performed to ensure that the eating quality of the product never gets adversely affected.
4. **Quality control:** The modern day concept of 'Total Quality Management' (TQM) involves quality evaluation at all stages of product manufacturing. The changes in product quality in terms of colour, flavour and texture during processing is regularly monitored using sensory evaluation.
5. **Selection of packaging material:** Today's quality conscious consumers prefer to buy properly packaged processed food. This has resulted into development of various types of packaging materials for food applications. The newer types of packaging materials, particularly in forms of flexible films, pouches and laminates are being developed. The suitability of these films for packaging a particular dairy product in respect of safe containment of the product, its non reactivity with the product inside and compatibility to storage conditions is examined adopting sensory analysis along with some chemical and microbiological methods.
6. **Shelf life studies:** Dairy products during storage undergo many types of chemical changes that alter the sensory properties, such as taste, colour, flavour, texture and appearance. Application of sensory evaluation not only monitors these changes but also determine the nature and extent of the defects in dairy product during storage so that corrective measures can be adopted. As per the existing laws, it is mandatory to mention the 'best before' date or period on the label of any packaged. This date is determined by using sensory and chemical methods together.

Physiology of Sensory Evaluation

Our perception of the environment, including food, is through specialized sense organs, which houses sensory receptors. The eyes are used for determining appearance and colour, the nose for the sense of smell, the tongue for taste, skin for touch and the ear for any possible sound effect. Stimuli are defined as triggers from the environment that generate sensory impressions. The study of the physiology and human reaction to stimuli is fundamental to sensory evaluation.

Humans possess and utilize five primary senses for perceiving stimuli: sight, hearing, touch, taste and smell. Other human senses include temperature sensation (heat and cold), pain, hunger, thirst, fatigue and balance. Senses may be separated based on the type of

stimuli to which they respond. Sight, hearing, touch and temperature are considered to be physical senses in that they respond to physical stimuli. By contrast, the sensations of smell, taste and pain are considered to be chemical senses in that the respective receptor sites all respond to chemical stimuli.

Chain of Sensory Perception

When we perceive a stimulus (singular of stimuli), our response is a multi-step process. The chain of sensory perception could be described as follows:

Stimulus → Sensation → Perception! Response

Each sense organ responds to a particular range of stimuli and transmits information in terms of nerve signals to the brain via the central nervous system. Specific sites in the brain are stimulated by the initial sensory input and the brain interprets the incoming information into a perception. This perception is then translated into a response by the individual.

Sensory perception may be divided into either an objective or a subjective response. An objective response measures the intensity of both the stimulus and the sensation. The objective response arises from the relationship and physiological response of the central nervous system, which is a physical or chemical reaction within individuals. By contrast, the subjective response arises from the statements, either verbal or written, that the individual makes about the sensations that he/she perceives. Examples of subjective response are 'the dahi too sour' or 'the lassi is very thick' etc.

Sequence of Observing Sensory Characteristics of Milk and Milk Products

When a dairy product is offered for sensory evaluation its appearance aspect is first noticed. It is perceived quickly and non-evasively. Appearance of food is consisting of a number of characteristics including colour, size, shape, surface texture, clarity etc. The colour of any food is composed of four characteristics. These are, description – the actual name of the colour; intensity – the strength of the colour from dark to light; brightness – the purity of the colour which ranges from dull to bright; and evenness – the distribution of the colour. These four factors combine to determine the colour of any food product. Appearance is the first attribute perceived by the consumer and often become deciding factor in purchasing decisions. After appearance, the ortho-nasal perception of odour or aroma of the food takes place. Upon taking the food in the mouth the retro-nasal (in nose) perception of aroma continues. Perception of foods consistency, texture, and possibly sound especially for crispy and crunchy foods are also perceived inside the mouth.

There are many terms related to the smell of any food products which is emanated from the volatile compounds of dairy products. Odour is the organoleptic attribute perceptible by the olfactory organ when volatile substances sniffed through the nose. Aroma is perceived by the olfactory organ via the back of the nose when tasting. Fragrance is the odour of a perfume or cosmetic. Smell sense is more refined than taste, because humans require more concentration of stimulus for taste than smell. Another term related to the smell perception of food is known as flavour. Though in common parlance it is used as synonym of smell but scientifically it is the sum total of the sensory impressions perceived when a food is placed in the mouth. Flavour includes the aromatics released from the product inside the mouth, taste sensations (sweet, sour, salty, bitter and umami) released from the soluble substances in the mouth, chemical feel factors such as astringency, cooling, metallic, spicy heat etc.

Upon ingestion of a food, the sensors in the mouth detect food texture and consistency. Texture is defined as response of the tactile senses to the physical stimuli that results from contact between some part of the body and the food. Components of texture include mechanical properties (e.g., hardness, cohesiveness, adhesiveness, denseness and chewiness etc), geometrical properties (smooth, gritty, grainy, chalky and lumpy) and moisture properties (juicy, oily or greasy). The noise produced by the food product, either during the rupture or the mastication of the food also helps to determine the textural attribute of any food. Texture is a complex term and is generated by the structure of the food product.

Physiology of Taste Perception

The perception of taste also known as gustation is a chemical sense. Taste begins on the tongue and involves the detection of stimuli dissolved in water, oil or saliva by the tongue. The raised portions on the tongue, known as papillae, are the sites of taste buds, the receptors of taste. Papillae are located primarily on the surface of the tongue as well as in the mucosa of the palate and some areas of the throat. Four types of papillae are found on the human tongue, filiform, fungiform, foliate and circumvallate. Filiform papillae are highest in numbers among the taste buds. These papillae are evenly distributed on the frontal two-thirds of the tongue but contain no taste buds and have a purely mechanical function of holding the food constituents while masticating. The fungiform papillae are large and mushroom-like in appearance and are highest in number at the tip and sides of the tongue. Foliate papillae are found on the posterior one third of the tongue, usually in folds on the sides. These are also not well developed in human and have little function. The circumvallate papillae present in the form of V-shape on the back of the tongue are large and easily visible. Circumvallate papillae contain several hundred taste buds in their outer grooves.

In order for compounds to be carried to the taste buds and perceived, they must be in aqueous solution (saliva). Saliva is a complex solution of water, amino acids, proteins, sugars, organic acids and salts that immerse the taste receptors. Taste bud contains taste receptor cells and each taste receptor cell contains a pore. The taste molecules are bind to the hair-like cilia near the opening of the pore. Taste receptor cells are connected with taste nerves over a gap connection. When taste a molecule binds to the cilia, neurotransmitter molecules are released into the gap to stimulate the primary taste nerves and send the taste sensation signal onto the brain and taste perception takes place.

Distribution of taste buds is generally associated with a certain papillae. Consequently, response to specific tastes may be felt **more intensely** in some areas of the tongue as compared to other areas. For example, sweet taste at the tip, sour taste along the sides, saltiness along the sides and tip, bitter taste at the base of the tongue and umami taste along the sides and base of the tongue. However, different tastes are perceived with varying intensity all over the tongue and not only in these specific areas.

The Basic Tastes

A basic taste is one for which specific taste buds have been identified which is responsible for that particular taste sensation. There are five basic tastes:

Sweet: Sweetness, usually regarded as an enjoyable sensation, is produced by the presence of sugars and a few other substances like aldehydes and ketones, which contain a carbonyl group. Other substances such as lead salts, amino acids, proteins, non-nutritive sweeteners (cyclamates, saccharin, acesulfame K, aspartame, etc.) also taste sweet. Taste detection thresholds for sweet substances are rated relative to sucrose, which has an index of 1. The average human detection threshold for sucrose is 10 millimoles/liter. For lactose, the milk sugar it is 30 millimoles/liter, with sweetness index of 0.3.

Sour: Sourness is the taste that detects acidity of milk and milk products. This is the simplest taste as only acids (H^+) produce sourness and as the (H^+) increases the sourness increases. The sourness of substances is rated relative to dilute hydrochloric acid, which has a sourness index of 1. The mechanism by which animals detect sour is still not completely understood. There is evidence that the protons that are abundant in sour substances can directly enter the sour taste cells. This transfer of positive charge into the cell can itself trigger an electrical response. The most common food group that are naturally sour is fruit, such as lemon, grape, orange, tamarind, and sometimes melon.

Salty: Saltiness is produced primarily by the presence of sodium ions. Other ions of the alkali metals group also taste salty, but the further from sodium the less salty the sensation

is. The saltiness of substances is rated relative to sodium chloride (NaCl), which has an index of 1. Potassium, as potassium chloride (KCl) is the principal ingredient in salt substitutes, and has a saltiness index of 0.6. Many other crystalline water-soluble salts yield a salty taste, but only sodium chloride gives a pure salty taste.

Bitter: Bitterness is the most sensitive of the tastes, and is chiefly associated with unpleasant, sharp, or disagreeable aromas. Bitterness is mainly associated with alkaloids such as caffeine, quinine, strychnine and nicotine. Bitterness is generally perceived at very low concentration and a relationship appears to exist between sweet and bitter as many sweet substances produce a bitter aftertaste (saccharin). The threshold for stimulation of bitter taste by quinine is 0.000008 M. The taste thresholds of other bitter substances are rated relative to quinine, which is thus given a reference index of 1. Bitterness is the taste which most people have difficulty in detecting and response level varies greatly from individual to individual.

Umami: Also known as appetite taste, the words savoury, meaty and brothy has been used to describe umami taste. Umami (in Japanese means 'good flavour' or 'good taste') can be tasted in cheese, soy sauce, tomatoes, grains and beans. This taste has been shown to be associated with substances that contain glutamate. The most notable example is mono-sodium glutamate (MSG). MSG is well known as a flavour enhancer.

Physiology of Aroma Perception

The perception of aroma also known as olfaction is a chemical sense. Airborne odourants are sensed by the olfactory system that is positioned in the nasal cavity. The olfactory receptor area is located in the roof of the nasal cavity and is lined with a layer known as olfactory epithelium. The surface of the olfactory epithelium is coated by a layer of mucous. Embedded in this mucous are several million smell receptors coated with fine hair like substances known as cilia. The function of these cilia is to provide a greater surface area for receptors to interact with odourants. When a person sniffs a food sample, the mix of volatile compounds flows over the receptors in the olfactory region in the nose. This activates the olfactory receptors specifically responsive to the compounds present. An array of intracellular signaling events is initiated, which are propagated along the olfactory sensory nerve to the brain and interpreted by the brain as aroma or odour. In order for a compound to be perceived by the olfactory system its molecular weight must be less than 300Da.

Physiology of Vision

Vision is the psychological response to the stimulus generated by the physical nature of the food being viewed. The human eye is virtually spherical, with muscles providing mobility of almost 100°. Retina, the innermost lining of the eye and contains light sensitive nerve tissue. During perception, light is either reflected from an object or passes through an object, then enters the eye and focused by the eye lens onto a depression in the retina - the fovea. Fovea is located in a 2–3mm diameter yellow pigmented area, but the central area of the foveal pit is non-pigmented and free of blood vessels. Fovea contains two types of photoreceptor cells, rods and cones. Cones are responsible for detecting colour while rods are responsible for low intensity and/or colourless vision. Cones are exclusively packed in the center of the fovea while the rods increase in density to 20° from the fovea and then decrease toward the periphery of the eye. Rods and cones contain photosensitive pigments that bleach upon exposure to light. The subsequent electrical neural impulse generated travels to the brain via the optic nerve and the brain interprets the signal and perception of vision takes place. Cone vision is trichromatic and contains three colour-sensitive pigments, responding to red, green and blue light. Colour blindness results if the individual lacks any of these pigments, with the most common type being red/green colour blindness. Colour blindness afflicts about 8% males and 0.44% females. If sensory evaluation activities involve colour evaluation, panelists should be screened for colour blindness.

Physiology of Hearing

The sound emitted when certain foods when bitten and chewed is the reflection of the texture of these foods. Sound is perceived through the vibrations conducted through the air, which subsequently cause the eardrum to vibrate. Via the small bones in the middle ear, the vibrations are transmitted to create hydraulic motion in the fluid of the cochlea in the inner ear. The cochlea is a spiral canal covered in hair cells. When agitated at their individual harmonic frequency, these hair cells send neural impulses to the brain where the particular sound is perceived. Two noise-producing mechanisms relates to crispiness and crunchiness of food. Crunchiness is more related to a larger proportion of low-pitched sounds (frequencies <1.9 kHz), whereas, crispiness is related to a larger proportion of high-pitched sounds (frequencies > 1.9 kHz). Crisp foods break in a single stage while crunchy foods break in several successive stages of applied pressure. The intensity and pitch of crispiness and crunchiness can be measured in terms of decibels.

Physiology of Touch

In the sense of touch the stimuli is the physical contact between the food and body tissue. The receptors involved are the muscles and nerves in fingers or mouth and the resultant perception is texture, viscosity or consistency of the food. In general, the skin senses are able to perceive three types of stimulus: mechanical, thermal and pain. Kinesthesia is the deep pressure sense - the result of stimuli pressing upon or displacing connective tissue without injury. It is felt through nerve fibers in muscles, tendons and joints. Somesthesia is the tactile sense or skin-feel caused by displacement of hairs or deformation of the skin without injury. Epidermis, dermis and subcutaneous tissues are responsible for somesthetic sensations of touch, pressure, heat, cold, itching and tickling. Texture is the response of the tactile senses to the physical stimuli that results from contact between some part of the body and the food. Sensory assessments of texture are made on the basis of sensations perceived when the food sample is manipulated in the fingers and in mouth. Mouthfeel is another oral tactile attribute which is defined as the mixed experience deriving from the sensations of the skin in the mouth during ingestion of a food.

Requirements of Sensory Evaluation

Scientific sensory evaluation of milk products requires the following four major components:

1. Sensory Evaluation Laboratory

A design of sensory evaluation laboratory is shown in Fig. 6.1. A sensory evaluation laboratory is consists of the following:

Briefing Room: Sensory panel members are first assembled here. They are here briefed about the objective of the sensory evaluation programme, the score card used and its use. This room should be adjoining to testing booths and have facilities for comfortable sitting.

Sample preparation room: Here the food samples are distributed into the exact serving sizes before they are offered for sensory evaluation. It should be located adjacent to the testing area and properly ventilated. The main components the preparations room for dairy products are: working space, sink, cooking range, oven, refrigerator, deep freeze, blender, scoops, knives, trier, balance, dishes, spoons, and cleaning and storage facilities.

Testing booths: This is the area where panel members carry out actual sensory evaluation of dairy products (Fig. 6.2). Testing area shall be located separately but in the immediate vicinity of the preparation area. This area is divided into small booth usually between 5-10 numbers so that the panel members can independently evaluate the product.

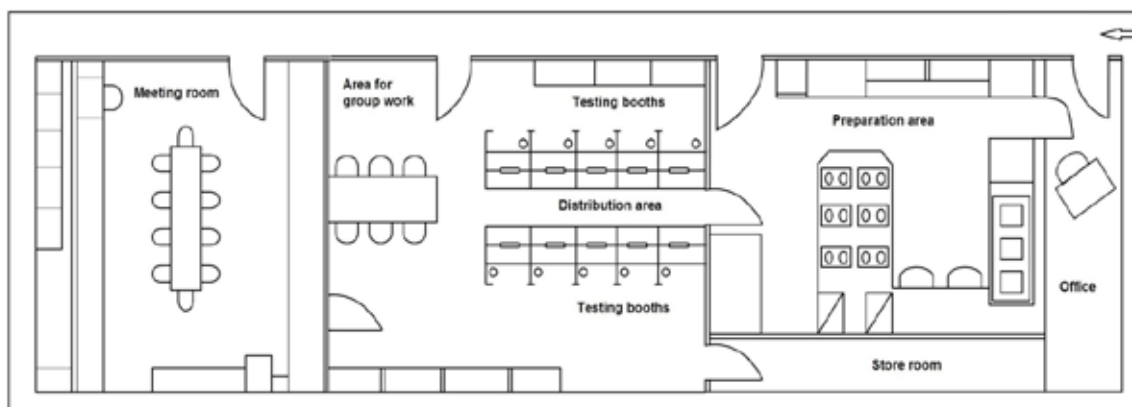


Fig. 6.1: Layout of a Sensory Evaluation Laboratory.

