COURSE OVERVIEW

LPT-311: MILK AND MILK PRODUCTS TECHNOLOGY (1+1)

This course should comprehensively aim at various constituents of milk and milk products, its technology and standards to make students competent to meet the needs of dairy industry. The course will motivate them to carry out research and facilitate hands on training. This course should impart sound knowledge on various aspects of dairy science, viz technology, chemistry and microbiology so as to enable the veterinary graduate to assist the poor farmer or animal owner in augmenting his income.

Out of 120 Million tons of milk produced annually, 85 per cent of the milk comes from unorganised sector involving poor framers owning one or two animals. The economic status of people involved in any industry is correlated to the net income and surplus generated from its output. Thus the state of the veterinary profession and its field is far and best decided by the income and surplus generated from its outputs viz. milk, meat and egg. The major share is based on the performance of dairy business and it is ultimately based on the status of dairy cattle owners. The responsibility of Indian veterinarian not only vests with animal health care and welfare but also assuring hygienic milk production, providing adoptable processing technologies for value addition, preservation and marketing of milk and milk products to raise the gross income. Dairying dominates veterinary practice compared to other animal husbandry activities.

Importance of milk and milk products in human nutrition

- Milks and dairy products are highly nutritious and play s vital role in human diets for both children and adults. The composition of milk varies according to the animal from which it comes, assisting for required rate of growth and development of the young ones of that species. Thus, for human infants, human milk is better than cows' milk or any other milk product. Exclusive breastfeeding without other foods or liquids is the optimum means of feeding for the first six months of an infant's life. Continuing breast feeding for many more months is of great value, while the baby is introduced to other foods. If breast milk remains an important food for the child into the second or even third year of life, then animal milk is not necessary in the child's diet.
- Casein and whey proteins are of high biological value, are the most important constituents of cows' milk. The carbohydrate in cows' milk is disaccharide lactose. Fat is present as very fine globules, which on standing tend to coalesce and rise to the surface as cream layer. The fat has a rather high content of saturated fatty acids. The calcium content of cows' milk (120 mg per 100 ml) is four times that of human milk (30 mg per 100 ml). When a human infant is fed entirely on cows' milk. The excess calcium does no good but causes no harm.
- Milk is also a very good source of riboflavin and vitamin A. It is a fair source of thiamine and vitamin C, but it is a poor source of iron and niacin. The mother usually provides her infant with a store of iron before birth. If feeding of milk alone is prolonged after sixth month, iron deficiency anemia may develop. Despite the variation in the composition of milk from different animals, all milk is rich in protein and other nutrients and constitutes a good food for humans, especially children. Although most animal milk for human consumption comes from cows, in certain societies the milk of buffaloes, goats, sheep and camels is important.
- In many parts of the world, milk is also consumed sour or curdled than fresh for curdled milk keeps longer, retains its nutritive value and may be more digestible and more hygienic than fresh milk. However, it is much safer to drink milk that has been
boiled and kept in a clean container, because milk can provide a vehicle for the transmission of some disease-causing organisms.

- Pasteurization of milk greatly reduces the risk of pathological organisms spreading, provided that the milk is placed in clean containers destined for direct delivery to the consumer.
- In many countries where cows’ milk is a normal item of the diet, it is customary to wean infants from breastmilk on to a diet in which cows’ milk plays an important part.
- Some people limit their milk consumption because they suffer from lactose intolerance, a condition resulting from low levels of the digestive enzyme lactase, a lactose spitting enzyme to mono saccharides. Research shows that most lactose-intolerant persons can in fact consume milk in moderate quantities (perhaps three to five cups of milk per day) without developing symptoms.
- To match an estimated demand of 180 million tonnes of milk by 2021-22, NDDB had drawn up a National Dairy Plan two years ago. This plan recommends a two pronged strategy. First, doubling of the milk production over a period of 15 years by improvement of milch animals and optimal use of feed and fodder in order to fully realize the improved genetic potential and secondly, increasing the share of marketable surplus of the organized sector, both cooperative and private dairies from 30% to 65%.

<table>
<thead>
<tr>
<th>Milk Utilization Pattern in India, 1943-2004</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1943*</td>
</tr>
<tr>
<td>Milk Production (million tones)</td>
<td>23.5</td>
</tr>
<tr>
<td>Milk Utilisation (Percentage)</td>
<td>100</td>
</tr>
<tr>
<td>Liquid Milk</td>
<td>28.0%</td>
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<tr>
<td>Traditional Products</td>
<td>72.0%</td>
</tr>
<tr>
<td>Ghee/Makhan (clarified butter)</td>
<td>58.7%</td>
</tr>
<tr>
<td>Dahi (Yogurt-like)</td>
<td>5.2%</td>
</tr>
<tr>
<td>Khova (Partially desiccated Milk)</td>
<td>5.0%</td>
</tr>
<tr>
<td>Channa and Paneer (unprocessed cottage cheese)</td>
<td>3.1%</td>
</tr>
<tr>
<td>Western Products: Milk Powder, etc</td>
<td>Neg</td>
</tr>
</tbody>
</table>

*Includes Pakistan and Bangladesh

Source: Handbook on Technology of Indian Milk Products

**MODULE-1: MILK INDUSTRY IN INDIA**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Current status of dairying in India,
- Market milk industry in India and Abroad,
- India’s Dairy Cooperative Movement,
- Three-tier "Amul Model" and
CURRENT STATUS OF DAIRYING IN INDIA: AN OVERVIEW

India is transforming into a developed country, while rural dairying happens to be an integral and interwoven part of the traditionally diversified system of agricultural farming. India is predominantly an agriculture-based country with more than 70% involved in agriculture.

India can take pride in some of its major achievements in the field of dairying since 1971, as under:

- India holds number one position in its annual milk production among the other countries of the world. The country’s total milk production has gone up from 21 million tons in the early seventies to over 120 million tones i.e., almost six folds, raising thereby the daily per capita milk consumption from 107gms to 240gms. India has the highest annual growth rate of around 5-6% in milk production unmatched by any country of the dairy world. Especially with respect to buffalo milk production, India remains first at the world level.
- Operation flood programmes viz phase I/II/ and III launched by NDDB, have brought out remarkable multi-directional progress and achievements in the dairy field in several parts of the country during its three phases of operation. Dr. V. Kurein, Former Chairman, NDDB, Anand, ‘affectionately referred as father of white revolution was the chief architect. The great success lies with co-ordinate assistance and support of the central, state governments, ICAR and concerned developmental agencies, dairy institutions, allied R & D organizations and by the active participation of millions of rural milk producers.

On the other hand

- India holds 12% of the cattle population of the world, but contributes only about 11.5% to the annual world milk production.
- Though India has attained first position in world milk production, the average milk productivity per milch cow falls far below than what has been achieved by the developed dairy countries of the world.
- The per capita milk consumption figure of India has reached a level of 240gm which is still below the ICMR recommendations of 280 g.

THE MARKET MILK INDUSTRY IN INDIA AND ABROAD

The Indian dairy scenario

Although a beginning to organised milk handling was made in India with the establishment of Military Dairy Farms (oldest; Allahabad, 1889), the salient features of the market milk industry so far have been detailed below.

- Handling of milk in co-operative Milk Unions (oldest: Allahabad, 1913) established all over the country on a small scale in the early stages
- Long distance refrigerated rail-transport of milk from Anand to Bombay since 1945. Pasteurization and bottling of milk on a large scale for organized distribution was started at Aarey (1950), Worli (1961), Calcutta Haringhata, 1959), Delhi (1959), Madras (1963), etc.
Establishment of milk plants under the five year plans for Dairy Development all over India. These were taken up with the dual object of increasing the national level of milk consumption and ensuring better returns to the primary milk producer, their main aim was to produce more, better and cheaper milk.

Indian Dairy sector has gained an vital position in Indian economy by providing secondary source of income for millions of rural families and has assumed a most important role in providing employment and income generating opportunity.

Per capita availability of milk was 252 grams per day in 2007-08 which increased from 241 grams per day in 2005-06, up from 112 grams per day in 1968-69. India's 3.8 -4 percent annual growth of milk production between 1997-98 and 2008-09 surpasses the 1.8 per cent growth in population; the net increase in availability is around 2 per cent per year.

The total number of liquid milk processing plants under cooperatives is 370.

The international dairy scenario

- World milk production was estimated to be around 688 million tonnes in 2008, about 1.7 per cent higher than in the previous year. Prices of skimmed milk powder and butter in the international market fell significantly during the year. In January 2009, prices of dairy commodities in the European countries fell below intervention levels and prompted a fresh declaration of export subsidies. However, by March 2009, prices started rising again.

The credits of Indian Dairying

- It ranks first with its 185.2 million cattle & 97.9 million buffaloes accounting for about 51 percent of Asia's and about 19 per cent of world's bovine population.
- It also ranks first internationally in milk production with a production of 110 million tonnes in 2009-10. Contributing about 5.4 per cent to India's agricultural GDP, milk has become the number one agricultural commodity contributing the highest level.
- The unique feature of the system is that about 120 million rural families are engaged in milk production activities as against big specialized dairy farmers in the west.
- Another notable feature of Indian dairying sector is that buffaloes contribute more than 53 per cent of the country's total milk production.
- Buffaloes are known for their efficiency as converters of coarse feeds into rich milk. Similarly about 45% of total cow milk produced is contributed by crossbred cows.

The lacunae in Indian dairy sector

- Despite India's position as highest producer of milk, productivity per animal is very poor. It is only about 987 kg/lactation as against world average of 2,038 kg/lactation. This low productivity is due to the gradual genetic deterioration and general neglect of animals over the centuries and consequent to the rise in the population of non-descript cows (80%) and buffaloes (50%). Other factors contributing to low productivity include continuing draughts in some parts of the country, chronic shortages of feed & fodder coupled with their poor nutritive value and poor fertility of dairy animals.
- Hence we have to face a twin challenge: increase milk productivity of animals with the limited resources on one hand and make best use of the available milk by processing it into hygienic packaged milk and milk products of high quality to give better returns to the farmer so that the profession sustains.

INDIA’S DAIRY COOPERATIVE MOVEMENT
The historical co-operative movement starts as early as 1946 in Anand, a small town in the state of Gujarat in western India. The exploitative trade practices followed by the local trade cartel like Polson and others triggered off the cooperative movement. Anguished by unfair and manipulative practices followed by the trade, the farmers of the district approached the great Indian patriot Sardar Vallabhbhai Patel for a solution. He advised them to get rid of middlemen and form their own co-operative, which would have procurement, processing and marketing under their control. In 1946, the farmers of this area went on a milk strike refusing to be cowed down by the cartel. Under the inspiration of Sardar Patel, and the guidance of leaders like Morarji Desai and Tribhuvandas Patel, they formed their own cooperative in 1946.

Subsequently Dr. Verghese Kurien, the World Food Prize and the Magsaysay Award winner, is the architect of India’s White Revolution, which helped India emerge as the largest milk producer in the world.

Impressed with the development of dairy cooperatives in Kaira District & its success, Shri Lal Bahadur Shastri, the then Prime Minister of India during his visit to Anand in 1964, asked Dr. V Kurien to replicate the Anand type dairy cooperatives all over India. Thus, the National Dairy Developed Board was formed and Operation Flood Programme was launched for replication of the Amul Model all over India.

Operation Flood, the world’s largest dairy development programme, is based on the experience gained from the ‘Amul Model’ dairy cooperatives. The Amul Model of dairy development is a three-tiered structure with the dairy cooperative societies at the village level federated under a milk union at the district level and a federation of member unions at the state level. The facilities at all levels are entirely farmer-owned. The cooperatives are able to build markets, supply inputs and create value-added processing. Thus, Amul Model cooperatives seem to be the most appropriate organizational force for promoting agricultural development using modern technologies and professional management and thereby generating employment for the rural masses and eradicating poverty in these undeveloped areas. India has already demonstrated the superiority of this approach.

THE THREE-TIER "AMUL MODEL"

- The Amul Model is a three-tier cooperative structure. This structure consists of a Dairy Cooperative Society at the village level affiliated to a Milk Union at the District level which in turn is further federated into a Milk Federation at the State level. The above three-tier structure was set-up in order to delegate the various functions, milk collection is done at the Village Dairy Society, Milk Procurement & Processing at the District Milk Union and Milk & Milk Products Marketing at the State Milk Federation. This helps in eliminating not only internal competition but also ensuring that economies of scale is achieved. As the above structure was first evolved at Amul in Gujarat and thereafter replicated all over the country under the Operation Flood Programme, it is known as the ‘Amul Model’ or ‘Anand Pattern’ of Dairy Cooperatives.
- Responsible for Marketing of Milk & Milk Products
- Responsible for Procurement & Processing of Milk
- Responsible for Collection of Milk
- Responsible for Milk Production

OPERATION FLOOD (OF) PROGRAMME/ TECHNOLOGY MISSION
In 1965, the NDDB (National Dairy Development Board) was created in response to then Prime Minister Lal Bahadur Shastri call, which drew up a project called “operation flood” in late sixties. The Amul model has helped India to emerge as the largest milk producer in the world. More than 13 million milk producers pour their milk in 1,28,799 dairy cooperative societies across the country. Their milk is processed in 176 District Co-operative Unions and marketed by 22 State Marketing Federations, ensuring a better life for millions.


- Operation Flood I (OF-I) was launched in 1970 following an agreement with the World Food Programme. The Programme had laid emphasis on setting up of the “Anand Pattern” rural milk producers cooperative organization to procure, process and market milk and to provide some of the essential input services for increasing milk production. The main aim was to set up dairy co-operatives in the milk sheds, so as to link them to four metro cities of Mumbai, Calcutta, Delhi and Chennai to capture a commanding share of the milk markets. The overall objective of OF-I was to lay foundation of a modern dairy industry in India to meet the country’s need for milk and milk products. Funds for operation of OF-I were generated by the sale of World Food Programme aided skim milk powder (SMP) and Butter oil (BO). A total of 116.4 crores was invested in the implementation of the programme.


- The IDA assisted dairy development projects in Karnataka, Rajasthan and Madhya pradesh were utilized as foundations for the operation of OF-II. In this phase there were successful replication of the Anand Pattern with a three tier cooperative structure of societies, unions and federations. The programme had a financial outlay of Rs.273 crores, and helped to market milk in about 148 cities and towns.

**Operation Flood III (1985-96)**

- Major emphasis of OF-III was to consolidate the achievements gained during the earlier phases by improving the productivity and efficiency of the dairy cooperatives and institutional strengthening in the form of training, research, market promotion, monitoring and evaluation. The number of dairy cooperatives societies increased to 70,000 and the capability of dairy processing infrastructure handling up to 137 lakhs litres of milk per day. The estimated cost of this phase of the programme for the period of 1987-96 was Rs. 1303 crores. Moreover, efforts were taken to expand the marketing infrastructure in all major markets, linking them to milk sheds through the national Milk Grid (NMG) to ensure year round stable milk supply.
- The surge in milk production was due to White Revolution under the title Operation Flood (OF)Programme launched in 1970. The real adoption of three tier model / Anand Pattern of dairy cooperatives, OF envisaged sustained increase in resource productivity culminating in improved quality of life of milk producers and assured supply of quality of milk and other dairy products to consumers at reasonable price in a free market environment.
- Following the cooperative path, market oriented milk production and modernization of dairying, milk production, processing and marketing progressed significantly. The programme was implemented with the assistance of World Bank and Food Aid from the European Economic Community (EEC).
- The commodities assistance was also provided from the World Food Programme in the form of milk powder and butter oil. In all, an amount of approximately Rs. 1750 crore was invested in the dairy cooperative sector. This amount was disbursed as 30% grant and 70% loan. The milk processing capacity established was 200 lakh litres per day and average rural milk procurement was 137 lakh litres per day. The programme
was implemented between 1970 to 1996 and covered 170 milk sheds falling under 22 State Cooperative Federations.

- As per World bank expert opinion, for an initial investment of Rs 200 crores in Operation flood II, the net return/year to rural economy has been 2400 crore rupees. No other major development programme all over the world has matched this input-output ratio.

### MILK PROCESSING

#### Introduction

- Normally milk is obtained from the domesticated animals (cow or goat, sheep, or water buffalo) under prevailing conditions at farm level. Smaller quantities, it can be used after boiling but when it is more, processing and storage are highly essential. Milk is collected by milk vendors in milk cans from farm's and transported to chilling centers or processing dairy plant. The milk is immediately cooled to 4°C within 2 hours of milking or the milk should be pasteurized and packed.
- The milk has to be pasteurized before marketed, except for products requiring raw milk at initial stages and or products need direct application of heat desiccation or other heating process.
- There is a consistent increasing demand for new products and processes. The major reasons are an increase in disposable incomes, changes in consumer concerns and perceptions on nutritional quality, hygiene and safety, arrival of foreign brands.

#### Demand forecast for major milk products in the organized sector expressed in metric tonne

<table>
<thead>
<tr>
<th>Product</th>
<th>Demand 1988</th>
<th>Project demand 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghee</td>
<td>100,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Cheese</td>
<td>4,200</td>
<td>15,000</td>
</tr>
<tr>
<td>Paneer</td>
<td>1,000</td>
<td>16,000</td>
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<tr>
<td>Shrikhand</td>
<td>3,000</td>
<td>5,650</td>
</tr>
<tr>
<td>Rasagolla</td>
<td>1,600</td>
<td>6,000</td>
</tr>
<tr>
<td>Gulabjamun</td>
<td>3,000</td>
<td>5,850</td>
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</tbody>
</table>

### DAIRY PLANT REQUIREMENTS AND MANAGEMENT - LOCATION

#### Dairy plant requirements

- The location of the plant should be in a non water logging, well protected / bound area with good access for transportation.
- Should have abundant water (potable) source, waste disposal facility and supply of electricity.

#### Infrastructure requirements

- Civil works with proportionate space and machinery for reception of milk, chilling, storage, separation, pasteurization, homogenization, packaging and product
manufacture. Provisions for quality control, storage, utility units like steam generation and refrigeration control.

- Selection of metals for dairy plant equipments

It should be non toxic non tainting, resistant to corrosion easy for cleaning low cost and durable. normally 18:8 stainless steel or aluminum alloys are preferred

**Layout and Buildings**

The civil works includes factory building, quarters, office, garages, security post etc. The factory building for the milk reception, quality control, processing, packing and storage of milk products should be as per the BIS. The total covered area depends on the processes involved, products manufactured, the quantity of milk handled and the equipment chosen for services and product manufacturing. About 4000 sq.ft. area of building is required for handling 10000 liters of milk

The milk processing plant shall have the following essential facilities.

- Milk Reception Dock consisting of can conveyor, can washer, weighting balance, dump tank etc.
- Processing Hall - cream separator, chiller, homogenizer, pasteurizer and other related machinery are installed.
- Storage area- for milk storage tanks.
- Products manufacturing area-depends upon the type of products and the quantity of milk handled, the required equipment needs to be installed.
- Packing area-for packing of liquid milk and other products.
- Cold storage-for keeping the milk and milk products before sending to market.
- Quality Control Laboratory-for testing the quality of milk and milk products.
- Utilities area-for installing boiler, generator set, water treatment plant, maintenance and store area for spares.
- Waste water treatment plant area-for treating the dairy effluents before releasing to the fields.
- Quarters and office area-for all the essential staff.
- Vehicle parking area-both for the milk procurement and distribution vehicles.
- Input supply area- for providing veterinary service, supply of feed, fodder seeds, etc.

**Plant management**

- Management is the optimal utilization of scarce resources to achieve the organizational objectives like prompt supply of quality milk, providing employment opportunities, protecting the growth and sustainability of dairy industry. It should aim at perfect human resource utilization, minimum energy consumption (water, electricity) and maximum utilization of equipments with assured quality production satisfying the consumer preferences.

**Good manufacturing practice (GMP)**

Good manufacturing practice (GMP) is that part of quality assurance which ensures that products are consistently produced and controlled to the quality standards appropriate to their intended use and as required by the marketing authorization.

- GMP is aimed primarily at diminishing the risks inherent in any production, which may broadly be categorized in two groups: cross contamination/mix-ups and false labeling. Above all, manufacturers must not place clients at risk due to inadequate
safety, quality or efficacy; for this reason, risk assessment (HACCP/ISO certification) has come to play an important role in WHO quality assurance guidelines.

**COMPOSITION AND NUTRITIVE VALUE OF MILK**

**Introduction**

- Milk is an opaque white liquid produced by the mammary glands of mammals. It provides the primary source of nutrition for young mammals before they are able to digest other types of food. The early secretion of udder immediately after parturition is known as colostrum, and carries the immunoglobulins to the young ones. It can reduce the risk of many diseases in the new born. The exact components of raw milk varies by species, but it contains significant amounts of fat, protein and calcium.
- Milk can be defined as the whole, fresh, clean, lacteal secretion obtained by complete milking of udder of one or more healthy milch animals, excluding that obtained in 15 days before or 5 days after calving or such periods as may be necessary to render...
the milk practically colostrum free and containing the minimum prescribed percentages of milk fat and milk solids not fat (SNF).

- Milk serum is defined as milk plasma minus casein micelles, which is close to the composition of whey.

The major constituents of milk are

- Milk
- Water Total Solids (TS)
- Fat Solid Not Fat (SNF)
- Protein (Casein+ Whey Proteins+ NPN) Lactose Minerals and
- Vitamins enzymes etc

<table>
<thead>
<tr>
<th>MILK</th>
<th>FAT</th>
<th>SNF(Solid Not Fat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>TRUE FAT</td>
<td>ASSOCIATED FAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PHOSPHOLIPID</td>
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<td></td>
<td></td>
<td>CHOLESTEROL</td>
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<td>CAROTENE</td>
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<td>LACTOSE</td>
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</tbody>
</table>

**Water**: Constitutes the medium in which the other milk constituents are either dissolved or suspended.

**Milk fat** (lipid) The bulk of the fat in milk exists in the form of small globules, which average size of approximately 2 to 5 microns in size (range 0.1 to 22 microns). Fat exist in oil in water type emulsion. Chemically milk fat is composed of a number of glyceride esters of fatty acids; on hydrolysis, milk fat furnishes a mixture of fatty acids and glycerol.

**Milk proteins** : Proteins are among the most complex of organic substances. Proteins are composed of a large number of amino acids, some are essential and others are none essential Amino acids. The essential amino acids are necessary in the diet for the formation of body proteins. The proteins of milk consist mainly of casein and whey proteins (Beta-lactoglobulin, alpha-lactalbumin, etc). Casein exists only in milk and is found in the form of a calcium caseinate phosphate complex.

**Lactose** / Milk sugar : Lactose, a disaccharide sugar exists only in milk. It is in true solution in the milk serum.
Minor constituents

- Mineral matter of ash: The mineral matter or salts of milk, although present in small quantities, exert considerable influence on the physico chemical properties and nutritive value of milk.
- Phospholipids: In milk three types of phospholipids exist, viz., lecithin cephalin and sphingomylin.
- Cholesterol: This appears to be present in true solution in the fat, as part of the fat globule membrane complex and in complex formation with protein in the non fat protein of milk.
- Pigments: These are (i) fat soluble, such as carotene and xanthophyll and (ii) water soluble, such as riboflavin.
- Enzymes: these are biological Catalysts which can hasten or retard chemical changes themselves participating in the reactions. The important milk enzymes and their specific actions are as follows
  - Analyses (diastase) is a starch splitting enzyme. Lipase is a fat splitting enzyme leading rendering rancid flavour. Phosphatase is capable of splitting certain phosphoric acid esters (basis of phosphates test for checking pasteurization efficiency). Protease is capable of splitting protein. Peroxidase and catalase decomposes hydrogen peroxide.
- Vitamins: Although present in foods in very minute quantities, these are vital for the health and growth of living organisms. Fat soluble vitamins A, D, E and K, and water soluble vitamins of B complex group (such as thiamine or B1, riboflavin or B2, Pantothenic acid niacin pyridoxine or B6 biotin, B12 folic acid etc. and vitamin C (ascorbic acid).

### Percentage Composition of various constituents of milk

<table>
<thead>
<tr>
<th>Species</th>
<th>Water</th>
<th>Fat</th>
<th>Protein</th>
<th>Lactose</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>86.6</td>
<td>4.6</td>
<td>3.4</td>
<td>4.9</td>
<td>0.7</td>
</tr>
<tr>
<td>Buffalo</td>
<td>84.2</td>
<td>6.6</td>
<td>3.9</td>
<td>5.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Goat</td>
<td>86.5</td>
<td>4.5</td>
<td>3.5</td>
<td>4.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Ewe</td>
<td>79.4</td>
<td>8.6</td>
<td>6.7</td>
<td>4.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Camel</td>
<td>86.5</td>
<td>3.1</td>
<td>4.0</td>
<td>5.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Human</td>
<td>87.7</td>
<td>3.6</td>
<td>1.8</td>
<td>6.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Ass</td>
<td>90.0</td>
<td>1.3</td>
<td>1.7</td>
<td>6.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Mare</td>
<td>89.1</td>
<td>1.6</td>
<td>2.7</td>
<td>6.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Dog</td>
<td>75.4</td>
<td>9.6</td>
<td>11.2</td>
<td>3.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Cat</td>
<td>84.6</td>
<td>3.8</td>
<td>9.1</td>
<td>4.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Elephant</td>
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<td>19.6</td>
<td>3.1</td>
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<td>4.8</td>
<td>1.3</td>
<td>3.4</td>
<td>0.9</td>
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<td>19.6</td>
<td>9.5</td>
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<td>45.8</td>
<td>11.2</td>
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</tr>
</tbody>
</table>
FOOD AND NUTRITIVE VALUE OF MILK

- Milk is a balanced established basic food because of its nutrients and biological value in human nutrition. It is a good source of high quality protein, calcium, phosphorus apart from riboflavin and other B-vitamins. The calcium and phosphorus of milk are well utilized by the body. Milk protein has a biological value of 90 per cent. Lysine is one of the essential amino acids, which is abundant in milk proteins. Cheese, khoa, and milk powders are in concentrated forms hence containing high amount of nutrients per unit.
- The unique milk sugar lactose, which is made up of glucose and galactose. Galactose is which is essential for the synthesis of myelin sheath. Lactose, not being easily digestible in the stomach favours the growth of lactic acid bacilli in the intestine, which decreases the pH. This drop in pH favour calcium absorption and non survival of pathogenic micro organisms. Lactose also increases the permeability of the small intestine for calcium ions.
- The milk fat adds specific odour and palatability to milk and is easily digestible. It contains important fatty acids like linoleic acid (2.1%), linolenicacid (0.5%) and arachidonic acid(0.14%). By using cream separator, cream and skim milk can be collected. Skim milk contains only less than 0.5 % fat. Buffalo milk contains high amount of fat.
- Dairy foods are a major source of calcium because of the significant amount of the mineral present. The calcium phosphorus ratio (1:2) in milk is regarded as most favorable for bone development. In addition, dairy products contain other nutrients such as vitamin C and lactose, which favor calcium absorption. The calcium requirement cannot be met easily without taking milk. Milk is a poor source of iron.
- Thiamine occurs in only fair concentration in milk, but is relatively constant in amount. Riboflavin is present in a higher concentration in milk than the other B-vitamins and its stability to heat makes milk a dependable source of this vitamin. In cheese making, riboflavin is present in whey. Because of its sensitivity to light, exposure to sunlight results in 50% reduction in riboflavin. Milk is not a good source of niacin but it is an excellent source of tryptophan. Milk is a very poor source of vitamin C. The fat soluble vitamin A and D in milk depends on their availability in the feed.

Energy value

- Milk fat 9.3 kc/g
- Milk protein 4.1 kc/g
- Milk sugar 4.1 kc/g

MILK CARBOHYDRATE

Carbohydrates are sugar substances made up of molecules called saccharides.
- **Lactose**: Lactose is the milk carbohydrate which is a disaccharide comprising of glucose and galactose. Milk contains approximately 4.9% carbohydrate that is predominately lactose with trace amounts of monosaccharides and oligosaccharides.

- **Physical Properties of Lactose**
  - Lactose exist in solution portion/ serum phase in a dissolved form of fluid milk. Two isomeric forms of lactose, called the α-lactose hydrate anomer and β-lactose hydrate anomer are found in milk. They get converted back and forth between each other.
  - Crystallization of lactose occurs when the concentration of lactose exceeds its solubility. The physical properties of lactose crystals are dependent on the crystal type and can greatly influence the texture of final product. Temperature affects the equilibrium ratio of the α- and β-lactose anomers. Lactose crystals formed at temperatures below 70°F (20°C) are mainly α-lactose crystals. The α-monohydrate lactose crystals are very hard and form, as in ice cream which goes through numerous warming and freezing cycles. This results in an undesirable gritty, sandy texture in the ice cream and condensed milk. The crystal form of β-lactose is sweeter and more soluble than the α-monohydrate lactose and may be preferred in some bakery applications. When a lactose solution is rapidly dried it does not have time to crystallize and forms a type of glass. Lactose glass exists in milk powders and causes clumping due to highly hygroscopic nature.

- **Influence of heat treatments on lactose properties**
  - Lactose is not influenced much by the normal pasteurization conditions. High temperatures used for ultra high temperature (UHT) pasteurization of extended shelf life products and spray drying can cause browning and isomerization reactions, which may affect product quality and nutritional properties. Maillard reaction (The browning reaction), occurs between the lactose and free amino group of protein in milk and produces undesirable flavors and color, and decreases the available content of the amino acid lysine in milk protein. The isomerization reaction is a molecular rearrangement of lactose to lactulose. Lactulose is produced by alcoholic isomerisation of lactose and is used by the pharmaceutical industry in pill production.
Milk fat contains approximately 65% saturated, 30% monounsaturated, and 5% polyunsaturated fatty acids.

Milk fats are made up of fatty acid molecules attached to glycerol. Triglyceride, or triacylglycerol, is the most common type of fat. Mono- and diglycerides are used as emulsifiers, compounds that keep the fat and water from separating in foods such as ice cream.

Individual fatty acids can range in length from 4 to 22 carbons, and may be straight or branching chains. Carbon atoms have 4 bonding sites. Fatty acids may be saturated, which means that each carbon has a single bond to another carbon and 2 hydrogen atoms, or fatty acids may be unsaturated, which means that a carbon has two bonds to the adjacent carbon, called a double bond, and a single bond to another carbon and a hydrogen atom.

A monounsaturated fat has 1 double bond and a polyunsaturated fat has 2 or more double bonds in the carbon chain. A method to denote fatty acids is to write the number of carbons followed by a colon and the number of double bonds.

Other fatty compounds include phospholipids and sterols. The phosphate group, a combination of phosphorus and oxygen, provides phospholipids with surface properties that are active at the interface between compounds soluble in water and those that are not, like fats. Phospholipids are important components of cell membranes. Phospholipids make up approximately 1% of the fat in milk. The two most abundant phospholipids are phosphotidyl choline and sphingomyelin. Sphingomyelin has been shown to have a protective effect in some cancers. Sterols, such as cholesterol, are complex chemical compounds that are important components of hormones.

**Milk fat chemistry**

Milk contains approximately 3.4% total fat. Milk fat has the most complex fatty acid composition of the edible fats. Over 400 individual fatty acids have been identified in milk fat. However, approximately 15 to 20 fatty acids make up 90% of the milk fat. The major fatty acids in milk fat are straight chain fatty acids that are saturated and have 4 to 18 carbons (4:0, 6:0, 8:0, 10:0, 12:0, 14:0, 16:0, 18:0), monounsaturated fatty acids (16:1, 18:1), and polyunsaturated fatty acids (18:2, 18:3). Some of the fatty acids are found in very small amounts but contribute to the unique and desirable flavor of milk fat and butter. For example, the C14:0 and C16:0 β-hydroxy fatty acids.
spontaneously form lactones upon heating which enhance the flavor of butter.

- The fatty acid composition of milk fat is not constant throughout the cow's lactation cycle. The fatty acids that are 4 to 14 carbons in length are made in the mammary gland of the animal. Some of the 16 carbon fatty acids are made by the animal and some come from the animal's diet. All of the 18 carbon fatty acids come from the animal's diet. There are systematic changes in milk fat composition that are due to the stage of lactation and the energy needs of the animal.

- Milk fat contains approximately 65% saturated, 30% monounsaturated, and 5% polyunsaturated fatty acids. From a nutritional perspective, not all fatty acids are created equal. Saturated fatty acids are associated with high blood cholesterol and heart disease. However, short chain fatty acids (4 to 8 carbons) are metabolized differently than long chain fatty acids (16 to 18 carbons) and are not considered to be a factor in heart disease. Conjugated linoleic acid is a trans fatty acid in milk fat that is beneficial to humans in many ways. These issues are discussed in the Milk and Human Health section.

- The fatty acids are arranged on the triglyceride molecule (Figure 1) in a specific manner. Most of the short chain fatty acids are at the bottom carbon position of the triglyceride molecule, and the longer fatty acids tend to be in the middle and top positions. The distribution of the fatty acids on the triglyceride backbone affects the flavor, physical, and nutritional properties of milk fat.

**Physical properties of milk fat**

- The melting point of Milk fat is over a wide temperature range, of approximately -40°F (-40°C) to 104°F (40°C). This is evident from the firmness of butter at refrigerator temperature versus room temperature. At refrigerator temperature butter is approximately 50% solid, but is only about 20% solid at room temperature, which is why it spreads more easily as the temperature increases. The melting properties of milk are a result of the melting points of the individual fatty acids that make up milk fat and their arrangement on the triglyceride molecule.

- The triglycerides of milk fat are in the form of globules. The globules are surrounded by a protein and phospholipid membrane that stabilizes the globules in the serum (water) phase of milk. The native globules range in size from less than 1 µm to over 10 µm. The uneven size distribution allows the larger globules to float in a process called creaming, thus resulting in a “cream line” at the top of the container. Milk is homogenized to reduce the size of the large globules to less than 1 µm, create a uniform distribution of globules throughout the serum phase, and minimize creaming.

<table>
<thead>
<tr>
<th>Molecular formula</th>
<th>Chain length</th>
<th>Melting point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyric</td>
<td>CH₃(CH₂)₂COOH</td>
<td>C₄</td>
</tr>
<tr>
<td>Caproic</td>
<td>CH₃(CH₂)₄COOH</td>
<td>C₆</td>
</tr>
<tr>
<td>Fatty Acid</td>
<td>Chemical Formula</td>
<td>Chain Length</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Caprylic</td>
<td>CH₂(CH₂)₆COOH</td>
<td>C₈</td>
</tr>
<tr>
<td>Capric</td>
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<tr>
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<td>CH₃.CH₂(CH=CH.CH₂)₃(CH₂)₆COOH</td>
<td>C₁₈: 3</td>
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</table>

### General Protein Definition & Chemistry

- Proteins are chains of amino acid molecules connected by peptide bonds.
- There are many types of proteins and each has its own amino acid sequence (typically containing hundreds of amino acids). There are 22 different amino acids that can be combined to form protein chains. There are 9 amino acids that the human body cannot make and must be obtained from the diet. These are called the essential amino acids.
- The amino acids within protein chains can bond across the chain and fold to form 3-dimensional structures. Proteins can be relatively straight or form tightly compacted globules or be somewhere in between. The term “denatured” is used when proteins unfold from their native chain or globular shape. Denaturing proteins is beneficial in some instances, such as allowing easy access to the protein chain by enzymes for digestion, or for increasing the ability of the whey proteins to bind water and provide a desirable texture in yogurt production.

### Milk Protein Chemistry

- Milk contains about 3.3% total protein. Milk proteins contain all 9 essential amino acids required by humans. Milk proteins are synthesized in the mammary gland, but 60% of the amino acids used to build the proteins are obtained from the cow's diet. Total milk protein content and amino acid composition varies with cow breed and individual animal genetics.
- There are 2 major categories of milk protein that are broadly defined by their chemical composition and physical properties. The casein family contains phosphorus and will coagulate or precipitate at pH 4.6. The serum (whey) proteins do not contain phosphorus, and these proteins remain in solution in milk at pH 4.6. The principle of coagulation, or curd formation, at reduced pH is the basis for cheese curd formation. In cow's milk, approximately 82% of milk protein is casein and the remaining 18% is serum, or whey protein.
- The casein family of protein consists of several types of caseins (α-s1, α-s2, β, and 6) and each has its own amino acid composition, genetic variations, and functional properties. The caseins are suspended in milk in a complex called a micelle.
• The serum (whey) protein family consists of approximately 50% ß-lactoglobulin, 20% α-lactalbumin, blood serum albumin, immunoglobulins, lactoferrin, transferrin, and many minor proteins and enzymes. The functions of many whey proteins are not clearly defined, and they may not have a specific function in milk but may be an artifact of milk synthesis. The function of ß-lactoglobulin is thought to be a carrier of vitamin A. It is interesting to note that ß-lactoglobulin is not present in human milk. α-Lactalbumin plays a critical role in the synthesis of lactose in the mammary gland. Immunoglobulins play a role in the animal’s immune system, but it is unknown if these functions are transferred to humans. Lactoferrin and transferrin play an important role in iron absorption and there is interest in using bovine milk as a commercial source of lactoferrin.

Milk Protein Physical Properties

• The caseins in milk form complexes called micelles that are dispersed in the water phase of milk. The casein micelles consist of subunits of the different caseins (α-s1, α-s2 and ß) held together by calcium phosphate bridges on the inside, surrounded by a layer of 6-casein which helps to stabilize the micelle in solution.
• Casein micelles are spherical and are 0.04 to 0.3 µm in diameter, much smaller than fat globules which are approximately 1 µm in homogenized milk. The casein micelles are porous structures that allow the water phase to move freely in and out of the micelle. Casein micelles are stable but dynamic structures that do not settle out of solution.
• The whey proteins exist as individual units dissolved in the water phase of milk.

