Retrospect and Prospects of Dairy Industry in India:

In brief, the history of India's dairy cooperative movement is highlighted by key milestones:

- **Kaira District Cooperative Milk Producers' Union (AMUL)** was established in **1946** in response to the exploitation of local farmers by middlemen. It aimed to empower farmers by controlling milk procurement, processing, and marketing.
- The **National Dairy Development Board (NDDB)** was founded in **1965** to replicate the successful Amul model across India.
- **Operation Flood**, a significant initiative launched by the NDDB on **January 13, 1970**, aimed to increase milk production and improve rural incomes. It consisted of three phases:
    - **Phase I** (1970-1980)
    - **Phase II** (1981-1985)
    - **Phase III** (1985-1996)
- Looking ahead, it is projected that India's total milk production will reach **330 million tonnes by 2034**.

This cooperative model has not only transformed the dairy industry in India but has also positioned the country as the world's largest milk producer.

Dairy industry Scenario in India

- India's dairy sector has shown remarkable growth, with total milk production reaching 230.58 million tonnes in the 2022-23 period.
- The per capita availability of milk during this period is estimated at 459 grams per day, which is significantly higher than the global average of 322 grams per day.
- Uttar Pradesh is the leading state in milk production, contributing 15.72% of the total output.
- India ranks 1st in world in terms of milk production and maximum contributor in that is buffalo (44.81%)
- **Milk Man Of India/ Father of white revolution in India: Dr. Verghese Kurien**
- **World Milk Day: 1st of June**
- **National Milk Day: 26th November**

Milk constituents and Physico-chemical properties

Milk: whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy milch animals, excluding that obtained within 15 days before or 5 days after calving, colostrum-free, and containing the minimum prescribed percentage of milk fat and milk solid not fat (FSSR, 2011)

Market milk refers to whole fluid milk that is sold directly to consumers for drinking and is not used for further processing or manufacturing of dairy products.

Composition and Properties of Milk

- Water: 85-88%
- Total Solids: 12-15%
- Fat: 4-6%
- Proteins: 3.3% (Casein 82%, Whey Proteins 18%)

- Lactose: 4.9%
- Minerals and Vitamins: Includes calcium, potassium, and vitamins A, D, E, K.

	Water	**Fat**	**Protein**	**Lactose**	**Ash**
Cow	86.6	4.6	3.4	4.9	0.7
Buffalo	84.2	6.6	3.9	**5.2**	0.8
Sheep	79.4	**8.6**	**6.7**	4.3	1.0
Goat	86.5	4.5	3.5	4.7	0.8
Sow	89.6	4.8	1.3	3.4	0.9
Mare	89.1	**1.6**	2.7	**6.1**	0.5
Ass	90.0	**1.3**	1.7	**6.5**	0.5

Type of Milk	**Fat % (min)**	**SNF % (min.)**
Cow milk	3.5	8.5
Buffalo Milk	5	9
Standardized milk	4.5	8.5
Toned milk/ Recombined milk	3	8.5
Double Toned milk	1.5	9
Skim milk	0.5 max	8.7

Milk Fat: Milk fat is the most variable and economically important constituent of milk. It exists primarily in the form of glycerides, with **triglycerides** being the most common type. **Milk fat is an oil-in-water type emulsion**, present as fat globules ranging from 0.1 to 22 microns in size, with an average size of **2 to 5 microns** (1-5 microns in cows and 3-8 microns in buffaloes).The fatty acids in milk fat can be categorized as:

- **Saturated fatty acids (65%)**
- Monounsaturated fatty acids (MUFA) (30%)
- Polyunsaturated fatty acids (PUFA) (5%)

Milk fat can be divided into two main categories:

- True fat (98-99%), which consists of the most common triglycerides
- Associated fat (1-2%), which includes:
    - Phospholipids (lecithin, cephalin, and sphingomyelin)
    - Steroids and cholesterol
    - Fat-soluble vitamins (A, D, E, K)
    - Pigments (carotene and xanthophyll)

PROTEINS: Milk proteins primarily consist of **casein** (82%) and **whey proteins** (18%). They exist in a colloidal form, which scatters light and gives milk its characteristic white color.

- **Casein**:
    - Comprises about 3% of cow's milk and 4.3% of buffalo milk.
    - Found as a calcium caseinate phosphate complex.
    - Contains phosphorus and coagulates at a pH of 4.6.
- **Whey Proteins**:
    - Do not contain phosphorus and remain soluble in milk at a pH of 4.6.