Following conditions have to be maintained in testing area for obtaining best results:

- The size of each testing both shall be sufficiently large to accommodate the sample, utensil, sink, rinsing agents and score card. An area of 0.9 m wide and 0.6 m deep is considered optimum for this purpose.
- The temperature and relative humidity shall be maintained about 20°C and 62% respectively for the comfort of the evaluators.
- The testing area must be kept free from odours. A slight positive pressure may be created in the testing area to prevent the inflow of extraneous odours.
- Adequate lighting is very important in all sensory testing. Light having a correlated colour temperature of 6500K (or 110 candle foot light) is desirable.
- A counter with openings, covered by sliding doors, of convenient size is provided for supplying samples in to the booth from the sample preparation room.

Office: It is the room located adjacent to the testing booths where all paper and works related the statistical analysis of the data and interpretation of the result is done based on the scores given by the panel members.

2. Sensory Evaluation Panel Members

Sensory evaluation panel members also known as the evaluator or judges are the persons who actually perform the sensory evaluation. He/she should have following qualities:

Availability: Sensory evaluation work is often time consuming and tedious. The evaluator should therefore have availability, interest and motivation to participate in training and sensory evaluation programme.



Fig. 6.2: Sensory evaluation of ghee is in progress in a testing booth

Attitude towards foods: Persons having strong liking or disliking towards a dairy product should not be a sensory evaluator. The assessor should have ability to concentrate and must be unbiased. He should have the basic knowledge on the principal sensorial attributes of milk products.

Health: The evaluator should be in good health. The sensitivity of the evaluator in respect of sense of smell and taste should be normal. He/she should not be suffering from anosmia (loss of smelling ability) and ageusia (loss of tasting ability).

Age: Evaluators should preferably be in age group of 18-50 years. Person of younger age are unable to properly interpret and communicate the sensory result whereas at older age the memory decreases.

Adaptation: Continuous exposure of evaluator to a stimulus, particularly at high concentration for long time lead to decrease in his sensitivity (also called as fatigue). It is therefore desirable either to give sufficient to time between the sample or rinse mouth with taste sanitizers, such as brine solution, fruits and mild acids.

Other requirements: Smoking, chewing pan and taking intoxicants by the evaluator should have lapse of at least an hour before the test. Use of strong odoriferous substances such

as perfumes, flavours, hair oil should be avoided by the evaluator on the day of sensory evaluation.

3. Training of the Panel Members

The sensitivity and experience of an evaluator influences the accuracy of results. The training of the evaluators is therefore, very essential for efficient conduct of sensory evaluation of milk and milk products. During training the assessors are acquainted with the desirable and undesirable attributes of the product, correct terminology, use of score card, scoring technique and sequence of observations. The sensory evaluation training must start with a large group of people but finally a trained panel comprising of 5-6 members should be retained rejecting who are insensitive or under performer.

4. Sensory Evaluation Score Card

Sensory evaluation score card is a prescribed form in which the judges record their scores. The evaluation card should be simple, brief and easy to follow and all important sensory attributes are included in it. It should be clearly printed and the matter should be arranged in logical sequence. Terminologies used shall be clear and understandable. A score card used for sensory evaluation of milk prescribed by Bureau of Indian Standards (BIS) is presented in Fig. 2.

Types of Sensory Panelists

There are three types of sensory panelists who are selected and trained by the sensory leader/ coordinator depending on the type of the product.

1. **Trained panel:** They should be carefully selected and trained, and need not be expert panelists. The trained panel should be used to establish the intensity of a sensory character or overall quality of a food. A trained panel should comprise of small number of members varying from 5 to 10 and may be used in all development, processing and storage studies. A small highly trained panel will give more reliable results than a large untrained panel.
2. **Semi-trained panel (D & C Panel):** This type of panel should be constituted from persons normally familiar with quality of milk and different classes of dairy products. This panel is capable of discriminating differences and communicating (D & C) their reactions, though it may not have been formally trained. In a semi trained panel individual variations can be balanced out by involving greater number of panelists. The panel should normally consist of about 25 to 30 members.

- 3. Consumer Panel:** The members of the consumer or untrained panel should be selected at random and ensure due representation to different age, sex, race and income groups in the potential consumer population in the market area. Usually 80-120 members are sufficient to constitute a consumer panel.

Different Types of Sensory Methods

Sensory tests used for judging milk and milk products could be divided into following categories:

1. Difference or Discriminative Testing

Difference test is one of the most useful sensory tests. It is generally used for selection and training of sensory panelists. Difference test is designed to discriminate difference between two or more samples. Within this general class are a variety of specific methods, viz., paired comparison, duo-trio, triangle and multiple sample tests. The main features of these tests are discussed below.

Paired Comparison Test: It is a two products (e.g. A & B) test, and the panelist's job is to compare these and identify whether the samples are similar or different. If different, which attribute, such as sweetness, acidity, hardness, colour etc. is responsible for this difference. This part of the test is called as directional difference test. The test can be further extended and the preference component of the panelists can be included. The paired comparison test is relatively easy to organize and implement. The two coded samples in order of AA, BB, AB, BA, (4 pairs) are served simultaneously, and panelist has to decide if there is any difference or not. Paired comparison is typically used in comparing new and old processing techniques, change of ingredients in a product, preference testing at the consumer level, etc.

Duo-trio Test: In this test one sample identified as the reference (R) is first given to the panelists for evaluation. Subsequently two coded samples, one of which is identical to reference, are presented. The panelist is asked to indicate, which of the two samples is the same as 'R'. The test is suitable for products that have relatively intense odour or taste such that sensitivity of evaluator is significantly reduced. It is used for quality control and for selection of panelists.

Triangle Test: Triangle test is most well known and more frequently used out of the three difference tests. As its name implies, it is a three product test in which all the samples are coded and the panelist's task is to determine which two are similar or which one is most different from the other two. Triangle test is more difficult test because the panelist

must recall the sensory characteristics of two products before evaluating the third and then make a decision. It should, therefore, preferably be used by trained panel for quality control work, and also for further training of panelists.

Multiple Sample Test: Test involving more than 3 stimuli are classified as multiple sample tests. They may have equal (symmetrical) or unequal (asymmetrical) numbers of each stimulus. When they are applied as true difference tests, the judge is required to separate the sample into two groups of like samples. When they are applied as directional tests, the judge is asked to identify the groups of higher or lower intensity of a given criterion. Difference test designs involving more than three stimuli have only limited use due to increase in psychological complexity and physiological fatigue, which accompanies an increase in number of stimuli.

2. Scoring Technique

In this method certain weightage or score is given to each sensory attribute arranged in logical order on a score card. The weightage is given on the basis of importance of the attribute. For example, if flavour is considered to be most important and highest score is allotted to this attribute. Score cards wherein 25 to 100 total points have been allotted to different quality attributes are in use for milk and milk products. Scoring method is most frequently used because of its diversity, simplicity and ease of statistical analysis. Rigorous training is not required for panelists as information on defects and scoring guide is also provided on the scorecard.

3. Ranking Test

In ranking method two or more samples are provided to the panelists who are asked to arrange them in an ascending or descending order of intensity of a specific attribute, e.g. sweetness, hardness, etc. Ranking is often used for screening inferior from superior samples in product development. This method is also suited for comparison of market samples of different brands and ranking them first, second and so on.

4. Hedonic Rating Test

Hedonic relates to the psychology of pleasurable and non pleasant states of consciousness. In hedonic method, psychological states of likeness or dislikeness are measured on a rating scale. The nine point hedonic scale as given in table 6.1. has been most extensively used for new product development and consumer studies.

Table 6.1: A nine point hedonic scale used for new product development

Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

5. Descriptive Analysis

Descriptive method of sensory evaluation provides quantitative descriptions of a product based on the perception of a group of qualified judges. It is a total sensory description of a product taking into account all sensations that are perceived: visual, auditory, olfactory, gustatory, kinesthetic, etc. A descriptive method enables us to relate specific process variables to specific changes in some of the sensory attributes of a product, for example, the flavour changes in milk at high temperature processing. From the view point of product development, descriptive information is essential in finding out those product variables that are different and from which one can establish the cause and effect relationships. A descriptive test involves relatively few judges, who have been screened, selected and trained for the particular product category. Training of this group is primarily focused on development of descriptive language, which is used as a basis for scoring a new product. There are numerous applications for descriptive analysis including monitoring competitor's products, determining shelf life, product development, and quality control, establishing physical / chemical and sensory correlation.

6. Acceptance/Preference Testing

Acceptance or preference testing refers to measuring liking or preference for a product. Preference can be measured directly by comparison of two or more products with each other. Indirect measurement of preference is achieved by determining which product has scored significantly higher rating than another product in a multiproduct test. The two methods most frequently used to directly measure preference and acceptance are the paired comparison test and a 9- point hedonic scale.

Fundamental rules for scoring and grading of milk and milk products: There are some basic rules for sensory evaluation of milk and milk products that are given below:

Physical and mental condition for sensory evaluation: The evaluator should be physically and mentally in good condition. Sensitivity of the evaluator in respect of sense of smell and taste should be normal. It is helpful to rinse the mouth with plain water before sensory evaluation. Stimulation of saliva flow can be done by chewing mild flavoured chewing gum.

Know the score card and ideal sensory characteristics for each product: The evaluation card should be simple, brief, and easy to follow and all important sensory attributes included in it. It should be clearly printed and the matter should be arranged in logical sequence. Terminology used should be clear and understandable.

Learn important sensory characteristics of each product and range of defect intensities: This implies through study of flavours and defects and relative desirability or undesirability of each items of the assigned numerical values. Thus for a given product one must know what to expect.

Have the sample properly tempered: Flavour, body and texture characteristics can be best determined when the product is neither too cold nor too warm, each sample should be tempered to the optimum for that product. Milk is warmed to 40°C and butter as well as cheese at 15°C. Ice cream is tempered around – 18 to – 15°C. If the product sample is too cold, the taste buds may be temporarily anaesthetized, consequently some of the delicate, more elusive flavours may not be possible to detect.

Sample number and quantity: Normally 5-8 samples with average intensity of flavour are considered optimum. The amount of each sample should be about 25- 50 ml or gm, which is sufficient for one full sip or bite.

Observe the aroma immediately after the obtaining the sample: Some aroma becomes less intense and disappears when exposed to atmosphere. The best time to test aroma is when container is first opened.

Take a large volume for testing: Sample should be sufficiently large so that delicate flavours may be detected and yet small enough to permit manipulation of the sample in the mouth.

Do not consume the product: While performing sensory evaluation avoid eating or drinking the product. Once tasted, expectorate the sample. Consuming the product during evaluation leads to satiation of hunger and concentration from the finer sensorial attributes is deviated.

Fix the proper quality idea in mind: The sensory evaluator must know the ideal characteristics of the product being tested. This could be achieved by working samples of superior quality.

Observe the sequence of flavours: Keep a mental record of the first taste or odours which are sensed and note whether they change or remains constant. If the flavours gradually disappear one should note what other is, if any take their place(s). After expectoration, note the relative time lapse before the taste sensation disappears.

Rinse the mouth occasionally: The mouth should be reconditioned or cleansed occasionally especially after having evaluated a particularly intense flavour sample. This could be done using clean warm water or warm saline solution known as test sanitizers.

Practice introspection: Introspection is accomplished by closing the mind and eyes and concentrating thought solely about tasting. Look back and take mental note of various tastes and smell sensation perceived for each product. Judges should relax briefly after evaluating each sample since sustained concentration can be tiring.

Do not be too critical: Don't try to find objectionable flavours that are not present. Give the sample benefit of doubt and keep an open mind.

Be honest with yourself: Judge the sample itself. Don't be carried away by name, trademarks or score assigned to similar product of same manufacture in past. The evaluator should keep a straight face and not try to communicate to others their feelings about particular samples by facial expressions. One must believe in his/her own judgment.

Practice and experience are essential to make a good judge: One must practice in order to develop the ability to taste, smell and distinguish the delicate often elusive flavours of dairy products.

Sensory Evaluation Procedure of Milk and Milk Products

For every milk and milk product there is a specific score card and scientific technique for sensory evaluation. However the sequence of observation is mostly same for almost all the products. First, for a packaged product the quality of the package in which the product is marketed is evaluated. This is followed by observing the appearance characteristics of the product. In the next step flavour of the product is judged and finally the body and texture is evaluated. In the following section the detailed procedure for sensory evaluation of milk is described.

Desirable Sensorial Attributes of Milk

Flavour: Excellent quality milk should seem pleasantly sweet with no foretaste, leave only a clean, pleasing sensation after the sample has been expectorated or swallowed, with no aftertaste. The flavour of milk is imparted by the natural components such as proteins,

Evaluation Technique

SENSORY SCORE CARD FOR MILK

Name: _____

Date: _____

Characteristics	Maximum score	Sample Scores		
		Sample No. 1	Sample No. 2	Sample No. 3
Flavour	40			
Consistency	30			
Odour	20			
Colour & Appearance	10			
Total	100			

Comments, if any:

Signature of the Judge

Table 6.1. Score card for sensory evaluation of milk prescribed by Bureau of Indian Standards (BIS)

After averaging of data (recorded in the score card by the panelists) the following grades should be awarded to each sample. Any attribute showing pronounced defect should be graded poor and rejected.

Quality	Score	Grade
Excellent	90 and above	A
Good	80 to 89	B
Fair	60 to 79	C
Poor	59 and below	D

Dairy Products Technology (Dairy Technology)

Practical Manual for Class XII



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Preface

The attempt of CBSE to introduce Dairy Technology practical courses for Class XII is to encourage young minds to begin their career in dairying. In the present book, with a view to make the students understand the industrial scale operations in a dairy plant, things-to-observe during the visit of different sections of a dairy plant have been included. It is expected that these observations give the students first-hand information of dairy products manufacturing technology. Further, with a view to complement the theoretical aspects of dairy products technology covered in theory, the practical aspects and intricacies of dairy products manufacturing technologies have been covered. The student is expected to carefully follow the protocols given in this book to understand the role of processes involved and ingredients used in manufacturing different dairy products such as cream, butter, ghee, khoa, chhana, paneer, shrikhand, ice-cream, condensed milk, milk powder, etc.

Vineet Joshi, IAS
Chairman, CBSE

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भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [सम्पूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य] बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता

प्राप्त कराने के लिए, तथा उन सब में, व्यक्ति की गरिमा और [राष्ट्र की एकता और अखण्डता] सुनिश्चित करने वाली बंधुता बढ़ाने के लिए दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई० को एतद्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से “प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य” के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से), “राष्ट्र की एकता” के स्थान पर प्रतिस्थापित।

भाग 4 क

मूल कर्तव्य

51 क. मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

- (क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;
- (ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;
- (ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;
- (घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;
- (ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;
- (च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परीक्षण करे;
- (छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;
- (ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;
- (झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;
- (ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ² [unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY TO OURSELVES THIS CONSTITUTION.**

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) To promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

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Dairy Products Technology (Time 80 hrs)

(Practical)

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Demonstration of manufacture of products in lab/at dairy plant/ through video aids- cream, butter, ghee, khoa, channa, paneer, curd/dahi, yoghurt, chakka, shrikhand, cheese, ice cream, kulfi, dried and condensed milk products: milk powder- skim milk, whole milk, whitner, condensed milk and dairy by-product (skim milk, casein, caseinate, whey concentrate, powder, lactose, ghee residues)	50
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Exercise-1

Visit to Dairy Plant

Section 1

Butter manufacturing unit

Objective

- To understand the working of butter production plant
- To learn procurement of raw materials, testing and storage
- To learn the marketing strategies

Introduction

Butter is a fat rich dairy product, generally made from cream by churning and working. It contains 80% fat, which is partly crystallized. Fat is separated from milk in the form of cream using cream separator. The cream can be either purchased from a fluid milk dairy or separated from whole milk by the butter manufacturer. The cream should be sweet (pH greater than 6.6), not rancid, not oxidized, and free from off flavors.