VITAMINS & MINERALS IN MILK

Vitamins in milk

• Vitamins play many roles in the body, including metabolism co-factors, oxygen transport and antioxidants. They help the body to use all nutrients.
• Milk contains the water soluble vitamins thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), pantothenic acid (vitamin B5), pyridoxine (vitamin B6), Cyanocobalamin (vitamin B12), vitamin C, and folate. Milk is a good source of thiamin, riboflavin and vitamin B12. Milk contains small amounts of niacin, pantothenic acid, vitamin B6, vitamin C, and folate and is not considered a major source of these vitamins in the diet.
• Milk contains the fat soluble vitamins A, D, E, and K. The content level of fat soluble vitamins in dairy products depends on the fat content of the product. Reduced fat (2% fat), lowfat (1% fat), and skim milk must be fortified with vitamin A to be nutritionally equivalent to whole milk. Fortification of all milk with vitamin D is voluntary. Milk contains small amounts of vitamins E and K and is not considered a major source of these vitamins in the diet.

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Role of vitamin in human health</th>
<th>Amount in 1 glass (250mL) of regular milk</th>
<th>Daily requirement - Australian adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Healthy skin, eyes &amp; hair; immunity</td>
<td>120 ug</td>
<td>750 ug RE*</td>
</tr>
</tbody>
</table>
B1 - Thiamin | Energy production and growth | 0.05 mg | 0.8 - 1.1 mg

B2 - Riboflavin | Promotes growth; healthy eyes, hair, skin & nails | 0.5 mg | 1.2 - 1.7 mg

B6 - Pyridoxine | Essential for protein metabolism; healthy skin, hair & nails | 0.15 mg | 1.2 - 1.6 mg

B12 - Cyanocobalamin | Growth & maintenance of the nervous system; required for body cell formation & healthy blood | 1 ug | 2 ug

D | Works together with calcium and phosphorous for healthy bones & teeth | 2 ug | No RDI set

Folate (folic acid) | Acts with B12 to assist body cell formation; important before and during early pregnancy | 15 ug | 200 ug

*RE = retinol equivalents

Vitamins are essential for good health, growth and development. Lack of vitamins can result in deficiency diseases. Milk is a source of many vitamins, including vitamins A, B1, B2, B6, B12, vitamin D and folate. Vitamins A and D are soluble in fat and can be stored in the body. The B vitamins and folate are soluble in water, and as they are not stored in the body, must be obtained regularly from the foods we eat.

**Minerals in milk**

- Minerals have many roles in the body including enzyme functions, bone formation, water balance maintenance, and oxygen transport. The specific content of minerals in milk is listed in the Nutrient Content Tables in the Nutrition Facts section.
- Milk is a good source of calcium, magnesium, phosphorus, potassium, selenium, and zinc. Many minerals in milk are associated together in the form of salts, such as calcium phosphate. In milk approximately 67% of the calcium, 35% of the magnesium, and 44% of the phosphate are salts bound within the casein micelle and the remainder are soluble in the serum phase.
- Milk contains small amounts of copper, iron, manganese, and sodium and is not considered a major source of these minerals in the diet.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Role of mineral in human health</th>
<th>Amount in 1 glass (250mL) of regular milk</th>
</tr>
</thead>
</table>

*RE = retinol equivalents
**Calcium** Maintains strong bones & teeth; regulates nerve & muscle function | 295 mg
---
**Phosphorous** Works with calcium and magnesium to maintain bone structure | 232 mg
---
**Magnesium** Maintains bone structure; required for muscle & nerve function | 27 mg
---
**Zinc** Important for immunity; healing; reproduction | 1 mg

- Minerals are nutrients required by humans in small amounts for body metabolism and functions such as body maintenance, structure and regulation. Minerals can’t be made in the body and must be obtained from foods we eat.
- There are two classes of minerals: major minerals and trace elements, which are equally important for optimal health. There are seven major minerals (calcium, sodium, potassium, magnesium, phosphorous, chloride and sulphur) which are required in the body in larger amounts than the trace element minerals. Trace element minerals, such as iron, fluoride and iodine, are required in trace (very small) amounts by humans.

**MILK ENZYMES**

- Enzymes are a group of proteins that have the ability to catalyze chemical reactions and the speed of such reactions. The action of enzymes is very specific. Milk contains both indigenous and exogenous enzymes. Exogenous enzymes mainly consist of heat-stable enzymes produced by psychrotrophic bacteria: lipases, and proteinases. There are many indigenous enzymes that have been isolated from milk. The most significant group are the hydrolases:
- Enzymes are proteins that have biological functions. Milk enzymes come from several sources: the native milk, airborne bacterial contamination, bacteria that are added intentionally for fermentation, or in somatic cells present in milk.
- Each enzyme has a specific site of action on its target molecule, and optimal conditions (pH and temperature).
- Lipases are enzymes that degrade fats. The major lipase in milk is lipoprotein lipase. It is associated with the casein micelle. Agitation during processing may bring the lipase into contact with the milk fat resulting in fat degradation and off-flavors. Pasteurization will inactivate the lipase in milk and increase shelf life.
- Proteases are enzymes that degrade proteins. The major protease in milk is plasmin. Some proteases are inactivated by heat and some are not. Protein degradation can be undesirable and result in bitter off-flavors, or it may provide a desirable texture to cheese during ripening. Proteases are important in cheese manufacture, and a considerable amount of information is available in the cheese literature.
- **Alkaline phosphatase:** Alkaline phosphatase is a heat sensitive enzyme in milk that is used as indicator of pasteurization. If milk is properly pasteurized, alkaline phosphatase is inactivated. Phosphatase enzymes are able to split specific phosphoric acid esters into phosphoric acid and the related alcohols. Unlike most milk enzymes, it has a pH and temperature optima differing from physiological values; pH of 9.8. The enzyme is destroyed by minimum pasteurization temperatures, therefore, a phosphatase test can be done to ensure proper pasteurization.
- Lactoperoxidase is one of the most heat-stable enzymes found in milk. Lactoperoxidase, when combined with hydrogen peroxide and thiocyanate, has antibacterial properties. It is suggested that the presence of lactoperoxidase in raw
milk inhibits the disease causing microorganisms (pathogens) present in milk. However, since there is no hydrogen peroxide or thiocyanate present in fresh milk, these compounds would have to be added to milk in order to achieve the antibacterial benefits. Lysozyme is another enzyme that has some antibacterial activities, although the amount of lysozyme present in milk is very small.

- **Lactoperoxidase:** Lactoperoxidase is present in cow milk in considerable amount (30mg/ml) but is absent in human milk. This enzyme has been found to be identical with L2 fraction of lactenin. In bovine raw milk the inhibitory action of this enzyme is due to formation of an anti microbial system or LP system under normal conditions.

- The secretion of thiocyanate component in milk is governed by nutrition of the cow. Hydrogen peroxide can be contributed either by polymorpho-nuclear-leucocytes (PMN) or by hydrogen peroxide producing udder micro flora E.g. Streptococci.

- The LP system is bacteriostatic to MO like Group B and Group N Streptococci where as it is bacteriocidal for Group A Streptococci, E.coli, S.typhimurium etc. It protects calf against enteric problems and may have some role in providing defence mechanism to mammary gland against infections.

- Lately attempts have been made to exploit the LP system as a method of preservation (cold sterilization) for raw milk. Unlike in the conventional method of preservation by heat treatment, there is no inactivation of anti microbial substances and other heat labile constituents of raw milk in the process (like certain vitamins). In these efforts, the two components of LP system viz thiocyanate and Hydrogen peroxide are added from outside to attain their balanced proportions.

- **Lipoprotein lipase (LPL):** A lipase enzyme splits fats into glycerol and free fatty acids. This enzyme is found mainly in the plasma in association with casein micelles. The milk fat is protected from its action by the FGM. If the FGM has been damaged, or if certain cofactors (blood serum lipoproteins) are present, the LPL is able to attack the lipoproteins of the FGM. Lipolysis may be caused in this way.

- **Plasmin:** Plasmin is a proteolytic enzyme; it splits proteins. Plasmin attacks both β-casein and alpha(s2)-casein. It is very heat stable and responsible for the development of bitterness in pasteurized milk and UHT processed milk. It may also play a role in the ripening and flavour development of certain cheeses, such as Swiss cheese.

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**MODULE-4: FACTORS AFFECTING COMPOSITION OF MILK**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Genetic factor and
- External factor.

**FACTORS AFFECTING COMPOSITION OF MILK**

- Milk differs widely in composition. The constituents of milk are same irrespective of species, breed and age. The vary in quantity of availability. Milk from individual cows shown greater variation than mixed herd milk. In general, milk fat shows the greatest daily variation, then comes protein, followed by ash and sugar.

- The factors affecting the composition of milk are:
  - **Species:** Each species yields milk of a characteristic composition eg Cow, buffalo, dog or deer
  - **Breed:** In general there is difference in composition among different breeds of the same species.
**Interval of milking:** Longer the interval between milking more will be the quantity of milk with lesser fat and vice versa.

**Completeness of milking:** If the cow is completely milked, the test is normal. Incomplete milk leads to residual milk and thus the fat content gets reduced.

**Frequency of milking:** Whether a cow is milked twice, thrice or four times a day, there is increase in volume during early lactation. (times/day vs. 2 times/day milking. In dairy cattle, milking 3X/day results in increased milk yield, although the observed increase is variable. Generally 3X/day milking increases milk production by up to 25%. But, ~2/3 of this increase is due to better feeding and management and ~1/3 is due to decreased udder pressure. 3X/day milking must be accompanied by a compensatory feeding program; if not, then yield from the continued 3X/d milking will decline back to that from 2X/d. Three times per day milking is more beneficial in late lactation, for example during the first 4 mos. of lactation 3X/day milking increases yield 7-12% over 2X/d. In contrast, during later lactation 3X/day milking increases yield 16-90% over 2X/d. Both first lactation and older cows show increased yield in 3X/day vs. 2X/day milking.

**Irregularity of milking:** frequent changes in the time and interval of milking result in lower tests.

**Day-to-day milking:** May show variations for the individual cows.

**Disease and abnormal conditions:** These end to alter the composition of milk, especially when they result in a fall in yield.

**Portion of milking:** fore-milk is low in fat content (less than 1 per cent), while strippings are highest (close to 10 per cent). The other milk constituents are only slightly affected on a fat free basis.

**Stage of lactation:** The first secretion after calving (colostrum) is very different from milk in its composition and general properties. The change from colostrum to milk takes place within a few days.

**Yield:** For a single cow; there is a tendency for increased yields to be accompanied by a lower fat percentage, and vice versa.

**Feeding:** Has temporary effect only.

**Season:** The percentages of both fat and solids not fat show slight but well defined variations during the course of the year

**Age:** The fat percentage in milk declines slightly as the cow grows older.

**Condition of cow at calving:** If the cow is in good physical condition when calving, it will yield milk of a higher fat percentage than it would if its physical condition was poor.

**Excitement:** Both yield and composition of milk are liable to transient fluctuations during periods of excitement, for whatever reason.

**Administration of drugs and hormones:** Certain drug may effect temporary change in the fat percentage, injection of feeding of hormones results in increase of both milk yield and fat percentage.

Milk composition is affected by genetic and environmental factors.

## GENETIC FACTOR

### Breed and individual cow

- Milk composition varies considerably among breeds of dairy cattle: Jersey and Guernsey breeds give milk of higher fat and protein content than Shorthorns and Friesians. Zebu cows can give milk containing up to 7% fat.

### Variability among cows within a breed
• The potential fat content of milk from an individual cow is determined genetically, as are protein and lactose levels. Thus, selective breeding can be used to upgrade milk quality.
• Heredity also determines the potential milk production of the animal. However, environment and various physiological factors greatly influence the amount and composition of milk that is actually produced.
• Herd recording of total milk yields and fat and SNF percentages will indicate the most productive cows, and replacement stock should be bred from these.

**EXTERNAL FACTOR**

**Interval between milkings**

• The fat content of milk varies considerably between the morning and evening milking because there is usually a much shorter interval between the morning and evening milking than between the evening and morning milking. If cows were milked at 12-hour intervals the variation in fat content between milkings would be negligible, but this is not practicable on most farms.
• Normally, SNF content varies little even if the intervals between milkings vary.

**Stage of lactation**

• The fat, lactose and protein contents of milk vary according to stage of lactation. Solids-not-fat content is usually highest during the first 2 to 3 weeks, after which it decreases slightly.
• Fat content is high immediately after calving but soon begins to fall, and continues to do so for 10 to 12 weeks, after which it tends to rise again until the end of the lactation.

**Age**

• As cows grow older the fat content of their milk decreases by about 0.02 percentage units per lactation. The fall in SNF content is much greater.

**Feed and feeding practices**

• Underfeeding reduces both the fat and the SNF content of milk produced, although SNF content is more sensitive to feeding level than fat content. Fat content and fat composition are influenced more by roughage (fibre) intake.
• The SNF content can fall if the cow is fed a low-energy diet, but is not greatly influenced by protein deficiency, unless the deficiency is acute.

**Health status**

• Both fat and SNF contents get altered due to disease. During mastitis the milk changes to alkalinity.

**Method of milking**

• The first milk drawn from the udder is low in fat while the last milk (or strippings) is always quite high in fat. Thus it is essential to mix thoroughly all the milk removed, before taking a sample for analysis.
The fat left in the udder at the end of a milking is usually picked up during subsequent milkings, so there is no net loss of fat.

**MODULE-5: PHYSICOCHEMICAL PROPERTIES OF MILK**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Physical properties and
- Chemical properties of milk.

**PHYSICOCHEMICAL PROPERTIES OF MILK**

Milk is the physiological secretion of normally functioning udder. It is a very complex substance having many characteristics and physical properties, the knowledge of which is essential since it will be useful when milk is used to prepare products and when it is subjected to many processing to make it safe.

Water is the dispersion media for other solids. It is in continuous phase of liquid to which the constituents are dispersed. Solids exist in 3 states of dispersion. They are,

- Coarse dispersion [particles greater than 0.001 mm]
- Colloidal dispersion [particles between 0.001 mm and 0.000001 mm]
- Molecular dispersion [particles Less than 0.000001 mm].

**Materials in solution**

- Materials in solution are called materials in molecular dispersion. These include most of salts, lactose, part of albumin, globulin. A true solution is defined as one in which the molecules are dispersed individually. Some of the albumin and globulin, which are large in size, also exist in colloidal state.

**Materials in colloidal dispersion**

- Here the particles are microscopic but they are large enough to be held by an ultra filter. E.g. Calcium caseinate, part of albumin and globulin and calcium phosphate. These can be separated by dialyzes through appropriate membrane [semi permeable membrane]. For the suspension of these colloids, certain materials are required and these are called as stabilizers. In milk, the colloids themselves function as stabilizers to each other.

**Materials in coarse dispersion**

- Butterfat is suspended as tiny spherical particles called fat globules. Cellular constituents also come under this category [E.g. In mastitis, leukocyte count of milk exceed 5 lakhs]. Fat particles vary in size from 0.1 m to 10 m in diameter, with an average of 3 m .1 ml of milk will contain approximately 2-4 million fat globules.
PHYSICAL PROPERTIES OF MILK

Milk Acidity

- pH of milk is approximately 6.6, which lies on the acid side of neutral (7). Fresh milk drawn from the udder possesses a certain acidity termed as natural acidity, which has to be distinguished from developed acidity in the form of lactic acid. Normal acidity or natural acidity is due to casein, acid phosphates and citrate and to a lesser extent by albumin, globulin and CO₂. Natural acidity varies from one cow to another. It ranges from 0.08-0.30%. Colostrum has high natural acidity because of its high protein content. Acidity is higher than normal during the early lactation period. It falls to normal in about 2 months of lactation.
- Titrable acidity or total acidity is equal to natural acidity and developed acidity. Natural acidity is also called as apparent acidity. Developed acidity is also called as real or true acidity. Titrable acidity is used as rapid platform test for accepting or rejecting milk and to find whether the milk is suitable for heat processing, because the developed acidity lowers the temperature of heat coagulation of casein. 0.18 to 0.19% is taken as a deciding line between satisfactory and unsatisfactory milk samples.
- Milk of high natural acidity is usually high in their total solids content. They have a fair quantity of buffering substances like proteins, phosphates and citrate, which resist changes in pH when acids or alkali are added. So milk of high natural acidity is highly buffered. Such milk requires more lactic acid to develop before the pH reaches the isoelectric point of casein [pH 4.6] which means that a longer time will be required before such samples curdle at ordinary temperature. High natural acidity increases the keeping quality.

Colour

- Characteristic white colour or white opalescence of the milk is due to scattering of light by the colloidal particles. Yellow colour of the milk is due to the carotene. The intensity of yellow colour increases in cow milk when they are fed with green fodder. Buffalo milk is white in colour due to the absence of carotene which is efficiently converted to vitamin A. Dilute acid or rennet when added results in coagulation of casein and fat and the separated whey will be having a distinct greenish yellow colour due to the pigment riboflavin.
- The colour of the opaque object is the colour it results. Thus an object is yellow because more yellow light is reflected to the eye than any other colour. (A white object reflects all the colours of the light that fall on it while a black object absorbs all of them).

Flavour

- A property very difficult to define. It is a combination of taste and smell. Milk has a characteristic mild, pleasant flavour. Sweet taste of lactose is balanced against the salty taste of chlorides. Some research workers attribute the rich flavour of milk to the fat present in milk. As lactation advances, lactose declines while chloride increases; the taste is deflected towards salty. A similar effect is caused by udder infections. When odouriferous substances like garlic are fed, milk gets the characteristic taste, by its passage to the milk from the blood. Milk also absorb the volatile vapors present in the atmosphere. Both these types can be avoided by feeding such feeds immediately after milking. Feeding molasses and beet by-products sometimes causes fishy flavour. Metals like copper acts as a catalyst to develop oily taints if it is present in a concentration of 3 ppm; it imparts a metallic taste. Cows
suffering from ketosis produce milk with cowy odour due to entry of ketone bodies from blood to milk. As lactic acid develops, the flavour of milk changes towards characteristic sour odour. This is due to the production of various by products like butyric acid, diacetyl, etc.

**Specific gravity**

- The term specific gravity as applied to milk means the weight of the given volume of milk compared with the weight of same volume of water at the same temperature
- Average specific gravity of milk and its components at 60 ° F (15.6 ° C)
  - Cow milk : 1.028-1.030
  - Skim milk : 1.035-1.037
  - Buffalo milk : 1.030-1.032
  - Water : 1
  - Fat : 0.93
  - Protein : 1.346
  - Lactose : 1.666
  - Salts : 4.12
  - SNF : 1.616
- The variation in specific gravity of different individuals milk is due to the flocculation in water, fat, protein, lactose and minerals of milk. There will be difference in specific gravity of liquid fat and solid fat. One of the peculiarities of milk fat is that there is appreciable time lag in adjusting its physical condition to a change in temperature. Addition of water lowers the specific gravity. High fat milk has low density. Removal of fat results in separated milk or skim milk or defatted milk, which has a higher specific gravity, can be restored by adding water.
- Specific gravity is lowered by addition of water, addition of cream or by increasing the temperature, while the contrary effect is caused by addition of separated milk or skim milk, removal of fat or lowering the temperature.

**Recknagel phenomenon**

The specific gravity of freshly drawn milk is low. It increases by 0.001 as time advances. This is due to

- Partial cooling and solidification of fat
- Hydration of protein
- Loss of CO₂
- Escape of air bubbles.

**Surface tension**

- Surface tension is due to the force of attraction between molecules. When compared to water surface tension of milk is low. The surface tension of milk at 20 ° C is 54.5 dynes/cm. It decreases as the temperature is raised (at 60 ° C it is about 40-45 dynes/cm). The presence of fat lowers the surface tension. Whole milk has a slightly lower surface tension than skim milk and that of cream is still lower. Milk and cream on aging undergo a slight decrease in surface tension. Colloidal constituents like proteins also lower the surface tension along with fat globules. The substances, which lower the surface tension, will get concentrated at the liquid air interspace. When milk is warmed, calcium caseinate gather at the liquid air interspace together with small amount of fat globules, albumin & globulin. If milk is agitated similar concentration occurs around the air bubbles & the phenomenon of frothing or foaming occurs.
• Recknagel found that the specific gravity of freshly drawn milk was lower than the specific gravity subsequently obtained, after an hour or later. He found that the rise in specific gravity to be regular, more rapid at lower temperatures than at higher ones and to amount on an average of 0.001. This is called Recknagel's phenomenon.

**Viscosity**

• The viscosity of a substance refers to its resistance to flow. It is a measure of friction between molecules as they slide. Milk is considerably more viscous than water mainly on account of fat emulsion and colloidal particles. Homogenization increases viscosity. Increase in temperature causes reduction in viscosity. At 20 °C, milk will be half viscous as it is at 0 °C and at 40 °C, it will be 1/3rd viscous as it is at 0 °C.

**Oxidation-reduction potential**

• In case of organic materials, oxidation is defined as the uptake of oxygen or loss of hydrogen. In the same manner, reduction may be defined as the process of loosing oxygen or gaining hydrogen. In ionic system, it can be demonstrated that phenomenon may involve loss or gain of electrons. In practice, the potential difference created by platinum electrode in a solution of an oxidant or reductant is measured by completing a circuit through calomel half-cells and a potentiometer. The voltage measured under these conditions reflects the oxidizing or reducing capacity of the solution. This potential is called as oxidation-reduction potential or O-R potential (or) redox potential and is designated by Eh.

• The O-R potential of milk normally falls within the range of +0.2 to +0.3 volts. In milk, the O-R potential is controlled by the following substances.
  o Dissolved O2
  o Ascorbic acid
  o Riboflavin
  o Lactose
  o Cysteine
  o Cystine

• Milk under anaerobic conditions as in udder has O-R potential of 0.13 volts. It increases to +0.3 volts on contact with air in the atmosphere. The bacterial action reduces the O-R potential. Methylene Blue dye Reduction Test (MBRT) is based on the principle of lowering of the O-R potential through use of available oxygen by the microorganisms.

**Refractive index**

• Milk has a refractive index of about 1.35 and that of water is 1.33. So addition of water lowers the refractive index.

**Boiling point**

• Boiling point of any liquid is the temperature at which at the given pressure the material is in equilibrium both as a liquid and as a gas. This is the temperature at which the liquid phase will vaporize and the gas phase condense or liquefy according to the heat supply.

• Water boils at 100 °C under normal atmospheric temperature and pressure. The presence of dissolved substances increases the boiling point of a solution. Since milk contains several dissolved substances, it has higher boiling temperature than that of water. Because there is variation in the dissolved substances, the boiling point of milk also varies between 100.15-100.17 °C [100.2-101.02].
Freezing point

- The freezing point is the temperature at which, at a given pressure, a material is in equilibrium as both a solid and as a liquid. This is the temperature at which the liquid phase may freeze or crystallize and the solid phase may melt or liquefy.
- Pure distilled water freezes at 0 °C under normal atmospheric pressure. Milk freezes at a temperature slightly lower than that of water due to soluble constituents like lactose, soluble salts [chlorides] which lower and depress the freezing point [to an extent of 75% total depression]. Fat and protein, two variable constituents of milk will have very little influence on the freezing point depression. The range of value is – 0.525 to –0.565 °C [-0.55 °C]. Season has no influence on freezing point. By determining the freezing point in milk, it can be ascertained whether water is added or not. The equipment used to determine the freezing point of milk is Hortvet cryoscope.

Percentage of water

\[
\text{added to milk} = \frac{T-T'}{T} \times 100
\]

Where,

\[
T = \text{normal freezing point} \ [-0.55^\circ C] \\
T' = \text{observed freezing point of the given sample.}
\]

The addition of 1% water to milk will raise the freezing point by 0.006°C.

Limitations of freezing point estimation

- It is unable to find out addition of separated milk.
- It is unable to detect the removal of fat in milk.
- Freezing point is seriously affected by the developed acidity.

Electrical conductivity

- In a pure solution, the conductivity is a function of the ionic concentration. In an heterogeneous system such as exists in milk, the fat and the colloidally dispersed substances obstruct the ions in their migration and decrease the conductivity. The electrical conductivity increases with increase in temperature. About 80% of current in milk is carried by chloride ions [chloride content increases during mastitis]. The electrical conductivity value of cow milk is 0.005 ohm \( \cdot \) cm \( \cdot \) at 25 °C.

Adhesiveness of milk

- When a piece of paper is moistened with milk, it sticks to surface of wood or glass or metal due to casein glue.

Cream Raising

- When milk is allowed to stand, fat rises to the top and eventually forms a layer packed with fat globules called cream. This is due to the difference in the specific gravity of serum and fat. One drop of milk contains about one lakh globules with the diameter varying from 0.3 to 10 m.
Foaming

- It is due to materials that lower the surface tension like milk protein and fat. Milk fat not only increases the foaming, but also increases the stability of the foam.

**MODULE-6: MICROBIOLOGICAL DETERIORATION OF MILK AND MILK PRODUCTS**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Micro organisms milk and
- Microbial spoilage of milk and milk products.

**MICROORGANISMS IN MILK**

- Milk is sterile at secretion in the udder but is contaminated by bacteria even before it leaves the udder. Except in the case of mastitis, the bacteria at this point are harmless and few in number. Further infection of the milk by microorganisms can take place during milking, handling, storage, and other pre-processing activities.
- The bacteria can bring in beneficial effects or spoilage to milk. Some of the beneficial bacteria especially the lactic acid bacteria are called probiotics. These probiotics are finding a better place in the nutraceutical dairy and other food products which bring health benefits to the consumer like control of diarrhea, anti hypertensive, hypocholesterolemic, immunostimulatory, anticarginogenic etc

**Lactic acid bacteria**

This group of bacteria are able to ferment lactose to lactic acid called homofermentative and with more end products called heterofermentative. They are normally present in the milk and are also used as starter cultures in the production of cultured dairy products such as yogurt. Some examples in milk are:

- Lactococci
- *L. delbrueckii* subsp. *lactis* (*Streptococcus lactis*)
- *Lactococcus lactis* subsp. *cremoris* (*Streptococcus cremoris*)
- lactobacilli
- *Lactobacillus casei*
- *L. delbrueckii* subsp. *lactis* (*L. lactis*)
- *L. delbrueckii* subsp. *bulgaricus* (*Lactobacillus bulgaricus*)
- *Leuconostoc*

Other species present in milk includes strains of *Bacillus, Clostridium, Cornebacterium, Arthrobacter, Lactobacillus, Microbacterium, Micrococcus*, and *Streptococcus* can survive pasteurization and grow at refrigeration temperatures which can cause spoilage problems.

**Coliforms**

- Coliforms are facultative anaerobes with an optimum growth at 37º C. Coliforms are indicator organisms; they are closely associated with the presence of pathogens but not necessarily pathogenic themselves. They also can cause rapid spoilage of milk because they are able to ferment lactose with the production of acid and gas, and are
able to degrade milk proteins. They are killed by HTST treatment, therefore, their presence after treatment is indicative of contamination. *Escherichia coli* is an example belonging to this group.

**Significance of microorganisms in milk**

- Information on the microbial content of milk can be used to judge its sanitary quality and the conditions of production
- If permitted to multiply, bacteria in milk can cause spoilage of the product
- Milk is potentially susceptible to contamination with pathogenic microorganisms. Precautions must be taken to minimize this possibility and to destroy pathogens that may gain entrance
- Certain microorganisms produce chemical changes that are desirable in the production of dairy products such as cheese, yogurt.

**Spoilage microorganisms in Milk**

- The microbial quality of raw milk is crucial for the production of quality dairy foods. Spoilage is a term used to describe the deterioration of a foods' texture, colour, odour or flavor to the point where it is unappetizing or unsuitable for human consumption. Microbial spoilage of food often involves the degradation of protein, carbohydrates, and fats by the microorganisms or their enzymes.
- In milk, the microorganisms that are principally involved in spoilage are psychrotrophic organisms. Most psychrotrophs are destroyed by pasteurization temperatures, however, some like *Pseudomonas fluorescens*, *Pseudomonas fragi* can produce proteolytic and lipolytic extracellular enzymes which are heat stable and capable of causing spoilage.

**Pathogenic microorganisms in milk**

- Hygienic milk production practices, proper handling and storage of milk, and mandatory pasteurization has decreased the threat of milk borne diseases such as tuberculosis, brucellosis, and typhoid fever. There have been a number of foodborne illnesses resulting from the ingestion of raw milk, or dairy products made with milk that was not properly pasteurized or was poorly handled causing post-processing contamination. The following bacterial pathogens are still of concern today in raw milk and other dairy products:
  - *Bacillus cereus*
  - *Listeria monocytogenes*
  - *Yersinia enterocolitica*
  - *Salmonella* spp.
  - *Escherichia coli* O157:H7
  - *Campylobacter jejuni*
- It should also be noted that moulds, mainly of species of *Aspergillus*, *Fusarium*, and *Penicillium* can grow in milk and dairy products. If the conditions permit, these moulds may produce mycotoxins which can be a health hazard. *M. luteus*, *M. varians*, and *M. freudenreichii*, are sometimes referred to as milk micrococci and can result in spoilage of milk products.

**MICROBIAL SPOILAGE OF MILK AND MILK PRODUCTS**

- Spoilage occurs when microorganisms degrade the carbohydrates, proteins, fats of milk and produce noxious, end products. Milk products as follows;
<table>
<thead>
<tr>
<th>Spoilage type</th>
<th>Organisms involved</th>
<th>Signs of spoilage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soursing</td>
<td>Lactobacillus sp. Streptococcus sp.</td>
<td>Sour milk, Curd formation</td>
</tr>
<tr>
<td>Proteolysis</td>
<td>Pseudomonas sp. Bacillus sp. Bacillus subtilis, B. cereus var. mycoides, Pseudomonas putrefaciens, p. viscose, Streptococcus, liquefaciens, and proteus spp.</td>
<td>Bitterness</td>
</tr>
</tbody>
</table>
| Sweet curdling| Bacillus sp. | Alkaline pH  
Proteus sp.  
Micrococcus sp. | Curd formation |
| Lipolysis     | Pseudomonas sp. Pseudomonas fluorescens Achromobacter lipolyticum; yeasts, e.g., Candida lipolytica; and moulds, e.g., Pencillium spp., Geotrichum candidum. | Rancid odour |
| Gas production| Clostridium sp.  
Coliform bacteria, Certain yeasts, e.g., Torula cremoris, Candida pseudotropicalis, and Torulopsis sphaerica | Gassiness |
| Ropiness      | Alcaligenes sp., Klebsiella sp., Enterobacter sp. | Stringy or slimy milk |
| Red rot       | Serratia marcescens | Red coloration |
| Grey rot      | Clotridium sp. | Gray coloration, Foul smell |
| Dairy mould   | Aspergillus sp. Penicilium sp., Geotrichum sp. | Mouldy appearance |

**MODULE-7: COLLECTION, CHILLING AND STANDARDIZATION OF MILK**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:
• Collection of milk,
• Chilling of milk and
• Standardization of milk.

COLLECTION OF MILK

• In almost all developed dairying countries, production of milk is confined to rural areas, while demand is mostly urban in nature. Hence milk has to be collected and transported from production points in the milk-shed areas to processing and distribution points in cities.
• the common systems for collection (assembling ) of milk are as follows.
  o By co-operative organization. Formed by individual or collective milking societies. Suits producers best as no profit marking middlemen are involved.
  o by contractors. Less return to producers.
  o By individual producers. Practical for those situated near processing in dairies.
  o Note: a milk shed is the geographical area from which a city dairy received its fluid milk supply. The allocation of definite milk sheds to individual dairies for the purpose of developing the same is now being considered in India.
• Milk collection cum chilling centers/depots. Normally attached to city dairies.
• Objects: these are
  o to preserve the quality of raw milk supplies, and
  o to provide easy transport to the processing dairy.
• Location. This is guided by
  o adequate milk production
  o adequate (potable) water supply
  o proximity to a good road or railway station
  o electric supply and
  o sewage disposal facilities.
• Major items of equipment
  o Milk weigh tank/pan and weighing scale
  o Drop (dump) tank with cover
  o Cashwasher
  o Milk pump (sanitary type)
  o Surface/plate cooler
  o Refrigerating unit (of suitable capacity7);
  o Cold room (of suitable capacity);
  o Milk testing unit, etc.
• Operational procedure. Essentially this is the same as a in a small dairy. On arrival, the milk is graded for acceptance/rejection, weighed, sampled for testing, cooled and stored at a low temperature until dispatch to the processing diary.

CHILLING OF MILK

Cooling of milk

• Cooling
  o Milk contains some microorganisms when drawn from the udder, their numbers increase during subsequent handling. The common milk microorganisms grow best between 20 and 40 c. Bacterial growth is invariably accompanied by deterioration in market quality due to development of off flavors, acidity etc. One method of preserving milk is by prompt cooling to a low temperature.
• Milk plate Chiller: To maintain the quality of milk received in the Dairy/Chilling Center, it is chilled to 4°C by milk chiller. The chiller consists of stainless steel plates. Chilling is done by flowing milk from one side and chilled water from other side of the plates.

• Methods
  o In can or can immersion method. From carrying pails, the not only is the milk cooled, but it also stays cool and a much smaller mechanical refrigeration unit is required.
  o Surface cooler
    • Advantages: (i) Transfer heat rapidly and efficiently. (ii) is relatively inexpensive (iii) also aerates the milk, thus improving its flavor.
  o In tank or bulk tank cooler
    • Advantage: Permits collection of producers milk on alternate days.

Cooling and storage of raw milk

• Cooling
  o As soon as milk is received in the plant, it is chilled to 5°C or below and stored cool till used, to prevent deteriorating in its bacteriological quality during the interim period.

• Object
  o To maintain milk at a low temperature so as to prevent any deterioration in quality prior to processing/product manufacture
  o To facilitate building for the raw milk supply, which will ensure uniform composition
  o To flow for uninterrupted cooperation during processing and bottling
  o To facilitate standardization of the milk.

Importance of Chilling

• Chilling of milk means rapid cooling of raw milk to sufficiently low temperature so that the growth of micro-organisms present in milk is checked. In chilling process the temperature of milk should be reduced to less than 10 degree Celsius preferably 3 - 4 degree Celsius. Milk inside the udder is almost sterile and as soon as it leaves the udder, it is exposed to atmosphere. The microorganisms gain entry into the milk, the moment it comes to atmosphere. The microorganisms gain entry into the milk, the moment it comes to atmosphere.

• Various sources which contribute to the micro flora in milk are containers, udder of the animal, dust and dirt particles, fodder, leaves, atmospheric air, the milker and the animal itself. The number and types of microorganisms would depend upon the conditions and the sources of contamination. As soon as microorganisms get into the milk, they start growing rapidly because milk contains all the nutrients required for their growth, and the conditions for their growth are favorable.

• If the growth of microorganisms is not checked then their growth will continue and several biochemical changes will take place in milk. Due to these changes the quality of milk is adversely affected so much so that sometimes milk becomes unfit for consumption as fluid milk. Since most of the milk is produced in the rural areas under unhygienic conditions and atmospheric temperature remains fairly high throughout the year, keeping quality of raw milk is very low.

• If milk has to be transported to longer distances, considerable time is involved between production and heating process. During this period milk must be protected from spoilage by the action of microorganisms.

• Chilling, therefore, is considered necessary soon after it is received at the chilling canters. The most effective means of controlling the growth of microorganisms without affecting the physico-chemical properties and nutritive value of milk is to chill it.
Lower temperatures inhibit the growth of most of the microorganisms. It should be clearly understood that chilling process does neither kills microorganisms nor it renders milk safe for human consumption. It is only a means of checking the growth of microorganisms for sometime.

**Methods of chilling**

- Can Immersion
- In Can Cooling
- Surface Cooler
- Tubular Cooler
- Plate Chiller
- Bulk Milk Cooler

**STANDARDIZATION OF MILK**

**Standardization**

- Definition: Standardization of milk refers to the adjustment, ie., raising or lowering, of the fat and / or solids not fat percentages of milk to desired value, so as to conform to the legal or other requirements prescribed.
- Problem: How many parts by weight of 40% cream and 3% milk must e mixed to make milk testing 5% fat?
- Solution: Hence, 2.0 parts of 40% cream when mixed with 35 parts of 3.0% milk will give 37 parts of 5% milk.

**Pearson square method**

- The Pearson Square or Rectangle Method, also called Pearson's Square or Pearson’s Rectangle, is a simplified method for solving a two variable simultaneous equation. While it is being used here with milk it is widely used in standardization calculations for sausage manufacture, jam manufacture and blending various drinks; anywhere where it is necessary to calculate the amounts of two components that need to be mixed together to give a final known concentration.

<table>
<thead>
<tr>
<th>Cream</th>
<th>REQUIRED FAT</th>
<th>0.5</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skim milk</td>
<td></td>
<td>21.5</td>
<td>Parts</td>
</tr>
</tbody>
</table>

**MODULE-8: PASTEURIZATION, HOMOGENESATION, BACTOFUGATION AND DEHYDRATION**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:
Heat treatment of milk

The term pasteurization has been coined after the name of Louis Pasteur of France, who in 1860-64 demonstrated that heating wine at a temperature between 122 to 140 °F killed the spoilage organisms and helped in its preservation. The application of this process resulted in coining a new term ‘pasteurization’, which soon became current in technical language. Although Louis Pasteur pioneered studies on heat treatment for preservation of the wine, pasteurization of milk first was attributed to Dr Soxhlet of Germany in 1886.