The principle of coagulation at reduced pH is fundamental to cheese and curd formation. Additionally, riboflavin contributes to the color of whey proteins, while casein is responsible for the white color of milk.

Casein:

Caseins in milk form complexes known as **micelles**, which are dispersed as a colloidal suspension in the water phase of milk, primarily as a **calcium caseinate phosphate complex**.

- **Composition of Casein Micelles**:
    - Consist of subunits from different types of caseins: **α, ß, and γ**.
    - **ß-casein** is divided into two parts: **A1** and **A2**, differentiated by the 67th amino acid (A1 has histidine, while A2 has proline). A1 protein upon digestion produces beta casoporphin-7 (BCM-7) which has adverse health properties.
- **Characteristics**:
    - Casein micelles are spherical in shape and range from **0.04 to 0.3 µm** in diameter.
    - **Kappa casein** is the specific site where rennin acts during cheese-making.
- **Uses**:
    - The adhesiveness of milk, attributed to casein, makes it useful in glue production.

WHEY/ Serum Proteins:

Whey proteins account for about **18%** of the total protein content in milk, primarily consisting of:

- **ß-lactoglobulin** (approximately **50%**)
- **α-lactalbumin** (about **20%**)
- Other components include **blood serum albumin**, **immunoglobulins**, **lactoferrin**, **transferrin**, and various minor proteins and enzymes.

Functions of Key Whey Proteins:

- **ß-lactoglobulin**: Acts as a carrier for **vitamin A**.
- **α-lactalbumin**: Plays a critical role in the synthesis of **lactose**.
- **Lactoferrin and Transferrin**: Involved in the absorption and transportation of **iron**.
- **Immunoglobulins**: The major type is **Ig G1**, which contributes to immune function.

Whey proteins are present in milk as a **colloidal solution**, contributing to the nutritional and functional properties of milk.

CARBOHYDRATES: Lactose is the sugar found in milk, composed of **glucose** and **galactose**. **It exists as a true solution in the milk serum and is the least variable component of milk.**

- Lactose plays a crucial role in the **absorption of calcium** and **phosphorus** from the intestine.

Chemical Reactions Involving Lactose

- **Maillard Reaction**: This reaction occurs at ultra-high temperatures between lactose and the amino acid **lysine** in milk, leading to browning and flavor changes.
- **Isomerization**: Lactose can be converted to **lactulose**, which has laxative properties and potential antineoplastic effects.

Forms of Lactose

- Lactose exists in two anomeric forms: **α-lactose** and **ß-lactose**.
- The **α-monohydrate lactose** crystals contribute to the sandy texture found in products like **ice cream** and **condensed milk**.

VITAMINS AND MINERALS:

- **Mineral Content**:
    - **Good Sources**: Milk is a good source of calcium (Ca), phosphorus (P), sodium (Na), potassium (K), and magnesium (Mg).
    - **Poor Sources**: It is a poor source of iron (Fe) and copper (Cu).
    - The **calcium to phosphorus (Ca:P)** ratio in bovine milk is approximately **1:2**.
- **Vitamin Content**:
    - **Good Sources**: Milk is rich in the **Vitamin B complex**.
    - **Poor Sources**: It is a poor source of **Vitamin C** and **Vitamin K**.

MILK ENZYMES:

- **Lipoprotein Lipase**:
    - **Type**: Major lipase.
    - **Association**: Linked with casein micelles and fat globule membranes (FGM).
    - **Function**: Plays a role in the digestion of milk fats.

- **Plasmin**:
    - **Type**: Major protease.
    - **Association**: Associated with casein micelles.
    - **Function**: Contributes to desirable flavor and texture in cheese.
- **Alkaline Phosphatase**:
    - **Type**: Heat-sensitive enzyme.
    - **Function**: Used as an indicator of pasteurization. It can cause oxidation and rancidity of fats in milk.
- **Lactoperoxidase**:
    - **Location**: Present in milk serum.
    - **Function**: Exhibits antibacterial properties, helping to preserve milk.
- **Catalase**:
    - **Significance**: Generally insignificant in normal milk.
    - **Function**: Increased concentrations may indicate udder infection.
- **Lysozyme**:
    - **Amount**: Present in very limited quantities in bovine milk.
    - **Function**: Has antibacterial properties, contributing to milk's natural defense mechanisms.