Important sections of Butter manufacturing unit

1. Raw material procurement section
2. Cream processing section
3. Cream churning plant
4. Cold storage (4°C) and Butter storage section (-18°C or below)
5. Steam generation unit/Boiler section
6. Sales and Marketing section

Observations under each section

I. Raw material procurement section

1. Raw material used for Butter making – Sweet Cream / Ripened or sour cream

2. Quantity of raw material purchased per batch _____Tons
3. Cost of raw material _____Rs/Kg
4. Tests conducted to ensure chemical quality of raw material
5. Tests conducted to ensure microbial quality of raw material

II. Cream processing

1. Cream neutralization
 - a. Acidity of cream used for butter production
 - b. Type of neutralizer used
2. Cream standardization
 - a. Fat percentage of cream
3. Cream pasteurization, cooling and aging
 - a. Time temperature combination of cream pasteurization
 - b. Cooling temperature
 - c. Aging time and temperature

III. Cream churning

1. Type of butter churn – Batch or Continuous
2. Capacity of butter churn
3. Number of butter churn installed
4. Time taken to complete each batch of butter
5. Temperature maintained during churning

IV. Cleaning of Butter churn

1. Cleaning frequency – everyday, every shift, alternate days etc.
2. Chemical used in cleaning the lines
3. Temperature of cleaning solution and concentration

V. Butter milk utilization

1. Quantity of butter milk obtained per day

2. Ways of butter milk utilization
3. If disposing butter milk – note down the ways of disposal

VI. Cold storage for cream or butter

1. Capacity of cold store
2. Temperature maintained in the cold store
3. Cold store cleaning and maintenance

VII. Steam generation/Boiler section

1. Capacity of Boiler
2. Make of the boiler
3. Steam consumption per day
4. Type of boiler

VIII. Sales and Marketing section

1. Cost of production per kg of Butter
2. Sale price of Butter
3. Marketing strategies/techniques used to boost the sale of the product
4. Ways of marketing – own parlors / supply chain/ Bulk or retail marketing
5. Annual turn-over of the company

Review Questions

1. Draw the layout of butter manufacturing plant
2. Draw the neat diagram of butter churn
3. What is butter milk?
4. What do you mean by cream neutralization?
5. Which microbical and chemical tests are preferred for Butter?

Section 2

Ghee refinery

Objective

- To understand the working of ghee refinery
- To learn procurement of raw materials, testing and storage
- To learn the marketing strategies

Introduction

Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no coloring matter or preservative has been added. Ghee essentially consists of 99 to 99.5% milk fat. The Major raw material used in the ghee refineries are **Butter or Cream**.

Important sections of Ghee refinery

1. Raw material procurement section
2. Ghee processing section
3. Cold storage
4. Ambient storage
5. Steam generation unit/Boiler section
6. Sales and Marketing section

Observations under each section

I. Raw material procurement section

1. Raw material used for ghee making – Cream/Butter
2. Quantity of raw material purchased per batch _____Tons
3. Cost of raw material _____Rs.
4. Tests conducted to ensure chemical quality of raw material
5. Tests conducted to ensure microbial quality of raw material

II. Ghee processing section

1. Processing capacity of the refinery
2. Continuous or batch type processing
3. Number of ghee boilers installed
4. Capacity of each ghee boiler
5. Heating medium used for heating the fat
6. Time taken for completion of each batch
7. Final heating temperature
8. Number of ghee settling tanks installed
9. Capacity of each ghee settling tank
10. Filtration/clarification process following
11. Temperature of ghee clarification
12. Capacity of the clarifier
13. Number of ghee settling tanks installed
14. Capacity of each ghee storage tank
15. Type of flooring to avoid slippages

III. Cleaning of ghee refinery

1. Cleaning frequency – everyday, every shift, alternate days etc.
2. Chemical used in cleaning the lines
3. Temperature of cleaning solution and concentration

IV. Ghee residue utilization

1. Quantity of ghee residue obtained per day
2. Ways of ghee residue utilization
3. If disposing ghee residue – note down the ways of disposal

V. Cold storage for cream or butter

1. Capacity of cold store

2. Temperature maintained in the cold store
3. Cold store cleaning and maintenance

VI. Ambient store/product storage

1. Capacity of ambient store
2. Quantity of product stored at the time of visit
3. Cleaning and maintenance of the store

VII. Steam generation/Boiler section

1. Capacity of Boiler
2. Make of the boiler
3. Steam consumption per day
4. Type of boiler

VIII. Sales and Marketing section

6. Cost of production per kg of ghee
7. Sale price of ghee
8. Marketing strategies/techniques used to boost the sale of the product
9. Ways of marketing – own parlors / supply chain/ Bulk or retail marketing
10. Annual turn-over of the company

Review Questions

1. Draw the layout of Ghee refinery
2. Draw the neat diagram of ghee boiler
3. What do you mean by ghee residues?
4. Give chemical composition of ghee?
5. Give storage temperature of ghee?

Section 3

Milk Condensing Plant

Objective

The students should be able to realize the production process and recognize the equipment available at the milk condensing plant/section.

Introduction

Compared to other milk products, the production of sweetened condensed milk (SCM) and evaporated milk is very less in India. However, concentration of milk is done in milk factories for its use in milk powder production. Very few dairy industries namely AMUL and Nestle are manufacturing condensed milk in India.

Observations to be made

1. Note down the quality and analytical tests performed for the raw milk intended for SCM and evaporated milk manufacture
2. Note down the fat and SNF content of milk after its standardization for use in SCM
3. Note down amount of sugar added to milk during SCM preparation and calculate the sugar ratio
4. Perform alcohol stability test for milk intended for condensed milk manufacture
5. Note down the Baume refractometer reading of condensed milk
6. Note down the amount of seeding material i.e. lactose used for proper crystallization in SCM manufacture
7. Note down the time and temperature combination applied during forewarming of milk
8. Point out the type of evaporator employed in the condensing plant
9. In case of multiple effect evaporators, note down the number of effects and the temperature and vacuum maintained in each effect
10. Note down various accessories fitted on evaporators
11. Observe which type of vacuum pump is employed for maintaining vacuum in the evaporator

Review Questions

1. What do you mean SCM?
2. List dairy industries manufacturing SCM?
3. What do you mean by evaporated milk?
4. What is the role of evaporator?
5. What are the uses of SCM and evaporated milk?

Sector 4

Milk Powder Plant (Spray Drying)

Objective

The students should be able to realize the production process and recognize the equipment available at the milk powder plant/section (spray drying)

Introduction

Drying of milk is essential to preserve milk for longer periods. Excess milk is dried and the dried milk is used in lean season to compensate the decreased milk supply. Compared to whole milk powder (WMP) the production of skimmed milk powder is more due to the lower keeping quality of the former caused by milk fat oxidation. India produces 4,00,000 tons of SMP every year. Pakistan, Bangladesh, Egypt, Afghanistan and some Southeast Asian countries are the major buyers of Indian SMP.

Observations to be made

1. Note down the quality and analytical tests performed for the raw milk intended for milk powder manufacture
2. Note down the fat and SNF content of milk after its standardization for use in WMP and SMP
3. Note down the time and temperature combination applied during forewarming of milk for use in low heat, medium heat and high heat SMP manufacture
4. Note down the percent total solids of concentrated milk before going to the spray dryer
5. Note down the inlet milk and outlet powder temperature at spray dryer
6. Note down the inlet and outlet air temperature at spray dryer
7. Point out the type of atomizer employed in the spray dryer
8. Note down how instantization is achieved during WMP/SMP production

Review Questions

1. Differentiate SMP and WMP
2. What is the purpose of instantization?
3. List dairy industries manufacturing SMP and WMP.
4. Give inlet and outlet temperature of spray dryer during milk powder preparation.
5. What are the possible uses of SMP?

Section 5

Milk Powder Plant (Roller Drying)

Objective

The students should be able to realize the production process and recognize the equipment available at the roller drying section

Introduction

Roller drying of milk causes more protein denaturation and yields in a product with low solubility and objectionable cooked flavour. After the invention of spray dryers, roller drying of milk became obsolete. However, roller dried milk powder finds special application in the manufacture of *khoa*, *gulabjamun* powder, confectionary and ice cream where higher degree of protein denaturation is preferred. Generally only the skim milk is preferred for roller drying.

Observations to be made

1. Note down the quality and analytical tests performed for the raw milk intended for milk powder manufacture by roller drying
2. Note down the quality and analytical tests performed for the raw milk used in roller drying
3. Note down the time and temperature combination applied during forewarming of milk
4. Note down the percent TS of concentrated milk before going to the roller dryer
5. Note down the inlet steam temperature at roller dryer
6. Note down the rpm of the drums (rollers)

Review Questions

1. What are the applications of roller dried milk powder.
2. Which types of drums are used in roller drier?
3. What is the purpose of forewarming of milk?

Section 6

Ice Cream Plant

Objective

Students will learn the production process and recognize the equipments available the ice-cream section.

Introduction

Ice cream plant typically consists of ice cream mix processing equipments, ice cream freezer, hardening system, refrigeration plant and storage room for ice cream. Ice cream mix processing equipments involve:

Equipments

Mixing vat: for mixing “or” blending of all the ingredients

Homogeniser: for homogenisation of ice cream mix

Pasteurizer: for mix pasteurization. It may be batch type or continuous depending on the requirements and capacity of the plant.

Chiller: it is usually a plate heat exchanger used particularly with batch type pasteurizer as the later does not have intact chilling unit as that of continuous pasteurizer.

Ageing tank: used to keep ice cream mix under cold conditions

Ice cream mix is frozen in ice cream freezers. These may be batch type or continuous.

Ice cream freezer: these are special type of freezers used for freezing ice cream under dynamic conditions of simultaneous aeration, mixing and freezing. This results in rapid freezing and forms smaller ice crystals. Main parts of ice cream freezer are barrel, scraper and beater. Beater and scraper together form dasher.

Hardening systems: It may be of three different types: 1) hardening tunnels 2) hardening rooms and 3) hardening cabinets

Storage rooms: used to store ice cream.

Refrigeration unit: used to produce desired refrigeration in order to freeze ice cream, keeping the temperatures in hardening system and storage rooms.

Observations to be made

1. Installed capacity of the plant
2. Product line of the plant i.e. how many types of ice cream variants are being manufactured in the plant.
3. Type, make and capacity of pasteurizer
4. Type, make and capacity of homogenizer
5. Capacity of mixing and aging vats/tanks
6. Type, make and capacity of ice cream freezer
7. Provision for air incorporation: Yes/No
8. Provision for fruit and nut feeding: Yes/No
9. Refrigerant being used in the refrigeration plant
10. Capacity of the refrigeration plant
11. Type of hardening system
12. Storage capacity of storage rooms
13. Storage pattern in storage rooms i.e. first in first out (FIFO) or Last in first out (LIFO)

Activities

1. Prepare a process outline for preparing ice cream with mention of the equipments needed for each process.
2. List out five important equipments required for commercial ice cream making unit.

Review Questions

1. What is the pasteurization temperature of ice cream mix?
2. Give freezing temperature used during ice cream making?
3. Give hardening temperature of icecream.
4. List ice cream making industries.

Section 7

Cheese Plant

Objective

To learn production process and recognize various equipments used in cheese section.

Introduction

Commercial production of cheese may be fully automated and mechanized, semi-automatic or batch type. Equipments and accessories available in cheese plant depend on the type of operation i.e. automated or batch.

Equipments/materials in cheese plant

1. **Bactofuge:** Bactofuge is a machine which works on the principle of centrifugal separation and is used to remove microorganisms and spores from milk to be used for cheese making.
2. **Starter culture:** starter culture are live microorganisms added to cheese milk to carry put desirable fermentation required essentially for cheese making.
3. **Rennet:** Rennet is an enzyme which is used for coagulating cheese milk. It may be calf rennet, microbial or plant rennet.
4. **Cheese vat:** Cheese vats are used for performing various operations of cheese making. These are jacketed vessels with input and output provisions for hot water. Cheese milk after standardization is added to vats and all operations beginning from culture addition upto cheddaring are performed in vats only.
5. **Cheese knives:** these are used for cutting curd after rennet addition and setting of curd. Two types of knives are used: horizontal and vertical.
6. **Ladle:** It is used to stir or mix the contents of vat.
7. **Milling machine:** is used to cut cheese into smaller pieces before salting.
8. **Cheese hoops:** Cheese after milling and salting is filled into cheese hoops and kept for pressing.
9. **Cheese press:** is used to press cheese hoops for removal of whey.
10. **Ripening room:** it is used to ripen cheese at specified relative humidity and temperature.

Observations to be made

1. Installed capacity of the plant
2. Product line of the plant i.e. how many types of cheese variants are being manufactured in the plant.
3. Type of operation in the plant (automated or batch)
4. Type, make and capacity of pasteurizer
5. Type, make and capacity of Bactofuge
6. Type and capacity of cheese vats
7. Type and capacity of cheese press
8. Type and capacity of milling machine
9. Conveying system for cheese curd
10. Details of ripening rooms
11. Storage capacity of storage rooms

Review Questions

1. Differentiate cheese and paneer
2. List various dairy industries manufacturing cheese
3. List down the equipments required for cheese manufacturing.

Section 8

Casein Making Unit

Objective

- To understand the working of casein making units
- To learn about the manufacturing process of different types of caseins

Introduction

Casein is a long established dairy byproduct finding its use as an ingredient in many dairy, food and non-food products. Manufacture of edible casein differs from that of non-edible casein (also called industrial casein). Edible casein is produced under sanitary conditions, with the use of food grade chemicals and sufficiently heat treated to make it safe for human consumption. Edible non-animal rennet casein is the product obtained after washing and drying the coagulum remaining after separating the whey from the skimmed milk which has been coagulated by non-animal rennet or by other coagulating enzymes. In commercial practice, pH adjustment is achieved either by direct addition of the appropriate acid to skim milk or in the case of lactic acid, by formation of lactic acid from lactose fermentation using a bacterial culture.

Important sections of casein plants

1. Raw material procurement section
2. Cream separation section or membrane filtration unit
3. Cold storage
4. Steam generation unit/Boiler section
5. Sales and Marketing section

Observations to be made

I. Raw material procurement section

1. Type of milk used for casein making _____
2. Quantity of milk handled by the plant: _____
3. Cost of raw milk Rs. _____ / Kg

4. Tests conducted to ensure chemical quality of raw material
5. Tests conducted to ensure microbial quality of raw material

II. Cream separation section

1. Processing capacity of the cream separation section
2. Observe whether it is a continuous or semi-continuous separator and note its operational capacity _____ Kg/ hour
3. Temperature of milk used for separation _____ °C
4. Quantity of cream obtained _____ Kg
5. Quantity of skim milk obtained _____ Kg
6. Note the fat content of cream _____%
7. Note the fat content of skim milk _____%

III. Membrane filtration unit

If the industry uses ultrafiltration retentate system for casein making, then observe the following

1. Type of UF module: _____
2. Quantity of milk fed into UF system per hour (feed rate): _____ L/hr
3. Quantity of permeate: _____ L/hr
4. Quantity of retentate: _____ L/hr

IV. Casein making unit

1. Quantity of skim milk taken per batch for casein making _____ Kg
2. Type of casein being manufactured: _____ (Edible or Industrial Casein)
3. Note whether non-animal rennet or acids are used for casein manufacture.
4. If rennet is used, note the type of rennet (microbial or plant) _____
5. How much water is used for dilution of rennet _____ Litres / g of rennet
6. Time taken for coagulation of milk or curd formation after rennet addition _____
7. If acid is used, note the type of acid _____

8. Quantity of acid used _____
9. Quantity of whey generated _____ Kg
10. Quantity of casein curd obtained _____ Kg
11. Drying temperature used for drying casein curd _____ °C
12. Final moisture content of casein _____ %
13. Packaging size of casein _____ Kg
14. Packaging material used for packing casein _____
15. Storage temperature of casein _____ °C

IV. Steam generation/Boiler section

1. Capacity of Boiler
2. Make of the boiler
3. Steam consumption per day
4. Type of boiler

V. Sales and Marketing section

1. Cost of production per kg of casein
2. Sale price of casein

Review Questions

1. Draw the layout of casein making unit
2. What are the uses of casein?
3. List dairy industries manufacturing casein?
4. What do you mean by membran filtration of milk?