The term pasteurization as applied to market milk today, refers to the process of heating every particle of milk to at least 63 °C for 30 minutes, or 72 °C for 15 seconds or to any temperature time, which is equally efficient, in an approved and properly operated equipment. After pasteurization the milk is immediately cooled to 5 °C or below.

The objectives of pasteurization are,

- To render the milk safe for human consumption by destruction of cent percent pathogenic microorganism.
- To improve the keeping quality of milk by destruction of almost all spoilage organisms. (85-99 per cent.)

The standards for Pasteurization were such as to ensure:

- Complete destruction of pathogens.
- Negativate phosphatase test and
- Least damage to the cream layer.

As Coxiella burnetti are destroyed by a heat treatment slightly lower than that for phosphatase inactivation, pasteurization is carried out at a heat treatment temperature above that for phosphatase inactivation and below that for cream line reduction.

**DIFFERENT METHODS OF PASTEURIZATION**

**In- bottle pasteurization**
Bottle filled with raw milk and tightly sealed with special caps is held at 63-66 °c for 30 minutes. Then the bottles pass through water sprays for decreasing temperature, which cools both the product and the bottle.

**Advantage**

- Prevents the possibility of post pasteurization contamination.

**Disadvantage**

- The transfer of heat is very slow and there is greater risk of bottle breakage.
- This method at present is out dated, although in bottle sterilization is widely prevalent.

**Batch or holding pasteurization (LTLT)**

- This is also called the low-temperature –long time –method. The milk is heated to 63 °C for 30 minutes and promptly cooled to 5 °C. The pasteurizers may be of three types

**Water-jacketed vat**

- This is double walled around the sides and bottom in which hot water or steam under partial vacuum circulates for heating and cold water for cooling. The outer wall is usually insulated to reduce heat loss. The heat exchange takes place through the wall of the inner lining. The milk is agitated by slowly moving paddles or propellers. When heating, the vat cover is left open for escape of off-flavours, and when holding, the cover is closed.
- Advantage: Flexibility in use.

**Water spray type**

- A film of water is sprayed from a perforated pipe over the surface of the tank holding the product.

**Coil vat type**

- The heating /cooling medium is pumped through a coil placed in either a horizontal or vertical position, while the coil is turned through the product. The turning coil agitates the product.

**High Temperature Short Time (HTST) pasteurization**

- It is the modern method of pasteurizing milk and is invariably used where large volume of milk is handled. The HTST pasteurizer gives a continuous flow of milk, which is heated to 72 °C for 15 sec. and cooled promptly to 5 °C or below.
- The following steps or stages are involved as milk passes through the HTST pasteurization system: float controlled balance tank; pump; regenerative heating; heating; holding; regenerative cooling; and cooling by chill water or
brine. An arrangement for incorporation of the filter / clarifier, homogenizer, etc., in the circuit is also made when desired.

Float controlled balance tank (FCBT)

- Maintains a constant head of milk for feeding the raw milk pump; also receives any sub-temperature milk diverted by FDV.

Pump

- Either a positive pump between the regenerative heating section and heater or a centrifugal pump with a flow control device to ensure constant flow, after FCBT is used.

Plates

- The plate heat exchanger, also called Para flow is a compact, simple, easily cleaned and inspected unit. Its plate may be used for heating, cooling, regeneration, and holding. A space of approximately 3-mm is maintained between plates by a non-absorbent rubber gasket. These plates are designed to provide a uniform turbulent flow of product with rapid heat transfer. Corrugations on the plate in the form of knobs, diamonds, and channels, help to provide the turbulent action required.

Regeneration (heating)

The raw incoming milk is partially and indirectly heated by the hot outgoing milk. This adds to the economy of HTST process. For example,

- Milk entering at 4ºC
- Heated in regenerator to 34ºC
- Heated in heating section to 74ºC
- Cooled in regenerator to 44ºC
- Cooled in cooling section to 4ºC

Here, the increase from 4ºC to 34ºC is a change of 30ºC, and the decrease from 74ºC to 44ºC is also a change of 30ºC. Without regeneration, the milk would need to be heated by hot water or steam from 4ºC to 74ºC, a difference of 70ºC. With regenerative heating, however, hot water or steam need not be used for the temperature change between 4ºC and 34ºC. This temperature change is brought about by use of the outgoing hot milk. The saving of heat due to regeneration here is thus 43%. On the other hand, without regeneration the milk would need to be cooled by chilled water from 74ºC to 4ºC, a difference of 70ºC. With regenerative cooling, however, chilled water need not be used for the temperature change from 74ºC to 44ºC, a difference of 30ºC. This temperature change is brought about by use of cold incoming milk. The savings of refrigeration due to regeneration are thus 43%. Currently, as much as 90% efficiency has been achieved by the use of counter-current flow.

Filter
• Variously shaped filter units to connect directly to the HTST system are placed after the regenerative heating section.

Holding

• The holding tubes or plates ensure that the milk is held for a specified time not less than 15 sec at the pasteurization temperature of 72 °C or more.

Flow diversion valve (FDV)

• This valve diverts the unpasteurized milk automatically back to the FCBT for reprocessing.

Regeneration (cooling)

• The pasteurized hot outgoing milk is partially and indirectly cooled by the incoming cold milk. This again adds to the economy of the HTST process.
• Steam or hot water is used for the heat treatment of milk. For the cooling, chilled water is used. The milk to be heated flows across one side of the plate and heating or cooling medium flows across the other side in the opposite direction. Inserting more plates can increase the capacity of this heater.
• Plate Heat Exchanger and corrugated plates with gaskets controlling the flow of milk

Advantages

• Capacity of the equipment to heat treat the milk can be done quickly and effectively, while maintaining the quality control over both the raw and finished product.
• Less floor space is required
• Lower initial cost
• Milk packaging can be started as soon as pasteurization begins thus permitting more efficient utilization of labour for packaging and distribution.
• Easily cleaned and sanitized, this system adopts itself well to CIP-cleaning.
• Lower operating cost. Reduced milk losses.
• Development of thermophiles is not a problem.

Disadvantages
• This system is not well adopted for small quantities of several liquid milk products.
• Gaskets require constant attention for possible damage and lack of sanitation.
• Complete drainage is not possible.
• Margins of safety in products sanitary control are so narrow that automatic control precision instruments are required in its operation.
• Pasteurization efficiency of high thermoduric count raw milk is not as great as it is when the holder system is used.
• Greater accumulation of milk stone in the heating section.

**Electric pasteurization**

Electric pasteurization of milk or Electro pure process:

• This method employs electricity, as the heating agent and is fairly popular in America. Milk is heated in a small specially constructed chamber. This pasteurizer is a rectangular, vertical chamber of 2 feet height, and about 2 inches in cross section, with two sides made up of carbon electrode separated by intervening walls of plate glass.
• The cold milk passes through the regenerative section on which it is preheated to about 120 ° F by the outgoing hot milk and then pass through the electric heating chamber, here it is heated to a temperature of 161 ° F to 163 ° F by the resistance offered by the milk to the passage of a 110-volt alternating current. The milk is exposed at this temperature for 15-20 sec. after which it is cooled.

**Vacuum pasteurization (vacreation)**

• This refers to pasteurization of milk /cream under reduced pressure by direct steam. This process removes feed and other volatile flavors from cream, and to pasteurize it for butter making. The equipment used in this process is called “vacreator” and the process is called “vacreation.”
• The vacreator consist of three stainless steel chambers connected to one another for steam heating and vacuum treatment with continuous product flow. The product in the form of droplet enters the first chamber of the vacreator where pasteurization occurs. The chamber is operated under a vacuum of 5 inches Hg, which maintains a temperature of 90-95 ° c. While steam is fed from the top and falls by gravity to the bottom of the chamber, then the product and free steam is removed from the bottom of the first chamber to the top of the 2nd chamber.
• The temperature of 2nd chamber is maintained at 71-82 ° c under a vacuum of 15 – 20 inch Hg. A portion of the steam previously added is removed and the product moves down through the chamber. Some of the tainting substances and off-flavours are removed by heat and vacuum treatment.
• The product then moves on to the 3rd chamber at 43 ° c by maintaining a vacuum of 26- 28 inches of Hg. And here more water and off flavours are removed. A multistage centrifugal pump removes the product from the 3rd chamber. This process takes about 10 seconds to pass through the three chambers.

**Stassanization**
Henri Stassano invented it in France. This method of pasteurization is carried out in a tubular heat exchanger consisting of three concentric tubes. The principle of its operation is the heating of milk to the desired temperature by passing it between two water-heated pipes through the narrow space of 0.6 to 0.8 mm. The milk is heated to about 74 °c for 7 sec. and then promptly cooled.

**Ultra high temperature pasteurization**

- Ultra high temperature pasteurization was developed in the 1950s; this usually encompasses temperature time combination of 135 °C to 150 °C for no hold. The success of UHT heat treatment of milk depends on immediate aseptic packaging.

**Uperization**

- This is otherwise called as “ultra – pasteurization” and it was developed in Switzerland. In this process, milk is heated with direct steam up to 150 °c for a fraction of a second. This is a continuous process.
- The first step in the uperization process is fore warming of milk to 50 °C and intended to remove most of the dissolved oxygen and volatile off-flavours by vacuum treatment. In the second part, the milk is first preheated to about 80-90 °C and then heated on the uperization chamber with high-pressure steam to around 150 °C for ½ to ¾th of a second. After this heating, the product moves into an expansion chamber at near atmospheric pressure, thereby forcing some evaporation of moisture. The product is then moved to a cooler and then into storage chamber.

The advantages of uperization are

- Long keeping quality.
- Removal of feed and other volatile off-flavours:
- Appreciable homogenization effect.
- Reduction in acidity.
- Efficient destruction of microorganism.
- Effect of uperization on nutritive value and flavour are not greater than that of pasteurization.

**Boiling of milk**

- The boiling of milk brings about important changes in milk. Milk boils at a temperature of 212.3 °F at sea level. At this temperature the milk sugar is burnt causing a condition called caramelisation in which the milk is brown in colour. The casein and albumin are somewhat hardened. The calcium, magnesium, and phosphoric salts are partially precipitated, all of which renders milk less digestible. The enzymes are destroyed. Prolonged heating at high temperature causes a destruction of vitamin C, A, and D in that order, but boiling under ordinary conditions does not destroy vitamin A. When milk is brought to the boiling point in the air, a thin film forms over the surface due
to the coagulation of small amount of casein, albumin, small amount of calcium salts, and fat.

**Sterilization**

- The term sterilization when used in association with milk means heating continuously to a temperature of 115 °C for 15 min. or 145 °C for 3 sec. or equivalent approved temperature time combination to ensure preservation of milk at room temperature for a period of not less than 15 days from the date of manufacture. Sterilized milk shall show absence of albumin by a negative turbidity test. Sterilized milk shall be sold only in the container in which the milk was sterilized.

**HOMOGENIZATION**

- Homogenised milk is produced by mechanically forcing milk through a small passage at high velocity. This breaks down the fat globules in milk into much smaller ones and creates a stable fat emulsion. Homogenisation diminishes the tendency of the fat globules to clump together and coalesce into cream.
- Homogenised milk has many advantages
  - Uniform distribution of fat, no cream layer
  - Full-bodied flavour
  - Whiter, more appetising colour
  - Faster coagulation in the manufacture of rennet cheese
- Milk is an oil-in-water emulsion, with the fat globules dispersed in a continuous skim milk phase. If raw milk were left to stand, however, the fat would rise and form a cream layer. Homogenization is a mechanical treatment of the fat globules in milk brought about by passing milk under high pressure through a tiny orifice, which results in a decrease in the average diameter and an increase in number and surface area, of the fat globules. The net result, from a practical view, is a much reduced tendency for creaming of fat globules. Three factors contribute to this enhanced stability of homogenized milk: a decrease in the mean diameter of the fat globules (a factor in Stokes Law), a decrease in the size distribution of the fat globules (causing the speed of rise to be similar for the majority of globules such that they don't tend to cluster during creaming), and an increase in density of the globules (bringing them closer to the continuous phase) owing to the adsorption of a protein membrane. In addition, heat pasteurization breaks down the cryo-globulin complex, which tends to cluster fat globules causing them to rise.

The homogenizer consists of a high-pressure pump fitted with a minute orifice having an adjustable opening through which fluids are forced at high pressure, thereby causing a marked change in the physical properties of the product treated and producing a very intimate mixture of the ingredients of the fluid.

The effect of homogenization upon milk may be described as follows.

- The fat globules in normal milk are usually in sizes varying from 1 to 15 microns, depending upon the breed of cow and various other factors. By means of homogenization, the fat globules are broken up into numerous smaller ones and all the fat globules are under 2 microns in size.
- The fat globules no longer rise to the top to form a cream layer, as a normal milk, for they are so small that few of them have the power to rise against the pull of gravity.
- The curd tension of the homogenized milk is reduced.
An increase in viscosity of the milk, and an apparent increase in creaminess and richness.

**Homogenization**

The process of making a stable emulsion of milk fat and milk serum by mechanical treatment is termed as “homogenization. The machines used for this purpose is called homogenizer. The size of the fat globules in milk is between 1 and 20 microns, the average being 4-6 microns. When milk or cream is passed through the homogenizer, there is desired reduction in the size of the fat globules. Most of them are reduced to 2 microns or less. No cream line is formed on milk after homogenization or butter granules cannot be produced from the homogenized cream by churning. Furthermore, there is an increase in the viscosity of milk like cream, which means that the smaller fat globules encounter greater resistance. The increase in viscosity is attributed to the fact that a larger proportion of the milk protein will be adsorbed on the surfaces of the greater number of the fat lobules. When milk is homogenized its clotting properties are altered, so that the curd produced when rennet or pepsin is added is said to be softer. Homogenized milk or cream may become rancid more quickly than untreated products owing to the hydrolysis of fat by lipolytic enzymes adsorbed on the additional surfaces furnished by the more numerous small fat globules. To avoid these changes the milk or cream must be pasteurized immediately before or after homogenization.

The milk is usually homogenized following primary heating before it is pasteurized. Heated milk is forced through a small valve against hard surfaces and is subjected to a pressure of 2500 psi. and in a second stage to 500 psi. The aperture through which the liquid is forced is extremely minute, having a diameter of 1/10000 inch.

The following types of homogenizes are at present in use.

- High pressure type
- Low-pressure rotary type
- Sonic vibrator or oscillator.

In the manufacture of evaporated milk it is important that the fat globules be reduced in size to avoid churning upon agitation. In the preparation of ice cream mix, the entire mixture is passed thorough the homogenizer immediately after pasteurization. The result is a smoother texture in the finished ice cream.

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**BACTOFUGATION**

- Bactofugation is a process in which specially designed hermetic centrifuge, the Bactofuge®, is used to separate bacteria, and especially the spores formed by specific bacteria strains, from milk. The RPM goes up to 60000
- Bactofugation has proved to be an efficient way of reducing the number of spores in milk, since their density is higher than that of milk.
- Bactofugation normally separates the milk into a fraction that is more or less free from bacteria, and a concentrate (bactofugate), which contains both spores and bacteria in general and amounts to up to 3% of the feed to the Bactofuge.

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**DEHYDRATION**
The milk can be preserved by dehydrating to various degrees. The dehydrated milk has a longer "shelf-life" than the milk preserved by pasteurization and refrigeration.

Milk from which part or all of the water as been withdrawn is termed concentrated or dried milk (milk powder).

More than 80 percent of milk is water. The best way to preserve milk is by removal of water. It can be done hydram drying or spray drying or by freeze drying.

### CONDENSED MILK

Condensed milks are the milks obtained by evaporating part of water of whole milk, orfully or partly skimmed milk, with or without the addition of sugar. The term ‘condensed milk’ is commonly used when referring to “full cream sweetened condensed milk” while the term evaporated milk is commonly used when referring to ‘full cream unsweetened condensed milk’. Skimmed milk products are known as “sweetened condensed skim milk” and “unsweetened condensed skim milk”. The ratio of concentration of milk solids is about 1: 2.5 for full cream products and 1: 3 for sweetened condensed skim milk.

According to the PFA (1976) the various condensed milks have been specified as follows:

- **Unsweetened condensed milk (evaporated milk)** is the product obtained from cow or buffalo milk or a combination thereof, or from standardized milk, by the partial removal of water. It may contain added calcium chloride, citric acid and sodium citrate, sodium salts oforthophosphoric acid and polyphosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Unsweetened condensed milk should contain not less than 8.0 percent milkfat, and not less than 26 per cent milk solids.

- **Sweetened condensed milk** is the product obtained from cow or buffalo milk or a combination thereof, or from standardized milk, by the partial removal of water and after addition of cane sugar. It may contain added refined lactose, calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Sweetened condensed milk should contain not less than 9.0 percent milk fat, and not less than 31 per cent milk solids and 40.0 per cent cane sugar.

- **Unsweetened condensed skim milk (evaporated skimmed milk)** is the product obtained from cow or buffalo milk or a combination thereof, by partial removal of water. It may contain added calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Unsweetened condensed skim milk should contain not less than 20.0 percent total milk solids. The fat content should not exceed 0.5 per cent by weight.

- **Sweetened condensed skim milk** is the product obtained from cow or buffalo skimmed milk or a combination thereof by the partial removal of water and after addition of cane sugar. It may contain added refined lactose, calcium chloride, citric acid and sodium citrate, sodium salts of orthophosphoric acid and polyphosphoric acid not exceeding 0.3 per cent by weight of the finished product. Such addition need not be declared on the label. Sweetened condensed skim milk should contain not less than 26.0 per cent total milk solids and not less than 40 per cent cane sugar. The fat content should not exceed 0.5 percent by weight.

### Detailed Composition of the condensed milk (percentage)

<table>
<thead>
<tr>
<th>Type of condensed milk</th>
<th>Water</th>
<th>Total solids</th>
<th>Fat</th>
<th>Milk solids not Fat</th>
<th>Protein</th>
<th>Lactose</th>
<th>Ash</th>
<th>Total milk solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensed milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Indian Standard Specifications for condensed milk

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirement for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Condensed milk</td>
</tr>
<tr>
<td>Total milk solids (%wt.) Min</td>
<td>31.0</td>
</tr>
<tr>
<td>Fat (% wt)</td>
<td>Not less than 9.0</td>
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<tr>
<td>Sucrose (% wt.) Min</td>
<td>40</td>
</tr>
<tr>
<td>Acidity(% lactic) Max</td>
<td>0.35</td>
</tr>
<tr>
<td>Bacterial count (per g.)</td>
<td>500</td>
</tr>
<tr>
<td>Coliform count (per g)</td>
<td>Negative</td>
</tr>
<tr>
<td>Yeast and mould count (per g.) Max</td>
<td>10</td>
</tr>
</tbody>
</table>

Food and Nutritive value of condensed and evaporated a milk

- Both have high nutritive value, both are rich in fat and fat-soluble vitamins A, D E and K, body building proteins, bone forming minerals and energy-giving sucrose, evaporated milk is suitable for infant feeding since it makes a soft curd which is easily digested.

Physico-chemical properties

- Specific gravity/density: Evaporation of water in the manufacture of condensed milks raises their specific gravity/density, which is universally employed to control their composition. Baume hydrometers are widely used for this purpose.
- Freezing point: The freezing point of condensed milk is –14.9°C and that of evaporated milk is - 1.3°C
- Colour and flavour: Heat treatment during manufacture of condensed milks tend to darken their color and develop cooked flavour, the darkening/browning-discoloration results from the interaction of the amino-compounds with sugar (casein and lactose) and is called as Maillard-type browning. The brown pigment is called as melanoidin.

Role of Milk constituents in condensed milk

- Milk fat: Imparts a rich and pleasing flavour, soft body and smooth texture to both condensed and evaporated milks. Affects viscosity. Significant in flavour problems, such as rancidity, tallowiness, etc.
- Milk-Proteins: Technologically of great importance and their physico-chemical reactions to processing-heat largely determine the heat stability and viscosity of the condensed milks.
• Milk sugar: Plays an important role in the successful control of the texture of condensed milk. The size of the lactose crystals determines the relative smoothness of the condensed milk, and is controlled by the procedure used for the cooling and crystallization of this product.
• Mineral salts: These—particularly calcium and magnesium together with citrates and phosphates control the salt balances and heat stability of milk. A disturbed salt-balance causes objectionable heat-coagulation of milk.

Method of manufacture, packaging and storage of condensed milk

Receiving milk
↓
Filtration /Clarification (38-40ºC)
↓
Standardization
↓
Fore warming/preheating (115-118 ºC / No Hold)
↓
Condensing (2.5:1)
↓
Addition of sugar
↓
Homogenization
↓
Quickly cooled to 30ºC
↓
Seeded with 0.1 - 0.3% lactose
↓
Vigorous stirring and slow cooling for 1 hour.
↓
Temperature of 15 ºc reached
Details of manufacture

- The basic principle in the production of condensed milk and evaporated milk is that high quality milk is filtered /clarified, standardized, fore-warmed and condensed /evaporated to the desired level. The concentrated product is preserved by the addition of sugar for condensed milk and by heat sterilization for evaporated milk.

- When the milk is received at the plant, its temperature should be at 10ºC or below. The milk should be clean, sweet, and free from off-flavours and odours and reasonably free from extraneous material. Contamination by antibiotics, pesticides and other chemical residues and metals is highly undesirable; abnormal milk should not be accepted. Acid development is objectionable for not only does this indicate an excessive bacterial count, but it also reduces the heat stability of milk.

- The various platform tests and laboratory tests usually performed on the intake milk to determine its acceptance /rejection are
  - Alcohol test
  - Clot on boiling tests.

  Alcohol test: To make this test, 5 ml of milk is placed in a test tube and an equal amount of solution with 68 % alcohol added, the mixture is shaken and any formation of clot or flake denotes a positive test, i.e., the milk is susceptible to heat coagulation. A disturbed salt balance affects alcohol coagulation in the same manner as heat coagulation. The test detects: abnormal milk including colostrum. Which is high in mineral salts and developed acidity in milk, mastitis milk likely to result in sweet curdling etc., It is more sensitive than the COB test.

  Alcohol index: determined by placing absolute alcohol in the burette and 10 ml of milk in a beaker. The number of ml of alcohol required for flake formation is known as the Alcohol Index (AI). An AI of 7 is indicative of good stable milk for acceptance, while 3 or less shows that the milk is fit for rejection.

  Alcohol alizarin test: This test not only determines the heat stability of milk but also the pH.

  Clot on boiling test: In this test, 5 ml of milk is placed in a test tube and kept in a boiling water bath for 5 minutes, afterwards it is removed and examined for precipitation, if curd is observed, the milk is said to fail the COB test and should be rejected.

Filtration/clarification

- This is done in order to remove the visible foreign matter at a temperature of 35-40ºC, and then cooled.

Standardization

Standardization of the raw milk is carried out in 3 stages, for

- The first standardization which establishes the desired fat / SNF ratio (usually 1:2.44, done in raw milk)
The second, which establishes the desired ratio of added sugar to the total milk solids (done prior to condensing)

The third, which adjust the concentration of the finished product to the required, total solids Content (after finishing the batch, i.e., prior to homogenization)

**Forewarming / Pre-heating**

- Which is done for making the finished product free from microorganisms and enzymes, to ensure uninterrupted boiling in pan and to control age thickening in the finished product. The time temperature combination varies over 82-93°C for 5-15 minutes. Tubular heat exchangers are commonly used.

**Addition of sugar**

- Sugar is added for preserving the condensed milk, without resorting to sterilization process, and cane or beet sugar is the commonly added as sweetening agent.

**Amount of sugar to be added**

- This ranges from 40-45 % in the finished product, which requires 18-20 percent sugar on milk basis. As per Hunziker, (scientist), advocated a sugar ratio (sugar-in – water concentration) of 62.5 to 64.5 per cent. Sugar Ratio Determination (SR). This can be calculated either by using

\[
\text{\% SR} = \frac{\% \text{sugar}}{\% \text{sugar} + \% \text{water}} \times 100
\]

---

**Flow diagram and manufacture**

```
Receiving milk
↓
Filtration / Clarification (35-40°C)
↓
Standardization
↓
Forewarming / Pre-heating (115-118°C / No hold)
↓
Evaporation (1:2.5)
↓
Homogenization first stage - 2000psi
↓
Second stage - 500psi
↓
Cooling (7°C)
↓
Pilot sterilization test (117°C, for 15 mins)
↓
Packaging
↓
Sterilization (116-118°C / 15 mins)
↓
Cooling (27-32°C)
↓
Shaking
↓
Storage (5-15°C)
```
Filtration/clarification

- This is done in order to remove the visible foreign matter at a temperature of 35-40ºC, and then cooled.

Standardization

Standardization of the raw milk is carried out in 3 stages,

- For desired fat/SNF ratio, (usually 1:2.44, done in raw milk)
- Desired ratio of added sugar to the total milk solids (done prior to condensing)
- To adjust the concentration of the finished product to the required total solids content (after finishing the batch, i.e., prior to homogenization).

Forewarming/Pre-heating

- Which is done for making the finished product free from microorganisms and enzymes, to ensure uninterrupted boiling in pan and to control age thickening in the finished product. The time temperature combination varies over 82-93ºC for 5-15 minutes or 115-118ºC for no hold. Tubular heat-exchangers are commonly used.

Evaporation

- Evaporation means the concentration of milk or liquid products: the water has to reach a boiling point: and the steam must have a pressure equivalent to ambient pressure. Vapour (steam) is removed by the pressure difference. No sugar is added here and normally a continuous operation takes place. It is customary to slightly over-condense themilk to facilitate standardization later.

Homogenization

- After evaporation and before cooling, the evaporated milk is thoroughly homogenized to obtain a uniform fat emulsion and reduce separation of fat to a minimum during storage. The temperature is usually 49 ºC as the product is removed from the last part of the evaporator. Two-stage homogenization is generally recommended, 2000 psi in the first stage and 500-psi in the second stage. After which the samples are cooled to 7 ºC and stored.

Pilot sterilization test

- Purpose to determine the amount of chemical stabilizers (trisodium citrate or disodium phosphate) to be added to any given batch of evaporated milk for the most satisfactory heat stability.
- An approximate 10 percent solution of stabilizer is prepared for use, so that 0.1 ml of the solution is equivalent to the addition of 1 g of dry salt for every 16 kg of evaporated milk.
- The amount of stabilizers to be added to any batch is determined by trial. The sample cans containing measured amount of stabilizer solution and a fixed quantity of evaporated milk are sterilized at 117 ºC for 15 minutes and then cooled rapidly to 24 ºC. As soon as they have been cooled the cans are opened, examined for smoothness and colour and tested for viscosity. According to Mojonnier and Troy, a viscosity of 150ºR on the Mojonnier-Doolittle viscosimeter represents the correct viscosity of evaporated milk as it comes out of the sterilizer.
• If the viscosity tests for pilot sterilized can show that no stability correction is necessary, the batch is ready to be filled into the cans. However if the tests show otherwise, stability corrections becomes necessary.

• Based on the pilot sterilization test, the calculated quantity of stabilizer should be added to the evaporated milk in the form of a solution using just enough water to dissolve it.

Packaging

• The cans are now mechanically filled with volumetric fillers, the types of one used for this purpose are the sanitary can, the can with a solder seal, and the vent hole can. The temperature of evaporated milk when filling the cans should be neither high nor low, but around 5 °C; a higher temperature cause foaming; while a lower temperature increases the tendency towards 'flipping'. This refers to the sudden snapping of can ends from their slightly concave contour to a convex outward bulge, which is usually accompanied by an audible sound. The cans should be filled as nearly full as possible.

Sterilization

• Immediately after sealing and before sterilization, each can is tested by means of a dependable leak checker/detector, where the cans pass submerged in a hot-water bath. In case of leaky cans, air bubbles rise to the top; these cans are removed for repair. The filled and sealed cans, which have passed the test for leaks, are now ready for sterilization. The purpose of sterilization is to destroy all germ life and enzymes present, thereby preserving the product permanently. During sterilization, the temperature is raised to 116-118 °C and held at this temperature for 15 minutes. If the cans cannot be sterilized within an hour or two, they should be then held under refrigeration.

Batch method

• This consists of a water steam boiler-like, horizontal steam drum, with hollow interior having a revolving frame, in which the cans are loaded. The sterilizer rotates at 6-12 rpm, with uniform distribution of heat.

Continuous

• Here the cans are progressively heated to a few degrees below the boiling point, and finally enter the sterilizing area proper. Later cooling process starts with the cans gradually moving through progressively less hot-water chambers and finally through cold water.

Cooling

• Immediately after holding time is over, the evaporated milk is cooled within 15 minutes to 27-32°C. Rapid and uniform cooling is important. Bulging of the cans can be avoided by using cold water and in continuous system, cooler operates at 10 psi.

Shaking

• This is done to break mechanically, any curd, which might have formed during the process of sterilization to a homogenous smooth consistency.
Storage

- Though evaporated milk can be stored at room temperatures, a storage temperature of 5-16 ºC is generally used, which helps to keep the product acceptable even up to 2 years. Inversion of cans once in 3-6 months during storage will help to minimize fat separation.

USES / DEFECTS IN CONDENSED AND EVAPORATED MILKS

Uses of Condensed and Evaporated Milks

Condensed milk

For reconstitution into sweet milk drinks

- In tea or coffee
- In ice-cream preparation
- In candy and confectionery
- In prepared foods

Evaporated milks

For reconstitution into milk for feeding infants and persons with weak stomach etc.,

- In ice-cream;
- In tea and coffee

Plain condensed milk: This is unsweetened condensed milk, made from whole milk, partly skim milk or entirely skim milk, and condensed to 2.5 to 4:1. It is used in ice cream factories and bakeries. The product is neither sterile nor preserved by sugar. Its keeping quality is similar to that of high quality, efficiently pasteurized milk.

Superheated condensed milk: This is plain condensed milk superheated by blowing live steam during condensing, to increase the viscosity.

Frozen condensed milk: This is plain condensed milk frozen to give it a longer storage life and is used in ice-cream factories mostly.

ROLLER DRYING / DRUM DRYING

Basic principle

- The product to be dried is applied in a thin layer (film) onto the surface of one or two steam heated drums by using different application systems. The temperature on the drum surface is above 100 ºC, and heat can be transferred rapidly to the product. This helps in transferring moisture that is evaporated to the ambient air and removing it by airflow.
- After a three-quarter turn of the drum, the drying process is finished, and the film is removed from the drum by special knives (doctor blades) as a thin film, air-cooled, and milled into powder in a special mill. After intermediate storage in silos the powder is filled and packed. (OR)
- The principle of the roller drying process is that milk is applied in a thin film upon the smooth surface of a continuously rotating steam heated metal drum. The film of dried
product is continuously scraped off by a stationary knife located opposite the point of application of the milk. The drier may consist of a single drum or a pair of drums. The milk may be pre-concentrated before it is being applied to the drum, and the degree of concentration varies with the design of the dryer. The rule is that a single-drum dryer can handle milk of higher concentration than that of a double dryer. The dried milk film is milled to break up the film. The particles of a roller drier powder are solid, flat, irregular flakes containing no air. The absence of occluded air retards oxidation, resulting in good keeping quality.

**Design and Operation of drum driers**

Drum driers may be of the following types,

- Monocylinder/single drum drier with applicator
- Double drum drier with spraying device/double drum drier
- Double drum drier with sump

**Flow diagram of drumdrying system**

<table>
<thead>
<tr>
<th>Milk concentrate (Pre-condensed to 2:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustable pump</td>
</tr>
<tr>
<td>Feeding</td>
</tr>
<tr>
<td>Drying drum (150°C, for 3 sec)</td>
</tr>
<tr>
<td>Scraper (Doctor blades)</td>
</tr>
<tr>
<td>Grinder (Pulveriser)</td>
</tr>
<tr>
<td>Sifter (Removal of coarse particles)</td>
</tr>
<tr>
<td>Dried product</td>
</tr>
</tbody>
</table>

**Mono-cylinder with applicator**

- From the product trough, the concentrated milk is picked up by the concentrate drum and is transferred to the applicator drum. From the applicator drum the product is delivered to the surface of the drying drum which is steam heated and has an inside temperature of 115-130°C, and rotates at 10-30 RPM. Ambient airflows over the surface of the drum, mixes with the vapor, and is sucked through the vapor hood.
to the outside atmosphere. The process is controlled by the film thickness by adjusting the applicator drum and drum speed.

**Double drum drier with spraying device**

- Here the drying process is similar to the above explained one, but the product application is through small spraying discs, which rotate in the concentratetrough and transfer a thin concentrate film, which is transferred onto the drying drum by the air flow. The concentrate droplets, which gain surface area by this process, undergo gentleand rapid drying.

**Double drum drier with sump**

- The key difference is the sump between the two drums resulting in direct application of the product onto the drum surface. Doctor knives remove the dried product as a thin film from the drum surface; in some cases the product is cooled on cooling drums before being milled.

**Technical notes**

Control of drying, ratios, and capacities.

Drum drying is influenced by the following factors:

- Thickness of the film
- Uniformity of the film
- Drying temperature and time, controlled by steam pressure, speed of the drum velocity
- Concentrate temperature and dry matter content or concentration ratio

In order to achieve constant operation and therefore constant product quality all parameters must be kept constant, such as

- The drying time should be kept within 1.8-2.5 seconds.
- The specific steam consumption is 1.3-1.6 Kg/Kg of evaporated water and 4.3-5.0 Kg/kg of powder
- The drying capacity of drum driers is in the range of 300-2000 L of concentrate per hour with a dry matter of 45%.
- Factors which affect the capacity of the drum driers include:
  - Concentration ratio or dry matter content of the concentrate
  - Viscosity of the concentrate
  - Acidity of the concentrate (higher acidity decreases the capacity)
  - Surface temperature the drum.

**Advantages and Disadvantages (over Spray-drying System)**

**Advantages**

- Relatively low capital and operating costs
- Plant is movable and occupies little floor space
- Plant is easy to handle
- Suitable for operating small quantities of milk economically
- Produces milk of better keeping quality
Disadvantages

- Produces milk powder with low solubility
- Produces a definitely cooked/scorched flavour in the reconstituted milk

**SPRAY DRYING**

**Principle**

- Spray drying can be described as the instantaneous removal of moisture from a liquid. To achieve this, the liquid is converted into a fog-like mist (atomised), whereby it is given a large surface. The atomised liquid is exposed to a flow of hot air in a drying chamber. The air has the function of supplying heat for the evaporation and, in addition, it acts as a carrier for the vapour and the powder. When the atomised product is in contact with the hot air, the moisture evaporates quickly and the solids are recovered as a powder consisting of fine hollow spherical particles with some occluded air. Exhaust air is removed on the side and passes through cyclones and filters (where entrained powder particles are separated and recovered).

**Flow diagram of spray drying system**

```
Air supply
  ↓
Air filter
  ↓
Air intake fan
  ↓
Air heater
  ↓
Air dispenser
  ↓
Milk concentrate atomizer
  ↓
Drying chamber dried product
  ↓
Exhaust air fan
  ↓
Exhaust air hood
  ↓
Exhaust air
```

**Classification of spray dryers**

- Hydraulic pressure jet
- Pneumatic (compressed air)
- Centrifugal disc

**Methods of furnishing heat**
- Steam
- Gas
- Fuel oil
- Electricity

**Methods of heating air**
- Direct (gas or fuel)
- Indirect (utilizing plate heat exchangers or coils)

**Position of drying chamber**
- Vertical
- Horizontal

**Direction of airflow in relation to product flow**
- Counter-current
- Parallel
- Right-angle

**Pressure in drier**
- Atmospheric
- Vacuum

**Method of separation of powder from air**
- Cyclone
- Multi-cyclone
- Bag filter
- Liquid dust collector
- Electrical dust collector

**Removal of powder from drying chamber**
- Conveyor
- Vibrator
- Sweep conveyor
- Air conveyed to cyclone

---

**SPRAY DRYING METHOD**

**Receiving milk**
- Only high-grade milk should be accepted.

**Cooling**
- To preserve the quality of milk.

**Standardization**

- This is done to adjust the ratio of fat and solids-not-fat in raw milk to meet the legal standards for composition in dried product. Raw milk is standardized by adding to it a calculated amount of skim milk or cream. The fat: SNF ratio here is standardized to 1:2.769.

**Pre-heating**

- For efficient filtration/clarification milk is pre-heated to 71ºC.

**Filtration/clarification**

- The chief object of this is to remove extraneous matter. This operation can also be done before standardization.

**Homogenization**

- It is being done to improve the keeping quality and prevent fat churning while reconstitution. A pressure of 3000 psi (2500 psi on the first stage and 500 psi on the second) at 63 to 74ºC.

**Heat**

- This main objective is to prolong the shelf life of the dried product by inactivation of lipase. The pre-heating should also ensure pasteurization, thus reducing the viable microorganisms. A combination of 82 ºC for 15 minutes is used in practice.

**Condensing**

- Normally a concentration of 35-40 per cent total solids is produced, and the concentrate is continuously removed from the evaporator with the help of a density tester.

**Pumping**

- The preheated concentrate at 71º C is forced through the atomizer at a pressure of 2500 psi.

**Spray drying**

- The concentrated milk is dried with inlet air at 143-232º C and the exit air at 74 to 93º C depending on the product characteristics.