PIGMENTS & GASES:

Carotene: Responsible for the **yellowish color** of cow's milk.

- In buffalo milk, carotene is converted to **Vitamin A** by the enzyme **carotenase**.
- **Carotene Content**:
    - Cow milk: **30 µg/g**
    - Buffalo milk: **0.25 - 0.48 µg/g**

- **Riboflavin** (also known as lactochrome or lactoflavin):
    - Contributes to a **greenish tinge** in whey.

Gases in Milk: Carbon Dioxide (CO_2), Nitrogen (N_2), Oxygen (O_2)

Nutritive value

- **Cow Milk**: **Energy**: 75 kcal per 100 g
- **Buffalo Milk**: **Energy**: 100 kcal per 100 g

Nutritional Composition

- **Energy Contribution**:
    - **Milk Fat**: 9.3 kcal/g

- **Protein**: 4.1 kcal/g
- **Sugar (Lactose)**: 4.1 kcal/g

Cholesterol Content

- **Cow Milk**: 3.14 mg/g
- **Buffalo Milk**: 0.65 mg/g

Vitamins and Minerals

- **Vitamins**: Good source of vitamins, except for **Vitamin C** and **Vitamin K**.
- **Minerals**: Good source of minerals, except for **Iron (Fe)** and **Copper (Cu)**.

Protein Quality

- **Biological Value**: High biological value proteins (85-95), indicating a good amino acid profile.

Essential Fatty Acids: Contains essential fatty acids, including **linoleic acid** and **arachidonic acid**.

Antimicrobial properties of Milk:

Specific antimicrobial agents: act by targeting specific pathogens:

- **Immunoglobulins**: These are antibodies that play a crucial role in identifying and neutralizing pathogens. In milk, secretory IgG is particularly important for mucosal immunity.
- **Complement**: A system of proteins that enhances the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promoting inflammation and attacking the pathogen's cell membrane.
- **Bifidus Factor**: This is associated with the growth of beneficial bacteria like *Bifidobacterium*, which can modulate immune responses and enhance specific immunity through the promotion of regulatory T cells and anti-inflammatory cytokines.

Non-Specific agents: Non-specific immunity provides a general defense against pathogens and includes:

- **Lactoferrin**: An iron-binding protein with antibacterial properties that helps inhibit the growth of bacteria and fungi.
- **Lysozyme**: An enzyme that breaks down bacterial cell walls, providing a defense against bacterial infections.
- **Lactoperoxidase**: An enzyme that exhibits antibacterial properties, contributing to the antimicrobial activity of milk.
- **Lactanins**: These are bioactive components that can exert antimicrobial effects, further enhancing the non-specific immune response.

Physico-Chemical Properties of MILK:

1. Acidity and pH

- Amphoteric Nature: Freshly drawn milk is amphoteric, meaning it can act as both an acid and a base. This is due to the presence of amino acids that exist in a zwitterionic form.
- pH Levels:
    - Overall Milk pH: Approximately 6.6.

- Cow Milk: Ranges from 6.4 to 6.6.
- Buffalo Milk: Ranges from 6.7 to 6.8.

Variations: The pH of milk will be higher in cases of mastitis (inflammation of the mammary gland). The pH will be lower in colostrum (the first milk produced after calving, rich in antibodies).

Buffering Action: Milk has a buffering capacity that helps maintain its pH, which is critical for its stability and quality. The buffering action is provided by:

- Proteins
- Phosphates
- Citrates and Carbon Dioxide (CO_2)

Titratable Acidity in Milk: Titratable acidity is the total acidity present in milk, which can be divided into two components:

1. **Natural or Apparent Acidity**:
    - Freshly drawn milk has some inherent acidity due to its constituents like casein, acid phosphates, citrates, and carbon dioxide (CO_2) present in the solids-not-fat (SNF) portion.
    - Typical values for natural acidity:
        - Cow milk: 0.13 to 0.14%
        - Buffalo milk: 0.14 to 0.15%
2. **Real or Developed Acidity**: This acidity develops due to the formation of lactic acid by bacterial fermentation of lactose.