Exercise-2

Manufacture of Milk Products

Part A

Preparation of Khoa

Objective

- a) To learn the method of preparation of Khoa from different varieties of milk
- b) Evaluation of organoleptic qualities of Khoa

Introduction

Khoa is a partially dehydrated traditional Indian milk product obtained by thermal evaporation of buffalo, cow or mixed milk. According to Food Safety and Standards Regulation (FSSR), 2011 Khoa/ khoya by whatever variety of names it is sold such as Pindi, Danedar, Dhap, Mawa or Kava means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination there of by rapid drying. The milk fat content shall not be less than 30 per cent on dry matter basis of finished product. It may contain citric acid not more than 0.1 per cent by weight. It shall be free from added starch, added sugar and added colouring matter.

Materials

- 1. Steam jacketed kettle
- 2. Stirrer-cum-scrapper
- 3. Muslin cloth
- 4. Weighing balance
- 5. Thermometer
- 6. Parchment /butter paper
- 7. Milk
- 8. Fat and acidity testing set
- 9. Lactometer with jar

Procedure

1. Take a representative sample of milk & analyses it for fat, SNF & acidity also evaluate its organoleptic quality (colour, smell, taste, presence of extraneous matter, etc.)
2. Standardize the milk to desired fat & SNF ratio to meet the FSSR requirement of 30% fat on dry matter basis in final product (generally SNF: Fat ratio should be 2.25 in cow or buffalo milk to meet the FSSR standards in final product or fat should be $0.45 \times \text{SNF}$, but for good quality Khoa from buffalo milk SNF: Fat ratio should be 1:67 or fat should be $0.67 \times \text{SNF}$).
3. Filter the milk through muslin cloth into double jacketed stainless steel kettle & start heating by opening the steam valve.
4. While boiling stir the milk continuously in circular motion through sides of the kettle to remove the deposited solids.
5. When foam subsides and once the mass reaches pasty consistency reduce the steam slightly and scrape continuously to avoid formation of milk soil due to burning of the deposited solid.
6. Continue with the process of stirring and scraping continuously until final step is reached which is characterized by the mass leaving the sides of the kettle.
7. Close the steam and spread the content across sides of the kettle so that it cools down.
8. Remove the contents into aluminum or steel tray smeared with butter or covered by parchment paper after forming a pat.
9. Take the weight of Khoa and record the yield and milk equivalent.
10. Evaluate the organoleptic qualities of the product

PRODUCTION CHART OF KHOA

I. Particulars of Milk

Type _____ Quantity _____ kg.
Acidity _____ % Lactic acid Lactometer Reading _____ at _____ °C
Fat _____ % Total Solids _____ %
Solids-Not-Fat _____ %

II. Processing

Time when heating started _____ AM/PM
Boiling point of milk _____ °C
Time taken to reach pat forming stage _____ Hours _____ Minutes
Type of equipment used _____

III. Making Pats

Time when pat formation started _____ AM/PM
Time when product preparation finished _____ AM/PM
Total time taken for product preparation _____ Hours _____ Minutes

IV. Physical Characteristics of Khoa

Flavour _____
Body and Texture _____
Colour _____
Overall sensorial quality _____

V. Chemical Composition of Khoa

Moisture _____ % Fat _____ %
Total Solids _____ %

VI. Yield of Khoa

Quantity _____ g
Yield _____ % Milk equivalent _____ kg

Remarks _____

This image shows a full page of a handwriting practice worksheet. It consists of multiple rows of horizontal dashed lines spaced evenly apart, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text on the page.

Signature of the Teacher

Review Questions

1. Define Khoa as per FSSR (2011).
2. How much buffalo milk is required to prepare one kg of Khoa?
3. What are the characteristics of good quality Khoa?
4. Name the types of Khoa available in market.
5. Is it possible to prepare good quality Khoa from sour milk?
6. What do you mean by 'pat' formation in Khoa preparation?
7. What precaution and care you must take while production of Khoa?
8. Is it possible to make Khoa from concentrated milk?
9. How will you differentiate Khoa made from cow and buffalo milk by visual observation?
10. Yield of Khoa depend on which factors?

Part B

Preparation of Table Cream

Objective

To learn the production of cream

Introduction

Milk fat being most expensive component, the recovery of fat is of importance in dairy processing because of its economic value. The separation of milk into cream and skim milk is the foremost unit process to which the milk is subjected at the dairy plant. Cream is generally produced by separating milk into its components – fat and solid-not-fat. Table cream is a pasteurized sweet cream. As per FSSR 2011 Cream including sterilized cream means the product of cow or buffalo milk or a combination thereof. It shall be free from starch and other ingredients foreign to milk. It may be of following three categories, namely:—

1. Low fat cream—containing milk fat not less than 25.0 percent by weight.
2. Medium fat cream—containing milk fat not less than 40.0 percent by weight.
3. High fat cream—containing milk fat not less than 60.0 percent by weight.

Since the fat of cream is low, it has thinner consistency. The consistency of the cream may be improved by homogenization. A good quality table cream should be clean, pleasant nutty flavor with smooth and uniform body.

Materials/Equipments required

1) Milk, 2) Thermometer, 3) Heating device, 4) SS vessel, 5) Stirrer, 6) Fat and acidity testing kits

Procedure

1. Clean all parts of the cream separator and assemble the bowl.
2. Place the bowl over the spindle and cover the system.
3. Put on the separator motor and allow to attain maximum speed.
4. Weigh the given milk sample and test for fat and acidity content.
5. Heat water at 70 – 80° C and take into supply tank.

6. Allow the hot water to run through the bowl to clean and pre-heat the bowl.
7. Heat the milk to 45 – 50° C and transfer to the supply tank.
8. Open the valve and allow the hot milk to enter the bowl.
9. Take pre-weighed containers to receive cream and skim milk separately.
10. At the end of operation allow hot water to run through the bowl.
11. Take weight of cream and skim milk and test them for fat content.
12. Dismantle the bowl and clean all parts with detergent solution, rinse with hot water and allow to air dry.
13. Calculate the percent recovery of fat
14. Calculate percent fat loss during operation using the following formula –

PRODUCTION CHART FOR TABLE CREAM

I. Particulars of cream separator

Name of manufacturer _____ Model _____

Hand / Power operated _____ Capacity _____

II. Particulars of milk

Type _____ Quantity _____ kg.

Acidity _____ % Lactic acid Lactometer Reading _____ at _____ °C

Fat _____ % Total Solids _____ %

Solids-Not-Fat _____ %

III. Processing and cream separation

Time when heating started _____ AM/PM

Temperature of cream separation _____ °C

Time when cream separation started _____ AM/PM

Time when cream separation finished _____ AM/PM

Total time taken for cream separation _____ Minutes

V. Separation efficiency

Fat in cream _____ % Total fat in cream _____g

Fat in skim milk _____ % Total fat in skim milk _____ g

Total fat recovered in cream _____ % Yield of cream _____kg

Total fat lost in skim milk _____ %

Total fat lost during operation _____ %

VI. Chemical composition of cream

Fat _____ % Acidity _____ % LA

Total Solids _____ % Moisture _____ %

Formuals -

1. $\% \text{ fat recovery in cream} = \frac{\text{Kg fat in cream} * 100}{\text{Kg fat in milk}}$

2. $\text{Yield of cream} = \frac{M * (fm - fs)}{(fc - fs)}$

Where

C = Weight of cream (kg)

M = Weight of milk (kg)

fm = % fat in milk

fc = % fat in cream

fs = % fat in skim milk

Result & Inference

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Signature of the Teacher

Review Questions

1. Write the FSSR, 2011 standards for different varieties of cream
2. What is the pasteurization temperature for cream?
3. Why milk should be heated to 45°C before it is subjected to cream separation?

Part C

Preparation of Chhana

Objective

1. To make Chhana from cow and buffalo milk
2. To compare the yield and quality of Chhana from cow and buffalo milk

Introduction

Chhana is a traditional Indian milk product obtained by heat and acid coagulation of milk followed by partial removal of whey. Chhana is used as a variety of a sweet like Sandesh, Rasogolla, Rasomalai, chamcham, pantooa etc. According to the Food Safety and Standard Regulation (FSSR, 2011), Chhana means the product obtained from cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid. It shall not contain more than 70.0 per cent moisture and the milkfat content shall not be less than 50.0 per cent of the dry matter. Milk solids may also be used in preparation of this product. Low fat Chhana shall conform to the following requirements:

- (i) Moisture Not more than 70.0 percent
- (ii) Milk fat Not more than 15.0 percent of dry matter:

Materials

1) Double jacketed stainless steel (SS) kettle or karahi 2) SS ladle 3) Weighing scale/ Balance 4) Muslin cloth 5) Fat and acidity testing kits for milk and whey 6) Lactometer with cylinder 7) Thermometer 0-110°C 8) Aluminum dishes for total solid estimation 9) Milk: cow and buffalo 10) Citric acid.

Procedure

Chhana from cow milk

1. Take the representative sample of milk and determine its fat, SNF and acidity content as well as organoleptic quality.
2. Transfer the milk into a clean and dry SS kettle/karahi through a muslin cloth.
3. Start heating milk with continuous stirring and scraping with the help of a stainless steel ladle to prevent burning of milk solids.

4. Heat the milk up to 90°C without any holding.
5. Cool milk up to the temperature at which coagulation is to be achieved. Optimum temperature of coagulation is 80°C for cow milk.
6. Simultaneously heat the coagulant solution (1% citric acid) to a temperature of 80°C (or any other temperature at which milk is to be coagulated).
7. Add calculated quantity of the coagulant slowly throughout the container while stirring milk gently but continuously.
8. Stop adding coagulant as soon as coagulation of milk is completed as observed by separation of clean greenish whey. Normally 45-60 second is required to achieve complete coagulation.
9. Record the pH at this stage which should be preferably between 5.4 - 5.5
10. Transfer the curd and all the solids that are sticking to the kettle, immediately over a piece of clean and wet muslin cloth. Collect the whey in another container.
11. Tie the four ends of the cloth containing the coagulum with a knot and hang it onto a hook/stand. Collect the whey that drops off from the mass in a container.
12. Let the product drain for 30 min or until most of the free whey is drained out.
13. Remove the product from muslin cloth and keep in a clean container preferably previously sterilized.
14. Record the weight of Chhana and whey and take their representative sample for chemical analysis.
15. Evaluate the organoleptic qualities of the product

Chhana from buffalo milk

1. Take the representative sample of milk and determine its fat, SNF and acidity content as well as organoleptic quality. If the fat content is more than 5%, standardize the milk to 5% fat.
2. Transfer the milk into a clean and dry SS kettle/karahi through a muslin cloth.
3. Start heating milk with continuous stirring and scraping with the help of a stainless steel ladle to prevent burning of milk solids.
4. Add potable water @ 30% of the initial quantity of the milk.
5. Heat the milk just up to 90°C without any holding.

6. Cool milk up to the temperature at which coagulation is to be achieved i.e. to 65°C.
7. Simultaneously heat the coagulant solution (1% citric acid) to 65°C.
8. Add calculated quantity of the coagulant slowly throughout the container while stirring milk gently but continuously.
9. Stop adding coagulant as soon as coagulation of milk is completed as observed by separation of clean greenish whey. Normally 45-60 second is required to achieve complete coagulation.
10. Record the pH at this stage which should preferably be between 5.6 - 5.7
11. Keep the curd in whey for about 15 min (called delayed straining) and then transfer over a piece of clean and wet muslin cloth.
12. Transfer the curd and all the solids that are sticking to the kettle, immediately over a piece of clean and wet muslin cloth. Collect the whey in another container.
13. Tie the four ends of the muslin cloth containing Chhana with a knot and hang it onto a hook/stand. Collect the whey that drops off from the mass in a container.
14. Let the product drain for 30 min or until most of the free whey is drained out.
15. Remove the product from muslin cloth and keep in a clean container preferably previously sterilized.
16. Record the weight of Chhana and whey and take and their representative sample for chemical analysis.
17. Evaluate the organoleptic qualities of the product

PRODUCTION CHART OF CHHANA

I. Particulars of Milk

Type _____ Quantity _____ kg.
Acidity _____ % lactic acid Lactometer Reading. _____ at _____ °C
Fat _____ % Total Solids _____ %
Solids-Not-Fat _____ %

II. Coagulation

Name of Coagulant used. _____ Strength of the coagulant added _____
Amount of coagulant _____ pH after coagulation _____
Temperature of coagulation _____ °C Citric acid used per kg of milk _____

III. Straining

Type of strainer used _____ Time taken for straining _____ min
Temperature when straining started _____ °C
Time taken to prepare Chhana _____ min

IV. Physical Quality of Chhana/Paneer

Colour _____
Flavour _____
Body and Texture _____
Overall sensorial attributes _____

V. Chemical Composition of Chhana

Moisture _____ % Fat _____ %
Total Solids _____ %

VI. Yield of Chhana

Quantity _____ g Yield _____ %
Milk equivalent _____ kg

VII. Whey

Amount _____ kg. Acidity _____ % lactic acid
Fat _____ % Fat loss in whey _____ g

Remarks: _____

Calculation & Inference:

Date:

[illegible]

Signature of the Teacher

Review Questions

1. What should be the desired fat: SNF ratio for making Chhana from cow milk?
2. What is the yield of Chhana made from cow milk?
3. Why cow milk Chhana has different texture than buffalo milk Chhana?.
4. How do we judge the end point at the time of coagulation in Chhana making?
5. What is the optimum temperature and pH of coagulation of cow milk for Chhana making?

Part D

Preparation of Paneer

Objective

- a) To learn the preparation of paneer from cow and buffalo milk
- b) To evaluate the organoleptic properties of paneer prepared from cow and buffalo milk

Introduction

Paneer is an indigenous milk product obtained by heat and acid coagulation of milk followed by pressing. According to the Food Safety and Standards Regulations (2011), paneer shall contain not more than 70.0 per cent moisture and the milk fat content shall not be less than 50.0 per cent of the dry matter. Paneer prepared from skim milk shall contain not more than 70.0 % moisture and milk fat content shall not be more than 15 % on dry matter basis. Paneer is used in a variety of culinary dishes usually prepared from buffalo milk.

Materials

1) Double jacketed SS vat/ SS kettle or karahi, 2) SS ladle, 3) Weighing balance, 4) Muslin cloth, 5) Lactometer with jar, 6) Fat testing kit for milk, 7) Thermometer, 8) Coagulant solution (citric acid), 9) Paneer pressing moulds, 10) Milk, 11) pH meter

Procedure

1. Collect representative sample of milk and analyze it for fat, SNF, acidity and organoleptic quality.
2. Standardize milk to 4.5% fat and 8.5% SNF
3. Filter the standardized milk into a clean SS kettle through a muslin cloth.
4. Heat the milk up to 90°C without holding while stirring it continuously with the help of a stirrer or ladle.
5. Simultaneously heat the coagulant (1% citric acid) to a temperature at which coagulation of milk is to be achieved.