**Cooling**

- The dry product should be removed promptly from the hot air stream to maintain better flavour and body characteristics and also keeping quality. The higher the temperature and the longer the time the product is above the melting point of fat, the greater the amount of free fat obtained thus adversely affecting keeping quality.
Hence it is essential to cool the powder immediately to a temperature below the melting point.

Sifting

- A12-mesh screen is used for sifting dry whole milk.

Packaging

- The powder-packaging unit should be isolated to reduce the spread of powder dust to the drier building. Of the several packing material used, fiberboard carton with an over wrap of foil laminated to paper, or with an inner lining of foil laminated to paper. A polythene bag inside the fibreboard carton is also used. Plastic coated paper bags are the latest. Powder packing should be carried out in a dry atmosphere, sealed promptly hermetically in moisture proof package to prevent caking of lactose and fat decomposition leading to off-flavours. Usually, in packaging of milk powders, the headspace is reduced followed by removal of oxygen, by injecting vacuum and then replacing it with nitrogen.

Storage

- Should be stored at temperatures lower than, 24º C, in a cool, dry place.

DRIED MILK

- Drying is the separation of a liquid from a compound or blend of compounds by evaporation. The product to be dried exists either in a solid or solid–liquid phase. The separation is into a solid and a gas phase. Dried milk products are manufactured to reduce bulk so as to reduce packaging and the transportation costs, to improve the storage life of the product, etc.

Definition

- “Dried milk or milk powder is the product obtained by the removal of water by heat or the suitable means, to produce a solid containing 5 per cent or less moisture. The dried product obtained from whole milk is called Dried whole milk or whole milk powder (WMP); and that from skim milk is known as Dried Skim Milk or Skim Milk Powder (SMP), or Non-fat Dry Milk (NFDM).

PFA Legal Standards

- Whole Milk Powder
  - “According to the PFA Rules, (1976), whole milk powder is the product obtained from cow or buffalo milk, or a combination thereof, or from standardized milk, by the removal of water. It may contain calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acids, not exceeding 0.3 per cent by the weight of the finished product, and 0.01 per cent of butylated hydroxy anisole (by weight) of the finished product. Such additions need not be declared on the label. Milk powder should contain not more than 5.0 per cent of moisture and not less than 26.0 per cent of fat. The total acidity expressed as lactic acid should not be more than 1.2. per cent. The standard plate count may not exceed 50,000/g and the Coliform count may not exceed 90/g. The maximum
solubility index should be 15.0 for roller dried and 2.0 for a spray dried product.

- **Skim Milk Powder**
  - According to the PFA Rules (1976), skim milk powder is the product obtained from cow or buffalo milk, or a combination thereof, by the removal of water. It may contain calcium chloride, citric acid and sodium citrate, sodium salts of ortho phosphoric acid and poly phosphoric acids, not exceeding 0.3 per cent by the weight of the finished product. Such additions need not be declared on the label. Skim milk powder should contain not more than 1.5 per cent of fat and the moisture may not exceed 5.0 percent. The total acidity expressed as lactic acid should not be more than 1.5 per cent. The standard plate count may not exceed 50,000/g. and the Coliform count may not exceed 90/g. The maximum solubility index should be 15.0 for roller dried and 2.0 for a spray dried product.

### Composition

The average percentage composition of whole milk and skim milk powder is given in the following table: (Percentage)

<table>
<thead>
<tr>
<th>Type of dried milk</th>
<th>Average composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moisture</td>
</tr>
<tr>
<td>Whole milk powder</td>
<td>2.0</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>3.0</td>
</tr>
</tbody>
</table>

### Food and nutritive value

- Under modern methods, the nutritive value of milk is preserved to a great extent. While there appears to be only a slight destruction of lysine in spray drying, the severe heat treatment of roller drying destroys more lysine. Dry whole milk is a good source of vitamin A, calcium and phosphorus. It is also a valuable source of riboflavin.

### Milk drying systems

- The manufacturing process consists of unit operations of milk selection and pre-treatment, concentrate manufacture, homogenization, drying and filling/packaging. The basic difference is in the type of drying, and can be achieved in several ways and means.

### Drying by Cold Treatment

- Drying milk by freezing out the water and centrifuging. This system was proposed and patented as early as 1884 and is now obsolete.
- Drying milk by freezing and sublimation: This freeze-drying method, which seems to have been developed in 1945, consists of freezing the product and supplying heat, so that moisture is removed by sublimation by maintaining a vacuum in the vaporizing chamber.

### Drying by application of heat

- Roller/Film/Drum drying
• Spray drying
• Dough or paste drying
• Foam drying
• Fluid bed drying.

Pre-requisites

Milk selection and pretreatment

• Milk is selected according to the requirements and clarified and standardized in the usual ways.

Heat Treatment

• Milk or milk products must be heat treated by an officially approved pasteurization process in order to inactivate possible pathogenic or other harmful germs and to inactivate most of the enzymes. Another intensive preheating, such as is normal for evaporated milk, is not required here, because the recontaminating germs cannot grow at the moisture levels available in the powders, and protein stabilization is not necessary. On the contrary, very gentle pasteurization is required in order to have the least whey protein denaturation.
• Among the other factors, the quality of skim milk powder is measured by the non-denatured whey-protein-nitrogen index (WPN index), which characterizes the heat treatment involved. From this heat classification the application or utilization of the powder can be derived. For certain applications, e.g., baby food, the classification of the gently heated proteins by the WPN is not sufficient, and other criteria such as the protein number (ratio of casein nitrogen and whey protein nitrogen Vs. total protein nitrogen), organoleptic evaluation of the reconstituted milk or the coagulation and acidification capability (e.g., for cheese manufacture) must be taken into account.
  o For the manufacture of “low-heat” skim powder, the short-time heat treatment must be used; for “high-heat” skim powder, the process temperature is 90ºC for 30 minutes.
  o For the production of whole milk powder base, milk is heated to 90-95º C and held for 15-30 should, which is considered optimal.

Homogenization

• To improve the fat distribution, homogenization is advantageous during the manufacture of whole milk powder. If the base is fat-standardized by adding cream, partial-flow homogenization is possible before concentration. Otherwise the concentrate is homogenized.

Concentration

• The objective of concentration is to remove a maximum amount of water from the milk and obtain a maximum dry matter content, as the drying process requires three times more energy than the removal of water in the evaporator.
• The milk is concentrated to its flow limits, i.e., dry matter will be 40-50 %.
• The concentration ratio selected is controlled by the finished product and the drying process; the ratios are as follows:-
  • Drum-dried milk powder 1 : 3.5-4
  • Drum-dried skim milk powder 1 : 4-6
  • Spray-dried whole milk powder 1 : 3.5
  • Spray-dried skim milk powder 1 : 4-5
A further increase of the concentration ratio in the evaporator is characterized by a significant increase in viscosity and is very difficult due to the flow limits of the concentrate.

**Comparision of Physico-Chemical Properties of Drum-Dried and Sprays Dried Milks**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Drum-dried</th>
<th>Spray-dried</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>8-20µM</td>
<td>10-20µM</td>
</tr>
<tr>
<td>Surface</td>
<td>Wrinkled</td>
<td>Normally smooth</td>
</tr>
<tr>
<td>Shape</td>
<td>Irregular; angular with rough edges</td>
<td>Regular; usually spherical</td>
</tr>
<tr>
<td>Air cell</td>
<td>Normally absent</td>
<td>Normally present</td>
</tr>
<tr>
<td>Bulk density (g/ml)</td>
<td>0.3-0.5</td>
<td>0.5-0.6</td>
</tr>
<tr>
<td>Flowability</td>
<td>Slightly lower</td>
<td>Slightly higher</td>
</tr>
<tr>
<td>Dustiness</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>Reconstitutability</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Flavour</td>
<td>Definitely cooked</td>
<td>Same as pasteurized milk</td>
</tr>
<tr>
<td>Colour and appearance</td>
<td>Slightly darker</td>
<td>Same as milk</td>
</tr>
</tbody>
</table>

**Defects in Whole / Skim Milk Powders Ther Causes and Prevention**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name of the defect</th>
<th>Causes</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Flavour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Stale/Old</td>
<td>1. Long storage</td>
<td>Short Storage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Storage at high temperatures</td>
<td>Storage at low temperature (24°C) or below</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Excessive high pre-heating temperatures</td>
<td>Optimum pre-heating temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. High moisture content</td>
<td>Optimum moisture content</td>
</tr>
</tbody>
</table>
during storage

2. Scorched / Burnt
   1. Excessively high temperature (lipase not inactivated)
   2. Drum surface has pits
   3. Scraper knives blunt (in drum drying)

Optimum drying temperature
Drum surface kept smooth
Scraper knives kept sharp

B Body and Texture

1. Lumpy
   1. Insufficient drying
   2. Absorbtion of moisture (due to exposure to humid atmosphere)
   3. Drippage from pressure spray nozzle

Sufficient drying
Preventing absorption of moisture (by using moisture-impervious package)
Using centrifugal disc atomizer

2. Caked
   1. Absorbtion of moisture

Preventing absorption of moisture (by suing moisture-impervious package)

C Colour and appearance

1. Browning/ Darkening of colour
   Long storage
   Storage at high temperature
   Delayed cooling-and-removal of dried product from drying chamber
   High moisture content during storage

   Short storage
   Storage at a low temperature
   Prompt cooling and removal
   Preventing absorption of moisture (by using moisture-impervious package)

Uses

Skim milk powder

- In the preparation of toned, double toned andrecombined milks;
- In tea and coffee
- In ice-cream manufacture
- In prepared food, breads and rolls, biscuits,cultured milk products and in indigenous sweets.

Whole milk powder

- In the preparation of reconstituted milk
- In tea and coffee
In baby-food
In candy and confectionery, bakery products etc.,

**MODULE-9: CREAM AND BUTTER**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Methods of cream production,
- Factors influencing the fat percentage of cream,
- Quality, standardization and pasteurization of cream,
- Manufacture, packaging and storage of cream,
- Defects in cream, their causes and prevention,
- Manufacture, packaging and storage of butter,
- Judging of butter,
- Churning,
- Types of churner and
- Theories of churning.

**CREAM**

**Cream**

- According to the PFA rules (1976), cream, excluding sterilized cream, is the product of cow or buffalo milk or a combination thereof, which contains not less than 25 per cent milk fat. 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 may be broadly classified into Market cream, which is used for direct consumption, and Manufacturing cream, which is used for the manufacture of dairy products. The three different types of cream are

- Table cream/Light cream contains 20-25% milk fat.
- Coffee cream/Whipping cream contains 30-40% milk fat, and
- Heavy cream/Plastic cream contains 65-85% milk fat.

**Composition of cream**

The average chemical composition of cream is as follows:

- 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%

The solids not fat (SNF) content of cream can be determined by
% SNF in cream = \((100 - \% \text{ fat in cream} / 100 - \% \text{ fat in milk}) \times \% \text{ SNF in milk}\)

Cream can be separated from milk by either ‘gravity’ or ‘centrifugal separation’ methods. The basic principle of cream separation is based on the fact that milk fat is lighter than the skim milk portion (difference in densities). The average density of milk fat is 0.93 and skim milk is 1.036. Hence when milk is subjected to centrifugal force, the two components, viz., cream and skim milk, gets separated.

### METHODS OF CREAM PRODUCTION

#### I. Gravity method

When the milk is allowed to stand undisturbed for some time, there is a tendency for the fat to rise. This is given by the following equation, which is known as Stokes Law:

\[ V = \frac{2G (ds - df) r^2}{\mu} \]

where,
- \(V\) = velocity or rate at which a single fat globule rises
- \(G\) = acceleration due to gravity.
- \(ds\) = density of skim milk
- \(df\) = density of fat.
- \(r\) = radius of fat globules.
- \(\mu\) = viscosity of skim milk.

Applying the stokes law it can be observed that theoretically, velocity is increased by:
- Increase in radius of fat globules: Increase indifference in densities of skim milk and fat, Decrease in viscosity of skim milk.

The rate of rise of fat globules in gravity methods is affected by

- Size of fat globules: as the size of fat globules increases, the rate at which cream rises also increases.
- Temperature: As temperature increases, viscosity decreases and hence the velocity increases.
- A clump or cluster acts like a single globule in so far as movement through skim milk is concerned.
- Gravity methods being very slow, are no longer used commercially for cream separation.

#### II. Centrifugal method

Centrifugal cream separators are similar to clarifiers in that they consist of a stack of conical discs housed in a separator bowl and rotated at high speed by an electric motor.

The Separator

- The separator is a unit, which removes most of the milk fat from milk by centrifugal force. Its principal components are power source, a separator bowl, a set of gears and shafts, a product inlet and a product outlet for cream and skim milk.
- The separator bowl consists of an outer shell within which are a large number of cone shaped discs constructed so that between each pair is a very small space of not more
than 0.5mm. As the milk enters the bowl, it is distributed into these spaces between the discs; it is immediately subjected to a tremendous force. While both the fat and skim milk subjected to the centrifugal force, the difference in density affects the heavier portion (skim milk) more intensely than the lighter portion (i.e. Cream) thereby the skim milk is forced to the periphery while the fat portion moves towards the centre. The skim milk and cream both form vertical walls within the bowl and are separated by being led through separate outlets.

- Any insoluble particles in the milk, such as bits of curd or dirt etc., collects as ‘separator slime’ and is thrown outward as the bowl operates. These pass along with the skim milk into the space between the outer edge of the discs and the inner face of the bowl shell. Such material is deposited on this face of the bowl shell, which is removed latter. Separator bowl operate at speeds as great as 20,000 rpm. The separator is a precision instrument and hence has to be in good condition and operated properly to get maximum skimming efficiency.

**Centrifugal force (F) = K \cdot W \cdot R \cdot N^2**

Where

- W = mass of the revolving body,
- R = radius of the circle in which body revolves.,
- N = R.P.M of the revolving body.
- K = constant.

**Stokes’s law applied to centrifugal separation is as follows**

\[
\left(\frac{ds-df}{n}\right) \times V = r^2 \cdot N^2 \cdot R \cdot K.
\]

Where

- V = velocity
- n = viscosity of skim milk
- r = radius of fat globule,
- ds = density of skim milk
- df = density of fat,
- N = speed of the bowl
- R = distance of fat globule from the axis of rotation.
- K = constant

**FACTORS INFLUENCING THE FAT PERCENTAGE OF CREAM**

The important factors that influence the fat percentage of cream by centrifugal cream separation methods are:

- Position of the cream screw
  - The cream screw / outlet consists of a small threaded, hollow screw pierced by a circular orifice thorough which the cream emerges. This screw can be driven IN and OUT thus bringing it nearer to and away from, the center of rotation. Similarly the skim milk screw / outlet for the removal of skim milk, once the cream screw or skim milk screw has been adjusted, the cream separator delivers, under normal conditions, a definite ratio of skim milk and cream, which is usually 90:10 (or 85:15) by volume. By altering the position of the cream screw or skim milk screw the ratio of skim milk to cream changes. Thus when the cream screw is IN towards the axis of rotation, a higher fat
percentage in cream is obtained and vice versa. This is because the force
tending to discharge cream through the orifice is decreased while that
tending to discharge skim milk remains unaltered. Smaller proportions of cream is
therefore discharged, which, containing the same quantity of fat, shows a
higher fat percentage. Screwing OUT the cream screw produces thinner
cream. Similarly the skim milk screw OUT results in richer cream and vice
versa.

- Fat percentage in milk
  - The higher the fat percentage in milk, the higher the percent fat in cream. And
  vice versa. Since practically all the fat in milk is contained in the cream.

- Speed of bowls
  - Higher the speed of the bowl, the higher the fat percentage on cream, and vice
  versa.

- Rate of milk in-flow
  - The higher the rate of milk inflow, lower the fat percentage in cream and vice
  versa.

- Temperature of milk
  - The lower the temperature of milk during separation, the higher the fat
  percentage of the cream and vice versa.

- Amount of water or skim milk added to flush the bowl.
  - The greater the quantity of water added to flush the bowl, the lower the fat
  percentage in cream, and vice versa.

Factors affecting fat loss in skim milk during separation

The ‘skimming efficiency (SE) of a cream separator refers to the ‘percentage total fat from
milk recovered in the cream. The higher the fat percentage in milk and/or the greater the fat
loss in skim milk, the lower the skimming efficiency and vice versa.

The factors affecting the fat loss in skim milk are

- Temperature of milk
  - The lower the temperature, higher the fat loss in skim milk and vice versa. For
  the efficient separation the temperature of milk should be above the melting
  point of fat, so that the milk fat in the fat globules is uniformly in liquid form.
  A satisfactory temperature for separation is around 40 °C. The milk is heated
  before separation to 35-40 °C in plate or tubular heaters for efficient
  separation. This is known as ‘preheating /fore warming’ of milk.

- Speed of the bowl
  - The lower the speed, the higher the fat loss in skim milk and vice versa. At
  below –rated speed, there will be more fat loss in skim milk because
  insufficient centrifugal force is generated for efficient cream separation. With
  above rated speeds, the skimming efficiency will not increase greatly.

- Rate of milk inflow
  - The higher the rate of inflow, the higher the fat loss in skim milk and vice
  versa.

- Position of cream screw
  - Upto 50% of fat in cream, there is little effect on the fat loss in skim milk, but
  when the cream fat test is greater than 50-60%, there is greater fat loss in skim
  milk; if above 60% of cream is obtained still higher fat loss in skim milk
  results.

- Mechanical condition of the machine
  - Unsatisfactory mechanical condition of the cream separator causes greater fat
  loss in skim milk that include, vibration of the separator, conditions of discs,
  amount of separator slime in the bowl.
- **Size of the fat globule**
  - The greater the number of fat globules of less than 2 microns size, the higher the fat loss in skim milk and vice versa, as they escape the centrifugal force and to be recovered in cream.
- **Degree and temperature at which milk is agitated before separation**
  - The higher the degree and temperature of agitation the greater the loss in skim milk and vice versa.
- **Presence of air in milk**
  - The greater the amount of air, the higher the fat loss in skim milk.
- **Acidity of acidity**
  - The higher the acidity, the lower the efficiency of separation. The higher acidity, the lower the stability of casein particles, which in turn get precipitated and clog the bowl, thereby lowering the efficiency of separation.

### QUALITY, STANDARDIZATION AND PASTEURIZATION OF CREAM

#### Quality of cream

Cream is no better than the milk from which it is made. It is not possible to obtain good bacteriological quality cream from low grade milk. In order to produce high quality cream, the following steps are needed,

- Clean milk production
- Cooling of milk soon after production
- Separating milk under hygienic conditions
- Prompt cooling of cream and its storage at a low temperature

#### Standardization of cream

- This refers to the adjustment of the fat level in cream to the desired percentage conforming to standard requirements. The fat percentage in cream is usually adjusted to the prescribed level by the addition of calculated amount of skimmilk by Pearson’s square method.

#### Pasteurization of cream

- Pasteurization of cream refers to the process of heating every particle of cream to not less than 71°C and holding it at such a temperature for at least 20 minutes, or to any suitable temperature – time combination using approved and properly operated equipment.

#### Objectives of pasteurization

- To destroy the pathogenic microorganism in cream so as to make it, and also resultant butter, safe for human consumption.
- To destroy undesirable microorganisms and inactivate the enzymes present, so as to prolong the keeping quality of the cream and butter.
- To complete the neutralization process.
- To eliminate some of the gaseous tainting substances.
- To make possible the removal of some volatile off-flavours.
**Methods**

- **Holding pasteurization**
  - The cream is heated to 71 °C for 20 minutes and then promptly cooled.

- **HTST pasteurization**
  - The Plate Pasteurizer is better suited to freshly separated sweet cream than neutralized cream, as the latter more easily forms burnt-on films on the plates. The maximum heating temperature may be 95-100 °C for 5-16 seconds.

- **Vacuum pasteurization**
  - This is a continuous process and removes the off-flavours effectively. This process dilutes the cream and it will lower the fat percentage of cream up to 6-8%.

**MANUFACTURE, PACKAGING AND STORAGE OF CREAM**

**Manufacture of different types of cream**

- **Sterilized or canned cream**
  - Sweet cream is standardized to 20% fat, pre-heated to 80 °C without holding and then double homogenized immediately, cooled to 16 °C filled in to tin cans and immediately sealed. It is then sterilized at 118 °C for 12-15 minutes.

- **Plastic cream**
  - This is obtained by re-separating normal cream in a normal cream separator, or separating milk in a specially designed cream separator.

- **Frozen cream**
  - Objectives: To improve the keeping quality of cream during transportation over long distance, to store surplus cream for use during shortage mainly used by ice cream manufacturers who add sucrose to cream before freezing to prevent oiling off after thawing. First the cream is standardized to 40-50% fat, pasteurized at 77 °C for 15 minutes cooled to below 4 °C and filled into paper/plastic container or tin can and sealed well and then frozen at ~12 °C or below.

- **Clotted cream**
  - This is prepared by heating cream to 77-88 °C in shallow pan and then allowing it to cool slowly. The surface layer consists of clotted cream, which is skimmed off and strained.

- **Sour cream**
  - This is a heavy bodied ripened cream of high acidity (0.6%) clean flavor and smooth textures made by inoculating sweet, pasteurized and homogenized cream with a culture of lactic acid and allowing fermentation to proceed until these qualities are obtained.

- **Synthetic cream**
  - This is mixture of flour, egg-yolk, sugar, water, and vegetable fat usually groundnut oil.

**Packaging and storage of table cream**

- **Packaging**: Table cream is packaged for retail sale in units similar to those for milk such as glass bottle, paper cartons LDPE sachets, plastic bottles etc.

- **Storage and distribution**: Cream is preferably at 5-10 °C and distributed as early as possible, but preferably within three hours of removing from, cold storage.
<table>
<thead>
<tr>
<th>Name of the defect</th>
<th>Causes</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Table cream Flavour</strong></td>
<td>Excessive heating of cream during preparation.</td>
<td>Proper heating of cream during pasteurization.</td>
</tr>
<tr>
<td>Cooked flavour</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Feed and weed flavour | Feeding of milk-tainting feeds and weeds within 3 hours before milking | I) Feeding of milk-tainting feeds and weeds soon after milking  
ii) eradication of milk tainting weeds  
iii) vacuum pasteurization of cream |
| Highly acid/sour cream | Use of sour milk for separation.  
Acid development in cream. | Using fresh, sweet milk for perpetration.  
Neutralization |
| Oxidized/oily/metalllic/tallow. | Fat oxidation due to direct contact of milk with copper or iron, exposure of milk or cream to sunlight etc. | Proper tinning of milk or cream or cream holding vessels or using aluminum alloy or stainless steel as contact surface.  
Vacuum pasteurization of cream. |
| Rancid | Fat hydrolysis due to lipase action in milk or cream. | Inactivating lipase by proper pasteurization of milk and cream. |
| **Miscellaneous** | excessive homogenization pressure  
Using sour cream  
Addition of salts. | Proper homogenization pressure using sweet cream  
Avoiding addition salts. |
| Feathering on hotcoffee | Poor ventilation of milking byre/barn  
Not keeping milk properly covered during production. | Proper ventilation of milking byre/barn  
Keeping milk properly covered during production. |
| **Manufacturing cream Flavor** | Intake of bitter weeds by milk animals  
Lipase activity during cream | Eradication of offending weeds.  
Checking lipase activity by avoiding the danger zone during |  
Barney | | |
Butter may be defined as a fat concentrate, obtained by churning cream, gathering the fat into compact mass and then working it.

According to the PFA rules (1976), table creamery butter is the product obtained from cow or buffalo milk or a combination thereof, or from cream or curd from cow or buffalo milk or a combination thereof with or without the addition of common salt and annatto or carotene as colouring matter. It should be free from other animal fats, wax, and mineral oils, vegetable oils and fats. No preservatives except common salt and no colouring matter except annatto and carotene may be added. It must contain not less than 80% by weight of milk fat, not more than 1.5% by weight of curd, and, not more than 3% by weight of common salt. Diacetyl may be added as a flavoring agent but, if so used the total diacetyl content must not exceed 4 ppm. calcium hydroxide, sodium carbonate, sodium polyphosphate may be added, but must not exceed the weight of butter as whole by more than 0.2%.

**Classification**

Many kinds of butter are found in the market. This differs with the type of cream from, which they are made, and with variations in the manufacturing process. The types of butter are

- **Pasteurized cream butter**
  - Made usually from pasteurized sweet cream. Such butter usually has a milder flavour than that made from similar cream not pasteurized.

- **Ripened cream butter**
  - Butter made from the cream in which butter culture is added and incubated till the desired acidity and flavour are produced. Properly made ripened cream butter has a delicate flavour which is referred to as ‘real butter flavour’

- **Unripended cream butter**
  - Made from unripended cream.
- Salted butter
  - Butter to which salt has been added
- Unsalted butter
  - Contains no added salt.
- Sweet cream butter
  - Butter produced from cream in which the acidity does not exceed 0.2% in the churned cream.
- Sour cream
  - Made from cream in which the acidity exceeds 0.2%.
- Fresh butter
  - Butter that does not undergo cold storage.
- Cold storage butter
  - Butter stored at a temperature of about -18 °C for some time.
- Dairy butter (USA)
  - Made on farm. It is usually made from unpasteurised sour cream, which has not been standardized for acidity. This butter generally has a sour flavour due to the high acid content of cream.
- Creamery butter
  - Made in a creamery or dairy factory. It is more uniform in quality than dairy butter.

**Composition**

According to PFA Rules (1976) Table/Creamery Butter should contain not less than 80% fat, not more than 1.5 % curd and not more than 3% common salt. The typical composition of Indian butter has been given below.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butterfat</td>
<td>80.2</td>
</tr>
<tr>
<td>Moisture</td>
<td>16.3</td>
</tr>
<tr>
<td>Salt</td>
<td>2.5</td>
</tr>
<tr>
<td>Curd</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Butter is very rich in fat and fat-soluble vitamins.

**MANUFACTURE, PACKAGING AND STORAGE OF BUTTER**

**Method of manufacture, packaging and storage**

- Receiving milk
- Preheating (35-40°C)
- Separation
- Cream Neutralisation Receiving cream
- Standardisation for Fat (cow milk – 40%) (buffalo milk – 35%) (around 40% Fat)
- Pasteurisation 82 – 88°C with out holding / 65°C for 30 mts / 74°C for 15 sec.
- Cooling (room Temp.)
- Butter culture (0.5 to 2.0%)
- Ripening (21°C/15-16 hrs.)
- Ageing (5-10°C) (at least 2 to 4 hours) (preferably 15 to 16 hours)
- Churning and Washing (9-11°C)
• Addition of butter colour*
• (3%) Salting and Working of Butter
• Packaging and storage (-23 to -29 °C)

Overrun is caused by the presence (in addition to that of fat) of moisture, curd, salt, etc. in butter. It is a source of profit to the butter-maker (economical aspect); and also helps to check the efficiency of factory operations (technical aspect).

Average Overrun in Butter – 25% (due to moisture, curd, salt)

Details of manufacture

• Receiving milk / cream
• Grading
  o Purpose of grading is to pay for the product on the basis of its quality. Cream is graded on the basis of smell, taste, appearance, touch, acidity and sediment. The technique of grading cream consists in removing the lid of each can, inverting it and smelling it. Next the cream is examined for appearance and the presence of any extraneous matter. Cream for butter making is graded in accordance with the grades of butter that can be made from it. The cream grades are:
    ▪ First grade cream - sweet or slightly sour
    ▪ Second grade cream - sour, coagulated
    ▪ Reject grade cream - markedly sour, fermented.
• Sampling
  o Before sampling, the cream in the cans is thoroughly mixed by a combined rotary and vertical movements of the plunger/stirrer. If required the lidded cans of cream may be sprayed with hot water to reduce cream viscosity, and facilitate mixing. Then a representative sample may be drawn for testing purposes.
• Weighing
  o The cans of cream, which have been accepted, are then weighed and the weight recorded for accounting and other purposes. First grade creams are tipped directly into the main neutralization vats. The cream adhering to the inner walls of the cans is recovered by inverting the cans over steaming jet for short periods.
• Testing
  o The cream samples drawn are tested for fat, solids – not fat, acidity, etc., by standard methods.
• Neutralization of cream
  o Neutralization of sour cream for butter making refers to a partial reduction in its acidity.

Objectives

• To avoid excessive fat loss in buttermilk that results from churning highly acid pasteurized cream. When pasteurizing sour cream, the casein curdles; thereby entrapping fat globules as the bulk of curd goes to butter milk this cause high fat loss.
• To guard against the production of an undesirable off-flavour in cream.
• To improve the keeping quality of butter made from high acid cream. Salted – acid-butter develops a fishy flavour during commercial storage at -23 to -29°C. Correct neutralization is done by
• Adoption of a definite standard of churning acidity. Butter for long storage, the cream acidity should be reduced to 0.06-0.08% before churning. Butter for early consumption the cream acidity should be reduced to 0.25-30 % before churning.
Testing correctly for acidity take a sample of cream after thorough mixing,
First partially neutralize acid cream with a known quantity of standard alkali, and then treat as above.
Determine the lactic acidity of cream by titration of a fixed weight with a standard alkali using phenolphthalein as an indicator.
Correct amount of neutralizers to be added

The considerations are

- The quantity of neutralizers to be added to a vat of cream varies with the acidity of cream, the final acidity desired in pasteurized cream and with the neutralizer compound used.
- It is necessary; first, calculate the quantity of lactic acid to be neutralized per 100 kg cream. Then the amount of neutralizer required must be calculated.
- There are two groups of neutralizers available for use viz., lime (calcium hydroxide, and magnesium hydroxide) and soda (caustic soda, sodium carbonate, sodium bicarbonate and sodium sesquicarbonate)

The requirement of two selected neutralizers are given in table.

<table>
<thead>
<tr>
<th>Types of neutralizers</th>
<th>Theoretical (kg)</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium bicarbonate</td>
<td>0.93</td>
<td>0.83 Up to 0.30 per cent cream acidity.</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>0.41</td>
<td>0.91. Beyond 0.30 per cent cream acidity 0.49</td>
</tr>
</tbody>
</table>

Correct procedure for adding neutralizer

- The neutralizer should never be dry when added, but dissolved in clean, potable water and properly diluted, mixed with 10-15 times of its weight in water. The temperature of cream when adding the neutralizer should be preferably is 29-32º C. The cream acidity should be determined to check whether it has been correctly neutralized.
- Pasteurization/vacreation of cream.

Ripening of cream

- This refers to fermentation of cream with the help of desirable starter cultures.
- Objectives:
  - To produce butter with a pleasing pronounced characteristic flavour, aroma, uniformly from day to day.
  - To obtain an exhaustive churning, i.e., a low fat loss in buttermilk.
- The butter starter culture containing lactic acid producers such as Lactococcus lactis subsp. lactis and Lactococcus lactis subsp. cremoris together with aroma (diacetyl) producers such as Lactococcus lactis subsp. lactis biovar diacetylactis, Leuconostoc mesenteroides subsp. dextranicum or L. citrovorum, in correct proportions, is added to the standardized, pasteurized and cooled (20-22 º C) cream at 0.5-2.0 per cent. After being thoroughly mixed, the cream is incubated at 21 º for 15-16 hours. The typical flavour of butter from ripened cream is mainly the effect
of diacetyl, and to a smaller extent, of acetic acid and propionic acids. There is no diacetyl in sweet cream. The normal diacetyl content of ripened cream butter is on average 2.5 ppm and very rarely over 4 ppm.

**JUDGING OF BUTTER**

**Judging of butter**

- Examine the packet of butter for the presence of molds and for neatness. Open the packet and immediately inhale and note the odour. Cut with spatula and note the firmness of the body. Examine the cut side for oozing of moisture and presence of water droplets and air packets. Examine for the uniform distribution of colour on the cut surface. About 1 gm of butter is put into the mouth and allowed to melt. Note the taste and odour. Quality of butter is graded according to score card ADSA grades.
- The characters (Flavour, body and texture, Colour, Salt, Package) and Maximum marks (45, 25, 15, 10 and 5 points, A for 92 Point, B for 90 points and C for 89 Points.

**Flavour**

- Flavour gets maximum score and it is the main character in butter. It is a combination of taste and odour and odour being most important. The desired flavour in butter is described as sweet and nutty. Flavour is also described as fishy, rancid, curdy, cooked and yeasty, Butter can absorb odours and are described as unclean, fruity and etc.
- Body: this includes texture. It should be recently formed, close textured and waxy. There should not be excess moisture and should not stick on to hands.

**Common defects**

- **Leaky and crumbly**
  - When butter is under worked crumbly butter results, if it is over worked. Greasy or sticky butter results. Cumbersome butter also results if it contains higher amount of HMTG (High melting Tri glycerides). If butter is produced with prolonged churning and high temperature of wash water, it results in leaky butter.
- **Colour** : Natural colour of butter
  - Cow – light yellow – golden yellow
  - Buffalo – White.
  - Distinct discoloration of surface occurs and it may be due to certain species of micro organisms. If colour is not uniformly distributed mottling results.
- **Salt**: if salt is added and not dissolved uniformly grittiness results. Salt is added to impart a pleasant taste and to prolong keeping quality.
- **Package**: Packing material differs depending upon the usage and market demand, whatever be the packing material it should be hygienically clean and it should provide protection to contents from moisture, sunlight.

**CHURNING**

Churning of cream consists of agitation at suitable temperatures until the fat globules adhere, forming larger and larger masses and until a relatively complete separation of fat and serum occurs. The object of churning is to produce butter from cream. The fat exists in the form of emulsion i.e. a continuous phase. This emulsion is fairly stable. As long as
it remains intact, there is no formation of butter. The factors contributing towards the stability of this fat in skim milk emulsion are:

- Force of surface tension: this causes the fat globules in milk/cream to retain their individuality and prevent butter formation.
- Phenomenon of adsorption: the surface layer of the fat globules contains an adsorbed, phospholipid protein complex, which resists deemulsion.
- Electric charge: the fat globules have negative charge and repel each other. The charge decreases as the cream acidity increases.
- Viscosity: increased viscosity retards churning.
- A greater concentration of fat globules in cream promotes amore profuse and rapid coalescence and aggregation than milk.
- Preparation of churn: a new churn requires careful pre-treatment before use. An old churn requires proper sanitation and cooling, to render it clean.
- Filling the cream into the churn: the amount of cream filled should be slightly below the rated capacity.
- Addition of butter colour: this is done to maintain the uniformity of yellow colour in butter throughout the year for consumer satisfaction. The amount of standard color added varies from 0 to 250 ml or more per 100 kg of butterfat. The butter colour should preferably be added to the cream in the churn.
- Butter colour should have the following properties: it should be harmless, free from offflavours, concentrated, permanent, and oil soluble. Butter colours are of following types:
  - Vegetable origin: annatto and carotene. Annatto is obtained from the seeds of the annato plant (Bixa orellana) carotene is extracted from carrots and other carotene rich vegetable matter. Its use growing for it increases vitamin A potency.

Churning of cream

- Good churnability refers to clear breaking stage churning until the grains of butter are of the correct size. Exhaustiveness of churning refers to fat losses in buttermilk, satisfactory washing and optimum churning period.

Factors influencing churnability of cream and body of fat

- Chemical composition of fat: an increase in the proportion of soft fat shortens the churning period, diminishes the firmness of butter and increases the fat losses in butter milk and vice versa. Fresh green succulent feeds increase the proportion of soft fat and dry hard feeds increase the proportion of hard fat.
- Size of the fat globules: the higher the proportion of the small – sized fat globules, the longer the churning time and the greater the fat loss in buttermilk and vice versa.
- Viscosity of cream: the greater the viscosity of cream, the greater the churning period and vice versa.
- Temperature of cream at churning: Under Indian conditions the optimum churning temperature ranges from 9-11 °C. A higher churning temperature causes a shorter churning time, higher fat loss and a weak body in butter, which is difficult to wash and from which it is difficult to remove curd particles properly. A lower churning temperature prolongs the churning period.
- Fat percentage of cream. The higher the percentage of cream, the lower the churning period. The fat percentage under Indian conditions will be 40 for cow milk and 35 for buffalo milk.
• Acidity of cream: according to Hunziker, acid cream churns more rapidly and exhaustively than sweet cream. However Mc Dowel believes that the reverse is the case.

• Load off churn: the butter churn should be filled with one-half to one-third of its total capacity with cream. Overloading prolongs churning time, while under loading reduces total capacity of the churn.

• Nature of agitation: this is influenced by the size, type, and RPM of the churn, and affects the churning period.

• Pre-churning ageing period. Refers to cooling and ageing of cream.

**Operating the churn**

• After initially rotating the churn for 5–10 min., the liberated gas is removed once or twice by opening the churn vent. Then the cream sample is drawn for the fat test. During the churning process there is invariably a rise in temperature from 1-3 °C. Churning is accompanied by foaming. Then comes the “breaking stage”. When the cream breaks away from the spyglass, which becomes clear. At this stage the fat in the skim milk emulsion breaks and very small butter granules of the size of pin heads make their appearance, it is sometimes necessary especially in the tropics, to add break water at this stage to reduce the temperature of churn contents, and there by control the body of the butter. The amount and temperature of breakwater depends on the temperate reduction required. After the breaking the churning is continued until the butter grains are of the desired size (viz., ‘pea size’ in large churns). In the tropics, addition of breakwater can be avoided by providing an air-conditioned butter making room and/or chill water spray over the butter churn.

**Factors affecting fat loss in buttermilk**

• Fat percentage of cream: Lower the fat percentage of cream, the lower the fat percentage in butter milk, but the greater is the percent total fat loss in buttermilk, vice versa.