    The total titratable acidity is the sum of these two components:

    Titratable Acidity = Natural Acidity + Developed Acidity

Color of Milk and Its Components

- White Color: Milk appears white due to the scattering of light by colloidal particles, primarily casein micelles.
- Yellow Color: The yellow color of milk is attributed to the presence of carotene pigments.
    - The intensity of the yellow color increases when cows are fed green fodder, as it is rich in carotene.
    - Buffalo milk appears white in color due to the absence of carotene, which is converted to vitamin A.
- Greenish-Yellow Color: Addition of dilute acid or rennet to milk results in a distinct greenish-yellow color due to the precipitation of casein, revealing the underlying pigment riboflavin.
- Whey Color: Whey appears greenish-yellow due to the presence of riboflavin.
- Skim Milk Color: Skim milk has a bluish tinge, attributed to the presence of lactochrome.

Sensory Properties of Milk

- **Taste and Smell Interaction**: The sensory property of milk is significantly influenced by both taste and smell, making it essential for overall evaluation.

- **Sweet Taste**: The sweetness in milk is primarily due to lactose, which contributes to its flavor profile.
- **Salty Taste**: The presence of chloride is responsible for the salty taste, particularly noticeable in mastitic milk and during the late stages of lactation.
- **Richness in Taste**: The richness is attributed to phospholipids, which enhance the flavor experience.
- **Cooked Flavor**: A cooked flavor can develop due to the presence of sulfhydryl compounds, often resulting from overheating during processing.
- **Cowy Flavor**: This flavor is associated with ketosis, where the presence of acetone contributes to the off-flavor.
- **Barny Flavor**: A barny flavor may arise from poor ventilation during storage or processing.
- **Malty Flavor**: The *Streptococcus lactis var. maltigenes* bacteria can produce a malty flavor, affecting the sensory quality of milk.

DENSITY & SPECIFIC GRAVITY

Density Measurement

- Pycnometer: A glass or metal container with a precisely determined volume, used for determining the density of liquids by weighing the defined volume.
- Hydrostatic balance: Also known as a Mohr balance, it is a reliable and precise method used by national metrology institutes as the primary method for density measurement.

Specific Gravity Measurement

- Lactometer: Used for measuring the density (creaminess) of milk. It is based on the Archimedes principle, where the lactometer sinks deeper in less dense samples.
- Types of Lactometers:
    - Quevenne lactometer
    - Zeal's lactometer
- Specific gravity: 1+ CLR/1000 Where CLR is the corrected lactometer reading

Typical Values

- Cow milk: 1.028 to 1.030
- Buffalo milk: 1.030 to 1.032
- Skim milk: 1.035 to 1.037
- Colostrum: Around 1.070 due to high total solids content

Other Points

- Milk fat is the lightest constituent of milk
- Milk is heavier than water due to the presence of milk solids

Factors Affecting Specific Gravity

- **Increased Specific Gravity**:
    - Addition of **skim milk**.
    - Removal of **fat**.
    - Lowering the **temperature** of the milk.
- **Lowered Specific Gravity**:
    - Addition of **water**.
    - Addition of **cream**.
    - Increasing the **temperature** of the milk.

Recknagel Phenomenon

- The Recknagel phenomenon refers to the observed increase in the specific gravity of fresh milk over time, typically by 0.001, due to the hydration of proteins. This phenomenon indicates that the density of milk measured immediately after milking is lower than that of milk stored for a longer period.

Measurement Recommendations

- For accurate determination of specific gravity, it is recommended to measure SG 1 hour after milking.
- The milk should be heated to 40 °C and then cooled before measurement to ensure consistency and accuracy.

Freezing Point Depression (FPD) refers to the decrease in the freezing point of a solvent (in this case, milk) caused by the addition of a solute (such as lactose, proteins, and minerals). FPD is measured using a **Hortvet Cryoscope**, which accurately determines the freezing point of milk.

Average Freezing Points

- **Cow Milk**: Average FPD is approximately **-0.547°C**.
- **Buffalo Milk**: Average FPD is approximately **-0.549°C**.

Effects of Water Addition

- **Addition of Water**: When water is added to milk, the freezing point moves closer to **0°C**. Specifically, the freezing point increases by **0.006°C for every 1% of water added**.
    - It is possible to detect the addition of up to **3% water** in milk based on changes in the freezing point.

Effects of Heat Treatment

- **Boiling and Sterilization**: Both processes increase the freezing point depression of milk.
- **Pasteurization**: This process has no significant effect on the freezing point depression of milk.