6. Coagulate buffalo milk at 70°C and cow milk at 80°C by slowly adding hot coagulant solution throughout the whole container while gently stirring the milk.
7. As soon as the coagulation of milk is completed (evidenced by the separation of clear greenish-yellow whey) stop adding the coagulation. The pH of milk at this stage should be about 5.3.
8. Leave the curd undisturbed for 5 minutes to settle down and then drain out the whey through a muslin cloth.
9. The temperature of curd should not be allowed to drop below 63°C during and at the end of draining.
10. Fill the curd into hoops lined with clean and wet muslin cloth. These hoops are generally rectangular/circular frames open both at bottom and top. Wooden/SS planks are used to cover these ends.
11. After proper filling of hoop, cover the curd with cloth, put a wooden plank on the top and apply pressure by placing adequate weights on top of the hoop (the weight depends upon the size of the paneer block). The pressure required is nearly 2-3 kg/cm² for 15 – 20 minutes.
12. Place the paneer cube in chilled water for about one hour to cool and making it firm.
13. After cooling drain the water and pack it in a suitable packaging material and store under refrigerated cooperators
14. Evaluate the organoleptic qualities of the product

PRODUCTION CHART OF PANEER

I. Particulars of Milk

Type _____ Quantity _____ kg.
Acidity _____ % lactic acid Lactometer reading. _____ at _____ °C
Fat _____ % Solids-Not-Fat _____ %
Total Solids _____ %

II. Coagulation

Coagulant used _____ Strength of the coagulant used _____ %
Amount of coagulant used _____ ml pH after coagulation _____
Temperature of coagulation _____ °C Quantity of Coagulant used per kg of milk _____ g

III. Straining

Type of strainer used _____ Time taken for straining _____ Minutes.
Temperature when straining started _____ °C
Time taken to prepare the product _____ min

IV. Physical Quality of Paneer

Colour _____ Body and Texture _____
Flavour _____

V. Chemical Composition of Paneer

Moisture _____ % Fat _____ %
Total Solids _____ %

VI. Yield of Paneer

Quantity _____ g Yield _____ %
Milk equivalent of paneer _____ kg (Buffalo milk) _____ kg (Cow milk)

VII. Whey

Amount _____ kg. Acidity _____ % lactic acid
Fat _____ % Fat loss in whey _____ g

Remarks: _____

Calculation & Inference:

Date:

[illegible]

Signature of the Teacher

Review Questions

1. What should be the desired Fat: SNF ratio for making paneer from buffalo milk?
2. What is the normal yield of paneer from buffalo milk?
3. Why do we keep the paneer in chilled water after pressing?
4. What is the optimum coagulation temperature of Buffalo milk for paneer production?
5. What should be optimum pH of coagulation to obtain good quality paneer?
6. How paneer differs from Chhana?

Part E

Preparation of Ghee

Objective

- a) To learn the method of preparation of ghee using butter
- b) Organoleptic evaluation of ghee

Introduction

Ghee means the pure heat clarified fat derived solely from milk or curd or from desi (cooking) butter or from cream to which no colouring matter or preservative has been added. Ghee is a very popular product since from ancient time and have greater demand during festival and other ceremonial functions where use of ghee in food has been considered to delicacy due to its pleasing flavour and aroma. The principle involved in ghee preparation includes concentration of milk fat in the form of cream or butter, followed by heat clarification of fat rich milk portion and thus reducing the amount of water to less than 0.5%. The curd content is then removed as ghee residue from clarified fat.

There are five methods of ghee making:

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

Materials

1) Milk, 2) Lactometer with cylinder, 3) Fat testing kit for milk, 4) Lactic culture, 5) SS vessel and ladle, 6) Muslin cloth, 7) Thermometer, 8) Weighing balance, 9) pH meter/ strips, 10) Heating medium, 11) Incubator

Procedure

1. Collect the representative sample of milk and analyse it for fat, SNF, acidity and organoleptic quality.
2. Standardize milk to 5.0% fat and 8.5 % SNF (based on the type of dahi) by adding calculated amount of cream.
3. Filter the milk into a clean SS kettle through a muslin cloth.
4. Heat the milk to 90°C for 15 minutes and cool it to 32°C.
5. Add the lactic culture to milk @ 1.5% and mix well and incubate at the temperature of 32°C for 6-8 hrs
6. Cool the curd to 10°C and churn to obtain *Makkan* (Butter)
7. Take the *Makkhan* in stainless steel vessel
8. Heat over the direct fire with continuous stirring and scraping till the temperature reaches 110-115°C
9. When the whole mass turns to golden yellow color and ghee residues turns brown color stop heating and allow it to cool to 70°C
10. Filter the whole mass through double layered muslin cloth to remove ghee residues
11. The product thus obtained is bottled, labeled and stored at room temperature (30°C)

PRODUCTION CHART OF GHEE

I. Particulars of Milk

Type _____ Quantity _____ Kg.

Acidity _____ % lactic acid Lactometer reading. _____ at _____ °C

Fat _____ % Total Solids _____ %

Solids-Not-Fat _____ %

II. Processing and filling

Quantity of cream required for standardization _____ g

Time temperature combination of milk processing _____ °C _____ Minutes,

Rate of culture addition _____ Quantity of culture added _____ g

Temperature of the milk during culture inoculation _____ °C

Temperature of incubation _____ °C, Time when incubation started _____ AM/PM

Time when incubation stopped _____ AM/PM

Duration of incubation _____ Hour _____ Minutes

III. Production of Makkhan

Quantity of dahi taken for *makkhan* preparation _____ kg

Temperature of churning _____ °C, Time when churning started _____ AM/PM

Time when churning finished _____ AM/PM, Time taken for churning _____ Hour _____ Minutes

Quantity of *Makkhan* obtained _____ Kg Milk equivalent of Lassi _____ kg

IV. Production of Ghee

Quantity of *Makkhan* taken for Ghee preparation _____ kg

Time when ghee preparation started ____AM/PM,

Temperature when the onset of first effervescence ____ °C,

Final clarification temperature ____ °C,

Quantity of ghee obtained ____kg,

Quantity of ghee residue obtained____kg,

IV. Organoleptic Quality

Flavour _____ Colour _____

Body texture _____

Overall sensorial attribute of Ghee _____

Remarks:_____

Calculation & Inference:

Date:

[illegible]

Signature of the Teacher

Review Questions

1. Define Ghee
2. List different methods of ghee making?
3. What do you mean by creamary butter method?

Part F

Preparation of Creamery and Table Butter

Objective

To learn preparation of butter by churning cream

Introduction

Butter is one of the leading milk product in developed countries of the world. It serves as a balance wheel of dairy industry. Surplus milk is generally converted into butter to be used during the times of scarcity. It is an article of commerce and a sign of wealth. Butter is a fat concentrate, which is obtained by churning cream, gathering the fat into a compact mass and then working it for proper distribution of moisture and salt. The water content was dispersed in fine droplets through consistent working, so that the butter attains smooth consistency for easy spreadability and mouthfeel. With introduction of artificial refrigeration systems and pasteurization process, the industrial production of butter developed rapidly and large scale butter making in factories became possible during the later part of the 19th century.

Definition

- (i) General – Butter may be defined as a fat concentrate which is obtained by churning cream, gathering the fat into compact mass and then working it.
- (ii) FSSR 2011 - Butter means the fatty product derived exclusively from milk of cow and/ or buffalo or its products principally in the form of an emulsion of the type water-in-oil. The product may be with or without added common salt and starter cultures of harmless lactic acid and / or flavour producing bacteria. Table butter shall be obtained from pasteurised milk and/ or other milk products which have undergone adequate heat treatment to ensure microbial safety. It shall be free from animal body fat, vegetable oil and fat, mineral oil and added flavour. It shall have pleasant taste and flavour free from off flavour and rancidity. It may contain food additives permitted in these regulations. It shall conform to the microbiological requirements prescribed in the regulation. It shall conform to the following requirements: Moisture 16.0 percent m/m, milk fat- Table butter (80.0 percent m/m), desi/cooking butter (not less than 76.0 percent m/m) milk solids not fat (not more than 1.5 %), common salt (not more than 3.0 percent).

BIS (Bureau of Indian standards) has specified two types of butter namely-

- A) Table butter** – Means product made from pasteurized cream obtained from pasteurized cow / buffalo milk / combination with or without ripening with standard lactic culture, addition of common salt, annatto or carotene as colouring matter and diacetyl as flavouring agent.
- B) White butter** – Means the product made from pasteurized cream obtained from pasteurized cow / buffalo milk / combination without ripening and addition of any preservative, colouring matter and added flavouring agent.

BIS – Standards (IS 13690:1992)

Contituents	White butter	Table butter
Milk fat (%)	82.0	80.0
Moisture (%) max.	16.0	16.0
Curd (%) max.	1.5	1.0
Salt (%) max.	Nil	2.5
Acidity (% L.A.) max.	0.15	0.10
Coliform count (NMT)	5/ml	5/ml
Yeast & mold count (NMT)	20/ml	20/ml
Diacetyl content (max.)	Nil	4 ppm

Material/Equipment required

1) Weighing balance 2) Cream pasteurization unit 3) Butter churn 4) Chilled water 5) Strainer 6) Plastic tubs 7) Butter trolley 8) Common salt 9) Butter colour

Procedure

Preparation of white butter (Cooking butter / unsalted butter)

1. Weigh the amount of cream received at the platform.
2. Draw a representative sample and determine fat content.
3. Standardize the cream to 35-38% fat and pasteurize at 80-82° C for 5-8 minute.
4. Cool the cream to 7-10° C and store over night at same temperature.

5. Transfer the cooled cream into the butter churn taking care to fill the churn to 1/3 rd of its capacity.
6. Lock the door and allow the churn to rotate at a speed of 40-50 rpm.
7. Stop the churn and press the air vent valve for few times (5 minutes intervals) during early stages of churning.
8. Allow the churn to rotate until the watch glass appears clear. This indicates that the emulsion is broken and fat granules are separated from the serum.
9. Stop the churn and add break water (10-15%) of cream at 2 °C lower than butter milk, into the churn.
10. Allow the churn to rotate for few minutes to develop the butter grains to suitable size.
11. Stop the churn and drain the butter milk using strainer. Measure the quantity and temperature of butter milk, also draw a representative sample for fat test.
12. Add chilled water (wash water), equal to the quantity of butter milk removed, into the churn.
13. Allow the churn to rotate at slower speed (15 rpm) for five minutes, to wash the butter grains of excess butter milk.
14. Stop the churn and allow the wash water to drain.
15. Allow the churn to rotate at the speed of 6-8 rpm for working of butter (gathering of butter grains into bigger lump and even distribution of moisture) for about 20-30 minutes.
16. Stop the churn, open the door and collect butter in plastic tubs or butter trolley.
17. Store the butter at - 6° to -8°C for further usage.

Note : Cooking butter is generally used as an intermediate product for manufacture of ghee.

Preparation of table butter

1. Weigh the amount of cream received at the platform.
2. Judge the cream for its sensory properties and taste.
3. Draw a representative sample and determine fat content.
4. Standardize the cream to 35-38% fat and pasteurize at 80-82° C for 10 minute.
1. Cool the cream to 5-7° C and store overnight at same temperature.

2. Fill the churn $\frac{1}{3}$ rd with hot water and rotate for 4-5 minutes, leaving the vent open.
3. Drain hot water and cool the churn using pasteurized chilled water (preferably chlorinated) for 5-8 minutes and then drain out.
4. Transfer the cooled cream into the butter churn taking care to fill the churn to $\frac{1}{3}$ rd of its capacity.
5. Measure calculated amount of butter colour and add evenly over the cream in the churn.
6. Lock the door and allow the churn to rotate at a speed of 40-50 rpm.
7. Stop the churn and press the air vent valve for few times (5 minutes intervals) during early stages of churning.
8. Allow the churn to rotate until the watch glass clears, indicating that the emulsion is broken and fat granules are separated from the serum.
9. Stop the churn and add pasteurized and chlorinated (30-40 ppm) break water (10-15% of cream) at 2°C lower than buttermilk into the churn.
10. Allow the churn to rotate for few minutes to develop the butter grains of suitable size (pea grain).
11. Stop the churn and drain the buttermilk using strainer. Measure the quantity and temperature, also draw a representative sample for fat test.
12. Add pasteurized chilled water equal to the amount of buttermilk removed at 1- 2°C lower than the buttermilk temperature.
13. Allow the churn to rotate at slower speed (15 rpm) for five minutes, to wash the butter grains of excess buttermilk. If need be second washing may be done with half the quantity of wash water in similar manner.
14. Stop the churn and allow the wash water to drain.
15. Weigh calculated amount of salt (@ 1.5-2.0%) and sprinkle evenly on to the butter grains.
16. Allow the churn to rotate at the speed of 6-8 rpm for proper working of butter (gathering of butter grains into bigger lump and even distribution of salt & moisture throughout the body of butter) for about 20-30 minutes.
17. During working process maintain temperature of contents by constant spraying of chilled water over the churn.

18. Stop the churn, open the door and draw a sample for moisture test to ascertain required moisture content in resultant butter using the formula -

$$\text{Kg of water to be added} = \frac{(A \times 1.5 \times B)}{100}$$

Where, A = percent moisture to be raised and B= Kg fat in churn.

19. If need be, add calculated amount of pasteurized chilled water to the churn for adjusting final moisture content of butter.
20. Unload the churn by collecting butter in pre-sterilized lined plastic tubs or butter trolley.
21. Clean the churn using hot detergent solution followed by hot and then cold rinsing.
22. Store the butter at -18° to -20°C for packaging at later stage.

Precautions

1. Wash and sanitize the churn before use with chlorinated water (40-50 ppm).
2. Ensure that the churn is cooled below 5° C before transferring cream.
3. Use only pasteurized and chilled water having low iron and copper content (max.5 ppm) as break and wash water.
4. Perform fat, salt and moisture test accurately and keep safety margin to meet legal standards.
5. Store door gasket of churn in cold store to avoid cracking.

PRODUCTION CHART – CREAMERY BUTTER

Particulars of Cream			
Type		Quantity	Kg
Fat	%	Amount of fat	Kg
Acidity	%LA		
Processing of cream			
(a) Neutralization			
Type of neutralizer		Amount of neutralizer	g
Cream acidity after neutralization	%LA		
(b) Pasteurization			
Time pasteurization start		Temperature	°C
Holding time		Cooling temperature	°C
Total time taken for pasteurization		Cream acidity	%LA
(c) Ripening			
Starter quality		Amount of starter added	
Incubation temperature	°C	Incubation time	
Acidity of ripened cream	%LA		
(d) Cooling & Aging			
Cooling temperature	°C	Cooling period	
(e) Particulars of churning			
Fat in cream	%	Rate of colour addition	
Cream acidity	%LA	Amount of colour added	ml
Temperature of cream	°C		
Time when churning started		Time when churning completed	

Time when break water added		Amount of break water	
Temperature of break water	°C		
Amount of butter milk		Temperature of buttermilk	°C
Fat in butter milk	%	Amount of fat lost in buttermilk	g
Total fat lost in buttermilk	%		
(f) Washing of butter grains			
Temperature of wash water	°C	Amount of wash water	ltr
(g) Salting and Working			
Amount of salt added	g	Quality of salt	
Time when first working started		First moisture test	%
Amount of water added	g	Time when second working started	
Final moisture	%	Total time for working	
(h) Recovery of butter			
Quantity obtained	Kg	Salt	%
Overrun	%	Total fat recovery	%
Moisture	%	Total time for butter making	

PRODUCTION CHART FOR TABLE BUTTER

Particulars of Cream			
Type		Quantity	Kg
Fat	%	Amount of fat	Kg
Acidity	%LA		

Processing of cream			
(a) Neutralization			
Type of neutralizer		Amount of neutralizer	g
Acidity of cream after neutralization	%LA		
(b) Pasteurization			
Time when pasteurization start		Temperature	°C
Holding time		Cooling temperature	°C
Total time taken for pasteurization		Cream acidity	%LA
(c) Ripening			
Starter quality		Amount of starter added	
Incubation temperature	°C	Incubation time	
Acidity of ripened cream	%LA		
(d) Cooling & Aging			
Cooling temperature	°C	Cooling period	
Particulars of churning			
Fat in cream	%	Rate of colour addition	
Cream acidity	%LA	Amount of colour added	ml
Temperature	°C		
Time when churning started		Time when churning completed	
Time when break water added		Amount of break water	
Temperature of break water	°C		
Amount of butter milk		Temperature of buttermilk	°C

Fat in butter milk	%	Amount of fat lost in buttermilk	g
Total fat lost in buttermilk	%		
Washing of butter grains			
Temperature of wash water	°C	Amount of wash water	ltr
Salting and Working			
Amount of salt added	g	Quality of salt	
Time when first working started		First moisture test	%
Amount of water added	g	Time when second working started	
Final moisture test	%	Total time for working	
Recovery of Butter			
Quantity obtained	Kg	Salt	%
Overrun	%	Total fat recovery	%
Moisture	%	Total time for butter making	

Calculations

1. For Moisture adjustment –

$$\text{Kg of water to be added} = \frac{(A * 1.5 * B)}{100}$$

Where, A = % moisture to be raised and B= Kg fat in churn.