• Size of fat globules. the greater the proportion of small sized fat globules, the greater the fat loss, and vice versa.

• Acidity of cream at churning. According to Hunziker, sour cream causes a lower fat loss than sweet cream; but according to Mc Dowell, the reverse is true.

• Physical properties of fat: the softer the fat, the more the fat loss and vice versa.

• Condition of cooling and ageing: insufficient cooling and ageing i.e. improper crystallization causes more fat loss and vice versa.

• Conditions of churn: overloading, gross under loading and under churning all a cause a greater fat loss in butter milk.

**Washing**

When the cream has been churned the churn is stopped in the proper position, adrain-plug fixed and the buttermilk removed thorough sieve.

The purpose of washing is

• Remove all loose buttermilk adhering to butter grains so as to reduce the curd content of butter, thereby improving its keeping quality.

• To correct defecfs in the firmness of butter by proper adjustment of wash water temperatures, and

• To decrease the intensity of certain off flavours
After buttermilk has been drained chilled water is added to the butter grains in the churn. The temperature of water is usually 1-2 °C lower than the churning temperature of cream and an amount equal to the quantity of buttermilk removed. Normally one wash is enough for good quality butter. The quality of water should be physically clean and bacteriologically and chemically safe. It is better to use freshly pasteurized and cooled water.

**Salting**

- Refers to addition of salt to butter.
- To improve keeping quality
- To enhance the taste.
- To increase overrun. Salt is usually added at the rate of 2.0-2.5 % of the butterfat. Excessive salt damages the quality of butter.
- The calculated amount of salt may be added to butter either by sprinkling the powder salt over the butter surface during working or it may be wetted in the least amount of potable water and then sprinkled over the butter during working. The salt is added in the form of a saturated solution of brine.

**Specifications of butter salt**

- The salt should be a coarse grained and free from lump. It should pass completely through and IS sieve-85 (aperture 842 microns). 99.5 – 99.85 % sodium chloride on dry matter. Bacterial counts less than 10/kg. Completely soluble. High rate of solution. Negligible sediment.

**Working**

This refers to the kneading of butter

**Objectives**

- To completely dissolve, uniformly distribute and properly incorporate the salt.
- To expel buttermilk and to control the moisture content of butter,
- To fully incorporate the added makeup water in butter.
- To bring the butter grains together into a compact mass for convenient handling and packaging.
- During working, the moisture in butter is reduced to droplets of microscopic size, which are mostly sterile.
- The working should be continued until the butter has a compact body, closely-knit grain, a tough waxy texture, and an even distribution of salt and moisture. Indicator paper develops a coloured spot if free moisture is present. Both over working and under working should be avoided; the over working damages the body and texture of butter and under working produces leaky butter. Working increases the air content of butter. Normally worked butter has an air-content of 0.5-10ml/100 g. The air content of butter is important because it affects I) the density of butter ii) its microbial spoilage; and iii) its oxidative spoilage.

**Keeping quality of butter**

The factors affecting the keeping quality are

- Temperature of storage
- Copper and iron content the higher the content the lower the salt content of butter keeping quality.
- Acidity content of butter
- Curd content of butter
- Air content of butter.
- Raw or pasteurized cream: pasteurization of cream increases the keeping quality.
- The method of packaging: sanitized high quality packaging materials and sanitary methods of packaging increase the keeping quality and vice versa
- Exposure to light lowers the keeping quality
- Sweet cream/unsalted butter has the maximum and acid cream/salted butter the minimum keeping quality under commercial cold storage.

**Over run in butter**

- Over run may be defined as the increase in the amount of butter made from a given amount of fat. It is usually expressed as a percentage. Over run is caused by the presence of moisture, curd, salt etc., in butter. It is a source of profit to the butter maker and helps to check the efficiency of factory operations.

**Types**

**Theoretical over run**

- Maximum obtainable, viz. 25%. Since the minimum legal fat content of butter is 80%, the maximum amount of butter that can be made from 100 kg of fat are 100/80x100=125 kg. This gives an overrun of 25%, which is not obtainable in actual practice.

**Actual over run**

On the basis of fat actually bought and butter made therefrom.

- Factors influencing over run
  - Inaccuracy in weight, fat test of milk, cream, butter
  - Fat losses in skim milk or buttermilk
  - Mechanical fat losses
  - Unavoidable fluctuations in the fat content of butter
  - Weight allowances in butter packs or cream or butter
  - Handling losses etc.

**Formula for calculation of overrun**

\[
\% \text{ OR} = \left( \frac{B-F}{F} \right) \times 100
\]

Where

- OR = overrun in butter
- B = butter made (kg)
- F = fat in churn (kg).

**Yield of butter**

This is calculated by the formula:
FX ((100+\%OR) / Y ) x 100

Where

Y = yield of butter(kg)
F = fat content of cream. (Kg)
\%OR = Percentage over run in butter (Ave. 20-22).

<table>
<thead>
<tr>
<th>TYPE OF CHURNER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Batch type</strong></td>
</tr>
<tr>
<td>• Churner may be swinging type (cream is made to move forward and backward in a horizontal way) or rotatory type (by rotatory jerking movements) or dash churns (only the blade kept inside the barrel rotates)</td>
</tr>
<tr>
<td><strong>Continuous type</strong></td>
</tr>
<tr>
<td>• Fritz, Westfalia, Paasch, alfa lavel, Melshein and Cherry Burrel.</td>
</tr>
<tr>
<td><strong>Parts of batch type churner</strong></td>
</tr>
<tr>
<td>• Barrel like containers made up of wood or insulated metal containers with lid fitted with glass eyeholes. The churner with Gear system can be operated manually or using motors at an RPM of 45.</td>
</tr>
<tr>
<td><strong>Materials required</strong></td>
</tr>
<tr>
<td>• Churner, Cream at churning temperature, Ice or chill water, Butter Scoop, sieve, knife and wooden worker, Collecting vessel for butter and butter milk.</td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td>• The butter churn is cleaned and sterilised as follows. Fill 1/3rd of churn with clean water at 43°C and run the churn for 10 min and drain. It is followed with washing water at 60°C for 15-20 min and then with hot water at 80°C for 15 min.</td>
</tr>
<tr>
<td>• A final rinse with chlorinated water (200 ppm) is carried out. The already weighed and sampled cream at lower temperature of 9-11°C is transferred to the churner to 1/2 or 1/3 capacity. Tightly close the lid and the churner is operated at the RPM specified by the manufacturer (45 RPM).</td>
</tr>
<tr>
<td>• The starting time of operation is noted. After 10 min, the gas liberated is released by opening the churn vent once or twice. Foaming and rise of temperature accompany churning. Then comes the breaking stage, when the cream breaks away from the spyglass which becomes clear. At this stage the fat in skim milk emulsion breaks and very small butter granules of pin head size makes their appearance.</td>
</tr>
<tr>
<td>• It is sometimes necessary to add breakwater (9-10°C) at this stage to reduce the temperature of churn contents and to control the body of butter.</td>
</tr>
<tr>
<td>• After breaking stage, churning is continued still the granules reach maximum size (pea-size or so). The closing time is noted to assess the time taken (normally it takes 30 min for churning good quality cream).</td>
</tr>
</tbody>
</table>
The buttermilk is drained through drain-plug after positioning the churner for better drainage.

- Fresh chill water at a temperature 1-2 degree less than churning temperature and a volume equal to the volume of buttermilk drained is added for washing.
- Washing is done to remove the adhering buttermilk and reduce the curd content. The washed butter is collected and transferred to butter worker.
- A good quality finely powdered salt free of bacterial contaminants is sprinkled at 2 per cent level.
- For uniform mixing of salt, removal of excess moisture and to bring the butter granules together into a compact mass, kneading of butter (working) using the wooden butter worker is done. The butter is then packed in the required packages.

Packaging

- Overrun is caused by the presence (in addition to that of fat) of moisture, curd, salt, etc. in butter.
- It is a source of profit to the butter-maker (economical aspect); and also helps to check the efficiency of factory operations (technical aspect).
- Average Overrun in Butter – 25% (due to moisture, curd, salt)
- Butter contains only traces of lactose, so moderate consumption of butter is not a problem for the lactose intolerant. People with milk allergies need to avoid butter, which contains enough of the allergy-causing proteins to cause reactions.
- Butter can form a useful role in dieting by providing satiety. A small amount added to low fat foods such as vegetables may stave off feelings of hunger.

THEORIES OF CHURNING

They are three main theories on the churning of cream in to butter. Viz.

- Fisher and Hooker’s phase reversal theory
- Rahn’s foam theory
- King’s modern theory.

Fisher and Hooker’s Phase Reversal Theory

- According to this theory, churning is a process of phase reversal, i.e. changing an oil-in-water type emulsion to a water-in-oil type emulsion such as butter. Agitation of cream in the churning process causes coalescence and clumping of fat globules until eventually the ratio of the surface area to the volume of fat units becomes so small that it can no longer contain all the buttermilk in stable form. The fat-in-water emulsion then suddenly breaks, yielding butter grains and free buttermilk.
- **Drawback**
  - Butter is not true water in fat emulsion. Microscopic studies reveal that a proportion of fat globules in butter is still intact in the worked butter.

Rahn’s Foam Theory

- According to this theory, the presence of foam/froth is essential for churning. It also postulates that there is a foam producing substance present in cream, which gradually solidifies as the cream or milk is agitated. Foam is created during the churning period. The fat globules due to surface tension effect tend to concentrate and clump on the foam bubbles. The foam producing substance assumes a solid character and the foam collapses. The fat globules then coalesce and butter is formed.
- **Drawbacks**
Foam formation is not required in some continuous butter making processes.

**King’s Modern Theory**

According to this theory,

- In cooled cream at churning temperature, the fat is present as clusters of fat globules; and within each globule it is present partly in liquid and partly in solid form.
- Churning breaks up the cluster and cause foam/froth formation. The globules become concentrated to some extent in the film around the air bubbles in the foam and are thus brought into close contact with each other.
- The movement of the globules over one another in the foam film and the direct concussion between them causes a gradual wearing away of the emulsion protecting surfacelayer of the phospholipid protein complex. The globules then adhere together to form larger and larger particles. Eventually these particles become visible as butter grains. As the granules form, they enclose some of the air from the foam. The fat in the granules is still mainly in globular form.
- The working of butter grains cause the globules to move over one another, under the effect of friction and pressure, some of them yield up a portion of liquid fat. Others are broken up during working. Finally there is enough free liquid fat present to enclose all the water droplets, air bubbles and intact fat globules.

**Continuous butter making (CBM)**

- A number of types of continuous butter making machines have been developed for commercial use.

**Advantages of CBM**

- More economical due to lower capital cost, lower running cost (reduced power, labour, refrigeration, steam, detergent etc.).
- Reduced floorspace, no expensive foundations to prepare, no time loss for fat crystallization, less in butter wastage, etc.
- More hygienic due to it’s being a closed system, free from air borne contamination.

**Disadvantages**

- Lack of uniformity on the quality.
- Difficulty in grading and analysis.

**Basic principles**

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

- **Groups I**
  - Fritz process or churning process: this involves the use of high-speed beaters to destabilize the fat emulsion in the chilled cream, and thus cause the formation of grains of butter in matter of seconds. The buttermilk is drained away and the resulting grains worked in a kneading section prior to extrusion.

- **Group II**
  - Alfa-Laval process or the concentration and phase reversal process. This involves a system whereby cream of 30-40 per cent fat is concentrated in a special cream separator to 80-82% fat. After standardization, the
concentrated cream or butter mix is subjected to combined cooling and mechanical action, which causes phase reversal and the formation of butter, followed by its expulsion from the machine.

- **Group III**
  - Cherry Burrell process which again involves the concentration of 30-40% cream. During concentration, the emulsion is broken and the fat, water, and salt content are standardized. This is followed by re-emulsification, cooling working, and finally extrusion.

### Defects in butter, their causes, and prevention

- Defects in butter may arise due to low quality milk or cream, and faulty method of manufacture and storage of butter. The common defects in butter, their causes, and prevention are given below.

### Uses of butter

- Direct consumption.
- In the preparation of sauces.
- As a cooking medium.
- In the baking and confectionery industries.
- In the manufacture of Ice cream, butter oil and ghee.
- In the production of reconstituted milk.

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**MODULE-10: PANNER AND CHANNA**

### Learning outcomes

At the end of this module the learner will be able to understand the followings:

- Preparation of paneer and channa,
- Judging of channa and
- Uses of channa.

---

**PREPARATION OF PANEER**

Paneer is primarily an acid coagulated milk solid.

### Procedure
Here are few paneer dishes as are as follows:

- Mattar paneer (paneer with peas).
- Paneer majestic (paneer fried in a spicy batter).
- Saag paneer or Palak paneer (paneer along with spinach).
- Shahi paneer (paneer cooked in a rich, Mughlai curry).
- Shahi tukda (a dessert from frying paneer).
- Paneer tikka (a vegetarian version of chicken tikka, paneer placed on skewers and roasted)
- Kadai paneer
- Chili Paneer (with spicy chilies, onions and green peppers, usually served dry and garnished with spring onions)
- Paneer pakora (Paneer fritters)
- Paneer Capsicum

### DEFINITION AND USES OF CHANNA

- Channa is a product obtained by acid coagulation of milk near its boiling point followed by removal of whey. As per PFA rules, channa may be defined as a product obtained from cow or buffalo milk or a combination thereof by precipitating with sour milk, lactic acid or citric acid. It should not contain more than 70 per cent moisture and milk fat should not be less than 50 per cent of the dry matter.
- Channa is an indigenous milk product obtained by coagulating whole milk and by subsequent separation of whey. This coagulation is done by addition of lactic or citric acid.
- Channa differs from paneer in the method of preparation that no pressure is applied to remove the whey. The coagulum is collected in a cloth and hung on a peg without applying pressure to drain off the whey.
Physical Appearance

- Cow milk channa is light yellow in colour has a moist surface, soft body
- Smooth texture
- Buffalo milk is whitish in colour.
- Both buffalo and cow milk have a pleasant, sweetish mildly acid flavour.

Yield

- For cow milk, generally 15 per cent and from buffalo milk the yield is higher.

Uses

- Widely used in eastern parts of India and Bangladesh for the preparation of many milk-based sweets.
- Channa is also produced in the rural milk sheds and transported by road or rail to larger urban agglomerates in wicker baskets which allow further drainage of whey.
- Channa so produced is usually used for the preparation of sandesh. High quality sandesh is usually prepared from fresh channa.
- It is also used for rasagolla preparation. Channa has the same legal requirements as those of paneer.

METHOD OF PREPARATION OF CHANNA

Apparatus required

- Stainless steel vessel, stirrers, balance muslin cloth, funnel container for whey.

Procedure / Method of Preparation

- Channa is usually prepared by mixing old channa whey with boiling hot milk. The dilution with whey also contributes to make a smooth coagulum, which is considered desirable for making many Bengali sweets. For channa production, cow milk is preferred since it yields a soft bodied and smooth textured product. Both these characteristics are suitable for production of high-grade channa sweets. Channa from buffalo milk has a slightly hard body, a greasy and coarse texture, and does not produce good quality channa sweets. In order to obtain a desirable body and texture in channa the pH of coagulation should be around 5.4, the temperature of coagulation is above 80°C and the time in which coagulation is effected should be less than a minute. The satisfactory strength of the coagulating acid solution is 1-2 per cent. The acids commonly used for coagulation are lactic and citric acids. Lactic acid group consists of chemical lactic acid or sour whey whereas the citric acid group consists of chemical citric acid or lime juice. While lactic acid tends to produce a granular product, citric acid produces a pasty one. Commercial manufacturers generally use sour whey for economic reasons. Weigh the empty container.
- Milk is taken in container and weighed again. The difference in weights furnishes weight of milk taken. Milk is brought to boiling point and 5% citric acid solution is added with simultaneous agitation. Curdling should be effected in 1-2 minutes and sufficient amount of acid should be added to precipitate all proteins.
- Contents of vessel emptied over a piece of muslin cloth fixed on to a funnel. Whey is then collected in a pre weighed container. No pressure is applied and Channa is transferred to butter paper, weighed and cold stored. Yield of channa from cow milk is 16-18% and buffalo milk is 22-24%.
MODULE-11: GHEE AND KHOA

Learning outcomes

At the end of this module the learner will be able to understand the followings:

- Preparation of ghee and khoa,
- Defects in ghee, their causes and prevention,
- Judging of ghee.

GHEE

- Ghee may be defined as clarified butterfat prepared chiefly from cow or buffalo milk. (To clarify means ‘to make clear’ a liquid or something liquefied, by removing unwanted solid matter or impurities.)
- According to the PFA (1976), ghee is the pure clarified fat derived solely from milk or from desi (cooking) butter or from cream to which no coloring matter is added.

Chemical composition of ghee

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cow</td>
</tr>
<tr>
<td>Milk fat</td>
<td>99 to 99.5 per cent</td>
</tr>
<tr>
<td>Moisture</td>
<td>Not more than 0.5 per cent</td>
</tr>
<tr>
<td>Carotene ( m g/g.)</td>
<td>3.2-7.4</td>
</tr>
<tr>
<td>Vit.A (I.U./g)</td>
<td>19-34</td>
</tr>
<tr>
<td>Tocopherol ( m g/g.)</td>
<td>26-48</td>
</tr>
<tr>
<td>Free fatty acids (% oleic)</td>
<td>Max. 2.8 (agmark)</td>
</tr>
<tr>
<td>Charred casein, salts of copper and iron, etc.,</td>
<td>Traces</td>
</tr>
</tbody>
</table>

Physico-chemical constants

Ghee is characterized by certain physico-chemical properties, which show some natural variations depending on such factors as, method of manufacture, age and condition of the sample, species, breed, individuality and animals stage of lactation, season of the year, region of the country, feed of the animal etc., Some of the important analytical constants or standards of mixed ghee produced under standard conditions are given below:

- Melting and solidifying points
  - The melting point varies from 28°C to 44°C, while the solidifying point varies from 28°C to 15°C. (As ghee fat is of a mixture of glycerides, it does not have a sharp melting or solidifying point).
- Specific gravity
  - This varies from 0.93 – 0.94.
- Refractive index
- The Butyro-Refractometer (B.R), reading (at 40ºC) varies from 40-45.
- Reichert-Meissl (RM) Value
  - This is also known as Reichert value, and this should be normally not less than 28. However, ghee from cottonseed feeding areas, the limit is 20.
- Polenske value (P.V)
  - This should be normally not more than 2 (except for cotton-seed feeding areas, where the limit is 1.5)
- Saponification value
  - This should be normally not less than 220.
- Iodine value
  - This should normally vary from 26 to 38.

(Cotton tract refers to the areas in the states where cottonseeds are extensively fed to the cattle and so notified by the state government concerned.)

- Ghee is defined as clarified butter fat with a strong characteristic flavor prepared by heating makkhan, in an open pan, to about 110-120ºC till all the moisture is evaporated and the characteristic flavor develops. It can be compared to butter oil. Butter oil is the western counterpart of ghee.

**Origin**

- Ghee originated in India much before recorded history and the name originates from the sanskrit word meaning “bright”. The Vedas contain numerous references to ghee.

**Final temperature of clarification**

- The final temperature to which ghee is heated during the manufacture depends upon the region of the country, normally it is around 110ºC in north India and 120ºC in south India.

**Cooling and granulation (crystallization)**

- Granularity in ghee is considered as an important criterion of quality and even purity. Granular form of ghee is assumed primarily to certain content of glycerides of high-melting saturated fatty acids, esp.palmitic and stearic acid. In this regard the buffalo ghee, which is more saturated, crystallizes more effectively than cow ghee. It has been observed that heating ghee to 60-100ºC, followed by rapid cooling, yields small grains inghee; however, if the ghee is held for crystallization at a temperature about 1ºC above the melting point of ghee (cow ghee – 29ºC; buffalo – 31ºC), a large number of big grains result. Cold storage of ghee should be avoided, as it leads to a loss of granularity and the product develops a waxy consistency when stored.

**Renovation of Ghee**

This refers to the market practice of attempting to improve the old and rancid ghee, so as to make it marketable as a product of secondary quality.

**Some of the methods employed for the renovation of ghee include**

- Re-heating inferior ghee with curd, betel leaves, etc., and subsequently filtering it;
- Adding a yellow substance, such saffron, annatto, turmeric juice, etc to make it as cow ghee
• Blending an inferior ghee with a superior quality product.

Neutralizing high-acid ghee

• Market ghee sometimes develops large quantities of free fatty acid (oleic), which results from faulty methods of preparation and storage. This produces harmful effects in the body system. This is tackled by the process neutralization. In one, the neutralizer used is sodium hydroxide, and other is lime. Lime is more preferable than sodium hydroxide. First the high acid ghee to be refined, is heated to 60-70ºC, and finely ground, good quality lime(shell-lime), powdered to 60 mesh is then sprinkled on the surface @ 3 % of ghee. The temperature is quickly raised to108ºC with gentle stirring and mass is cooled and filtered at 60ºC.

Antioxidants

• Lipidoxidation is a chain reaction involving initiation, propagation and termination stages. The unsaturated fatty acids are oxidized to form odorless, tasteless hydroperoxides, which further degrade to yield carbonyls and other compounds, which give out the characteristic unagreeable oxidised flavour. The various factors which affect oxidation include, oxygen concentration, light intensity, contact with metals etc., Anti-oxidants are substances used to inhibit the progress of lipid oxidation, and may be either natural (e.g., Tocopherols, carotene,) or synthetic substances(Butylated hydroxy anisole, Butylated hydroxy toluene, Hydroquinone, gallic acid esters etc.,) Metal-chelating agents, such as citric acid and phosphoricacid, EDTA act in conjunction with anti-oxidants and inhibit fat oxidation.

• Keeping quality of Ghee can be extended by the addition of antioxidants. Under the PFA Rules (1976), BHA at not exceeding 0.02 per cent can be added. Naturally, betel leaves and curry leaves are added while ghee making at 1 per cent level, which gives good flavour to ghee as well as it acts as antioxidant.

The AGMARK ghee-grading scheme

Literally Agmark is an insignia - AG for “agricultural” and MARK for ‘marketing ’ with a view to develop the orderly marketing of agricultural produce on all India basis, the Indian legislature had passed the agricultural produce (grading and marketing) act 1937, this act provides for the grading of ghee on a voluntary basis.

The Agmark grading scheme was introduced mainly to achieve the following objectives.

• To assure the consumer a produce of pre-tested quality and purity.
• To enable manufacturers of a high-grade product to obtain better returns.
• To develop an orderly marketing of the commodities by eliminating malpractices when transferring them from the producer to the consumer.

<table>
<thead>
<tr>
<th>PREPARATION METHODS OF GHEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• More than 90 percent of ghee is produced by the traditional method from desi butter or makkhan and then converting it into ghee.</td>
</tr>
<tr>
<td>• Makkhan, which is produced by churning the curd, is heated in a metallic vessel and stirred over a low fire to evaporate the moisture.</td>
</tr>
<tr>
<td>• When practically all the moisture is removed, further heating is stopped and the vessel is removed from the fire. After the residue has settled down on cooling, the clear fat is decanted into suitable containers a ghee.</td>
</tr>
<tr>
<td>Tests</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Baudouin</td>
</tr>
<tr>
<td>Phytosterol acetate</td>
</tr>
<tr>
<td>B.R. reading (40°C) [40.0-43.0]</td>
</tr>
<tr>
<td>R.M. Value [28.0]</td>
</tr>
<tr>
<td>P. Value [1.0-2.0]</td>
</tr>
<tr>
<td>Moisture (%)</td>
</tr>
<tr>
<td>FFA (% oleic)</td>
</tr>
</tbody>
</table>

- Percentage of ghee residue = (Weight of ghee residue x 100) / Weight of butter
- Percentage of ghee obtained = (Weight of ghee x 100) / Weight of fat in butter
- Weight of fat in butter = 80 x weight of butter

**Methods of preparation**

Ghee can be prepared by various methods, which are as follows:

- Country/Desi method
- Creamery butter method
- Pre-stratification method
- Direct cream method
- Continuous method

**Desi Method**

Fresh or accumulated over a few days, makkhan (butter) is taken in a suitable open mud-pot or metallic vessel, and heated and stirred on a low fire to drive out the moisture. When practically all the moisture has been removed, a stage judged by experience, further heating is stopped and the vessel removed from the fire. On cooling, when the residue has settled down, the clear fat is decanted into suitable containers.

**Merits**

- Desirable flavour, body and texture

**Demerits**

- Extremely small scale in operation, problems in collecting and marketing
- Low keeping quality and vitamin content.
**Creamery butter method**

- A standard method, where unsalted creamery butter is used. Butter is heated in an ghee boiler consisting of a steel jacketed pan with a stirrer, with steam supply and control valves. The butter mass, is cut into small pieces and heated on low heat and carefully stirred. Later after complete melting, the steam pressure is raised to bring the liquid mass to boil at a temperature of 90ºC. The contents are constantly agitated throughout the process of conversion of butter into ghee, to prevent scorching. The scum, gathering on the top is periodically removed, until there is profuse effervescence, followed by crackling sound, initially. When all the moisture have been driven out, the temperature of the liquid shoots up suddenly and end point is indicated by the appearance of effervescence for the second time together with browning of the curd particles. At this stage, characteristic ghee flavor emanates and the temperature now will be around 110-120ºC . Heating is then stopped, and after cooling and sedimentation, the ghee is filtered through a muslin cloth and goes for granulation and packaging.

**Merits**

- **Saving in labour, physical exertion and exposure to uncomfortably high temperatures and humidity during actual ghee making compared to the direct-cream heating method.**

**Pre-stratification method**

- The two above mentioned practices of ghee making has the disadvantage of poor quality of the finished product characterized by an over-heated and smoky flavour, along with high acidity, making it greasy and with reduced shelf life. Hence research work has led to the evolving of a newer method/technique, which yields a higher grade product at lower cost, known as the pre-stratification process.

- The basic principle of this method is that, when butter is left undisturbed 80-85ºC for 15 to 30 minutes, it stratifies, i.e., separates into 3 distinct layers, viz., a top layer of floating denatured particles of curd, a middle layer of fat, and a bottom layer of buttermilk. This separation is called pre-stratification. The bottom layer of buttermilk contains 60-70 percent of solids-not-fat and also over 80 per cent of the moisture originally present in butter. The buttermilk is removed mechanically without disturbing the top and middle layers. After wards, the temperature of the remaining two upper layers (of denatured curd and fat) is raised to the usual clarifying temperature of 110-120ºC.

**Merits**

- Economy in fuel consumption as compared to direct clarification
- Production of ghee with lower acidity and longer shelf life.

**Direct-cream method**

- Here, the cream obtained by normal separation of milk is heated in the same
ghee boiler described for the creamery-butter method and the procedure for heating and moisture removal, final temperature of clarification, cooling and sedimentation, granulation and packaging also remain the same.

Merits

- Over all economy in labor compared to the creamery method

Demerits

- Low fat recovery
- Slightly greasy texture of ghee

Continuous method

Objects

- To manufacture ghee on an industrial scale as an continuous process
- To reduce human labor

Advantages

- Large scale handling
- Utilization of machines for a large number of operations
- Uniform demand on services
- High fat recovery
- Possibility of in-place-cleaning (IPC)
- No stirring, no scrapping and no laborious effort on the part of the ghee operators required.

<table>
<thead>
<tr>
<th>Name of the defect</th>
<th>Causes</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavour Smoky</td>
<td>Smoky fire used for boiling milk or converting makkhan into ghee in desi method.</td>
<td>Using non smoky fire for boiling milk or converting makkhan in to ghee in desi method</td>
</tr>
<tr>
<td>Overcooked /burnt</td>
<td>Excessive high temperature of clarification of ghee</td>
<td>Optimum temperature of clarification of ghee</td>
</tr>
<tr>
<td>Undercooked</td>
<td>Excessive low temperature of clarification</td>
<td>Optimum temperature of clarification of ghee.</td>
</tr>
<tr>
<td>Rancid</td>
<td>Fat hydrolysis due to lipase action in milk / cream / curd / butter/kachcha ghee.</td>
<td>Inactivation of lipase by proper pasteurization heating of milk cream etc., Using optimum</td>
</tr>
</tbody>
</table>
clarification of the Packaging in small containers for retail sale.

Oxidized/oily/Metallic Fat oxidation due to direct contact of milk curd/cream/butter/ghee with copper or iron exposure of this product to sunlight etc. Storage of milk curd / cream / butter / ghee in properly tinned or aluminum alloy / stainless steel vessels.

Filling ghee up to the brim so as to avoid any head space air.

Avoiding storage of ghee at high temperature.

Avoiding use salted butter from ghee making avoiding long storage of ghee.

Storage of ghee in opaque containers.

Texture

Greasy

Rapid cooling of hot ghee after clarification.

Subjecting ghee to further heating and cooling treatments after preparation.

Slow cooling of hot ghee after clarification.

Avoiding further heating and cooling of ghee after preparation.

Colour

Burnt

Excessively high temperature of clarification of ghee.

Optimum temperature of clarification of ghee.

Sediment

High

Incorrect straining of ghee.

Correct straining of ghee.

Burnt

Excessively high temperature of clarification of ghee.

Optimum temperature of clarification.

Uses of Ghee

- As a cooking or frying medium
- In confectionery
- For direct consumption
- In indigenous pharmaceutical preparations (mainly cow ghee)
Ghee residue

This refers to the charred light to dark brown residue which is obtained on the cloth strainer after the ghee, prepared by different methods, is filtered. It is by-product of the ghee industry. Essentially it contains heat-denatured milk-proteins, caramelized lactose and varying proportions of entrapped fat,besides some minerals and water.

<table>
<thead>
<tr>
<th>Type of Residue</th>
<th>Chemical composition</th>
<th>Ave.Yield (kg) (per 100 Kg) Butter / Cream (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Fat</td>
</tr>
<tr>
<td>Cow</td>
<td>14.4</td>
<td>32.4</td>
</tr>
<tr>
<td>Buffalo</td>
<td>13.4</td>
<td>33.4</td>
</tr>
</tbody>
</table>

Ghee residue is a rich source of milk fat,proteins and minerals. Methods of recovery of ghee-residue includes, centrifugal and pressure techniques.

Uses

- For direct consumption.
- For preparation of ghee-toffees
- For preparation of sandwich paste and 4. For preparation of burfi sweets

JUDGING OF GHEE

Colour

- Though it is influenced by the method of production, the colour of ghee from cow milk is deep yellow, while ghee from buffalo milk is white with a characteristic yellowish or greenish tinge. When mixed, colour varies accordingly. Also the state of ghee as liquid or solid influences the colour.

Flavour: (smell and taste)

- It is an important characteristic small quantity of ghee is rubbed over the back of palm and smelled by inhaling. A well-prepared sample of ghee has a pleasant, cooked and rich flavour. The taste is usually sweet and characteristic of milk fat, although a slight acidic flavour is preferred.

Texture: (grain and consistency)

- Indian buyers relay on granulation for quality and purity. Granulation of ghee is partly due to glycerides of high melting saturated fatty acids (hard fat - palmitic and stearic etc.,) and thus buffalo ghee crystallizes more effectively than cow ghee. The desi method produces large crystals in ghee compared to direct-cream method. Heating ghee to 60-100°C and rapid cooling yields small grains in ghee. However if the ghee is kept at 1°C above the melting point of ghee (cow ghee ~29°C: buffalo ghee ~ 31°C) a large number of big graining results. Cold storage of ghee should be avoided, since it leads to loss of granularity and the development of waxy consistency in the stored product.
Packaging

- Non-toxic, non-tainting material with easy availability, economical, resistance to rough handling, suited for printing and capacity to hold desirable volume are preferred.

### KHOA

- Khoa/ Mawa / Khava refers to the partially dehydrated (heat coagulated) whole milk product prepared by continuous heating of milk in a karahi over a direct fire, while also constantly stirring-cum-scraping by using a khunti till it reaches a semi solid consistency. Thereafter the pan contents are removed from the fire and worked up in to a solid mass known as khoa pat.

- According to PFA Rules (1976), khoa is the product obtained from cow or buffalo (or goat or sheep) milk, or a combination thereof, by rapid drying. The milk fat content should not be less than 20 percent of the finished product.

### Classification

- Three main types of khoa, viz., Pindi, dhap and Danedar are prepared in the country.

### Composition

**Chemical composition of Khoa (percentage)**

<table>
<thead>
<tr>
<th>Type of milk</th>
<th>Moisture</th>
<th>Fat</th>
<th>Protein</th>
<th>Lactose</th>
<th>Ash</th>
<th>Iron (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>25.6</td>
<td>25.7</td>
<td>19.2</td>
<td>25.5</td>
<td>3.8</td>
<td>103</td>
</tr>
<tr>
<td>Buffalo</td>
<td>19.2</td>
<td>37.1</td>
<td>17.8</td>
<td>22.1</td>
<td>3.6</td>
<td>101</td>
</tr>
</tbody>
</table>

- Khoa has been prepared for centuries in India as a base material for manufacturing sweets. It is prepared by the traditional method by milk traders and halwais. A five times concentration of milk is normally required.

- The three main varieties are “pindi” for burfi, “dhap” for gulabjamun, pantooa etc., and “danedar” used for kalakand. Khoa making has been the easiest way of preserving rurally produced milk in the flush season.

- According to PFA Khoa is a product obtained from cow, buffalo, goat or sheep or mixed milk by rapid drying. The milk fat content should not be less than 20 per cent of the finished product. It is also called khawa or mawa. The product is obtained by heat desiccation of milk to 65 – 69 per cent solids in an open pan.

### Uses

- Khoa forms the base material for a variety of Indian sweets like gulabjamun and dishes.

#### METHOD OF PREPARATION OF KHOA

Three methods have been known in the production of khoa. They are
• Existing practice

Existing practice

• Required quantity of milk is taken as per batch and boiled in a karahi (vessel) of different shape and size over a brisk non-smoky fire. The milk is stirred vigorously and constantly with a circular motion by a ladle or khunti. During this operation, all parts of the pan with which the milk comes in contact are lightly scraped to prevent the milk from scorching. Constant evaporation of moisture takes place and the milk thickens slowly. However, no sugar is added and milk-dehydration continues until heat-coagulation of milk proteins begins and the concentrate becomes insoluble in water. There is change of colour at this stage, and heating is continued with greater control with increased stirring-cum scraping speed. Soon the viscous mass reaches a semi-solid/pasty consistency and begins to dry up. The final product is ready when it shows signs of leaving the bottom and sides of the karahi and sticking together, which is known as the khoa-pat. This is invariably made after removing the pan from the fire and working the contents up and down into a single compact mass.

Improved method

• This is followed in organized firms, where the equipment, conditions of dehydration, and the quality of the milk used are given importance. The karahi and openfire substituted with stainless steel jacketed-pan or kettle, which is heated by water or steam. Milk is boiled till it assumes pasty consistency and then held at 85°C and stirring at 100 rpm. Regarding the quality of the milk used, buffalo milk is preferred over cow milk as the latter produces soft, loose body and gives smooth a granular texture which is not relished. The milk should contain 4% and 5% fat respectively for cow and buffalo milk. Neutralization of acid milk improves the texture but does not improve the flavour of khoa. Starch adulterated milk gives hard khoa. Homogenization of milk produces softer body and fat leakage.

Continuous method

Here milk is continuously heated in the steam-jacketed drum heater, where it is partially concentrated. This is followed by another heating and concentration of the milk in open pans till a viscous semi-solid product is obtained and is removed mechanically. The equipment basically consists of

• A steam-jacket drum heater with a rotary scraper and milk outlet
• Two open steam-jacketed pans with outlet valves
• Two sets of scrapers for the pans and
• A power drive for the scrapers.
• A cover is provided in the pan to prevent any dust or dirt falling into it.

Physicochemical changes in milk on conversion into khoa

The following are the changes that are encountered while milk is being converted into khoa.

• Change of state: From liquid milk to solid khoa (due to considerable dehydration)
• Change in intensity of colour: From ‘light’ to a more intense shade of colour with a tinge of brown.
- Homogenization of milk fat: The fat globules are appreciably subdivided due to vigorous agitation of the milk at a high temperature.
- Free-fat formation: Considerable free fat is produced due to rupturing of the fat globule membrane by the scraping action of the stirrer.
- Heat coagulation of milk proteins: The serum proteins are coagulated by the action of heat and concentration.
- Super-saturated solution of lactose: From a dilute solution in milk, lactose is present in khoa as a super-saturated solution.
- Partial precipitation of milk salts: A portion of the milk salts are precipitated by the action of heat.
- Increase in Iron content: From 2 to 4 ppm in milk, the iron content in khoa exceeds 100 ppm due to scrapping of the pan surfaces during the manufacture.

**Yield**

- The type of milk, cow or Buffalo, influences the yield by virtue of its total solids content. Buffalo milk with higher total solids give higher yield than cow milk. Normally the yield of khoa ranges from 17 to 19% from cow milk and 21 to 23% for buffalo milk.

**Over-run**

The over-run in khoa refers to the excess weight of khoa obtained over the amount of total (milk) solids used. It is influenced by the moisture chiefly. The formula for calculating overrun (OR) in khoa is:

\[
\%\text{OR} = \frac{K - \text{TS}}{\text{TS}} \times 100
\]

Where,

\(K = \) weight of khoa (in kg)

\(\text{TS} = \) Weight of total solids in milk (in kg).

**Other Traditional Indian Products**

- **Burfi**
  - Akhoa based sweet, it is white to light cream in colour with firm body and smooth granular texture. Prepared by heating khoa over a low fire with 25-35% sugar to form a smooth mass. Nuts and flavourings may be added while heating to produce a variety of burfies.