Surface Tension: Surface tension is the stress at the surface of a liquid, which affects how the liquid behaves in various conditions.

- **Surface Tension Value**:
    - The surface tension of milk at 20 °C is approximately 54.5 dynes/cm.
    - As the temperature increases, surface tension decreases. For example, at 60 °C, it ranges from 40 to 45 dynes/cm.
- **Measurement Methods**:
        - Falling drop method
        - Platinum ring method
- **Comparison with Water**: The surface tension of milk is lower than that of water, primarily due to the presence of proteins in milk.
- **Factors Affecting Surface Tension**: The presence of fat, acidity, and the process of churning all contribute to lowering the surface tension of milk.

Oxidation-Reduction Potential (ORP)

- The oxidation-reduction potential of milk ranges from + 0.2 to + 0.3 volts.
- Tests such as the MBRT (Methylene Blue Reduction Test) and the Resazurin test are based on ORP to assess milk quality.

Viscosity

- The viscosity of milk is measured between 1.5 to 2 centipoises:
    - Cow Milk: Approximately 2 centipoises.
    - Buffalo Milk: Approximately 1.8 centipoises.
    - Skim Milk: Approximately 1.5 centipoises.
- Viscosity in milk is primarily due to the presence of casein and fats.
- Homogenization increases viscosity by promoting a uniform distribution of fat molecules.

Boiling Point: The boiling point of milk is slightly elevated, ranging from 100.15 to 100.17 °C.

Refractive Index: The refractive index of milk is measured using a Zeiss refractometer, with values ranging from 1.344 to 1.348.

FACTORS AFFECTING MILK YIELD & COMPOSITION

1. **Species**: Different species of dairy animals (e.g., cows, buffalo, goats) produce milk with varying compositions, including fat, protein, and lactose content.

2. **Breed**: Within a species, different breeds (e.g., Holstein, Jersey, Guernsey for cows) have distinct milk characteristics, such as fat content and protein levels. **Holstein Friesian (HF)**: Known for the **highest milk yield per lactation** but has the **lowest milk fat content**.

   Highest Milk Fat:

   Exotic Breeds: Jersey cows have a high milk fat content of approximately **5.5%**.

   Indian Breeds: The Red Sindhi breed is noted for its higher fat content.

   Buffalo: The **Bhadawari breed** is recognized for having exceptionally high milk fat content, reaching around **14%**

3. **Individuality**: Each animal has unique genetic traits that can affect milk yield and composition. Individual differences can result from genetics, health, and environmental factors.

4. **Interval of Milking**: The time between milking sessions can influence milk composition. Longer intervals may lead to increased fat and protein concentration due to the accumulation of milk in the udder.

5. **Frequency of Milking**: More frequent milking can lead to lower milk fat content, while less frequent milking may increase fat concentration due to higher milk accumulation.

6. **Disease and Abnormal Conditions**: Health issues such as mastitis or metabolic disorders can significantly alter milk composition, often resulting in increased somatic cell counts and changes in fat and protein levels.

7. **Portion of Milking**:

   - **Fore Milk**: The initial milk released, which is usually lower in fat and higher in lactose.
   - **Stripping**: The last portion of milk, which tends to be richer in fat and proteins.

8. **Stage of Lactation**: The stage of lactation affects milk composition. Early lactation milk (colostrum) is rich in antibodies, while milk later in lactation may have higher fat content.

9. **Feeding**: The diet of the dairy animal impacts milk quality. High-quality forage and balanced rations can enhance milk composition, while poor nutrition can lead to deficiencies.

10. **Season**: Seasonal changes can affect milk production and composition. For example, summer heat may stress animals and reduce milk yield, while winter feeding practices may alter nutrient intake.

11. **Age**: The age of the animal can influence milk production and composition. Mature cows typically produce more milk with a different fat and protein profile compared to younger cows.

12. **Condition of Cow at Calving**: The body condition of the cow at calving can affect milk yield and quality. Cows in good condition tend to have better milk production and composition.

13. **Administration of Drugs and Hormones**: The use of certain medications or hormones can impact milk composition, either positively or negatively. For instance, hormones can increase milk production, while some drugs may affect milk quality.