2. For calculating Over run

$$\text{Percent over run} = \frac{(\text{Wt. of butter} - \text{Wt. of fat in cream}) * 100}{(\text{Wt. of fat in cream})}$$

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Teacher's signature

Review Questions

1. What is the difference between table butter and creamery butter?
2. Write the method to calculate the quantity of salt.
3. How moisture is adjusted in buttermaking?
4. What should be the optimum load of churn?
5. Write optimum acidity, fat and temperature of churning.

Part G

Preparation of Dahi/Yoghurt

Objective

- a) To learn the method of preparation of dahi & yoghurt using different types of milk
- b) Organoleptic evaluation of dahi

Introduction

Dahi is a fermented dairy product, produced by fermentation process by deliberately adding live, harmless, lactic acid producing bacteria in the form of bacterial culture to milk. Lactic acid bacteria added in the form of starter culture multiply and grow, produces lactic acid, acetic acid and carbon dioxide by utilizing lactose present in the milk. Some bacteria use the citric acid of milk to produce certain volatile organic compounds mainly diacetyl, which is responsible for flavor of dahi. Judicious combination of acid producing and flavour producing microorganisms in the starter helps in the production of Dahi with a firm body and good flavour. Fermentation leads to partial breakdown of milk constituents particularly lactose and proteins and increases the digestibility of cultured milk products. As per Food safety and standards regulation (FSSR, 2011), Dahi shall have the same minimum percentage of milk fat and milk solids-not-fat as the milk from which it is prepared and it may contain added cane sugar.

Materials

1) Milk, 2) Lactometer with cylinder, 3) Fat testing kit for milk, 4) Lactic culture, 5) SS vessel and ladle, 6) Muslin cloth, 7) Thermometer, 8) Weighing balance, 9) pH meter/ strips, 10) Heating medium, 11) Incubator, 12) Dahi culture or yoghurt culture (*Streptococcus thermophilus* + *Lb. delbreuckii* Subsp. *bulgaricus*)

Procedure

1. Collect the representative sample of milk and analyse it for fat, SNF, acidity and organoleptic quality.
2. Standardize milk to 0 - 5.0% fat and 11 - 13% SNF (based on the type of dahi) by adding cream and calculated amount of skimmed milk powder.
3. Filter the milk into a clean SS kettle through a muslin cloth.
4. Homogenize at 175Kg/cm² and Heat the milk to 90°C for 15 minutes and cool it to 32°C.

5. Add the lactic culture to milk @ 1.5% and mix well (for Yoghurt:ST:LB)
6. Fill the product into dahi cups and Incubate at temperature of 32°C for 6-8 hrs/for yoghurt incubate at 42°C/5 hrs.
7. At the end of the incubation, make sure that the product has reached the pH of 4.6
8. Store at refrigerated temperature (<5°C)

PRODUCTION CHART OF DAHI/YOGHURT

I. Particulars of Milk

Type _____ Quantity _____ Kg.
 Acidity _____ % lactic acid Lactometer reading. _____ at _____ °C
 Fat _____ % Total Solids _____ %
 Solids-Not-Fat _____ %

II. Milk Standardization

Quantity of cream required _____ g Quantity of SMP required _____ g
 Time when mixing was started _____ Hour _____ Minutes

III. Processing and filling

Time temperature combination of mix processing _____ °C _____ Minutes,
 Rate of culture addition _____ Quantity of culture added _____ g
 Temperature of the mix during culture inoculation _____ °C
 Temperature of incubation _____ °C, Time when incubation started _____ AM/PM
 Time when incubation stopped _____ AM/PM
 Duration of incubation _____ Hour _____ Minutes
 Amount of Dahi obtained _____ kg

IV. Organoleptic Quality

Acidity of the product at the end of incubation _____ % LA
 Flavour _____ Colour _____
 Body texture _____
 Overall sensorial attribute of Dahi _____

Remarks: _____

[illegible][illegible]

1. Define Dahi as per FSSR 2011
2. Explain the importance of pasteurization and homogenization with respect to quality of dahi
3. Name the flavoring compound which is mainly responsible for flavor of dahi

Part H

Preparation of Chakka and Shrikhand

Objective

- a) To learn the method of preparation of Chakka and Shrikhand using different types of milk
- b) Organoleptic evaluation of Chakka and Shrikhand

Introduction

Chakka is a fermented, intermediate dairy product obtained during the production of Shrikhand. Scientifically chakka can be described as strained dahi, in other words it is the curd mass obtained after removing whey from dahi, either by muslin cloth or basket centrifuge. Chakka is the base material for the production of shrikhand and shrikhandwadi. Shrikhand is a popular fermented, sweetened, indigenous dairy product having semi solid consistency with typical sweetish-sour taste. It is very popular in the state of Gujarat, Maharashtra and part of Karnataka. It is prepared by mixing chakka (Strained dahi), with sugar, color, flavor, spices and other ingredients like fruit pulp, nuts etc. to form soft homogenous mass.

Materials

1) Milk, 2) Lactometer with cylinder, 3) Fat testing kit for milk, 4) Lactic culture, 5) SS vessel and ladle, 6) Muslin cloth, 7) Thermometer, 8) Weighing balance, 9) pH meter/ strips, 10) Heating medium, 11) Incubator.

Procedure

1. Collect the representative sample of milk and analyse it for fat, SNF, acidity and organoleptic quality.
2. Standardize milk to 0 - 5.0% fat and 9% SNF by adding cream and calculated amount of skimmed milk powder.
3. Filter the milk into a clean SS kettle through a muslin cloth.
4. Homogenize at 175 Kg/cm² and Heat the milk to 85°C for 30 minutes and cool it to 30°C.

5. Add the lactic culture to milk @ 1.5% and mix well.
6. Incubate the milk added with culture at temperature of 30°C for 8-10 hrs
7. At the end of the incubation, make sure that the product has reached the pH of 4.6
8. Break the curd and collect it in a muslin cloth and hang it for complete removal of whey or take the curd mass in basket centrifuge and process it for 30min at 900rpm
9. The product thus obtained is called chakka
10. Take the chakka in a stainless steel vessel or in a planetary mixer, weigh sugar @ 80% w/w of chakka and mix it well to get a homogenous mass.
11. To this mass add cardamom (1g/kg) may be added as optional ingredient to give pleasant flavor.
12. Mix the curd mass thoroughly; the product thus obtained is called as Shrikhand.

PRODUCTION CHART OF CHAKKA AND SHRIKHAND

I. Particulars of Milk

Type _____ Quantity _____ Kg.
Acidity _____ % lactic acid Lactometer reading. _____ at _____ °C
Fat _____ % Total Solids _____ %
Solids-Not-Fat _____ %

II. Milk Standardization

Quantity of cream required _____ g
Quantity of SMP required _____ g
Time when mixing was started _____ Hour _____ Minutes

III. Processing and filling

Time temperature combination of mix processing _____ °C _____ Minutes,
Rate of culture addition _____ Quantity of culture added _____ g
Temperature of the mix during culture inoculation _____ °C
Temperature of incubation _____ °C, Time when incubation started _____ AM/PM
Time when incubation stopped _____ AM/PM;
Duration of incubation _____ Hour _____ Minutes
Amount of Dahi obtained _____ Kg; Duration of hanging _____ Hour _____ Minutes;
Quantity of Chakka Obtained _____ Kg; Quantity of Sugar added _____ Kg
Quantity of Cardamom added _____ g; Quantity of Shrikhand obtained _____ Kg

IV. Organoleptic Quality

Acidity of the product at the end of incubation _____ % LA
Flavour _____ Colour _____
Body texture _____
Overall sensorial attribute of Lassi _____

Remarks: _____

Calculation & Inference:

Date:

[illegible]

Signature of the Teacher

Review Questions

1. Define Chakka and Shrikhand as per FSSR 2011
2. Write the flow diagram for the production of Shirkhand

Part I

Preparation of Sweetened Condensed Milk (SCM)

Objective

The students should be able to comprehend the production process of sweetened condensed milk.

Introduction

Sweetened condensed milk (SCM) is made from standardized whole milk with sugar acting as a preservative. Evaporation is done under vacuum. It is thick and highly viscous in consistency with clean appearance. The product can be readily reconstituted by the addition of water. One kg of SCM gives 2.5 kg of sweetened reconstituted milk. The milk received at the plant is subjected to platform tests. Clarification, Standardization, stabilization by adding salts, forewarming and concentration under vacuum. Sugar in the form of syrup is added and a final concentration of 74-75 per cent TS is reached. The product is cooled, crystallized and canned under aseptic conditions in automatic filling and sealing machines.

Materials Required

- a) Milk condensing unit (batch or, continuous)
- b) Sediment, fat, SNF, Acidity, MBR and alcohol test set
- c) Sample bottles and sampling device
- d) Refractometer
- e) Thermometer
- f) Sugar
- g) Seed lactose

Procedure

- 1) Test the quality of the incoming milk by standard platform tests. The milk should be free from an objectionable odour, have not more than 0.18 per cent lactic acid and be negative to the alcohol test.

- 2) Cool the clarified milk to 5°C.
- 3) Take a representative sample of the raw milk and determine its fat and SNF per cent.
- 4) Determine the fat and SNF per cent of the cream and skim milk available for standardisation.
- 5) Standardize the milk to the desired SNF: fat ratio (2.44), using cream/ skim milk.
- 6) Note the mode of heating employed for forewarming. Observe the time taken to reach the prefixed temperature and also the time of holding in the forewarmer.
- 7) Dissolve the sugar (88°C) in a separate vat and keep it ready to be drawn in the condensing unit at the end of the condensing process. Note down the proper concentration of sugar (65 per cent) by using a refractometer.
- 8) Rinse all parts of the pan with hot water and steam to a temperature of about 85°C or higher.
- 9) Open the water to the condenser and start the vacuum pump.
- 10) Obtain the required vacuum in the pan (25" vacuum}.
- 11) Draw the standardized milk through the forewarmer into the vacuum pan.
- 12) After the bottom coil is submerged in the milk, let the steam enter the bottom coil. Similarly, the steam is allowed in other coils, one by one, after they are covered with the milk.
- 13) Maintain the level of the milk in the pan to be just above the topmost coil and regulate the flow of the milk to the pan accordingly.
- 14) Note down the steam pressure in the coils, the level of the vacuum and the temperature of the milk in the pan at regular intervals. Also check the uniformity of the flow of water to the condenser. The sugar syrup is taken into the vacuum pan when the total solids are about 30 per cent.
- 15) Draw the sample at regular intervals and check the total solids concentration by using a refractometer.
- 16) Record the rate of evaporation.
- 17) Determine correctly the stage of striking by visual examination as confirmed by the refractometer reading of the sample.
- 18) For drawing out the condensed milk into the cooling tank, shut off the water to the condenser, stop the vacuum pump, open the vacuum release valve and open the

milk discharge valve, the steps being followed in succession.

- 19) Cool the condensed milk to 29 -30°C with continuous agitation.
- 20) Prepare seed material by mixing seed lactose with enough of condensed milk (2-3 kgs) and add 200-300 grams of ground lactose for each 1000 kg of the product.
- 21) Add the seed material to the pre- cooled milk in the cooling tank in the course of five to ten minutes ensuring satisfactory agitation and mixing of all the additives.
- 22) Rapidly cool the milk in the tank to 21°C and keep the agitator working until filling.
- 23) Store the sweetened condensed milk at the temperature of 15°C and below till filling.
- 24) See that the filling room, the filler and the pipes conveying the condensed milk have been properly sanitized and the temperature of the filling room is around 16-20°C.
- 25) Immerse the cans in a detergent solution and later scold the water before passing it through the sterilizers. Allow the dry hot cans to be carried to the filler.
- 26) Draw the condensed milk from the cooling storage tanks to the filler ensuring that the rate of pumping synchronizes with the rate of filling.
- 27) Check the operation of the seaming rolls prior to filling by working with a few empty cans and lids.
- 28) Fill the cans to the brim and see that the lids are tightly sealed.
- 29) Test the cans for leakage.

Precautions

- Make sure of the time-temperature combination of forewarming before commencing the process.
- Ensure free flow of the water through the condenser.
- Make sure that the steam supply to the steam coils is started after the coil gets submerged in the milk and the steam supply is closed immediately after the level of the condensed milk falls below the coil.
- Ensure continuous agitation during cooling.
- The seed lactose should be sterilized and it should be of uniform size, preferably 200 mesh or smaller.
- Maintain freedom from contamination during filling.

Review Questions

- Give a flow diagram of the preparation of sweetened condensed milk.
- How is seed material prepared and added and for what purpose?
- What do you understand by the term 'striking the pan'?

Part J

Preparation of roller dried milk powder

Objective

The students should be able, to identify and explain the steps involved in the production of roller dried milk powder.

Introduction

Dried milk products play a significant role in conserving the milk solids since their biological value can be retained for a long period of time under relatively simple storage conditions. The roller dried powder finds special application in the manufacture of confectionery, infant foods, ice-cream, milk sweets, etc. Milk is pre- condensed to about 20 -25 per cent total solids (TS) in a vacuum pan/evaporator and fed to the rotating drum driers which are internally heated with steam. The film of the dried product is continuously scraped off by a stationary knife located opposite the point of application of milk. The dried milk film so obtained is ground to obtain powder which is then sifted, packed and stored.

Materials Required

Raw materials: Condensed skim milk having 20-25 per cent total solids for skim milk powder (SMP) or Condensed standardized milk having 20-25 per cent total solids with a fat: SNF ratio of 1: 2.5 for whole milk powder (WMP)

Equipment: (i) Roller drier with powder grinding and sieving unit; (ii) Milk condensing unit

Procedure

- 1) Separate the milk (for SMP) or clarify and standardize it (for WMP).
- 2) Forewarm (95°C) and re-condense to 20 percent total solids. Homogenize the condensed milk in case of WMP manufacture.
- 3) Prepare the rollers: (a) Make sure that the knives are not touching the rollers; (b) Start revolving the rollers; (c) Clean the rollers by pouring water and detergent solution in the trough and rotate for 10-20 minutes; (d) Stop the rollers allow the detergent solution to drain flush with plenty of warm water and rotate the rollers; (e) Open the main steam valve and make sure that the condensate valve is open; (f) Maintain a

steady pressure of steam (55-65 psi); (g) Start the powder conveyors and the vapour exhaust fan.