- **Gulabjamun**
  - Khoa is mixed with small amounts of wheat flour and baking powder and kneaded into uniform dough. It is then rolled into small balls and deep fried in ghee. The balls are then put in 60% sugar solution and soaked for few hours before serving.

- **Kalajamun**
  - Similar to gulabjamun but darker, it can be prepared either from channa or khoa. The kneaded balls are deep fried to black colour and then soaked in 60% sugar solution for few hours.

- **Kalakand**
  - Made from granular khoa, it is light caramel in colour with a granular texture and firm body. Some citric acid is added during khoa making process to get
grains, then sugar is added and stirred to mix the sugar. Flavourings and nuts may be added and allowed to set, which is later cut into pieces.

- **Peda**
  - The base material is khoa, where it is mixed with sugar and flavourings. Khoa is mixed with sugar in the ratio of 3:1 and then gently heated till the mixture forms firm balls. Peda is whitish yellow in colour and has a coarse, grainy texture. Kesar peda is one in which saffron is mixed along with flavour and colour.

- **Chumchum**
  - A sweet prepared from channa, it has a firm body, a close knit texture and is coated with sugar or khoa. Channa is kneaded, made into balls and cooked in 50% boiling sugar syrup. Then they are taken, cut into half and a layer of khoa is sandwiched in between two halves of the balls and its surface is coated with sugar or khoa and decorated with silver foil.

- **Pantooa**
  - A product similar to gulab jamun, it has channa as the base material as compared to gulab jamun which used khoa. Channa is mixed with baking powder and wheat flour, and the mass in kneaded, made into balls and fried in 60% sugar syrup solution.

- **Rasagolla**
  - This is prepared using fresh and soft channa as the raw material, in the form of small round balls, which is cooked in sugar syrup for 15 minutes and transferred to sugar syrup of 45-50% concentration.

- **Sandesh**
  - A channa based sweet, which has a firm body and smooth texture. Channa (30-35%) and sugar are mixed together and kneaded and then heated after addition of colour and flavour.

- **Rabri**
  - A concentrated and sweetened milk product, containing several layers of clotted cream.

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**MODULE-12: LASSI AND DAHI**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Lassi,
- Preparation of dahi and
- Judging of dahi.

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**LASSI**

- **Lassi** is a popular drink of India and Pakistan. It is made by blending curd/yogurt with water or milk and Indian spices.
- Traditional lassi (also known as salted lassi, or, simply lassi) is a savory drink sometimes flavored with ground roasted cumin.
- Sweet lassi on the other hand is blended with sugar or fruits instead of spices.

---

**PREPARATION OF DAHI**
In India curd is also called Dahi. As per PFA rules, dahi is a product obtained from pasteurised or boiled milk by souring using previously cultured milk or otherwise by using selective lactic cultures.

**Apparatus required**

- Stainless steel wares, glass wares, water bath, incubator, refrigerator, etc.

**Starter required**

- Good quality milk, starter culture which includes *Streptococcus diacetylactis*, *Streptococcus cremoris*, ith an aroma producing bacteria mainly *Leuconostoc citrovorum* or *Leuconostoc dextranicum*.

**Procedure**

- Pasteurise milk at 85°C for 10 min and cool the milk immediately (20-25°C) by keeping the container in running water, by simultaneous agitation. Add 0.5% of starter culture at this temperature and mix thoroughly.
- Distribute this cultured milk into a small sterile steel or glass container taking aseptic precautions, and fix a sterile aluminium cap.
- Permit the cultured milk to remain undisturbed for 16-18 hours at 22-25°C, or to reach the acidity of 0.8-0.98.

**Requirements for dahi**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirement for sweet dahi</th>
<th>Requirement for sour dahi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity, lactic (percentage weight)</td>
<td>0.70</td>
<td>1.0</td>
</tr>
<tr>
<td>Yeast and mould count/gm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Coliform count/gm</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Phosphatase test</td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>

**JUDGING OF DAHI**

It is done to find whether the dahi offered for sale possess desirable characters for direct consumption.

**Procedure**

- If the container is taken from cold storage, it is allowed to warm slightly without opening the lid. Examine for the firmness of body, separation of whey at the bottom, middle or top, presence of gas bubbles and change in colour. Open the lid and immediately examine the contents for flavour, odour, etc.
- Desirable characters of market quality of dahi includes colour, appearance, flavour, body and texture and acidity. While examining the body and texture following defects have to be noted.
  - **Watery consistency**: Due to low solids or due to poor quality of milk. Too high or insufficient heat treatment can also cause this defect.
- **Hard and lumpy curd**: This is due to over ripening especially at high temperature and this defect is usually found along with same amount of whey formation.
- **Wheying off**: Wheying off in dahi may be due to low solid content or due to deliberate dilution with milk. Higher acidity also causes these defects. Disturbances or vibrations at the time of curd setting also result in whey formation.
- **Ropiness**: Ropiness due to faulty fermentation resulting in low acid production and sweet curdling due to certain microbes.

**Common flavour defects are,**
- Bitter and cheasy: due to peptonising proteolytic organisms.
- Cooked defect: due to overheating
- Flat: due to low acid and diacetyl production
- Rancid: due to lipolytic organisms
- Fruity and alcoholic: due to yeast and molds
- Malty defect: due to *S. lactis var. maltigenes*

### MODULE-13: ICE-CREAM AND CHEDDAR CHEESE

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Ice cream,
- Method of manufacture of ice cream,
- Cheese,
- Cheddar cheese and
- Varities/Defects in cheese.

**ICE CREAM**

- Ice cream may be defined as a frozen dairy product made by suitable blending and processing of cream and other dairy products together with sugar and flavour, with or without stabilizers or colour, and with the incorporation of air during the freezing process.
- According to the PFA rules (1976) ice cream is the frozen product obtained from the cow or buffalomilk or a combination thereof or from cream and or on the milk products, with or without the addition of cane sugar, eggs, fruits, fruit juices, preserved fruits, nuts, chocolate, edible flavours and permitted colours. It may contain permitted stabilizers and emulsifiers not exceeding 0.5 per cent by weight. The mixture must be suitably heated before freezing. The product should contain not less than 10% milk fat, 3.5% protein, and 36% total solids. However, when any of the aforesaid preparations contains fruits or nuts or both, the content of milk fat may be proportionately reduced but not less than 8% by weight, starch may be added to a maximum extent of 5%, with a declaration to that effect on the label.

**Classification**

Some of the frozen deserts can be classified as follows.
- **Plain**: Ice cream in which the colour and flavouring ingredients together amounts to less than 5 per cent of the volume of the unfrozen ice cream. Example: vanilla and coffee ice creams.
- **Chocolate**: Ice cream flavoured with cocoa or chocolate.
- **Fruit**: Ice cream containing fruits with or without additional fruit flavouring or colour. Fruits such as strawberry, apricot, pineapple, mango, banana, etc., may be fresh, frozen, frozen packed, canned or preserved.
- **Nut**: Ice cream containing nuts, such as almonds, pistachio, walnuts, cashew nuts, etc., with or without additional flavoring or color.
- **Milk ices or lollies**: According to the PFA rules (1976) these refer to the frozen product obtained from the milk or skim milk or milk products with or without the addition of cane sugar, eggs, fruits, nuts, chocolate, edible flavours, and permitted food colours. It may contain permitted stabilizers not exceeding 0.5 % of the product. The mixture should be suitably heat treated before freezing. The product should contain not more than 2.0% milk fat, less than 3.5% proteins and not less than 20.0% total solids.
- **Ices**: Made of fruit juices sugar and stabilizers with or without additional fruit acid, colour, flavouring, or water, and frozen to the consistency of ice cream. Usually contain 28 to 30 per cent sugar, 20 – 25 per cent over run and no dairy products.
- **Sherbet**: Made of juices, sugar, stabilizers and milk products. It is similar to an ice except that milk, either whole, skim, condensed or powdered, or ice cream mix, are used in place of all or, part of the water in an ice.
- **Fancy moulded**: Moulded in fancy shapes and composed either of one colour and flavour of ice cream or a combination of colours and flavours, or especially decorated. Examples: are brick ice cream, cakes, cake roll, moulds representing fruits, etc.
- **Novelties**: Novelty ice cream or frozen is an especially shaped and usually low priced package containing an individual serving whose main appeal consists in its shape, size, colour or convenience for eating.
- **Soft ice cream**: Sold as drawn from the freezer without hardening.

### Composition

The composition of ice cream is usually expressed as a percentage of its constituents, i.e. a percentage of milk fat, milk solids not fat, sugar, stabilizers, total solids etc. Its composition varies in different localities and in different markets.

The ISI specifications for ice cream are given below:

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Characteristics</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>weight (g./litre/min.</td>
<td>525</td>
</tr>
<tr>
<td>2</td>
<td>Total solids(%wt. min)</td>
<td>36.0</td>
</tr>
<tr>
<td>3.</td>
<td>Milk fat (% wt. Min.)</td>
<td>10.0 (Tentative)</td>
</tr>
<tr>
<td>4.</td>
<td>Acidity (% lactic acid max.)</td>
<td>0.25</td>
</tr>
<tr>
<td>5.</td>
<td>Sucrose (%wt. Max.)</td>
<td>1.50</td>
</tr>
<tr>
<td>6.</td>
<td>stabilizers/emulsifiers(%wt. Max)</td>
<td>0.5</td>
</tr>
<tr>
<td>7.</td>
<td>Standard plate counts (per g.)</td>
<td>Not more than 2,50,000</td>
</tr>
<tr>
<td>8.</td>
<td>Coliform count (per g.)</td>
<td>Not more than 90</td>
</tr>
</tbody>
</table>
Food and nutritive value

- Ice cream contains two to three times as much fat and slightly more protein than does milk. In addition it may contain other food products such as fruits, nuts, eggs, and sugar which enhance its food value. However, like milk, it lacks iron, vitamin C, and some of the trace minerals.
- Ice cream is a rich source of calcium, phosphorus and other minerals of vital importance in building good bones and teeth.
- Being rich in lactose, ice cream favours greater assimilation of the calcium content on the diet.
- The protein content of ice cream rates high both in quantity and quality. The milk and egg proteins are complete, that is, they contain all the amino acids essential to animal life and are especially important sources of tryptophan and lysine which are lacking in many plant proteins. Ice cream provides these valuable proteins in a very palatable form. In fact, ice cream is the most palatable source of milk proteins to vegetarians.
- Ice cream is an excellent source of food energy. Having twice to three times the fat content of milk. And more than half of its total solids being sugar the energy value of ice cream is very high. It is therefore, a very desirable food item for growing children and persons who need to put on weight.
- Ice cream, is a rich source of essential vitamins, without which normal health and growth cannot be maintained. Thus it is an excellent source of vitamin A, a good source of vitamin B and G (riboflavin) and a fairly good source of Niacin, vitamin E, and in fruit ice cream, of vitamin C. The digestibility and palatability of ice cream is also very high.

Role of the constituents in ice cream

- Milk fat: this is high in food value, but expensive. It enriches and mellows the ice cream, giving it a full, rich, creamy flavour. If the milk fat is even slightly off-flavoured, the defect will be noticeable. The fat also contributes to the body and melting resistance of ice cream while producing a smoothness of texture. Fat gives stability to the ice cream but impairs whipping ability.
- Milk solids not fat: they add very little to the smell, but improve its body and texture, however milk sugar adds to the sweet taste. The milk proteins help to make ice cream more compact and smooth. Milk SNF should be added in as large a quantity as possible without risking the danger of sandiness. They are high in food value and also inexpensive.
- Sugar: the main function of sugar is to increase the acceptability of ice cream. The desired sweetening effect is only produced by sucrose. Sugars are usually the cheapest source of total solids in the mix.
- Stabilizers: these are used to prevent the formation of objectionable large ice crystals in ice cream, especially during storage. Since they are added in very small quantities, they have a negligible influence on food value and flavor.
- Emulsifiers: These are used mainly to improve upon and provide a uniform whipping quality of the mixture, and to produce a drier ice cream with smoother body and texture.
- Flavor and colours: flavor increases the acceptability of ice cream, and colours its aesthetic appeal.

Properties of mix
The properties of practical importance on the mix are

- **Viscosity:** This is defined as the resistance offered by liquids to flow. Viscosity is considered an important property of the ice cream mix, and a certain amount of it seems essential for proper whipping and the retention of air. Two types of viscosity exist in ice cream mixes:
  - **Apparent viscosity:** This is a thickened condition that disappear with agitation, and Basic viscosity: which remains after the apparent viscosity disappears. The viscosity of ice cream mix is influenced by composition, kind and quality of ingredients, processing and handling of the mix, total solids concentration and temperature.

**Acidity and pH**

The normal acidity of ice cream mixes is dependent upon the serum solids content, and is calculated by the formula:

\[
\frac{\text{% serumsolids in mix}}{\text{% serumsolids in milk}} \times \text{% Acidity of mix} = \text{% Acidity of milk}
\]

The normal acidity of ice cream mix is 0.15%. The pH of ice cream mix should be 6.3. If the mix acidity is more, it maybe neutralized with suitable neutralizers Eg. Sodium bicarbonate. It should be remembered that good ice cream couldn’t be made from a highly acidic cream.

**Mixstability**

- This refers to stability or resistance to separation by the milk proteins in an ice cream mix. Instability results in separation of milk proteins as coagulated or precipitated material in the mix, and the resulting ice cream has a curdled appearance on melting. Mix stability is affected by high mix acidity, low citrate and phosphate content, high calcium and magnesium content, high homogenizing pressure, high heat treatment, low ageing time, destabilizing effect of freezing etc.

**Surface tension**

- This refers to the force of attraction between the molecules of a liquid at its surface. The greater the attraction between the molecules, the higher the surface tension and vice versa. The unit of measurement of surface tension is dyne.
  - The surface tension can be readily decreased by the addition of emulsifiers. Mixes with lower surface tension values will have excessive whipping rate, fluffy short body characteristics and susceptibility to the shrinkage defect. The normal surface tension value of ice cream mix may range from 48- 53 dynes/sq.cm.

**Freezing point**

- The freezing point of ice cream is dependent on the soluble constituents and varies with its composition. The mix constituents, which affect the freezing point directly, are sugar, milk sugar, milk salts, and any other substances that may have been added and are in true solution. Freezing point is indirectly affected by fat, protein and any other constituents not in true solution by replacing water. Glucose, sucrose and corn sugar depress the freezing point in the descending order. In fruit ice-cream the freezing point will depend on the type of sugar used in fruit preparations.
- An average mix has a freezing point of 27.5°F. Mixes with high sugar and milk solids but not fat content may range to 26.5°F, while high fat, low MSNF or low sugar content mixes may range to 29.5°F.

**Whipping rate**

- A high whipping rate means the ability to whip rapidly to a high overrun. The present hypothesis is that whipping ability is based on the tensile strength and the strength of the lamella (i.e., walls around the air cells). Whipping ability is improved by a high processing temperature, proper homogenization and ageing the mix for 2-4 hours.
- Smaller fat globules and less clumping of fat globules increase the whipping ability. Mixes made from butter, butter oil, or frozen cream have poor whipping ability. Egg yolks, fresh cream, buttermilk solids improve whipping ability. Sugar decreases the whipping ability except when added after homogenization, in which case it increases it.
- The construction and operation of the freezer affect the whipping ability.
- The rate of whipping is measured by calculating the overrun at one minute intervals while the mix is being frozen in a batch freezer. Normally, within 3 to 5 minutes after the freezing process starts, the mix is frozen and within 7 minutes an overrun of 90 percent is obtained. In mixes, which have a rapid whipping rate, 90 percent overrun may be reached in 5 minutes or less. Mixes requiring 8 minutes or more to reach 90 percent overrun are considered to have slow whipping rate.

**METHOD OF MANUFACTURE OF ICE CREAM**

**Method of manufacture**

**Selection of ingredients**

The selection of ingredients is without doubt the most important factor in successful ice cream manufacture. A clean fresh creamy flavour of the ice cream can be secured only by the use of products, which have been carefully selected and handled. The selection of ingredients depend on

- **Availability** of milk products
- **Perishability** of the products
- **Convenience** in handling
- **Effect on** flavour, body, and texture of ice cream
- **Cost** and
- **Equipment** available.

Ice cream ingredients may be grouped into dairy and non-dairy products.

**1. dairy products**

- **Source of fat**
  - Sweet cream: this is the most desirable concentrated source of fat for use in mixes
  - Frozen cream
  - Plastic cream
  - Unsalted butter
  - Butter oil.
- **Source of milk-solids - not fat**
  - Skimmilk
- Skim milk powder—this is most frequently used in the spray dried or flaked form.
- Condensed skim milk
- Sweet cream buttermilk.

**Sources of both fat and solids not fat**
- Wholemilk.
- Wholemilk powder
- Condensed whole milk
- Evaporated milk.

### II. Non-dairy products

#### Sweetening agents
- Canesugar or beet sugar.
- Cornsugar (dextrose)
- Cornsyrup solids (dextrose+maltose)
- Cornsyrup
- Invert sugar (glucose + fructose)
- Saccharin.

#### Stabilizers
- Gelatin—of animal origin.

It was one of the first of the commercial stabilizers and still used, its advantages lies in its ability to form a gel inthe mix during the aging periods as well as during the freezing process, and even after the frozen product is placed in the hardening room its peculiar gel stricture and its great affinity for waste prevent the formation of large ice crystals in ice cream and contribute to the smoothness on texture and firmness in body of the frozen product.

The amount of gelatin used depends on several factors such as the source of gelatin whether from calf, pork skin or bonematerials. Its gel structure is measured by bloom test.

Commonly gelatin is used at the rate of 0.25 to 0.5% for a 250 bloom gelatin. The ice-cream mix stabilized with gelatin usually requires about 4 hours of ageing to develop complete stabilizing properties, while other stabilizing materials do not require an ageing period.

- Sodiumalginate—of vegetable origin. The basic stabilizing principle ‘algin’ is extracted from ocean kelp (seaweed) growing on the shores of California and in Japan. This product improves whipping ability and leaves a slightly cleaner flavour in the mouth. It dissolves properly only when added to the mix at about 68-71°C. A slightly smaller amount is needed to produce the same stabilizing effect as gelatin.
- Guargum—of Indian origin.
- Carageenan
- Agaragar:
- Carboxymethyl cellulose
- Pectin

**Emulsifiers:** They are substances which help to form emulsions.

Glycerol Mono Stearate (GMS).

### Flavours

- Vanilla—this is the most popular flavour all over the world. Vanilla flavouring is obtained from the perennial climbing plant Vanilla Planifolia Andrews, a member of
the orchid family, vanillin is the principal flavouring material. The typical vanilla flavours is developed by fermenting the bean.

- Chocolate

Chocolate and cocoa rank second only to vanilla as flavoring of ice cream. They are obtained from cocoa beans, the fruit of the perennial tree Theobroma cacao, growing in such tropical regions as Mexico, Ghana, Brazil, Venezuela, Nigeria, Ecuador, The West Indies, African Gold Coast and The East Indies etc.

- Strawberry
- Pineapple
- Lemon
- Banana
- Mango
- Orange

**Colour**

- Yellow
- Green
- Pink.

**Egg solids**

- Egg yolk solids improve the whipping ability.

**Fruits and nuts**

- Apple
- Banana
- Mango
- Pineapple
- Grape
- Almond
- Pistachio
- Cashewnut
- Walnut
- Groundnut.

**Figuring the mix**

- Knowledge of calculation of ice cream mix is helpful in properly balancing the mix, inestablishing and maintaining a uniform quality and in producing ice cream that conforms to legal standards. Ice cream mix may be divided into two groups, namely simple and complex. Simple mixes require the least calculation and are made of ingredients, each of which supplies one constituent. Complex mixes are more difficult to calculate they include mixes where at least, one constituent is obtained from two or more products. Complex mixes require the use of the Pearson's square, algebraic methods.
- The calculations are simplified by first finding the weight of ingredients needed to make 100kg of the desired mix. With the algebraic method, symbols such as X, Y, Z is used to represent the weight of dairy ingredients required for a 100 kg batch of mix. These symbols are then used in writing the three equations that express the weight of
fat serum solids (SNF) and the total weight of dairy ingredients needed for 100kg of mix.

Making the mix

The order in which ingredients are added is as follows:

- All liquid ingredients are placed in a jacketed vat provided with a power stirrer, and the agitation and heating started at once, the dry ingredients, including skim milk powder, sugar, and stabilizers are added while the liquid material is agitated before the temperature reaches 49ºC. Proper suspension to avoid lumpiness of the dry ingredients may be obtained by either mixing the dry materials thoroughly with part of the sugar before slowly adding it to the liquid, or by sifting/slowly adding these substances to the liquid.
- If gelatin is the stabilizer used, it is best added after it is thoroughly mixed with equal volume of sugar, and before the liquid material reaches 49ºC. Alternatively, it can be sprinkled on the surface of the cold liquid and allowed to soak before the mixture is heated or soaked in water and the mixture heated to completely dissolve the gelatin, which is usually added to warm (38-49ºC) mix.
- If sodium alginate is used, it should not be added until the temperature of the liquid material has reached at least 66ºC. The dry Dariloid is not allowed to soak but is stirred up with cold water and immediately dumped into the hot mix.
- If butter, plastic cream, frozen cream, or other products are used, they should be cut into small pieces and added after time has been given to allow for complete melting before the pasteurizing temperature is reached. With a few exceptions, colouring and flavouring materials are added when the mix is frozen.

Pasteurization of mix

The purpose of pasteurization are

- It renders the mix completely free of pathogenic bacteria,
- It dissolves and helps to blend the ingredients of the mix.
- It improves flavour,
- It improves keeping quality, and it produces a more uniform product

The ISI specification for pasteurization temperature – time combination for ice cream mix are as follows:

- Batch system - 68.5ºC for not less than 30 min.
- HTST method - 80 ºC for not less than 25 sec.

In batch system the heating and holding may be accomplished in the vat used for mixing the ingredients.

Homogenization of mix

The main purpose of homogenization is to make a permanent and uniform suspension of the fat by reducing the size of the fat globules to a very small diameter, preferably not more than 2 microns.

The advantages of homogenization are

- It prevents fat separation during ageing.
Produces more uniform ice cream with a smoother texture.
Improves whipping ability
Shortens ageing period.
Decreases the risk of churning occurring in the freezer and
Leads to the use of slightly less stabilizer.
The mix is usually homogenized at temperature from 63 to 77º C at pressure of
2500 to 3000 PSI with one valve, or 2,500 to 3000 PSI at the first stage and 500
PSI at the second stage will usually give good results for an average mix (with 3 to 12% fat).

Cooling and ageing of mix.

- Cooling the mix immediately after homogenization to 0-5ºC is essential, after which
  it should be held in ageing tanks until used. Ageing refers to holding the mix at a low
  temperature for a definite time before freezing. The ageing temperature should not
  exceed 5ºC. The ageing time under commercial conditions may range from 3 to 4
  hours, except for sodium alginate which requires no ageing.

Ageing

- Improves the body and texture of ice cream
- Improves the whipping capacity
- Increases maximum overrun
- Increases melting resistance.

Freezing the mix

- Freezing is one of the most important operations in the making of ice cream for upon
  it depends the quality, palatability and yield of the finished product.
- The freezing process may be divided into two parts. The mix with the proper amount
  of colour and flavouring materials generally added at the freezer, is quickly frozen
  while being agitated to incorporate air in such a way as to produce and control the
  formation of small ice crystals which is necessary to give smoothness in body and
  texture, palatability and satisfactory overrun in the finished product.
- When ice cream is partially frozen to a certain consistency it is drawn from the
  freezer into packages and quickly transferred to cold storage rooms where the
  freezing and hardening is completed without agitation.

Classification of freezers

- Batch freezer: Horizontal position and direct expansion type.
- Continuous freezer: Horizontal position and direct expansion type.
- Soft serve freezer: Batch and automatic continuous freezer of the direct expansion
  type.

Importance of rapid freezing

- Rapid freezing is essential for a smooth product because ice crystals that are
  formed quickly are smaller than those formed slowly. Therefore it is desirable to
  freeze and draw the mix from the freezer in as short a time as possible. A continuous
  freezer accomplishes this in a few seconds, while batch freezer takes 6 to 10 minutes.
  Since the freezing continues after the ice cream is placed in the hardening rooms, the
  ice crystal formed during the hardening period are larger because they are formed
  more slowly than in the freezer. For this reason it is desirable to freeze the ice cream
as stiffly as possible and yet have it liquid enough to be able to draw it out of the freezer.

**Factors influencing the freezing time**

- Mechanical:
- Type of freezer
- Condition of freezer walls and blades
- Speed of dasher.
- Temperature of refrigerant.
- Velocity of refrigerant passing around the freezing chamber.
- Overrun desired.
- Temperature at which ice cream is frozen.
- Rate at which freezer is unloaded.
- Characteristics of mix.
- Composition of mix.
- Freezing point of mix.
- Acidity of the mix.
- Kind of ingredients, particularly those carrying fat.
- Method by which the mix is processed.
- Kind and amount of flavouring materials added.
- Changes occurring during freezing of ice cream mix.
- The function of freezing process is to freeze a portion of the water of the mix and to incorporate air into the mix. This involves:
  - Lowering of temperature of the mix from the ageing temperature to the freezing point.
  - Freezing a portion of the water in the mix.
  - Incorporating air into the mix.

Cooling the ice cream from the temperature at which it is drawn from the freezer to hardening room temperature.

The temperature of mix, which is put into the freezer drops very rapidly, this process, takes less than a minute or two. Meanwhile the rapid agitation reduces the viscosity by partially destroying the gel structure and by breaking up the fat globule cluster. The gel structure may restore itself partially during the hardening process in the hardening room. The rapid agitation hastens incorporation of air into the mix.

When freezing point is reached the liquid water changes to ice crystals, which appear on the mix. These ice crystals are practically pure water in a solid form, and thus the sugar as well as the other solutes becomes more concentrated on the remaining liquid water. Increasing the concentration of these solutes slightly depresses the freezing point of the liquid portion, so that the temperature must be lowered before anymore ice crystals will form. Thus, infreezing ice cream, the freezing point is continually being lowered by the formation of ice crystals and while the temperature drops, more ice crystals are formed, increasing the concentration of sugar and other solutes in the remaining liquid water until the concentration is so great that further freezing will not occur, thus all the water does not freeze even after long periods in the hardening room.

The first phase of freezing process accounts for the freezing of 3 to 6 per cent the water, depending on the drawing temperature. The second phase i.e. hardening process, this account for the freezing another 23 to 57 per cent, depending on the drawing temperature.
**Batch freezing:** the batch freezer consists mainly of a freezing chamber and a dasher. The dasher consists of two parts viz., scraper blades and the beater, the dasher performs the following functions:

Aids in transmission of refrigeration by keeping the mix in continuous contact with the freezer walls, scrape freezer walls free of ice crystals, beats in air, continually pushes mix forward, which is essential for unloading the freezer.

The freezing procedure in batch freezer consists of

- **Preparation of the freezer**
  - The freezer parts should be inspected to ensure that they are clean and dry. Then they should be assembled in accordance with the instructions from the manufacturer. The freezer is sanitized by running hot water or chemical (chlorine) sanitizers.

- **Adding the mix**
  - It is always desirable that the temperature of the mix be below 5°C when it goes into the freezer. Colour and flavourings should be added only when some ice crystals have been formed. The total volume of the mix, flavour, and colour should be about half the total capacity of the freezer chamber.

- **Freezing and incorporation of air**
  - The mix should now run into the freezer, the dasher should be started and then the refrigerant turned into the freezing chamber. This sequence must be maintained, the dasher must never be operated when there is no mix in the freezer. Neither should the refrigerant be turned on unless the dasher is in motion.

- **Drawing of ice cream**
  - When ice cream is drawn from the freezer, it should be sufficiently stiff to ‘ribbon’ or almost hold its shape, and yet soft enough to ‘settle’ or lose its shape within a minute or two. The container or package into which the ice cream is drawn should be cooled sufficiently to prevent the ice cream melting; this melting may cause a coarse and icy texture around the edge of the package and also loss of overrun. Formation of air pockets within the container should be avoided, the freezer should emptied rapidly to prevent wide fluctuations in overrun in the package. Therefore avoid filling small packages directly from the batch freezer.

- **Continuous freezing**
  - Continuous freezers are of two types in the market
    - One of these has two pumps just behind the freezer barrel; one pump pulls the mix from the supply tank and pumps it to the second one. The second pump operated at a speed approximately twice as great as that of the first pump. This has the effect of creating a partial vacuum between the two pumps. The valve device in the piping between the pumps allows for air to be sucked in. The amount of air incorporated can be regulated very accurately. The second pump pumps the mix and air into the freezer barrel. As the mix freezes, semi-frozen ice cream is forced out from the front of the machine.
    - The second type operated in a very similar fashion as the first, however here the two pumps are at the front. One pump pushes the mix into rear end of the freezer and the other helps to pull out the semi-frozen ice cream form the freezer. There is separate air pump that forces air directly into the freezer barrel. This second kind of continuous freezer is just as versatile as first one.

Some important **advantages** of the continuous freezing method are

- Less stabilizer is needed.
• A shorter ageing period.
• Less flavouring material is needed.
• Smoother ice cream is obtained.
• Tendency towards development of sandiness decreases
• A more uniform yield is obtained with less variation between packages.

Some **disadvantages** are

• Great care must be taken in handling the parts of the machine that fit with very small clearance. Operators and mechanics must have special experience and training in order to avoid operational difficulties and possible damage to the equipment.
• It is difficult to prevent excessive overrun.
• There is greater tendency for ice cream to shrink on volume after hardening.
• Initial cost of the equipment is high.

**Overrun in ice cream**

Overrun is usually defined as the volume of ice cream obtained in excess of the volume of the mix. It is usually expressed as a percentage. This increased volume is composed mainly of the air incorporated during the freezing process. The amount of air incorporated depends on the composition of the mix and the way it is processed; and is regulated so as to give that percentage overrun or yield which will give the proper body, texture and palatability necessary to a good quality product. Too much air will produce a snowy, fluffy, unpalatable ice cream while too little, a soggy, heavy product. The desirable overrun percentage in different ice creams is given below.

<table>
<thead>
<tr>
<th>Product</th>
<th>%OR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice cream packaged</td>
<td>70-80</td>
</tr>
<tr>
<td>Ice-cream bulk</td>
<td>90-100</td>
</tr>
<tr>
<td>Softy ice cerium</td>
<td>30-50</td>
</tr>
</tbody>
</table>

There are two basic or fundamental methods of calculating percentage overrun, viz., by volume and by weight.

\[
\text{ [(volume of ice cream) } - \text{(volume of mix) / volume of mix ] } \text{ i) } \% \text{ O R = } x 100.
\]

\[
\text{(weight of unit volume of mix weight of unit volume of ice cream / weight of unit volume of ice cream ) } \text{ ii) } \% \text{O R = } x 100
\]

**CHEESE**

• Cheese has been defined as a product made from the curd obtained from milk by coagulating the casein with the help of 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 and / or pressing which has been shaped in a mould, and then ripened by holding it at some time at suitable temperature and humidity.
• According to PFA rules (hard) cheese means the product obtained by draining after the coagulation of milk with a harmless milk-coagulating agent, under the influence of harmless bacterial cultures. It shall not contain any ingredients not found in milk, except coagulating agent, sodium chloride. Calcium chloride not exceeding 0.02
percent by weight, annatto or carotene colour; and may contain certain emulsifiers and/or stabilizers, namely citric acid, sodium citrate or sodium salts of ortho-phosphoric acid and poly-phosphoric acid nor exceeding 0.2 percent by weight, wax used for covering the outer surface should not contain anything harmful to the health. In case the wax is coloured, only permitted food colours may be used. Hard cheese shall contain not more than 43% moisture and not less than 42% milk fat on dry matter. Hard cheese may contain 0.1% sorbic acid or its sodium, potassium or calcium salts; 0.1% nisin.

Scientific basis of cheese making

Milk
↓
Souring / ripening
↓
Clotting / coagulation by rennet
↓
Cutting and drainage of whey.
↓
Matting of the curd.
↓
Maturing / curing

The above five steps are common for all types of cheeses, but the conditions vary considerably.

Classification

- World wide there are more than 2000 types of cheese, sometimes made by very different manufacturing processes. Cheese can be classified according to the following systems:
  - Geographical considerations: country, valley, institution, town or region where first produced / marketed.

Type of milk: cow, sheep, and goat, buffalo.

Method of manufacture: Temperature of cooking, degree of acidity, fineness of cutting etc. these affect moisture retention which in turn affect the firmness and slow the rate of ripening.

General appearance: flavour, size, colour, keeping quality.

Physical appearance and rheological properties

- Very hard - less than 25% per cent moisture
- Hard – 25 to 36% moisture
- Semi-hard 36 to 40% moisture and
- Soft cheese 40% moisture.

Chemical analysis: water, calcium, sodium chloride, casein, lactose, fat, acidity contents.

Microbiological properties: bacterial ripened, mould ripened, unripened etc.

A summary of classification of some important variety is of cheeses.
<table>
<thead>
<tr>
<th>Country of origin</th>
<th>Soft</th>
<th>Semi hard</th>
<th>Hard</th>
<th>External mould ripened</th>
<th>Internal mold ripened</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>Cream(c)</td>
<td>Lancashire</td>
<td>Cheddar</td>
<td>-</td>
<td>Stilton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cheshire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>Neufchatel</td>
<td>- gruyere(p)</td>
<td>Camembert</td>
<td>Roquefort/blue(G)</td>
<td>-</td>
</tr>
<tr>
<td>Belgium</td>
<td>-</td>
<td>Limburger(S)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Italy</td>
<td>-</td>
<td>-</td>
<td>Parmesan(VH)</td>
<td>-</td>
<td>Gorgonzola</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Romano</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provolone(W)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Romadur.</td>
<td>Munster</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Holland (The Netherlands)</td>
<td>-</td>
<td>-</td>
<td>Edam Gouda</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>USA</td>
<td>Cottage Cream(C)</td>
<td>Brick</td>
<td>Cheddar Swiss(P)</td>
<td>-</td>
<td>Blue(G)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-</td>
<td>-</td>
<td>Herrigard(p)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Switzerland</td>
<td>-</td>
<td>-</td>
<td>Swiss/Emmental, Sapsago</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Norway</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Gammelost.</td>
</tr>
<tr>
<td>Hungary</td>
<td>Liptau</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Remarks**

C=high fat content; G= a general name; P =propionic fermentation leading to holes (eyes) R = ripened; s= surface slime; U= un-ripened; W = washed (plastic) VH = very hard.

The average composition of some of the important varieties of cheeses

<table>
<thead>
<tr>
<th>Name</th>
<th>Moisture</th>
<th>Fat</th>
<th>Protein</th>
<th>Ash and salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>42.5</td>
<td>30.7</td>
<td>21.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Camembert</td>
<td>47.9</td>
<td>26.3</td>
<td>22.2</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>CHEDDAR</td>
<td>36.8</td>
<td>33.8</td>
<td>23.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Cottage</td>
<td>69.8</td>
<td>1.0</td>
<td>23.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Cream</td>
<td>42.7</td>
<td>39.9</td>
<td>14.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Edam</td>
<td>38.1</td>
<td>22.7</td>
<td>30.9</td>
<td>6.2</td>
</tr>
<tr>
<td>Limburger</td>
<td>54.8</td>
<td>19.6</td>
<td>21.3</td>
<td>5.2</td>
</tr>
<tr>
<td>Parmesan</td>
<td>17.0</td>
<td>22.7</td>
<td>49.4</td>
<td>7.6</td>
</tr>
<tr>
<td>Roquefort</td>
<td>38.7</td>
<td>32.2</td>
<td>21.4</td>
<td>6.1</td>
</tr>
</tbody>
</table>

**Food and nutritive value of cheese**

Cheese has high nutritive value

- It is an excellent source of milk proteins.
- A rich source of calcium and phosphorus.
- An excellent source of several fat-soluble vitamins, such as A, D, E, and K.
- A concentrated source of energy. Cheddar cheese has about 400 calories/100 g.
- Palatable and digestible; there is practically no waste.

**CHEDDAR CHEESE**

**Manufacture of cheddar cheese**

- Receiving of milk
- Preheating
- Filtration/clarification
- Standardization
- Pasteurization (63°C/30min.)
- Adding starter cultures (ripening)
- Adding colour
- Adding rennet (clotting) 31°C.
- Coagulation and setting
- Cutting
- Cooking (up to 37°C)
- Drainage of whey
- Cheddaring
- Milling
- Salting
- Hooping
- Dressing
- Pressing
- Drying
- Paraffining
- Curing/maturing.

**Receiving milk**
Only high-grade milk can yield high grade cheese. The quality of finished cheese depends upon the initial quality of milk from which it is made. Cheese is no better than the milk form, which it is made.

Successful cheese factories follow a system of daily, efficient grading of all milk received. This consist of

- Determining the odour of milk.
- Inspecting the appearance of milk,
- Determining the sediment
- Performing MBRT, Resazurin and rennet curd tests on the milk.
- Determining the percentage of titrable acidity.
- Examining milk for bacteriophage, antibiotics, and inhibitory substances.
- After the milk has been examined for quality and accepted, it is weighed, then a representative sample is taken for determining of fat and casein contents etc.

**Filtration and clarification**

- To remove visible dirt in milk. The milk is usually preheated to 35 to 40°C for efficient filtration and clarification.

**Standardization**

In cheese making standardization refers to adjustment of the casein/fat ratio in cheese to 0.68 to 0.70. The objectives are

- To regulate the fat in the dry matter of cheese.
- To produce the maximum amount of cheese per kg. of fat in cheese milk.

**Pasteurization**

The usual temperature time employed for pasteurization of cheese milk is holder – 63°C for 30 min. HTST – 72°C for 15 sec.

The objectives or advantages of pasteurization of cheese milk are

- To destroy all pathogens
- To destroy fault producing microorganism.
- To produce a more uniform product of high quality.
- To increase the yield.

The chief limitations of pasteurization are

- It destroys the typical flavour and body of cheese.
- It entails a longer ripening period.
- It encourages the use of low quality milk.
- It increases the overall cost of cheese making.
- **Homogenization:** cheese milk is not normally homogenized.
Addition of calcium chloride

- Excessive heat treatment of milk causes the precipitation of a part of calcium salts in milk, this results in slower renneting action and a weaker curd, which can be corrected by the addition of 0.001 to 0.03 per cent calcium chloride to milk.

Adding starter

- Ripening or souring of milk refers to the development of acidity in milk from the time it is received in the vat until renneting. In cheese milk, ripening is done by the addition of starter.
- The starter is the heart of the cheese. A bad starter is almost certain to give low quality cheese. A good starter may makeup for other defects, such as contaminated milk; there are different kind of cheese starters, such as those producing acids, aroma, special effects such as ‘eyes’ etc. A cheddar starter usually contains S. lactis and /or S. cremoris.
- The usual time to add the starter is before all the milk has been received in the vat. The amount of starter added is to the extent of 0.5 to 1 per cent of the milk, and the temperature of addition is 30 to 31°C. Before being added to the milk, the starter should be examined for its quality; it should then be stirred until smooth and creamy in consistency; then strained and added in the required quantity and mixed thoroughly and uniformly into the milk.
- Ripening in milk is measured by titration, rennet test and pH meter.

Adding colour

- The colour of cheese is usually an alkaline solution of annatto. The colour is usually diluted with approximately 20 times its volume of potable water for even distribution. The usual amount of colour is 30 to 200 ml or more for 1000 kg of milk.

Renneting

- Adding rennet to milk in cheese making is commonly known as renneting or setting.
- Rennet is the crude preparation or extract from the abomasum, rennet contains two principal enzymes viz., rennin, and pepsin. Rennin is an extremely powerful clotting enzyme, which causes rapid clotting without much proteolysis. On the other hand pepsin induces proteolysis leading to bitterness in cheese. Rennet is available as liquid or powder or as tablet. Commercial rennet should be stored in a closed vessel, in a dark room at below 10°C.
- Rennet: it is a sulphur containing protein. One part can clot about 5 million parts of milk. In cheese making one part of liquid rennet (2%) is used for about 5000 parts of milk. It is very sensitive to alkali. Heating to 70°C at pH 6.8 – 7.0 will destroy it in 14 minutes.

Factors affecting rennin action
- **Temperature**: below 20ºC, rennin is almost inactive; from 30 to 48ºC it is about equally active, the optimum temperature being 41ºC. Above 50ºC the activity falls off rapidly.
- **Acidity**: the rate of clotting increases rapidly with small increase in acidity. Alkalis retard the clotting of rennet.
- **Calcium ions**: coagulation of milk is very sensitive to changes in concentration of calcium ions, it is common practice to add calcium chloride to which has been severely pasteurized. E.g. at 80ºC for 30 seconds. This acts in three ways by lowering the pH value, increasing the calcium ion concentration and raising the colloidal calcium phosphate content.
- **Inhibitory substances**: Many colloidal substances interfere with rennin coagulation e.g. albumin, serum peptones, etc. Albumin and globulin retard coagulation (mastitis milk clots slowly with rennet; the alkalinity of such milk also contribute to this effect.). Boiling of milk resulting in denaturation of the protein removes the inhibitory effect. Five per cent peptone almost prevents clotting.
- **Homogenization**: This has an accelerating effect on rennet clotting, but decreases the curd tension.
- **Heating the milk**: Heat not only destroys rennin but also makes clotting of the milk by the enzyme less easy. The major reason for this is the removal or precipitation of calcium ion.
- **Rennet preparations other than calf rennet**: These include goat and lamb rennets, plant enzymes such as withania coagulans, ficus, papain etc.
- **Difference in behavior between animal and vegetable rennet**: Although vegetable rennet clots cow and vegetable milks, animal rennet do not clot vegetable milks even if the calcium ion concentration is raised to that of cow’s milk.
- **Bacterial rennet**: The use of enzymes from microorganisms, particularly aerobic spore formers (Bacillus subtilis) and some of the gram-negative rods (Serratia marcesens) is a fairly new development in cheesetechnology.
- **Adding rennet**: Rennet is added when it has been determined that the acid is developing at the desired rate. Thus, when making cheese from ripened milk rennet is added when the acidity has increased from initial level by 0.02 %. The ideal temperature for setting raw milk under normal conditions is 30ºC and for pasteurized milk, 31ºC. The amount of rennet extract used should be such as to form curd that is firmer enough to be cut in 25-30 minutes after the addition of rennet.

The amount of rennet, which should be added, depends on:
- Strength of the rennet
- Temperature of milk
- Acidity of the milk
- Composition of milk

Usually, liquid rennet is diluted with 20-40 times its volume of (potable) water before it is added, to ensure proper distribution for uniform coagulation. The milk is thoroughly stirred during the addition of the rennet and also for 3 to 5 minutes afterwards. The vat is covered as soon as possible when the stirring is over, to keep
thesurface warm and protect it from contaminating dust particles.

**Coagulation**

- This refers to liquid milk changing to a semi-solid junket. The first signs of coagulation are that bubbles of air stirred into the milk surface take longer to break and a spatula dipped into the milk and withdrawn shows small flakes of curd.

**Cutting**

- This refers to cutting of the ‘firm’ coagulum into cubes of a specific size.

**When to cut the curd**

- When a glass rod inserted at a 45º angle and lifted straight up makes a clean break in the curd, it is ready for cutting. If the curd is cut too soon, there will be a lower yield of cheese, if cut too late, cutting will be difficult and moisture expulsion delayed.

**Curd Knives**

- These consist of stainless steel wires or strips, 6 or 9 mm apart, one horizontal and the vertical.

**Method of cutting**

- The curd is usually first cut with the horizontal knife lengthwise, then with the vertical knife lengthwise and widthwise.

**Syneresis of cheese curd**

- This refers to the expulsion of whey and contraction of the curd. From the cheese-making point of view, the factors controlling the loss of whey and contraction of the coagulum are: cutting, temperature, acidity, agitation, time and salt.

**Behavior of curd after cutting**

- After the curd is cut, whey begins to appear between the cubes and a film begins to form on the outer surface of each cube. This film should not harden, i.e., become firm, too rapidly. Care has also to be taken to avoid breaking this film.

**Acidity of the curd after cutting**

- Decreases by 0.05 % to 0.08 % from that of milk at renneting.

**Stirring curd after cutting**
During the first 2–3 minutes after cutting, the curd is not stirred. Then gentle stirring starts. The speed of stirring increases with the gradual firming of curd cubes. Matting is indicative of inadequate stirring.

**Cooking**

- This refers to the heating of curd cubes; it begins within 15 minutes of cutting.

**Regulation of heating**

- The heat is applied slowly to begin with. If the temperature is raised too rapidly, a condition similar to ‘case-hardening’ will result, and the curd cubes will be hard on the outside but soft and ‘water-logged’ inside. The rate of heating is such that the temperature rises to 32ºC in about 15 minutes and thereafter to a maximum cooking temperature (37 to 39ºC) at the rate of 1º C every 4 minutes.

**Amount of heat required**

- This depends chiefly on the type of cheese required. For cheddar, a maximum of 37 to 39ºC is normal. Too high a temperature can reduce the souring rate and activity of the starter organisms.

**Drainage of whey (dipping)**

- This refers to the removal of whey from the curd. When the cubes have been reduced to about one-half of their size at cutting, the acidity approaches a desirable limit and the cube attain a desirable consistency (elastic feel when squeezed), stirring is stopped and the cubes ‘pitched’. (Pitching refers to the curd cubes dropped to the bottom of the vat and piling them up together). The curd cubes are pushed away from the gate of the vat, a strainer is inserted in the gate, a curd-pail is hung on the curd outlet, and the whey is drawn from the vat.

**Cheddaring**

This refers to the combined operations of packing, turning, piling and repiling the curd cubes.

- **Packing:** After the bulk drainage of whey, the curd cubes are kept closely together in two heaps with a channel in between. This is known as packing and takes 5 to 15 minutes after dipping. It results in the formation of two long slabs of curd. These are cut with a cheese knife into blocks or strips 15 to 20 cms wide.
- **Turning:** As soon as the blocks (strips) of curd can be handled without breaking, they are rolled bottom-side in the vat. This is called turning and is carried out every 15 minutes till the curd is ready for milling and salting.
- **Piling and repiling:** Within 30 to 45 minutes of packing, blocks of curd are turned and laid one over another in twos or threes. This is called piling. Then
the position of the curd block is altered and this is known as repiling.

The cheddaring operation usually lasts for two hours or more and is very important not only for moisture control but also for improving body and texture. After cheddaring, the curd becomes drier, more mellow and silky and changes from asorbo rubber-like material to one resembling chicken breast-meat. In the latter stages, it tends to tear apart in fibrous shreds and develops a characteristic nutty and buttery aroma.

**Milling**

This refers to the mechanical operation of cutting the blocks of cheddared curd into small pieces with the help of a cheesemill, with the following objectives:

- To promote the further removal of whey
- To enable quick distribution of salt in the curd
- To prepare curd for pressing into final form
- And also for de-odourization, cooling of the curd etc.

**Salting:** This refers to the addition of common salt to the curd pieces. Salt in cheese affects flavour, body and texture, and keeping quality. Cheese without salt is often soft, ripen quickly and rapidly develop unpleasant flavors.

**Objectives**

- For further removal of whey
- Hardening and shrinking of curd
- Retarding further formation of lactic acid
- Checking the undesirable fermentation
- Produce desirable quality characteristics

**Holding before salting:** Salting may be delayed (by more than 15 minutes if needed) when it seems desirable to develop more acid in the cheese curd to encourage further drainage of whey, or to aerate the curd to improve its flavour.

When done

- Cheese curd is normally salted
- About 15 minutes after milling
- When a hot iron test shows threads 1 to 2 cm long
- When acidity is 0.4 to 0.5 % and
- When pH is 5.4 to 5.

**Amount of salt added**

- This depends on the amount of curd in the vat and salt desired, and generally varies from 1 to 2 % (average 1.5 %).

**Hooping**
This refers to the curd being placed in hoops or moulds in which the cheeses curd is pressed into its final shape. For hooping operation all the added salt should have completely dissolved and the temperature at hooping should be 30-32º C. Hooping and pressing at too high a temperature causes an excessive loss of fat, decreased yield, development of abnormal flavours and exaggeration of bacterial defects. On the other hand, hooping and pressing at a too a low temperature result in an open texture, imperfect rind formation and lack of whey drainage.

Dressing

- Refers to arrangement of the cheesecloth before and after pressing.

Pressing

- This refers to the operation of forcing the particles of milled and salted curd into the hoops into the smallest possible space to give cheese its final shapes. Cheese pressing is done with the help of presses which may be, Screw or Pneumatic or Hydraulic or spring types.

Drying

- This is done for rind formation in cheese. It involves first taking the cheese out of the hoop and then stamping of date, batch, variety name etc., and keeping in a drying room at 12 to 16 º C for a few days. The cheese is turned at 24-hour intervals so that both ends and sides of the cheese can dry and form the desired rind.

Paraffining

- This refers to the operation of dipping the cheese for a few seconds in a bath of melted paraffin, whereby a thin coating of the paraffin is applied to the surface of the cheese.

Objectives

- To reduce the loss of moisture during curing
- To prevent extensive mould growth
- To protect it against insects

Curing

- The curing/ripening/souring/maturing of cheese refers to the storage of cheese for at least 2 to 3 months at a given low temperature (0-16ºC) during which its physical, chemical and bacteriological properties are profoundly changed, resulting in the development of a characteristic flavour, body and texture.
- The term 'green cheese' is usually applied to hard-pressed cheese in the early stages of ripening before the characteristic flavour, body and texture of ripened cheese developed.
The procedure involves dipping of cheese blocks quickly and completely in the melted paraffin held at 104-121° C for about 5 seconds, allowed to drain for 10 seconds.

Changes during curing

- Flavour
  - From a mildly acid taste and aroma in green cheese to the development of characteristic flavour of ripened cheese which is a blend of several odours and tastes of diacetyl, traces of butyric and caproic acid, esters of alcohol, salts of propionic and acetic acids in well aged cheeses.
- Body
  - The cheese becomes slightly harder, due to loss of moisture. There is a gradual change from the rubbery body in the green cheese to a mellow and waxy body in the ripened cheese.
- Texture
  - Curd cheese tends to acquire a fairly close to close texture.
- Chemical changes
  - The chief chemical changes which occur during the curing of cheddar cheese are: fermentation of lactose to lactic acid and small amounts of acetic acid, propionic acid and carbon dioxide; proteolysis; and a slight fat breakdown. The most obvious chemical changes are the breakdown of the proteins, the newly created solubility of about 25% of total proteins in the cured cheddar cheese. In addition to fat breakdown, the ammonia produced by moulds and certain bacteria may have considerable effect on the bacteria and so assist in the growth of other types of bacteria.
  - An increase in acidity and decrease in pH takes place for the first few days. The pH is lowest in cheese on about the third or fourth day after pressing, and is normally 5.10 to 5.05. It then decreases slowly and steadily during the curing period.
- Microbiological changes
  - In cheddar cheese type, which are low in moisture and close in texture sustain a steady changeover from Streptococci to Lactobacilli, some of which contribute to the flavour. Other types are of course present and the higher the proportion of miscellaneous types, the quicker is the curing and greater the possibility of off-flavours.

Shrinkage in Cheese

This refers to the loss in weight of cheese during curing/storage. Although a slight shrinkage is natural, excessive shrinkage should be prevented. Shrinkage is caused mainly by 'loss of moisture'.

Factors causing Shrinkage in Cheese:

- Temperature of curing: Higher the temperature, higher the shrinkage, and vice-versa
- Relative humidity of curing: Higher the humidity lower the shrinkage.
- Size (and shape) of cheese: Larger the size, lower the shrinkage and vice-versa
Moisture content of cheese: Higher the moisture content, higher the shrinkage.

Paraffining of cheese: Paraffined cheese undergoes less shrinkage, than non-paraffined cheese.

Ripening index

Protein degradation measurements have been used systematically in studying the ripening of cheese. The rate of ripening is measured by determination of the 'ripening index'

\[
\text{Index} = \frac{\% \text{ soluble nitrogen}}{\% \text{ total nitrogen}} \times 100
\]

Yield

This is affected by the quality of milk, nature of manufacturing operations, the skill of the manufacturer, and curing procedures.

VARITIES / DEFECTS IN CHEESE

Cottage cheese

This is a soft, unripened cheese usually made from skim milk. It has mildly acid flavour and consists of small particles or flakes or curd, which have a meaty consistency. Creamed cottage cheese has cream mixed to it upto 4% level. Both varieties are salted always.

Cottage cheese can be prepared by both, direct acidification and by starter culture methods. In direct acidification method, any food grade acid, phosphoric, lactic acid etc., are used.

Method of manufacture

- Receiving (pasteurized) milk
- Adding calcium chloride
- Adding starter culture (lactic cultures)
- Adding rennet (0.01%) Setting (30°C)
- Cutting Cooking (upto 46°C, over 2 hrs)
- Drainage of whey Washing and draining the curd
- Salting
- Creaming
- Packaging and storage

Details of manufacture

- Receiving of Milk
  - The skim milk should be fresh, sweet, low in fat and bacterial count and clean in flavour. It should be pasteurized immediately after separation preferably by LTLT method as it produces softer curd.
- Adding calcium chloride
  - Calcium chloride is generally added to the skim milk at the rate of 1
mlsaturated solution per 100 liters of milk, with the objective of increase the concentration of calcium for better setting

- Adding starter culture
  - A high quality starter consisting of either S.lactis, S.cremoris,S.diacetylactis, L.dextranicum, etc., singly or in combination is then added at 1 to 2.5 % levels and thoroughly mixed into it.

- Adding rennet
  - Rennet is added at 2-2.5 ml per 1000 litre of milk. It is diluted with water up to 40 times with water before adding.

- Setting
  - The temperature is set around 29-32ºC

- Cutting
  - The most desirable acidity of whey at cutting is approximately 0.5 % (pH 4.6-4.7). The whey should be clear and free from curd particles.

- Cooking
  - This begins soon after cutting and continues for an hour or two until the temperature reaches 45ºC or until the curd becomes hard enough for removal of whey. Stirring during cooking is done very gently and at a minimum rate.

- Drainage of whey
  - Whey is removed when the curd cubes no longer have a ‘soft center’ and when a handful of them squeezed gently show slight elasticity.

- Washing and draining
  - The curd is washed after removing all the whey to produce desired firmness and mildness in flavour. The wash water is at the temperature of 21ºC and after soaking for 15 minutes the water is drained. Second washing is done with water at 16ºC. Draining should be thorough; the cubes are placed in draining rack with perforations at the bottom, which can be wheeled into cold storage rooms.

- Salting
  - This is done when the free moisture has been drained from the curd. Salt can be added to the curd in the vat, or it can be dissolved in the cream for creamed cottage cheese. Salt is added at 1 % of curd weight.

- Creaming
  - This is done immediately after draining, if the product is to packed at once. Holding the curd overnight in a cold room before it is creamed makes it more firm when creaming. The amount of 20 % cream added is at 4 % level of the curd weight.

- Packaging and storage
  - Cottage cheese, creamed or uncreamed, may be packed in waxed / polythene-coated papercups or in polythene bags. Storage is at 5ºC or less.

Yield

The yield of cottage cheese before creaming depends essentially on

- The composition of the milk
- Manufacturing losses
• Moisture content of the cheese
• Approximately yield of cottage cheese is 15 %.
• Keeping quality of cottage cheese
• The keeping quality is short even under refrigerated conditions (5-10 °C).

**Processed cheese products**

• Processed cheese is produced by blendingshredded natural cheeses of different types and degrees of maturity with emulsifying agents, and by heating the blend under a partial vacuum with constant agitation until a homogeneous mass is obtained. In addition to natural cheeses, other dairy and non-dairy ingredients may be included in the blend.

**Advantages of processed cheese**

• Reduced refrigeration cost during storage and transport, which are especially important in hot climates
• Better keeping quality, with less apparent changes during prolonged storage.
• Great diversity of type and intensity of flavour, e.g. from mild to sharp, native cheese flavour or specific spices.
• Adjustable packaging for various usages, economical and imaginative.
• Suitability for home use as well as for snack restaurants, e.g. in cheeseburgers, hot sandwiches, spreads and dips for fast foods.

Processed cheeses are characterized essentially by composition, water content and consistency; according to these criteria, three main groups may be distinguished: **processed cheese blocks, processed cheese foods and processed cheese spreads**. More recently established sub-types of processed cheeses are: **processed cheese slices and smoked processed cheese**. The first sub-type belongs to the category of processed cheese blocks, while the second could be either block or spread. In addition, another group of processed cheese products should be mentioned, i.e., **processed cheese analogues**, which are usually based on vegetable fat-casein blends. Finally, the most recent development in cheese processing is processed cheese with a completely new look, i.e. natural cheese-like appearance. Developed in France, this product has an open texture, similar to traditional cheeses, with eyes of about 0.5 mm in diameter.

**General defects in cheese**

<table>
<thead>
<tr>
<th>Causes</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive acid development in cheese curd</td>
<td>Optimum acid development in cheese curd</td>
</tr>
<tr>
<td>Excessive addition of colour to cheese milk</td>
<td>Optimal addition of colour to cheese milk</td>
</tr>
<tr>
<td>i) combining cheese from two lots</td>
<td>Avoiding it and even development of uneven acid development in cheese curd</td>
</tr>
<tr>
<td>External appearance</td>
<td>Causes</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Cracked Paraffin</td>
<td>Excessive thickness of paraffin coating on cheese</td>
</tr>
<tr>
<td>Hill sided</td>
<td>Incorrect filling and pressing of curd cubes</td>
</tr>
<tr>
<td></td>
<td>Excessive acidity and/or moisture in cheese before curing</td>
</tr>
</tbody>
</table>

### Appearance

- **Cracked Paraffin**: Excessive thickness of paraffin coating on cheese.
- **Hill sided**: Incorrect filling and pressing of curd cubes.
- **Lopsided/misshapen**: Incorrect filling and pressing of curd cubes.
- **Rind rot**: Excessive acidity and/or moisture in cheese before curing.

### Body

- **Curdy/rubbery**
  - i) Low moisture content in cheese before curing
  - ii) Low acid development in curd
  - iii) Over-salting cheese
  - iv) Insufficient cheddaring of cheese curd
- **Optimal moisture before curing**
- **Optimal acid development**
- **Optimal salt level**
- **Proper cheddaring**

### Texture defects

- **Fish eyes/yeast holes**: Contamination with yeasts.
- **Avoiding contamination with yeasts**
- **Contamination with yeasts**

### Flavour

- **Bitter**: Low quality milk.
- **Low quality starter**
- **Excessive acid and/or moisture in cheese**
- **By using good quality milk, starter and maintaining optimal acid and moisture in cheese**

### Uses of cheese

- Direct consumption as such or in sandwiches
- In the preparation of special dishes (added incut or grated form)
- In the preparation of sauce.

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**MODULE-14: DAIRY BYPRODUCTS, GOOD MANUFACTURING PRACTICES, IMPLEMENTATION OF HACCP**

### Learning outcomes

At the end of this module the learner will be able to understand the followings:

- Dairy byproducts,
- Good Manufacturing practices (GMP),
- HACCP preamle and definitions,
- Principles of the HACCP system,
- Guidelines for the application of the HACCP system and
- FSSA.

### DAIRY BYPRODUCTS

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

<table>
<thead>
<tr>
<th>S.No</th>
<th>Main Product</th>
<th>By Product</th>
<th>Processing method</th>
<th>Products Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>cream</td>
<td>Skim milk</td>
<td>Pasteurization</td>
<td>Flavoured milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sterilization</td>
<td>Sterilized flavoured milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fermentation</td>
<td>Cultured Buttermilk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fermentation and Concentration</td>
<td>Concentrated sour skim milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concentration</td>
<td>Plain and Sweetened Condensed skim milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drying</td>
<td>Dried skim milk or Skim milk powder or Non Fat Dry Milk (NFDM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coagulation</td>
<td>Cottage cheese, Quarg, edible casein</td>
</tr>
<tr>
<td>2</td>
<td>Butter</td>
<td>Buttermilk</td>
<td>Fermentation and Concentration</td>
<td>Condensed buttermilk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concentration and drying</td>
<td>Dried buttermilk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coagulation</td>
<td>Soft cheese</td>
</tr>
<tr>
<td>3</td>
<td>Cheese, Casein, Channa, Paneer</td>
<td>Whey</td>
<td>Fermentation</td>
<td>Whey beverage, Yeast whey</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Concentration</td>
<td>Plain and sweetened condensed whey, whey protein concentrate, whey paste, lactose</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drying</td>
<td>Dried whey</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coagulation</td>
<td>Ricotta cheese</td>
</tr>
<tr>
<td>4</td>
<td>Ghee</td>
<td>Ghee residue</td>
<td>Processing</td>
<td>Sweetmeat, Toffee, Sweet paste</td>
</tr>
</tbody>
</table>
- Good manufacturing practice (GMP) is that part of quality assurance which ensures that products are consistently produced and controlled to the quality standards appropriate to their intended use and as required by the marketing authorization.
- GMP is aimed primarily at diminishing the risks inherent in any pharmaceutical production, which may broadly be categorized in two groups: cross contamination/mix-ups and false labelling. Above all, manufacturers must not place patients at risk due to inadequate safety, quality or efficacy; for this reason, risk assessment has come to play an important role in WHO quality assurance guidelines.

**HACCP PREAMBLE AND DEFINITIONS**

**Preamble**

- The first section of this document sets out the principles of the Hazard Analysis and Critical Control Point (HACCP) system adopted by the Codex Alimentarius Commission. The second section provides general guidance for the application of the system while recognizing that the details of application may vary depending on the circumstances of the food operation.
- The HACCP system, which is science based and systematic, identifies specific hazards and measures for their control to ensure the safety of food. HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end-product testing. Any HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments.
- HACCP can be applied throughout the food chain from primary production to final consumption and its implementation should be guided by scientific evidence of risks to human health. As well as enhancing food safety, implementation of HACCP can provide other significant benefits. In addition, the application of HACCP systems can aid inspection by regulatory authorities and promote international trade by increasing confidence in food safety.
- The successful application of HACCP requires the full commitment and involvement of management and the workforce. It also requires a multidisciplinary approach; this multidisciplinary approach should include, when appropriate, expertise in agronomy, veterinary health, production, microbiology, medicine, public health, food technology, environmental health, chemistry and engineering, according to the particular study. The application of HACCP is compatible with the implementation of quality management systems, such as the ISO 9000 series, and is the system of choice in the management of food safety within such systems.
- While the application of HACCP to food safety was considered here, the concept can be applied to other aspects of food quality.

**Definitions**

- *Control (verb):* To take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan.
- *Control (noun):* The state wherein correct procedures are being followed and criteria are being met.
- *Control measure:* Any action and activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level.
- *Corrective action:* Any action to be taken when the results of monitoring at the CCP indicate a loss of control.
- *Critical Control Point (CCP):* A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.
- *Critical limit:* A criterion which separates acceptability from unacceptability.
- **Deviation:** Failure to meet a critical limit.
- **Flow diagram:** A systematic representation of the sequence of steps or operations used in the production or manufacture of a particular food item.
- **HACCP:** A system which identifies, evaluates, and controls hazards which are significant for food safety.
- **HACCP plan:** A document prepared in accordance with the principles of HACCP to ensure control of hazards which are significant for food safety in the segment of the food chain under consideration.
- **Hazard:** A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.
- **Hazard analysis:** The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP plan.
- **Monitor:** The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control.
- **Step:** A point, procedure, operation or stage in the food chain including raw materials, from primary production to final consumption.
- **Validation:** Obtaining evidence that the elements of the HACCP plan are effective.
- **Verification:** The application of methods, procedures, tests and other evaluations, in addition to monitoring to determine compliance with the HACCP plan.

### PRINCIPLES OF THE HACCP SYSTEM

- The HACCP system consists of the following seven principles and by following them HACCP can be implemented.
  - PRINCIPLE 1: Conduct a hazard analysis.
  - PRINCIPLE 2: Determine the Critical Control Points (CCPs).
  - PRINCIPLE 3: Establish critical limit(s).
  - PRINCIPLE 4: Establish a system to monitor control of the CCP.
  - PRINCIPLE 5: Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
  - PRINCIPLE 6: Establish procedures for verification to confirm that the HACCP system is working effectively.
  - PRINCIPLE 7: Establish documentation concerning all procedures and records appropriate to these principles and their application.

### GUIDELINES FOR THE APPLICATION OF THE HACCP SYSTEM

- Prior to application of HACCP to any sector of the food chain, that sector should be operating according to the Codex General Principles of Food Hygiene, the appropriate Codex Codes of Practice, and appropriate food safety legislation. Management commitment is necessary for implementation of an effective HACCP system. During hazard identification, evaluation, and subsequent operations in designing and applying HACCP systems, consideration must be given to the impact of raw materials, ingredients, food manufacturing practices, role of manufacturing processes to control hazards, likely end-use of the product, categories of consumers of concern, and epidemiological evidence relative to food safety.
- The intent of the HACCP system is to focus control at CCPs. Redesign of the operation should be considered if a hazard which must be controlled is identified but no CCPs are found.
- HACCP should be applied to each specific operation separately. CCPs identified in any given example in any Codex Code of Hygienic Practice might not be the only ones identified for a specific application or might be of a different nature.
• The HACCP application should be reviewed and necessary changes made when any modification is made in the product, process, or any step.

• It is important when applying HACCP to be flexible where appropriate, given the context of the application taking into account the nature and the size of the operation.

Application

• The application of HACCP principles consists of the following tasks as identified in the Logic Sequence for Application of HACCP
• Assemble HACCP team
  o The food operation should assure that the appropriate product specific knowledge and expertise is available for the development of an effective HACCP plan. Optimally, this may be accomplished by assembling a multidisciplinary team. Where such expertise is not available on site, expert advice should be obtained from other sources. The scope of the HACCP plan should be identified. The scope should describe which segment of the food chain is involved and the general classes of hazards to be addressed (e.g. does it cover all classes of hazards or only selected classes).
• Describe product
  o A full description of the product should be drawn up, including relevant safety information such as: composition, physical/chemical structure (including A_w, pH, etc.), microcidal/static treatments (heat-treatment, freezing, brining, smoking, etc.), packaging, durability and storage conditions and method of distribution.
• Identify intended use
  o The intended use should be based on the expected uses of the product by the end user or consumer. In specific cases, vulnerable groups of the population, e.g. institutional feeding, may have to be considered.
• Construct flow diagram
  o The flow diagram should be constructed by the HACCP team. The flow diagram should cover all steps in the operation. When applying HACCP to a given operation, consideration should be given to steps preceding and following the specified operation.
• On-site confirmation of flow diagram
  o The HACCP team should confirm the processing operation against the flow diagram during all stages and hours of operation and amend the flow diagram where appropriate.
• List all potential hazards associated with each step, conduct a hazard analysis, and consider any measures to control identified hazards
  o The HACCP team should list all of the hazards that may be reasonably expected to occur at each step from primary production, processing, manufacture, and distribution until the point of consumption.
  o The HACCP team should next conduct a hazard analysis to identify for the HACCP plan which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of a safe food.
  o In conducting the hazard analysis, wherever possible the following should be included:
    o the likely occurrence of hazards and severity of their adverse health effects;
    o the qualitative and/or quantitative evaluation of the presence of hazards;
    o survival or multiplication of microorganisms of concern;
    o production or persistence in foods of toxins, chemicals or physical agents; and,
    o conditions leading to the above.
  o The HACCP team must then consider what control measures, if any, exist which can be applied for each hazard.
• More than one control measure may be required to control a specific hazard(s) and more than one hazard may be controlled by a specified control measure.

• Determine Critical Control Points
  o There may be more than one CCP at which control is applied to address the same hazard. The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree (e.g. Diagram 2), which indicates a logic reasoning approach. Application of a decision tree should be flexible, given whether the operation is for production, slaughter, processing, storage, distribution or other. It should be used for guidance when determining CCPs. This example of a decision tree may not be applicable to all situations. Other approaches may be used. Training in the application of the decision tree is recommended.
  o If a hazard has been identified at a step where control is necessary for safety, and no control measure exists at that step, or any other, then the product or process should be modified at that step, or at any earlier or later stage, to include a control measure.

• Establish critical limits for each CCP
  o Critical limits must be specified and validated if possible for each Critical Control Point. In some cases more than one critical limit will be elaborated at a particular step. Criteria often used include measurements of temperature, time, moisture level, pH, Aw, available chlorine, and sensory parameters such as visual appearance and texture.

• Establish a monitoring system for each CCP
  o Monitoring is the scheduled measurement or observation of a CCP relative to its critical limits. The monitoring procedures must be able to detect loss of control at the CCP. Further, monitoring should ideally provide this information in time to make adjustments to ensure control of the process to prevent violating the critical limits. Where possible, process adjustments should be made when monitoring results indicate a trend towards loss of control at a CCP. The adjustments should be taken before a deviation occurs. Data derived from monitoring must be evaluated by a designated person with knowledge and authority to carry out corrective actions when indicated. If monitoring is not continuous, then the amount or frequency of monitoring must be sufficient to guarantee the CCP is in control. Most monitoring procedures for CCPs will need to be done rapidly because they relate to on-line processes and there will not be time for lengthy analytical testing. Physical and chemical measurements are often preferred to microbiological testing because they may be done rapidly and can often indicate the microbiological control of the product. All records and documents associated with monitoring CCPs must be signed by the person(s) doing the monitoring and by a responsible reviewing official(s) of the company.

• Establish corrective actions
  o Specific corrective actions must be developed for each CCP in the HACCP system in order to deal with deviations when they occur.
  o The actions must ensure that the CCP has been brought under control. Actions taken must also include proper disposition of the affected product. Deviation and product disposition procedures must be documented in the HACCP record keeping.

• Establish verification procedures
  o Establish procedures for verification. Verification and auditing methods, procedures and tests, including random sampling and analysis, can be used to determine if the HACCP system is working correctly. The frequency of verification should be sufficient to confirm that the HACCP system is working effectively. Examples of verification activities include:
- Review of the HACCP system and its records;
- Review of deviations and product dispositions;
- Confirmation that CCPs are kept under control.
- Where possible, validation activities should include actions to confirm the efficacy of all elements of the HACCP plan.

- Establish Documentation and Record Keeping
  - Efficient and accurate record keeping is essential to the application of a HACCP system. HACCP procedures should be documented. Documentation and record keeping should be appropriate to the nature and size of the operation.
  - Documentation examples are
    - Hazard analysis;
    - CCP determination;
    - Critical limit determination.
  - Record examples are
    - CCP monitoring activities;
    - Deviations and associated corrective actions;
    - Modifications to the HACCP system.

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**THE FOOD SAFETY AND STANDARDS ACT, 2006**

- Multiplicity food laws, standard setting and enforcement agencies pervades different sectors of food, which creates confusion in the minds of consumers, traders, manufacturers and investors. Detailed provisions under various laws regarding admissibility and levels of food additives, contaminants, food colours, preservatives, etc., and other related requirements have varied standards under these laws. The standards are often rigid and non-responsive to scientific advancements and modernization. In view of multiplicity of laws, their enforcement and standard setting as well as various implementing agencies are detrimental to the growth of the nascent food processing industry and is not conductive to effective fixation of food standards and their enforcement.

- In as early as the year 1998, the Prime Minister’s Council on Trade and Industry appointed a Subject Group on Food and Agro Industries, which had recommended for one comprehensive legislation on Food with a Food Regulatory Authority concerning both domestic and export markets. Joint Parliamentary Committee on Pesticide Residues in its report in 2004 emphasized the need to converge all present food laws and to have single regulatory body. The Committee expressed its concern on public health and food safety in India. The Standing Committee of Parliament on Agriculture in its 12th Report submitted in April, 2005 desired that the much needed legislation on Integrated Food Law should be expedited.

- As an on going process, the then Member – Secretary, Law Commission of India, was asked to make a comprehensive review of Food Laws of various developing and developed countries and other relevant international agreements and instruments on the subject. After making an indepth survey of the international scenario, the then Member-Secretary recommended that the new Food Law be seen in the overall perspective of promoting nascent food processing industry given its income, employment and export potential. It has been suggested that all acts and orders relating to food be subsumed within the proposed Integrated Food Law as the international trend is towards modernization and convergence of regulations of Food Standards with the elimination of multi-level and multi-departmental control. Presently, the emphasis is on
  - responsibility with manufacturers,
  - recall,
  - genetically modified and functional foods,
  - emergency control,
risk analysis and communication and

- In this background, the Group of Ministers constituted by the Government of India, held extensive deliberations and approved the proposed Integrated Food Law with certain modifications. The Integrated Food Law has been named as 'The Food Safety and Standards Act, 2006'. The main objective of the Act is to bring out a single statute relating to food and to provide for a systematic and scientific development of Food Processing Industries. It is proposed to establish the Food Safety and Standards Authority of India, which will fix food standards and regulate/monitor the manufacturing, import, processing, distribution and sale of food, so as to ensure safe and wholesome food for the people. The food Authority will be assisted by Scientific Committees and Panels in fixing standards and by a Central Advisory Committee in prioritization of the work. The enforcement of the legislation will be through the State Commissioner for Food Safety, his officers and panchayati Raj/Municipal bodies.

- The Act, inter alia, incorporates the salient provisions of the Prevention of Food Adulteration Act, 1954 (37 of 1954) and is based on international legislations, instrumentalities and Codex Alimentarii Commission (which is related to food safety norms). In a nutshell, the Act takes care of International practices and envisages an over-reaching policy framework and provision of single window to guide and regulate persons engaged in manufacture, marketing, processing, handling, transportation, import and sale of food. The main features of the Act are:
  - movement from multi-level and multi-departmental control to integrated line of command;
  - integrated response to strategic issues like novel/genetically modified foods, international line of command;
  - licensing for manufacture of food products, which is presently granted by the Central Agencies under various Acts and Orders, would stand decentralized to the Commissioner of Food Safety and his officer;
  - single reference point for all matters relating to Food Safety and Standards, regulations and enforcement;
  - shift from mere regulatory regime to self-compliance through Food Safety Management Systems;
  - responsibility on food business operators to ensure that food processed, manufactured, imported or distributed is in compliance with the domestic food laws; and
  - provision for graded penalties depending on the gravity of offence and accordingly, civil penalties for minor offences and punishment for serious violations.

- The above said Act is contemporary, comprehensive and intends to ensure better consumer safety through Food Safety Management Systems and setting standards based on science and transparency as also to meet the dynamic requirements of Indian Food Trade and Industry and International trade. The Act seeks to achieve the aforesaid objectives.