- 4) Drying on the rollers: (a) Start taking the condensed milk in the feed line on to the feed trough and immediately adjust the knives. Ensure that the rate of milk flow to the trough is proper and that the dried milk is being scraped uniformly; (b) Half dried or charred powder obtained during initial setting may be collected separately and discarded. Cover the conveyors and adjust their running to remove the powder.
- 5) Start the grinding motor and conveyor, sieve the powder into the filling hopper.
- 6) Stopping the rollers: (a) When the milk is over, stop the conveyors and run some hot water over the rollers; (b) Take off the knives and stop the steam; (c) Stop the rollers only when there is no steam pressure inside and the rollers are sufficiently cool; (d) Stop the vapour exhaust fan.

Precautions

- Do not start the main drive motor if the knives are touching the rollers.
- In case of power breakdown immediately close the feed valve and let out the steam from the rollers.
- Ensure that the knives are properly ground.
- Ensure that the vapours do not fall back on to the dried milk.

Review Questions

- What should be the optimum TS in milk when taking it for roller drying?
- What pressure of steam should be maintained in the rollers?
- What should be done in case of a power breakdown during the roller drying operation?

Part K

Preparation of spray dried milk powder

Objective

The students should be able to comprehend the operation process of manufacture of spray dried milk powder.

Introduction

Dried milk products are capable of being stored at room temperature. Spray drying is the most important method of drying milk and milk products. By spraying into a stream of hot air the droplets formed present an extremely large amount of surface area and get dried immediately due to rapid evaporation of the moisture. Milk is pre-heated and concentrated to 40-45 percent TS. Hot air is filtered and directed into the drying chamber. The concentrate is atomized to obtain small particles ranging from 50-150 μm in diameter. The air leaving the drying chamber enters a cyclone separator where the fines are collected. The dried product is cooled sifted and packed in suitable packaging material.

Materials required

Raw materials: (i) Condensed skim milk having 40-45 per cent total solids for skim milk powder (SMP) or Condensed standardised milk having 40-45 per cent total solids with a fat: SNF ratio of 1: 2.5 for whole milk powder (WMP).

Equipment required: (1) Spray drier; (ii) Milk condensing unit

Procedure

- 1) Separate the milk (for SMP) or clarify and standardize it (for WMP).
- 2) Forewarm (95°C) and re-condense to 40 per cent total solids. Homogenize the condensed milk in case of WMP manufacture.
- 3) Operating the spray drier: (a) Clean the spray drier and connect the pipe lines, valves and cyclone separator; (b) Open the steam valve in the air heating coils; (c) Start the exhaust fan, keeping the main door partially open; (d) Start the blower and close the main door; (e) Adjust the temperature of hot air to 180°C and maintain this temperature for ten minutes to ensure sterility of the unit; (f) Start the atomizer and allow it to attain speed; (g) Run it With nearly 20 litres of water through the

feed pump; (h) When the outlet air temperature reaches 100°C, change the feed to concentrate. The temperature inside the drying chamber should be nearly 90°C; (i) Collect the powder in the powder silo.

- 4) Stopping the spray drier: (a) When the milk is over flush the balance tank with about 20 litres of hot water (90°C) and immediately reduce the flow of milk to the drier; (b) Stop the atomizer and the feed pump when the tank is empty; (c) Stop the steam in the air heating coils; (d) Stop exhaust fan and the air blower.

Precautions

- The atomizer is a very delicate and .the most important part of the spray drying plant and must be handled carefully.
- Never run the atomizer with cold milk or highly concentrated milk as the nozzles may get clogged.
- Maintain steady temperature of hot air in the drying chamber.
- In case of power breakdown, immediately close the milk valve to the drying chamber.

Review Questions

- What should be the optimum TS in milk when taking it for spray drying?
- What should be the inlet and outlet air temperature during spray drying?
- What sequence of operation will you follow when stopping the spray drying plant?

Part L

Preparation of Acid Casein

Objective

The student should be able to prepare good quality acid casein.

Introduction

Casein exists in milk as a calcium caseinate calcium phosphate complex which is held in colloidal solution. When pH of milk is lower by addition of acid, the complex is dissociated. The acid forms a soluble compound with calcium caseinate by displacing calcium with hydrogen ion (H^+) and sets free calcium phosphate in the soluble form releasing the casein free which is practically insoluble at pH 5.3. Casein begins to precipitate out from the solution and at isoelectric point (4.6) casein loses its hydrophilic property and maximum precipitate occurs. Casein is the major protein of milk contributing about 80 percent of total proteins and finds specific uses in edible foods, animal feeds and various industrial applications. The various acids used for precipitation are hydro chloric acid, lactic acid, sulphuric acid and the casein manufactured by using such acids is named accordingly for example lactic acid casein.

Materials required

- i. Vat
- ii. Strainer
- iii. Thermometer
- iv. Stirrer
- v. pH meter
- vi. Cheese or Curd milling machine
- vii. Skim milk with not more than 0.1 percent milk fat
- viii. Acids: hydro chloric acid (10 percent solution), lactic acid (10 percent solution), sulphuric acid (5 percent solution).

Procedure

- i. Take good quality skim milk in a vat and raise its temperature to 35 to 38°C. Add diluted acid slowly with constant stirring till clean greenish yellow whey is obtained.

- ii. Stop adding acid and stir for a minute.
- iii. Push the curd towards the back of the vat and drain the whey through strainer.
- iv. Wash the curd with water three times. The pH of the wash water for first two washing should be 4.6 and third washing with neutral water. Amount of wash water should be equal to whey removed. Before draining the wash water curd should be well stirred but care should be taken not to break the curd into fine particles.
- v. Drain the wash water. Collect the curd in muslin cloth and place it under pressure for 3-4 hours until the maximum moisture is drained out.
- vi. Pass the pressed curd through milling machine.
- vii. Then dry the curd in a drier at a temperature of 52-57°C until moisture content reduces to 8-10 percent.
- viii. Cool the dried casein and pulverize in a grinding mill to a desire particle size that is 30, 40, 60 or 90 mesh size.

Observations

- i. Type of milk taken: _____
- ii. Quantity of milk taken: _____
- iii. Heating temperature of skim milk: _____
- iv. Type of acid used: _____
- v. Amount of acid used: _____
- vi. Amount of whey obtained: _____
- vii. Amount of curd obtained: _____
- viii. Amount of casein obtained: _____

Calculations

- i. Calculate the yield of acid casein obtained using the following formula.

Results

Record the result in terms of quantity of casein obtained and yield.

Review Questions

1. What do you mean by acid casein?
2. Give uses of acid casein.

Part M

Preparation of Rennet Casein

Objective

The student should be able to prepare good quality rennet casein.

Introduction

The enzyme rennin and / or pepsin displace glycomacropeptide from *kappa* casein fraction of the casein. In the presence of calcium (Ca^{2+}), the casein precipitates.

Materials required

- i. Horizontal Vat
- ii. Strainer
- iii. Rennet / Rennin enzyme
- iv. Thermometer
- v. Stirrer
- vi. pH meter
- vii. Titratable acidity testing set (0.1 N sodium hydroxide, phenolphthalein indicator, burette and pipette)
- viii. Cheese or Curd milling machine
- ix. Cabinet / Tunnel / Tray drier
- x. Skim milk with not more than 0.1 percent milk fat

Procedure

- i. Take good quality skim milk in a vat and filter it to remove extraneous matter.
- ii. Raise its temperature of skim milk to 29 to 31°C in the vat.
- iii. Add calcium chloride at the rate of 0.02 percent of the skim milk.
- iv. Add 70-100 mL of rennet extract diluted with twenty times its volume of water or 2-3 g of rennet powder diluted in water to every 500 Kg of skim milk.
- v. Allow the milk to set without disturbing it. This would take about 25-40 minutes. Maintain the temperature of the milk in the vat during the setting period.

- vi. When the curd is set firmly enough to handle cut the curd into pieces.
- vii. Stir the curd slowly and at the same time start heating the curd-whey mixture until the temperature reaches to 46-48 °C.
- viii. Allow the curd to settle and drain the whey.
- ix. Wash the curd twice with water equal to the amount of whey drained.
- x. Drain wash water and press the curd for 1 hour.
- xi. Shred the curd and dry in thin layer in the cabinet / tunnel / tray drier.
- xii. Ground and pulverize the dried casein.
- xiii. Pack in bags and store.

Observations

- i. Type of milk taken: _____
- ii. Quantity of milk taken: _____
- iii. Heating temperature of skim milk: _____
- iv. Type of rennet used: _____
- v. Amount of rennet used: _____
- vi. Quantity of water used for dilution of rennet: _____
- vii. Amount of whey obtained: _____
- viii. Amount of rennet curd obtained: _____
- ix. Amount of casein obtained: _____

Calculations

- i. Calculate the yield of rennet casein obtained using the following formula.

$$\text{Yield of casein (\%)} = \frac{\text{Amount of acid casein obtained (g)}}{\text{Amount of milk taken (g)}} \times 100$$

Results

Record the result in terms of quantity of rennet casein obtained and yield.

Review Questions

1. What do you mean by rennet casein?
2. Give uses of rennet casein.

Exercise-3

Sensory Evaluation of Milk and Milk Products

Objective

In this chapter student will learn various sensory attributes that decides acceptability or rejectability of milk and milk products.

Sensory evaluation procedure of milk and milk products

For every milk and milk product there is a specific score card and scientific technique for sensory evaluation. However the sequence of observation is mostly same for almost all the products. First, for a packaged product the quality of the package in which the product is marketed is evaluated. This is followed by observing the appearance characteristics of the product. In the next step flavour of the product is judged and finally the body and texture is evaluated. In the following sections the detailed procedure for sensory evaluation of milk and milk products are described.

Part A

Sensory Evaluation of Milk

Name: _____

Date: _____

Desirable Sensorial Attributes of Milk

Flavour: Excellent quality milk should seem pleasantly sweet with no foretaste, leave only a clean, pleasing sensation after the sample has been expectorated or swallowed, with no aftertaste. The flavor of milk is imparted by the natural components such as proteins, fat, salts, milk sugar (lactose), and possibly small amounts of other milk components. The natural richness of milk is due to presence of milk fat and sweetness is due to milk sugar. Pasteurized milk commonly possesses some degree of heated flavour especially immediately after processing, but the intensity diminishes during storage.

Colour: Colour of cow milk is yellowish creamy white and buffalo milk is creamy white. The scattering (refraction) of light by the insoluble colloidal minerals, protein, and fat particles are mainly responsible for the opaqueness and white colour of milk. Cow milk contains more beta-carotene which scatters yellowish light lending to creamy-yellow hue to cow milk.

Evaluation technique

1. Examine the container for the extent of fullness, cleanliness and freedom from cracks or chips.
2. The container should have attractive appearance, clear and contain the full volume of milk.
3. Should reflect cleanliness, recently filling and should possess dry, firm and milk solid free surface free from cuts/nicks/pinholes.
4. Warm the sample to 40°C.
5. Fifty ml of sample should be served in clean, odourless glass or plastic bottles.
6. Observe the kind, amount and size of the sediment particles that may have settled at the bottom.
7. Immediately after opening the lid smell the milk and closely inspect the underside of the closure for presence of cream or foam and examine the top of the milk

sample for its colour, presence of cream plug or partially churned fat globules.

8. Gently swirling the container contents in a circular pattern to mix the sample properly and take a generous sip (not less than 10 ml) roll it in the mouth and note the flavour and tactual sensation, then expectorate.
9. Aftertaste may be enhanced by drawing a breath of fresh air very slowly through the nose.
10. By placing the nose directly over the container immediately after the milk has been swirled in the container and taking a full 'whiff' of air, any off-odor that may be present can be more readily noted.
11. Agitation (or swirling) of the milk leaves a thin film of milk on the inner surface of the container, which tends to evaporate, thus readily optimizing the opportunity to detect any odor(s) that may be present.
12. Indicate the scores on different attributes in the Evaluation Card (Table 1).

Sensory Score Card for Milk

Name: _____ Date: _____

A. Assign scores for each sample for different characteristics

Characteristics	Maximum score	Sample Scores		
		Sample No. 1	Sample No. 2	Sample No. 3
Flavour	40			
Consistency	30			
Odour	20			
Colour & Appearance	10			
Total	100			

Comments, if any:

Signature of the Judge

B. Indicate the degree of defects (if any) such as the following. Encircle the one applicable and deduct from the attributes.

Characteristic	Defect	Degree of Defect		
		Suspicion	Slight	Pronounced
Flavour	Cooked, oxidized, rancid, metallic, neutralizer, feed, barny, cowy, flavor defects due to adulterants and other additives	5	10	20
Consistency	Watery, ropy, curdy	5	10	15
Odour	Stale, acidic abnormal	5	10	15
Colour and appearance	Suspended particles, filth, foreign matter, bloody	2	4	10

After averaging of data (recorded in the score card by the panelists) the following grades should be awarded to each sample. Any attribute showing pronounced defect should be graded poor and rejected.

Quality	Score	Grade
Excellent	90 and above	A
Good	80 to 89	B
Fair	60 to 79	C
Poor	59 and below	D

Part B

Sensory Evaluation of Butter

Name: _____

Date: _____

Desirable Attributes of Butter

The desirable sensory attributes of good quality butter should be:

Package: Package for butter should be attractive, neat, clean and tidy in appearance and should have good “finish” (smooth and attractive surface). All packages should be fastened firmly and neatly.

Flavour: Good quality butter should have a mild, sweet, clean and pleasant flavour and delicate aroma. A characteristic feature of high-quality butter is that instigate appetite to ‘crave more of the product’.

Body and Texture: The body of good quality butter should be firm and exhibit a distinct waxy, close-knit texture. When broken, the appearance of broken surface of good quality butter should be somewhat jagged, irregular, wrought-iron like. It should have smooth “spreadability”.

Salt: It must be uniformly distributed and properly dissolved. If undissolved salt is present, gritty defect is usually noticed at once.

Colour and Appearance: Good quality butter should have a uniform light, pale yellow colour.

Scoring Technique of Butter

1. The judging room of butter should be clean, well ventilated and well lit. The temperature of the judging room should be 18-21°C. There should be no strong, offensive or irritating odour present in the room or adjacent areas.
2. Temper butter to 10°C. Delicate aroma of butter is more readily detected, body and characteristics is more easily and precisely determined when butter is at 10°C.
3. Take a representative sample of the product. For large blocks trier (two-edged, curved bladed tool) should be used for sampling of butter. The trier used should not be washed in warm water but should be wiped with-single service towel or absorbent paper. Washing the trier in warm water may result in a molten, greasy surface on the first plug of butter taken. This obscures the true condition of the body and makes observation of the colour more difficult.

4. Stand squarely in front of the sample and observe relative cleanliness and neatness of the package. Remove the cover or package and observe for evenness and neatness of the wrapping material. Observe the surface for possible discrepancies or yeast and mould growth. Hold the trier firmly in one hand, insert it straight down near the centre of the butter and turn it 180° and withdraw the plug. In case of retail pack (500g or less) a spatula or spoon may be used in place of trier.
5. Immediately after withdrawing the plug or drawing the sample using a spatula or spoon pass the butter slowly under the nose, inhale through the nose very slowly and notice the aroma present. Make a mental record of this aroma.
6. Examine the colour for its intensity and uniformity.
7. Examine the body and texture by pressing the ball of thumb against the sides of the plug until it shows a break. Notice the presence or absence of free moisture or beads of water and their clearness and also the nature of break, whether it is smooth or jagged/irregular.
8. Take 4-5 g of the sample and put it into the mouth. Chew until it melts. Roll the melted butter in the mouth until it comes to body temperature.
9. Feel the presence of “grit” (un-dissolved salt between the teeth).
10. Critically feel the manner in which the butter melts. Notice the various sensations of taste and smell.
11. Just before expectorating, roll it to the back of the mouth to detect the palate flavours.
12. Expectorate the sample, observe the aftertaste and notice whether or not the flavour persists.
13. Indicate the scores on different attributes in the Evaluation Card as shown in the following page. The hints given in Butter Scoring Guide will aid the judge to score the product properly.