### MODULE-15: TOXIC/PESTICIDE RESIDUES IN MILK AND MILK PRODUCTS, ORGANIC MILK FOOD PRODUCTS

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Toxic/Pesticide residues in milk,
- Legal and BIS standards and
Organic milk food.

TOXIC / PESTICIDE RESIDUES IN MILK

Milk is pooled from different sources and hence Mycotoxins (Aflatoxin M1), heavy metals, pesticides residues and veterinary residues due to several environmental reasons.

**Mycotoxins (Aflatoxin M1)**

- Mycotoxins are metabolites of moulds like *Aspergillus flavus* and *Aspergillus parasiticus* are carcinogenic and can be present in grains, nuts, cotton seed and other commodities associated with human food and animal feeds. Animals are exposed to aflatoxins by consumption of feeds that are contaminated by aflatoxin producing fungal stains. Aflatoxin M1 (AFM1) and it is quite stable towards normal milk processing methods such as pasteurization and if present in raw milk it may persist into final products for human consumption. Quantitative estimation of Aflatoxin M1 is done by HPLC method.

**Heavy metals**

The feed of polluted areas when regularly given to milch animals there is chance of contamination of heavy metals in milk. The contamination of arsenic, cadmium, mercury, lead in milk is reported and they cause the following diseases.

- Arsenic: Affects pulmonary, nervous system and skin.
- Mercury: Mercury and ethyl mercury are toxic. Mercury stores in kidney and liver has affinity for sulphahydryl groups.
- Cadmium causes kidney damage.
- Lead affects renal, gastrointestinal and nervous system. Lead inhibits Hb synthesis and leads to anaemia. It also affects nervous system leading to encephalomalacia. Organochlorine and Organophosphate pesticide residues from contaminated sources enter milk causing ill effects. eg. HCH isomers (Hexachlorocyclohexane) is a commercial insecticide, endosulfan, malathion, chlorpyrifos, and methyl-parathion.

Codex Guidelines for the establishment of a regulatory programme for control of Veterinary drug residues in foods (CAC GL16-1993) provides useful guidelines on selection of methods of analysis for veterinary drugs.

Various antibiotics like Ampicillin, Benzylpenicillin, Bacitracin, Cloxacillin, Kanamycin, Tetracycline in milk can be detected by various microbial inhibition assays.

DELVO MICROBIAL INHIBITION ASSAY IS USED FOR DETECTION of antibiotics and sulphonamides in milk. The higher concentration of cleaning agents and disinfectants in milk may give false positive results. The preservatives used to conserve milk for later analysis usually make the milk unsuitable for testing.

LEGAL AND BIS STANDARDS

**Milk and Milk Products**

- The Government of India has put forward definite guidelines for producer/exporters of milk and milk products which have been made mandatory vide the Milk and Milk Product Order (MMPO) 1992 As per the provisions of this order, any person/dairy
plant handling more than 10,000 liters per day of milk or 500 MT of milk solids per annum needs to be registered with the registering authority appointed by the Central Government.

- The main objective of the order is to maintain and increase the supply of liquid milk of desired quality in the interests of the general public and also for regulating the production, processing and distribution of milk and milk products. For more details regarding the standards that need to be followed during milking, processing and exporting milk and milk products from India visit e-library.

**National standards for milk and milk products**

- In India, the Ministry of Health and Family Welfare (MOH&FW), dealing with the subject of food quality and safety at the national level, has been designated the nodal ministry for maintaining food standards. The instrument for ensuring food quality and safety at the national level is through a legislation titled Prevention of Food Adulteration Act, 1954 (PFA) and Rules made thereunder as amended from time-to-time.

**Legal and BIS of milk and milk products**

<table>
<thead>
<tr>
<th>Type of Cream</th>
<th>Type of Count</th>
<th>Level in cfu/ml or g</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Cream</td>
<td>Standard</td>
<td>&lt; 4 lakhs</td>
<td>Very good</td>
</tr>
<tr>
<td>4-20 lakhs</td>
<td>Plate count / ml or g</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>20-100 lakhs</td>
<td></td>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>&gt;100 lakhs</td>
<td></td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Coliform Count / ml or g</td>
<td>Not more than 100</td>
<td>Satisfactory</td>
<td></td>
</tr>
<tr>
<td>Pasteurized cream</td>
<td>Standard plate count / ml or g</td>
<td>Not more than 60,000</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Coliform count / ml or g</td>
<td>Not more than 10</td>
<td>Satisfactory</td>
<td></td>
</tr>
</tbody>
</table>

**BUTTER**

**PFA Standards**

- Milk Fat - not less than 80% by weight
- Common Salt - not more than 3% by weight
- Curd - not more than 1.5% by weight
- Diacetyl - 4 ppm
- Moisture - not more than 16%

**Microbiological Standards (BIS)**

<table>
<thead>
<tr>
<th>Yeast &amp; Mold count/ml</th>
<th>Quantity</th>
</tr>
</thead>
</table>
SPC. No standard has been suggested.

Coliform count should not be more than 10/ ml for satisfactory quality butter.

### GHEE

### AGMARK Standards

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Tests</th>
<th>All-India</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Baudouin</td>
<td>Negative</td>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Phytosterol acetate</td>
<td>Negative</td>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>B.R. reading (40 °C )</td>
<td>40.0-43.0</td>
<td>41.5-44.0</td>
<td>42.5 – 45.0</td>
</tr>
<tr>
<td>4.</td>
<td>R.M. Value</td>
<td>Not less than 28.0</td>
<td>Not less than 23.0</td>
<td>Not less than 21.0</td>
</tr>
<tr>
<td>5.</td>
<td>P Value</td>
<td>1.0-2.0</td>
<td>0.5-1.2</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>6.</td>
<td>Moisture (%)</td>
<td>Not more than 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Free fatty acid (% oleic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Special grade Agmark Red label</td>
<td>Not more than 1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>General Grade Agmark Green label</td>
<td>Not more than 2.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R.M. Value in Tamil Nadu : 24

### ICE CREAM

### BIS Standards

#### Chemical

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/Litre) (min)</td>
<td>525</td>
</tr>
<tr>
<td>Total solids (% wt) (min)</td>
<td>36.0</td>
</tr>
</tbody>
</table>
### Microbiological

<table>
<thead>
<tr>
<th>Test</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard plate count (per g)</td>
<td>not more than 2,50,000</td>
</tr>
<tr>
<td>Coliform count (per g)</td>
<td>not more than 90</td>
</tr>
<tr>
<td>Phosphatase</td>
<td>negative</td>
</tr>
</tbody>
</table>

### MIK POWDER

### BIS Standards

#### Chemical

<table>
<thead>
<tr>
<th>Whole Milk Powder</th>
<th>Skim Milk Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavour and odour</td>
<td>Good</td>
</tr>
<tr>
<td>Moisture (%wt.) (max)</td>
<td>4.0</td>
</tr>
<tr>
<td>Total milk solids (%wt.)</td>
<td>96.0</td>
</tr>
</tbody>
</table>

#### Solubility

<table>
<thead>
<tr>
<th></th>
<th>Whole Milk Powder</th>
<th>Skim Milk Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Solubility index (max) ml</td>
<td>15.0 (if roller dried)</td>
<td>15.0 (if roller dried)</td>
</tr>
<tr>
<td>b. Solubility (%wt.) (min)</td>
<td>85.0 ml (if roller dried)</td>
<td>85.0 ml (if roller dried)</td>
</tr>
<tr>
<td>Total ash (on dry basis) % wt (max)</td>
<td>7.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Fat (% wt)</td>
<td>Not less than 26</td>
<td>Not more than 1.5</td>
</tr>
<tr>
<td>Titratable acidity (% lactic)</td>
<td>1.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

### Microbiological standards
<table>
<thead>
<tr>
<th>Types</th>
<th>WMP &amp; Extra Grade SMP</th>
<th>Standard Grade SMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total bacterial count, max, cfu/g</td>
<td>40,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Coliform count</td>
<td>Absent in 0.1 g</td>
<td>Absent in 0.1 g</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Absent in 25 g</td>
<td>Not specified</td>
</tr>
<tr>
<td>Staph. aureus (coagulase positive)</td>
<td>Absent in 0.1 g</td>
<td>Not specified</td>
</tr>
<tr>
<td>Shigella</td>
<td>Absent in 25 g</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

## CHEESE

### BIS Standards

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Natural Cheese (hard variety)</th>
<th>Processed cheese</th>
<th>Processed cheese spread</th>
<th>Cheese Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Moisture % by mass. maximum</td>
<td>43</td>
<td>47</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>2. Milk fat (on dry basis) % by mass. minimum</td>
<td>42</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>3. Salt (added NaCl) % by mass maximum</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5.5</td>
</tr>
<tr>
<td>4. Coliform count, per gram maximum</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>5. Stabilizer /</td>
<td>0.1%</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sorbic acid / Nisin</td>
<td>0.1%</td>
<td>0.1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Suggested bacteriological standards

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Product</th>
<th>Yeast and Mold Count</th>
<th>Coliform</th>
<th>Aerobic spore count</th>
<th>Anaerobic spore count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Processed cheese/gm</td>
<td>60</td>
<td>Nil</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>2.</td>
<td>Processed cheese spread/gm</td>
<td>60</td>
<td>Nil</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

## CONCENTRATED MILK
### BIS Standards

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Full Cream</th>
<th>Skim Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total milk solids (% by wt., minimum)</td>
<td>31.0</td>
<td>26</td>
</tr>
<tr>
<td>Fat (% by wt.)</td>
<td>min 9.0</td>
<td>max 0.5</td>
</tr>
<tr>
<td>Sucrose (% by wt., minimum)</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Acidity (% lactic acid, maximum)</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Bacterial count (cfu/g, maximum)</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Test for Coliforms</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Yeast and Mold count (cfu/g, maximum)</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### ORGANIC DAIRY PRODUCTS

- Processed organic food usually contains only organic ingredients. If non-organic ingredients are present, at least a certain percentage of the food's total plant and animal ingredients must be organic and any non-organically produced ingredients are subject to various agricultural requirements.
- Foods claiming to be organic must be free of artificial food additives, and are often processed with fewer artificial methods, materials and conditions, such as chemical ripening, food irradiation, and genetically modified ingredients. Pesticides are allowed so long as they are not synthetic.
- Cow's milk or indeed the milk of any creature is an ideal environmental indicator for registering the level of pollutants and pesticides in the environment. Why? Because what goes in the mouth of a cow gets processed into large quantities of milk. If it's on the grass it's going to end up in your pint of milk.
- Beyond this four main factors have led to the increasing interest by farmers and consumers in organic dairy farming:
  - consumer concerns about food safety and animal welfare
  - overproduction of food (perceived as low in quality)
  - the environmental effects of intensive farming
  - the premium milk price and expanding market for organic milk products
- As milk is a major contributor to our diet in the guises of butter, cheese, yoghurt and ice cream many people are now concerned about the quality of this staple foodstuff.
- Milk is one of the most important components of our daily diets and is vital to healthy bones, teeth, and general growth and development. Now through organic farming there is a new breed of dairy products widely available.
- Organic milk has been found to be even healthier than traditional milk, and demand for organic brands has been on the rise. While many may be skeptical, a recent study conducted in Wales supports the increased benefits, including high content of conjugated linoleic acid, also known as CLA9, and higher levels of vitamin E, beta carotene, antioxidants, and the presence of more omega-3 fatty acids.
- There are strict legal parameters around the diets of cows on organic farms which are granted independent certification. Organic milk is produced by cows that are fed all-natural foods by grazing and eating fresh grass, forage, and clover. Non-organic farms are allowed to use pesticides and fertilizer for the growth of fodder, and feed hormones and antibiotics to their cows. The excessive uses of these have resulted in some health-conscious consumers preferring organic milk.
- The study released by the Nafferton Ecological Farming Group found that the summer months lead to the biggest gap between organic and non-organic milk, because of the wider discrepancy in feeding techniques. Gillian Butler, who led the
study, stated that 84 percent of food for cows on organic farms in the summer was provided through natural grazing, and only 37 percent for non-organic farmed animals.

- Some farms are not located in areas that allow for cows to graze year round, because of the harsh winter weather and rainy seasons requiring them to keep cows inside and use food supplements, such as previously cut grasses and assorted cereals or grains. This doesn't remove the value of non-organic milk, but all naturally grazing fed cows seem to allow for even more nutritional benefits and value than non-organic, based on the recent study.
- Organic farms are more costly to operate because there is less milk produced for each unit of land. This also causes organic milk to be more expensive.
- The study was conducted to survey milk quality and ways to minimize the use of antibiotics in dairy products. Some of the most significant finds of the new released study were the differences in organic and non-organic milks compared seasonally. Researchers and scientist plan to take their research and use it to help improve the nutritional composition of milk while cows are kept indoors and fed mostly conserved grasses.
- Though organic milk is double the cost of non-organic milk there are many people who have reasons that they prefer the organic milk over non-organic. Whether it be the taste or the health benefits, yearly there are more and more people who or switching over to the even more healthy dairy drink. Non-organic milk is still very healthy for you, so if you are one of those who’s budget or conscious won’t allow you to pay double for the organic product, know that you are still benefiting from drinking a very healthy and necessary product when you choose to drink non-organic milk.

MODULE-16: PACKAGING, TRANSPORTATION, STORAGE AND DISTRIBUTION OF MILK AND MILK PRODUCTS

Learning outcomes

At the end of this module the learner will be able to understand the followings:

- Packaging,
- Packaging containers (forms) for milk and dairy products,
- Packaging Materials for milk and dairy products,
- Milk transport,
- Storage and distribution of milk.

PACKAGING

- Packaging is the technique of using the most appropriate containers and components to protect, carry, identify and merchandise any product. It constitutes a vital link between the manufacturer and eventual consumer for the safe delivery of the product through the various stages of manufacture, storage, transport, distribution and marketing. In order to deliver fresh, sound and convenient form of milk and to minimize the losses protective packaging is necessary to withstand the hazards of climatic changes, transportation, handling etc. The criteria by which a package is judged are usually the following:
  - It must protect and preserve the commodity from the time it is packed to the point of consumption.
  - It must be suitable for the chosen selling and distribution system.
  - It must be attractive to the consumer, easy to open, store and dispose.
It must cost no more than the market can bear.

- **Definition**
  - Packaging means placing a commodity into a protective wrapper or container for transport or storage.

- **Functions**
  - Package has a three fold functions of containing, protecting and merchandising:
    - **To contain the product**
      - Package should be large one with proper constructional features so as to avoid leakage and spoilage. It should be as compatible as possible with the product and finally it should have enough strength to withstand handling, transportation and storage hazards.
    - **To protect the product**
      - Protection of the product against contamination or loss and damage or degradation due to microbial action, exposure to heat, light, moisture and oxygen, evaporation etc.
    - **To help in selling the product**
      - The shape of the package should be favourable to dispensation and reclosure, and to its disposal and reuse.

- **Present status of the packaging industry**
  - In developed countries packaging industry has met tremendous advances. With newer marketing systems like super markets, self service stores etc packaging technology in these countries has risen to great heights. Newer and better packaging materials, development of packaging machinery and appliances have all advanced in an integrated manner. In developing countries like India, packaging is still in its infancy.

## Packaging Containers (Forms) for Milk and Dairy Products

- **Bottle**
  - The glass bottle still continues to be used for packaging of milk in some parts of the world. However in several developed countries and some of the developing countries it has lost ground to single service containers for packing milk.

- **Carton**
  - The cartons are the preferred medium or form for packaging milk. They are also used for packaging liquid, frozen and coagulated milk products. Cartons are commonly made of food grade paper coated on the inside with wax or plastics; or lined with paper, plastic films or aluminium foil; or made of laminates.
  - The merits include maximum space utilization in vehicles, and storage; ability to carry attractive printing and convenience as a means for stacking milk at super market shelves.
  - Retailers in the developed countries consider it the best available package for self-service selling. Cartons also play a role in the bulk packaging of milk. Cartons are commonly available either as preformed containers or as pre cut blanks ready to be formed in to containers. The carton systems in common use are as follows.

<table>
<thead>
<tr>
<th>Carton</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perga (preformed)</td>
<td>U.K</td>
</tr>
<tr>
<td>Pure pak (precut)</td>
<td>USA</td>
</tr>
</tbody>
</table>
- **Sachet / Bag / Pouch**
  - Flexible waterproof plastic bags are commonly used for packaging milk and liquid dairy products. Since it is difficult to pour from these, a jug is usually also provided. The popular laminate for such bag is black or dark brown (to exclude UV light) or white.
  - The bags may be formed from either a reeled or flat film. Generally it is a form-fill-seal system. Generally, ultra violet light is used to sterilize the films. The bags are heat-sealed and cut, the common sequence being to bottom seal, fill, move down on sachet length, top seal and cut off.
- **Can**
  - This is commonly used for packaging all types of solid, semi solid and powdered dairy products. Cans are traditionally made of soldered tin plate steel, generally lacquered on the inner surface to prevent corrosion.
  - Aluminium cans have now become famous. Cans are the most convenient for gas packing.
- **Box / Tub**
  - It may be made up of wood or paper board. White wooden boxes / tubs are used for bulk packing of butter and butteroil with butter paper / plastic liners, paperboard boxes are generally used as over-wraps.
- **Barrel / Cask**
  - Commonly made up of wood and coated with wax on the inner surface. Used for bulk packaging of sweetened condensed milk, semi solid butter milk / whey, butteroil etc.
- **Cup**
  - They are generally made up of paper with wax or plastic coating on the inside. Used for packing frozen dairy products such as ice cream and coagulated milk products.
- **Collapsible tube**
  - They are made up of aluminium and lacquered on the inside. Low cost, lightweight, ease of handling and dispensing, product protection are its advantages. Used for packing semi fluid products such as sweetened condensed milk, processed cheese spread etc.

**A summary of packaging materials / containers used in Dairy Industry**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Product</th>
<th>Packaging Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Liquid milk</td>
<td>Glass bottles (obsolete) &lt;br&gt; LDPE film in combination with LLDPE or octane / butane based films. &lt;br&gt; Paper laminates for tetra packs</td>
</tr>
<tr>
<td>2.</td>
<td>Milk Powder</td>
<td>Tin plate containers, nitrogen packed, and lacquered from outside. &lt;br&gt; Flexible laminates such as metallized PET / BOPP / Aluminium foil / Poly laminates. &lt;br&gt; Refill packs; lined cartons laminated with BOPP / PET, varnished on the outside. Paper laminated film is also used. &lt;br&gt; Bag-in-box; Powder filled in laminate and packed in cartons.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>3.</td>
<td>Butter</td>
<td>Duplex board with vegetable parchment paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin plate containers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aluminium foil</td>
</tr>
<tr>
<td>4.</td>
<td>Cheese / Cheese spread</td>
<td>Tin plate containers lacquered from inside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First packed in aluminium foil and then in duplex board carton</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Injection moulded PP / HDPE container</td>
</tr>
<tr>
<td>5.</td>
<td>Ghee</td>
<td>Tin plate containers lacquered from inside</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glass bottles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HDPE film pouches</td>
</tr>
<tr>
<td>6.</td>
<td>Ice cream</td>
<td>Thermoformed / Injection moulded plastic containers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duplex board carton (poly laminated)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laminates of BOPP(Biaxially Oriented Polypropylene) / PET</td>
</tr>
<tr>
<td>7.</td>
<td>Indian Dairy Products</td>
<td>Injection moulded / thermoformed containers (shrikhand, gulab jamun)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stand up laminated pouches</td>
</tr>
</tbody>
</table>

### PACKAGING MATERIALS FOR MILK AND DAIRY PRODUCTS

- The packaging materials include paper and paper based products (coated or lined), glass, tin plate, aluminium foil, timber (wood), plastics and laminates (Tetra packs)
  - **Paper and paper based products**
    - The paper and paper based products form an excellent packaging material for milk and milk products. They may be kraft paper, grease proof paper, vegetable parchment paper, glassine paper, wax coated paper, plastic coated paper, paper boards, solid fibre boards, liner boards, box boards etc.
    - The papers are used in the form of boxes, bags, wrappers, cartons, cups etc. The advantage of using paper is that it is weightless, capability for printing on the surface, low cost and easy disposability. The disadvantages include low wet and tear strength.
  - **Glass**
    - The glass may be transparent or opaque. Glass is used in the form of bottles, tumblers, jars, jugs etc.
    - The advantages cited for glass as a packaging material include its strength, rigidity, ability to have a barrier for water and gas and inertness to chemical substances. The disadvantage is its heavy weight, and fragility.
  - **Tin plate**
    - It may be made up of a thin sheet (0.025 mm thick) of mild steel coated on both sides with a layer of pure tin. It is desirable to have an internally lacquered can, which provides better resistance to corrosion.
    - The advantages cited for tin containers as a packaging material are their good strength and excellent barrier properties. The disadvantages are their high cost, heavy weight, difficulty in closing the lid of the container, and disposal. The containers are mostly used in the form of can.
  - **Aluminium foil**
The common thickness of the foil used is 0.012 – 0.015 mm. To increase corrosion resistance, it may be lacquered (coated with lacquer) or a thin film of plastic can be applied for packing dairy products.

The advantages of these containers are good barrier properties, grease proof, non-absorption, shrink proof, odourless, tasteless, hygienic, non toxic, opaque to light, bright in appearance etc. The demerits are its low tear strength, susceptibility to strong acids and alkalis. It is mostly used in the form of wrapper, carton and box.

**Timber**

The required qualities for the timber to act as a packaging material are it should be free from odour, have an attractive appearance, and required mechanical strength. It may be treated with casein formalin, or sprayed with paraffin wax or plastics or to make it more water resistant and to avoid the passage of timber taint to butter. It is generally used in the form of a box, tub, cask or barrel.

**Plastics**

The use of plastics in *packaging* has made tremendous progress in recent years all over the world. A wide variety of plastics can be used as thermoformed, injection moulded or blow moulded containers, such as bottles, cartons, cups, boxes etc. The merits of rigid plastic containers are its low cost and ease of fabrication. The demerits cited are lack of product compatibility, low barrier properties, plastic deterioration, lack of resistance to high heat and fragility at lower temperatures. Flexible plastic packaging films are used as wrappers or sachets or bags or pouches for packaging milk and dairy products. The flexible plastics can be classified in to two types.

**Low polymers**

They include cellophane (coated with plain or nitrocellulose / saran / polyethylene), treated with cellulose etc.

**High polymers**

Polyethylene, polypropylene, polystyrene, poly vinyl chloride, poly vinyledene chloride (cryovac), rubber hydrochloride (pliofilm), polyester, polyamide (nylon), saran (a mixed polymer), etc. form good packaging materials.

The merits cited for flexible packaging films are they can be easily applied and the packaging process can be readily mechanized; loss of moisture from the dairy product is practically nil; it confers protection to dairy products against attack by microorganisms, insects etc. The demerits are: not all technical problems in film packaging have been solved; failure to obtain a perfect seal and removal of all air before packaging may lead to spoilage; the most careful attention to detail is necessary, else faulty production will result; etc. Care has to be exercised in selecting food grade plastics for packaging of milk and dairy products; otherwise toxicity, if any, from the package will be transferred to the products.

**Laminates**

They are formed by combining the complete surfaces of 2 or more webs of different films with the primary object of overcoming the defects of single films.

Usually laminations are made to strengthen the film material, to improve barrier properties, to improve grease resistance, to provide a surface that will heat seal, etc. Some of the typical laminates available for packaging are paper-polythene, cellophane-polythene,
aluminium foil-polythene, paper aluminium foil-polythene, polyester-polythene, etc.

- **Tera pack** has internal polyethylene layer seals in the liquid,
- Polyethylene layer needed for lamination process
- Aluminium foil provides a barrier to oxygen, flavours and light
- Polyethylene adhesion layer needed for lamination process
- Paperboard gives stability and strength
- Polyethylene layer protects food from external moisture

### MILK TRANSPORT

- The milk transportation company shall be responsible for maintaining the tank and milk contact surfaces of a milk tank truck clean and in good repair. Milk or milk products shall not be placed in such tanks unless the tanks have been properly cleaned and sanitized at a milk plant, receiving station, transfer station, or other licensed milk tank truck cleaning facility.
- Suitable facilities for cleaning and milk contact surfaces of the milk tank trucks shall be provided and the washing and sanitizing of the tanks shall be carried out by the receiving milk plant, transfer station, receiving station, or other licensed milk tank truck cleaning facility. The milk transportation company representative or the bulk milk hauler/sampler shall be responsible for cleaning the hose, pump, and valves. After the cleaning and sanitizing operation is completed, a representative of the milk tank truck cleaning facility shall provide a suitable record identifying who washed the milk tank truck, the license or permit identification number of the milk tank truck, the date, and the location of the facility. The milk transportation company representative or the bulk milk hauler/sampler, after inspection of the tank, shall indicate on the record that the tank has been cleaned to that person's satisfaction. A copy of this record shall be kept with the vehicle until it is washed and sanitized again.
- A bulk milk hauler/sampler operating a bulk milk pickup tanker may make more than 1 trip daily without cleaning and sanitizing the bulk milk pickup tanker. The bulk milk pickup tanker shall be cleaned and sanitized after the final trip of the day, each day of use.
- A milk transport tank shall be cleaned and sanitized each time the tank is emptied.
- Milk may be picked up in the milk tank truck on the return trip to the bulk milk hauler/sampler's home if the milk tank truck is cool enough to maintain the milk placed in it at or below the legal storage temperature and if the pickup hose and pump are washed and sanitized at a licensed wash facility or at a cleaning facility approved in writing by the director on a case-by-case basis.
- A milk tank truck may be used to haul potable water, or other wholesome liquid food products, if the milk contact surfaces are properly cleaned and sanitized prior to picking up raw milk. Certain pasteurized products, as specified in the pasteurized milk ordinance, must be transported in milk tank trucks dedicated to hauling pasteurized products.
- A milk transfer station or receiving station shall keep daily records identifying which farm loads of milk have been commingled in each milk transport tank. These records shall be kept at the transfer station or receiving station for not less than 30 days.
- Producer samples shall accompany the milk transport tank holding the largest amount of the farm bulk milk pickup tanker's milk unless the samples are transferred or held for testing at other locations.
**STORAGE OF MILK**

- Milk storage vats or silos are refrigerated and come in various shapes and sizes. Milk is stored on farm at 4 degrees Celsius and less for no longer than 48 hours.
- Vats and silos are agitated to make sure that the entire volume remains cold and milkfat does not separate from the milk.
- After milk has been collected, storage vats and stainless steel pipes are thoroughly cleaned before the farmer milks again.

**DISTRIBUTION OF MILK**

- Because milk spoils so easily, it should, ideally, be distributed as quickly as possible. In many countries milk used to be delivered to households daily, but economic pressure has made milk delivery much less popular, and in many areas daily delivery is no longer available. People buy it chilled at grocery or convenience stores or similar retail outlets. Prior to the widespread use of plastics, milk was often distributed to consumers in glass bottles, and before that in bulk that was ladled into the customer’s container.
- In rural India, milk is delivered daily by a local milkman carrying bulk quantities in a metal container, usually on a bicycle; and in other parts of metropolitan India, milk is usually bought or delivered in plastic bags or cartons via-shops or supermarkets.
- Milk preserved by the UHT process is sold in cartons often called a “brick” that lack the peak of the traditional milk carton. Milk preserved in this fashion does not need to be refrigerated before opening and has a longer shelf life than milk in ordinary packaging. It is more typically sold unrefrigerated on the shelves in Europe than in America.
- Glass milk containers are now rare. Most people purchase milk in bags, plastic jugs or waxed-paper cartons. Ultraviolet light from fluorescent lighting can destroy some of the proteins in milk so many companies that once distributed milk in transparent or highly translucent containers are now using thicker materials that block the UV light. Many people feel that such “UV protected” milk tastes better.
- India: Commonly sold in 500 mL plastic bags. It is still customary to serve the milk boiled, despite pasteurization. Flavored milk is sold in most convenience stores in waxed cardboard containers. Convenience stores also sell many varieties of milk (such as flavored and ultra-pasteurized) in different sizes, usually in Tetra-Pak cartons.

**MODULE-17: SANITATION IN MILK PLANT**

**Learning outcomes**

At the end of this module the learner will be able to understand the followings:

- Definitions for Sanitizing terms,
- Principles of cleaning and sanitization and
- Sanitizers.

**SANITATION IN MILK PLANT**

Sanitation implies the destruction of all pathogenic and almost all non athogenic micro organism
**Definitions for Sanitizing Terms**

- **Antiseptic** - an agent used against sepsis or putrefaction in connection with human beings or animals.
- **Disinfectant** - an agent that is applied to inanimate objects; it does not necessarily kill all organisms.
- **Sanitizer** - an agent that reduces the microbiological contamination to levels conforming to local health regulations.
- **Germicide** - an agent that destroys microorganisms.
- **Bactericide** - an agent that causes the death of a specific group of microorganisms.
- **Bacteriostat** - an agent that prevents the growth of a specific group of microorganisms but does not necessarily kill them.
- **Sanitization** - the process of reducing microbiological contamination to a level that is acceptable to local health regulations.
- **Sterilization** - the process of destroying all microorganisms.

The premises surrounding the dairy plant shall be kept in a clean and orderly condition, and shall be free from strong or foul odors, smoke, or excessive air pollution. Construction and maintenance of driveways and adjacent plant traffic areas shall be of cement, asphalt, or similar material to keep dust and mud to a minimum.

A suitable drainage system shall be provided which will allow rapid drainage of all water from plant buildings and driveways including surface water around the plant and on the premises, and all such water shall be disposed of in such a manner as to prevent an environmental or health hazard.

The immediate surroundings shall be free from refuse, rubbish, overgrown vegetation, and waste materials, to prevent harborage of rodents, insects, and other vermin.

Detergent should have the following desirable properties:

- Wetting and penetrating power
- Emulsifying power
- Saponifying power
- Deflocculating power
- Sequestrating and chelating power
- Quick and complete solubility
- Should be non corrosive to metal surfaces.
- Free rinsing.
- Economical
- Stability during storage
- Should be mild on hands
- Should possess germicidal action.

Dairy detergents broadly classified into 4 different groups:

- **Alkalies**: Sodium hydroxide, Sodium bi carbonate, Sodium phosphates, Sodium silicate/sulphite etc.
- **Acids**: Mild-Phosphoric, Tartaric, Citric, Gluconic. Mild acids can be used for milk stone removal. Strong-Nitric.
- **Polyphosphates and chelating chemicals**: These are used together with acids and alkalis. Examples Tetraphosphate, Hexa meta phosphate, Tri poly phosphate, Pyrophosphate etc.
• Surface active/Wetting agents: These are used either alone or in conjunction with acids or alkalies. Examples—Teepol, Acinol N, Idet-10, common soaps etc.

Principles of cleaning and sanitization

• Cleaning or washing of dairy equipment implies the removal of soil from the surface of each machine.

Sanitization or sterilization

• Implies the destruction of all pathogenic and all most all non pathogenic micro organisms from the surface of the equipment.
• Detergents are the substances capable of assisting cleaning.
• Sanitizers are substances capable of destroying all pathogenic and almost all non pathogenic micro organisms.

Principles of cleaning and sanitization

• In the selection of any particular detergent consideration should be given to type of soil, quality of water supply, material of surface and the equipment to be cleaned and method of cleaning viz., soaking, brushing, spraying and or recirculation
• Heat is most reliable sanitizer especially when both temperature and time are controlled. Thus effective sanitization can be done by steam (15psi / 5 minutes or 0 psi / 15 minutes) or scalding water (90 – 950C/10 minutes)
• Drainage: To remove any residual loose milk and any other matter
• Pre rinsing: With cold or hot tap water to remove as much milk residue and other matters as possible
• Warm to hot detergent washing: With detergent solution of 0.15 to 0.60% alkalinity to remove the remaining milk solids.
• Hot water rinsing: To remove traces of detergents
• Sanitization: To destroy all the pathogenic and almost all the non pathogenic MO.
• Drainage and drying: To prevent bacterial growth and corrosion. Drying readily accomplished by heat and ventilation.

<table>
<thead>
<tr>
<th>Dairy detergents</th>
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</thead>
<tbody>
<tr>
<td><strong>Alkalies</strong></td>
<td><strong>Acids</strong></td>
</tr>
<tr>
<td>• NaOH</td>
<td>• Tartaric, phosphoric, citric, gluconic and nitric acids</td>
</tr>
<tr>
<td>• Na₂CO₃, Sodium phosphate</td>
<td>• Mild acids used to remove milk</td>
</tr>
<tr>
<td>• Sodium bicarbonate, Sodium silicate</td>
<td></td>
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<tr>
<td>• Strongalkalies saponify the fat</td>
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</tr>
<tr>
<td>• Weak alkalies dissolve protein</td>
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</tr>
<tr>
<td>Stone</td>
<td>Strong acids should not be used at more than 1%</td>
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</tbody>
</table>

**Sanitizers**

- Non toxic
- Quick acting
- Relatively non corrosive to hands and equipment
- Easily and quickly applied
- Relatively inexpensive

The commonly used dairy sanitizers are steam, hot water and chemicals like chlorine compounds, iodophor and quaternary ammonium compounds. The methods of chemical sanitization broadly consists of flushing, spraying, brushing, fogging and submersion.

<table>
<thead>
<tr>
<th>Name of the sanitizer</th>
<th>Mode of action</th>
</tr>
</thead>
</table>
| **Chlorine compounds** like chlorine gas, chloramines-T, hypochlorites, hexachlorophenol, dichloroisocyanic acid and trichloroisocyanic acid | \( \text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{H}^+ + \text{CH}^- \)  
HOCl is highly bactericidal  
Nascent \( \text{H}^+ \) destroys microbes by inhibiting enzymic reactions and glucose oxidation |
| **Iodophors** like iodine | Acts through halogenation and oxidation of sulphhydral groups. Dissociation of iodine from the surfactant is responsible for bactericidal action |
| **Quaternary ammonium compounds** like acetyl trimethyl ammonium bromide | Acts on cell membrane causes disintegration and denaturation of proteins essential for growth and metabolism. Inactivates special enzyme system essential for respiration of cells. |

**Methods of cleaning dairy equipment:** These include hand washing, mechanical washing and Clean – in – place or CIP method.

**Hand washing**

- Prepare 0.8 to 1.0% of detergent mixture in tap water so as to give a minimum alkalinity of 0.5% in a wash up tank and maintain the temperature at about 50°C
- Thoroughly rinse the utensils with clean cold water
- Introduce the detergent solution in to the equipment thoroughly brush the equipment surface, inside and out side with a clean can brush
• Wash the utensils with enough fresh cold water using a clean brush again if needed to remove all traces of detergents
• Allow the equipment to drain thoroughly and let it dry for at least one or two hours
• Sanitize the equipment surface by steam or hot water after cleaning and or by rinsing with chlorine solution (200 ppm available chlorine) just before using

**Mechanical washing:** This consists mainly of can and bottle washing

**Can washing**
- Drainage stage for liquid milk residue
- Pump-fed pre rinsing with cold or Luke warm water
- Drainage stage
- Pump fed jetting with detergent at not less than 70°C
- Drainage stage
- Rinsing stage – Pump fed or by steam and water ejector at not less than 88°C
- Final fresh water rinsing with steam and water ejector at 88 – 93°C
- Live steam injection
- Hot air drying at 95 – 115°C

**Bottle washing**
- Pre rinse using water at 32 – 38°C
- Detergent wash usually with 1 – 3 % caustic soda together with chelating and wetting agents, given preferably in two stages at different temperatures with in 60 – 75°C. Sanitize the bottles as well
- Warm water rinse: To remove all traces of detergents. Reduce the bottle temperature for next stage. Water temperature varies from 25 – 45°C and is usually re circulated.
- Cold water rinse: Normally re circulated chlorinated water (containing 35 to 50 ppm available chlorine) is used to prevent re contamination of bottles
- Draining after the bottles come out of the machine

**Cleaning – in – place:** This refers to that system of cleaning and sanitization which does not require the daily dismantling of dairy equipment.

- Pre rinse with cold water till discharge water runs clear
- Acid rinse with phosphoric acid solution of 0.15 to 0.60% acidity, re circulated at 65 to 71°C for 20 to 30 minutes (wetting agent may be added to increase cleaning ability)
- Drain out acid solution
- Hot water rinse with water at 65 to 71°C for 5 to 7 minutes. Rinse water should drain out
- Alkali rinse with alkali detergent solution of 0.15 to 0.60% alkalinity, re circulated at 65 to 71°C for 20 to 30 minutes (wetting agent may be added to increase cleaning ability)
- Drain out alkali solution
- Final hot water rinse with water at 71 to 82°C till the whole system has been heated. Rinse water should be drained out.

**Merits of CIP system**

- Ensure that all equipment receives uniform heat treatment day after day by eliminating the human factor
- Less damage to equipment
- Saving of total clean up costs and in man hours
- Reduces possibility of contamination through human error
- Improved plant utilization and appearance
Success factors

- Proper selection of pipes and fittings, installation and development of circuits
- Proper temperature of cleaning solution
- Adequate velocity of cleaning solution
- Use of detergents designed specifically for re circulation cleaning
- Proper concentration of detergent solution
- Sufficient cleaning time

Merits

- Eliminates the human factor
- Less damage to equipment
- Time saving
- Reduces the possibility of contamination through human error
- Improved plant utilization and appearance

Types of CIP systems

- Manual control
- Automation
  - Low level
  - Medium level
  - High level

Cleaning is the process of removing food and other types of soil from a surface, such as a dish, glass, or cutting board. Cleaning is accomplished using a cleaning agent that removes food, soil, rust stains, minerals, or other deposits.