Butter Score Card

Place score opposite the rating for perfect score. Check criticism in space opposite to the defect noted and in proper sample column. Write any other criticisms if necessary. DO NOT write anything in space indicating grade.

Perfect Score	Criticisms	Sample Number				
Flavour 12	Sample scores					
Normal range 7.5 to 12	Criticism					
	Acid					
	Bitter					
	Cheesy					
	Coarse					
	Cooked					
	Cowy					
	Feed					
	Fishy					
	Flat					
	Malty					
	Metallic					
	Musty					
	Neutralizer					
	Oily					
	Old Cream					
	Cream or Garlic					
	Rancid					
	Scorched					
	Tallowy					
	Unclean					
	Weedy					
	Whey					
	Yeasty					
Body and Texture 6	Sample scores					

Normal range 3 to 6	Criticism					
	Crumbly					
	Greasy					
	Gummy					
	Leaky					
	Mealy/Grainy					
	Ragged boring					
	Short					
	Pasty/Sticky					
	Weak/Soft					
Colour 3	Sample scores					
Normal range 2 to 4	Criticism					
	Mottles, uneven, wavy					
	specks					
Salt 2	Sample scores					
Normal range 2 to 3	Criticism					
	Gritty					
	Sharp					
Package 2	Sample scores					
	Criticism					
Total 25	Total score of each sample					
	Total grade per sample					

Butter Scoring Guide

The scores suggested here are to be used as a guide only and are not to be used as specific scores with no range. For example, a slight acid flavour defect may be scored 10.5 or 9.5 as well as the score of 10 suggested. The numerical score is to be used as an indication of the intensity of the defect.

Flavour			
	Slight	Definite	Pronounced
Acid	10	9	8
Bitter	9	8	7
Cheesy	9	8	7
Coarse	10	9.5	9
Cooked	10	9.5	9.5
Cow	9.5	9	8

Feed	10	9.5	9
Fishy	9	8.5	8
Flat	10	9.5	9
Malty	9.5	8	8.5
Metallic	9.5	8	8.5
Musty	9.5	9	8.5
Neutralizer	9.5	9	8.5
Oily	9	8.5	8
Old Cream	9.5	9	8.5
Onion or Garlic	8.5	8	8
Rancid	8	8.5	8
Scorched	10	9.5	9
Tallowy	9	8.5	8
Unclean	9.5	9	8.5
Weedy	9	8.5	8.5
Whey	10	9.5	9
Yeasty	9	8.5	8
Body and Texture			
Crumbly	5.5	5	2
Greasy	5.5	5	2
Gummy	5.5	5	2
Leaky	5.5	5	2
Mealy/Grainy	5.5	5	2
Ragged boring	5.5	5	1
Short	5.5	5	2
Pasty/Sticky	5	4.5	1
Weak/Soft	5.5	5	2
Colour			
Colour specks	2.5	2	1
Un-natural colour	2.5	2	1
Mottled	2.5	2	1
Wavy	2.5	2	1
Salt			
Gritty	1.5	1	1
Sharp	1.5	1	1

Part C

Sensory Evaluation of Ghee

Name: _____

Date: _____

Desirable Sensory Attributes of Ghee

Flavour: Perfect ghee flavour can be described as multitude of sensory perceptions which are pleasant, enjoyable and lingers in mouth. The village produced ghee (purely desi ghee) is characterized by a curdy flavour that lingers in the mouth. The highly prized characteristic flavour of ghee is due to a complex mixture of compounds produced during the various stages of processing. Carbonyls, dicarbonyls, lactones, free fatty acids, esters, alcohols, diols and hydrocarbons are the major compounds associated with the flavour of ghee.

Texture: Granulation of ghee is an important criterion for its selection. Good grainy texture is much appreciated by consumers. Milk fat has a unique property of forming grains. Texture of ghee depends on a number of factors such as source of fat, method of preparation, amount of free fatty acids, rate of seeding, storage conditions among others. Buffalo ghee is around 74% solid if stored undisturbed at 28°C for 20-24 h. Similarly, Cow ghee and goat ghee are 70% and 30% solids respectively under identical conditions of storage. Consumers do not like hard, greasy or waxy texture in ghee.

Colour: Cow ghee has distinct golden yellow colour due to its high carotenoids content (about 72µg/100g), while buffalo ghee has white colour with greenish tinge due to the presence of biliverdin and bilirubin. Colour of ghee also depends on its method of manufacture such as ghee made by direct cream method is darker in colour. Brown discolouration is a serious defect in ghee.

Technique for Sensory Evaluation of Ghee

1. Representative sample should be drawn from the bulk lot in a clean and dry glass bottle. The bottle should be capped.
2. Samples should be presented at room temperature. Odour, taste and residue are better detected at 40°C while texture is analyzed after solidification. Crystallization temperature for cow ghee is 25-30°C and for buffalo ghee is 30-35°C.
3. Start with the visual observation of the sample. Judge the colour first, and then look for suspended impurities (residue).

4. Remove the lid and perceive the odour immediately by inhaling the smell.
5. Take a spoonful of ghee in mouth for taste and aroma. After each sample, mouth should be rinsed with 1% lukewarm (40°C) saline water.
6. Body and texture is evaluated with the help of a spatula or glass rod.

Sensory Evaluation Card for Ghee

Name: _____

Date: _____

- A.** Assign score for each sample for different characteristics. First go through section B.

Characteristics	Defect	Sample Number				
Flavour 12	Normal					
	Flat/Lacking					
	Curdy					
	Burnt					
	Rancid					
	Oxidized					
	Smoky					
Texture 8	Greasy					
	Hard					
Colour 3	Brown/burnt					
Freedom from suspended impurities 2						
Total Score 25						

- B.** Indicate, if any, the degree of defects such as following. Encircle the one applicable and deduct from the attribute:

Characteristics	Defect	Degree of defect		
		Suspicious	Slight	Pronounced
Flavour	Flat/Lacking	0.5	1	2
	Curdy	1	1	4
	Burnt	1	1.5	4
	Rancid	2	4	6
	Oxidized	2	4	6
	Smoky	0.5	1	2
Texture	Greasy	1	1.5	5
	Hard	1	1.5	5
Colour	Brown burnt	0	1.5	2
Freedom from suspended impurities	Ghee residue	0.5	1	1.5

Grading: After computation of recorded scores in the above Table by the panelists, the following gradation should be specified:

Quality	Score	Grades
Excellent	22.5 or more	A
Good	20-22	B
Fair	18-19	C
Poor	17 and below	D

Part D

Sensory Evaluation of Dahi

Name: _____

Date: _____

Desirable Sensorial Characteristics of Dahi

Flavour: Good quality dahi should have pleasant, sweetish aroma and a mild clean acid taste. A good diacetyl flavour is always desired in dahi. It should be free from any off flavour. Any sign of bitterness, rawness, yeasty, sharp and unclean off flavour should not be present in dahi.

Body and Texture: Good dahi should be a weak gel like junket when made from whole milk. The body should be firm, homogenous and free from gas holes and air bubbles. On cutting, the edges should appear clean and sharp. The surface should be smooth, preferably with a creamy layer. Defects like graininess or lumpiness, ropiness, shrunken, thin and wheying off should be absent in dahi.

Acidity: Generally acidity in the range of 0.75-0.85% lactic acid is appropriated for good quality dahi. Excessive acidity imparts too much sourness and sharp astringent taste to the product, whereas low acidity is considered as raw or bland.

Colour and Appearance: It should be creamy yellow if made from cow milk and creamy white if made from buffalo milk. It should be attractive, pleasing and uniform without showing any sign of browning and visible foreign matter. Dahi should have smooth and glossy surface without traces of any free whey on sides or top. Consumers often judge the wholesomeness and purity of dahi on the basis of presence of a creamy layer on the top, hence it is usually desirable.

Sensory evaluation technique of dahi

1. First look outside of the container. Look for any smudges on the package, and whether the manufacturing date is easy to read and in the proper place.
2. Open the container without disturbing the product and immediately assess the product for its odour. View the top of the product, particularly notice for any whey separation, yeast or mould growth, discolouration or watery liquid exudates.
3. Look around the sides of the cup for possible indications that the product may have shrunken.

4. Trip the cup upside down on a plate and puncture the bottom. Then lift the cup to get a dahi 'mound' left on a plate. With the help of a spatula or a knife scrape out dahi remaining in the cup bottom. Notice for any unusual aromas.
5. Observe how it appears on the plate. The dahi should resemble a thick mass with little or no running.
6. Next, notice for the presence for any unusual colour. If the dahi colour does not resemble the type of milk from which it is prepared then the product is characterized to possess 'atypical colour'.
7. Place a spoonful of dahi in the mouth and notice how dahi clings or sticks to the tongue and sides of the mouth.
8. Move dahi in mouth using tongue and notice how fast the dahi dissipates off the tongue as it is being moved around. If dahi is low in total solids, it will dissipate fast, thus it's body perceived to be weak.
9. After noticing the texture and mouthfeel, perceive the first flavour sensations and notice where in the mouth they are being observed. One of the first sensations is acidity of dahi. The sensation is on the sides of tongue. After the acid sensation, the next flavours that are noticed are cooked, too high or low flavouring.
10. Then, notice for the presence of any strong off-flavours like oxidized, atypical (foreign), old ingredient, unclean, and yeasty.
11. Expectorate (spit it out) the dahi from mouth so that the flavour will not stay in the mouth for long time afterwards.
12. After expectorating, some flavours that are not associated with being the most pleasant are noticed. These include rancid, bitter, old ingredient, lacks freshness and unnatural flavours.
13. Indicate the scores for different attributes in the Evaluation Card. The hints given in Section B will aid the judge to score the product properly.
14. Defects arising from pronounced manufacturing, handling and storage errors, such as rancid, old ingredient, foreign, oxidized or spoilage issues, such as unclean or yeasty require greater penalties than less serious defects, such as low acid, high acetaldehyde, etc. The origin and remedies of some common defects of dahi are presented below.

Sensory Evaluation Card for Dahi

Name: _____

Date: _____

- A.** Assign score for each sample for different characteristics. **First go through section B.**

Characteristics	Maximum score	Sample Number				
Flavour	10					
Body & Texture	7					
Acidity	3					
Colour and appearance	3					
Container & Closure	2					
Total	25					

- B.** Indicate, if any, the degree of defects as given below by writing **S for Slight**, **D for Definite** & **P for Pronounced** in the respective box and assign score for the corresponding attribute:

Attributes	Slight	Definite	Pronounced	Sample No				
Flavour								
High acetaldehyde	9	8	7					
Lacks fine flavor	9	8	7					
Cooked	9	8	7					
Flat (Low diacetyl)	8	6	7					
Foreign	8	7	6					
Old ingredient/ Stale	8	5	3					
Oxidized	6	4	1					
Yeasty	6	4	2					
Unclean	6	4	1					
Bitter	5	4	2					
Rancid	4	2	1					
Body & Texture								
Wheying off	6	4	1					
Thick	6	4	3					
Thin	6	4	3					
Gel like	6	4	3					

Ropy	4	3	1					
Acidity								
High acid	3	2	1.5					
Low acid	2.5	2	1.5					
Colour & Appearance								
Atypical colour	2.5	2.0	1.5					
Presence of suspended particles/ foreign matter	2.0	1.5	1.0					
Excessive dark colour	1.5	1.0	1.0					
Whey separation	2.0	1.5	1.0					
Layered appearance	1.5	1.0	1.0					
Container & Closure								
Smudged/ Blurred print	1.5	1	0					
Difficulty of opening	1.5	1	1					
Deformed container	1.5	1	0					

Remarks, if any:

Signature

Part E

Sensory Evaluation of Paneer

Name: _____

Date: _____

Sensorial characteristics of good quality paneer

Colour and Appearance: Excellent quality paneer should have uniform marble white colour with greenish tinge if made from buffalo milk and slightly yellowish white colour if prepared from cow milk.

Body and Texture: The body of paneer should neither be too firm nor too soft. The texture of good quality paneer should be compact, smooth, slightly spongy and velvety. While masticating, it should impart a feeling of fibrous texture with modest degree of chewiness. Paneer should retain its shape while frying.

Flavour: Paneer must have a characteristics blend of the flavours of heated milk, coagulated curd and acid. It is pleasant, mildly acidic, slightly sweet and nutty.

Technique for Sensory Evaluation of Paneer

1. Tempering: The optimum temperature of sensory evaluation of paneer is 15°C. It is highly essential that the temperature of all the samples should be same for uniformity in evaluation of body and texture.
2. Start with the visual observation of the package for neatness and cleanliness, proper protection and absence of soiling material, moisture/whey droplets etc. on the surface. Collection of whey inside the package is highly undesirable.
3. Remove the sample from the package and immediately inhale the smell and observe the surface. The spoilage of paneer during storage starts from surface due to formation of bacterial slime (greenish/yellowish coloration) and production of putrid smell. Also, note the colour of the product, presence of burnt particles in the paneer samples.
4. Collect a slice/plug from the larger block with the help of a knife.
5. While cutting, note the resistance offered and whether the plug is intact or broken into pieces.
6. Apply some pressure on the paneer block with thumb and note whether the compressed area is returned back to its original form after removing the pressure.

7. Take a piece of paneer in the mouth and start masticating, while masticating note the ease of biting by teeth and the taste quality and overall flavour.
8. Expectorate the sample, observe the after taste and notice whether or not any off-flavour is present (this could be better observed by inhaling a whiff of fresh air and then slowly exhaling it, while noting for the presence of any off-flavour in the background).

Paneer Score Card

Section A: Evaluate the given sample of paneer for its sensory attributes and place appropriate scores against each sample in the following table. Use the scoring guide given in Section B.

Attributes	Maximum Score	Sample Scores				
Flavour	12					
Body and texture	10					
Colour and appearance	3					
Package	2					
Total	25					

Remarks:

Signature

SECTION B

Paneer Scoring Guide

The scores suggested here are to be used as a guide only and are not to be used as specific scores with no range. For example, a slight acid flavour defect may be scored 10.5 or 9.5 as well as the score of 10 as suggested. The numerical score is to be used as an indication of the intensity of the defect.

Attribute	Defect	Slight	Definite	Pronounced
Flavour (12)	Bitter	10	9	8
	Feed/weed	9	8	7
	Flat	11	10	9
	Foreign	10	9	7
	Musty	10	9	7
	Putrid/cherry	10	9	7
	Rancid	10	9	7

Attribute	Defect	Slight	Definite	Pronounced
	Smoky/Burnt	11	10	9
	Sour/acid	11	10	9
	Stale	11	9	8
	Unclean	10	9	7
	Yeasty	10	9	7
Body & texture (10)	Crumbly	9	9	7
	Hard	9	9	7
	Mealy /coarse	9	8	6
	Open	9	8.5	7
	Pasty	9	8	5
	Rubbery/chewy	9	8	7
	weak	9	8	7
Colour and Appearance (3)	Dull	2.5	2	1.5
	Dry/skin	2.5	2	1.5
	Mouldy	1	0	0
	Surface time	2	1	0
	Visible dirt/foreign matter	2	1	0
Package (2)	Damaged	1	0.5	0
	Soiled/greasy	1.5	1	0

Grade the sample as under:

Total score	Grade
23 or more	Excellent (A)
21-22	Good (B)
15-20	Fair (C)
19 or less	Poor (D)

Review Questions

1. What are the precautions that need to be taken during sensory evaluation of milk?
2. What are the desirable flavour attributes of milk?
3. What is the score card prescribed for sensory evaluation of milk?
4. What are the possible defects in butter?
5. Why is cow ghee golden yellow in colour?
6. What is the procedure for carrying out sensory evaluation of ghee?
7. What are the desirable body and texture attributes of dahi?
8. What is the technique for Sensory evaluation of paneer?