Cooling and Transportation of milk

Bacteria Growth in Milk

- Common milk bacteria grow best between 20-40°C

- Bacteria develop faster in severely contaminated milk than in milk with a low bacterial count
- Under poor hygiene conditions, bacterial counts can reach half a million or more
- Bacterial growth is accompanied by deterioration in milk quality due to off-flavors, acidity, etc.

Cooling Milk Immediately After Milking

- Freshly drawn raw milk should be promptly cooled to 5°C or below until processed
- Cooling milk stops the development of microorganisms at an early stage in the growth curve
- Cooling milk to below 4°C maintains its excellent quality until processing
- Each degree above 4°C elevates bacteria counts and decreases shelf life of finished products

Materials for Dairy Equipment

- 18:8 stainless steel (18% Chromium & 8% Nickel) or aluminum alloy are commonly used metals for dairy equipment
- Copper vessels can cause a green corrosion product called Verdigris when storing milk

LP System in milk:

Lactoperoxidase: Lactoperoxidase is an enzyme naturally present in bovine milk at a concentration of approximately **30 µg/ml**. It plays a crucial role in the lactoperoxidase system's antimicrobial activity.

Thiocyanate: Thiocyanate (SCN^-) is the substrate for the lactoperoxidase enzyme. It is naturally present in milk at low levels and can be supplemented to enhance the system's effectiveness.

Hydrogen Peroxide: Hydrogen peroxide (H_2O_2) acts as a promoter in the lactoperoxidase system. It is not naturally present in milk but can be generated by the enzyme glucose oxidase or added exogenously.

Activation of the Lactoperoxidase System: When sodium thiocyanate and hydrogen peroxide are added to milk in a ratio of **14:30 mg/litre**, respectively, the lactoperoxidase system is activated. This activation enhances the keeping quality of milk by inhibiting the growth of certain microorganisms.

The activated lactoperoxidase system exhibits:

- **Bactericidal activity** against Gram-negative bacteria
- **Bacteriostatic activity** against Gram-positive bacteria

Keeping Quality: When the lactoperoxidase system is activated by adding sodium thiocyanate and hydrogen peroxide in the specified ratio, the keeping quality of milk is improved. At a storage temperature of **37°C**, the activated system can extend the shelf life of milk up to **10 hours**.

Standardization: adjusting the fat and solids-not-fat (SNF) content of milk to meet specific standards or requirements by removal of excess fat or addition of skim milk or cream. standardized milk must have a minimum fat content of 4.5% and SNF content of 8.5%

Pasteurization: It is process of heating every particle of milk to at least 63°C for 30 min or 72°C for 15s or to any temperature-time combination which is equally efficient, in properly operated equipment. After pasteurization, the milk is immediately cooled to 5°C or below.

- started by Louis Pasteur in Wine and Dr. Soxhlet in milk

Importance of Pasteurization

1. Safety for Human Consumption

- **Destruction of Pathogens**: Pasteurization effectively destroys pathogenic microorganisms that can cause foodborne illnesses. This includes harmful bacteria such as like Coxiella burnetti. By eliminating these pathogens, pasteurization makes milk safe for human consumption.

2. Improved Keeping Quality

- **Reduction of Spoilage Organisms**: Pasteurization kills a significant percentage of spoilage organisms (approximately **85-99%**). This helps extend the shelf life of milk and maintains its quality during storage and distribution. By reducing microbial load, pasteurized milk is less likely to spoil quickly, making it more suitable for consumers.

Drawbacks of Pasteurization

1. Diminished Cream Line or Cream Volume

- **Denaturation of Cryoglobulins (IgM)**: Pasteurization can lead to the denaturation of cryoglobulins, which affects the cream line or cream volume in milk. This can result in a less appealing appearance and texture, particularly for consumers who prefer milk with a rich cream layer.

2. Increased Renneting Time

- **Impact on Cheese Production**: Pasteurized milk may increase the renneting time, which is the time it takes for milk to coagulate during cheese production. This can affect the efficiency of cheese-making processes and may require adjustments in production techniques.

3. Incomplete Destruction of Bacterial Toxins

- **Survival of Toxins**: While pasteurization effectively kills many microorganisms, it does not destroy all bacterial toxins that may be present in the milk. This means that if milk is contaminated with certain bacteria that produce heat-stable toxins, those toxins can still pose a risk to consumers.

4. Accumulation of Milk-Stone: The heating section of pasteurization equipment can experience the accumulation of milk-stone, which is a deposit formed by minerals and proteins. This buildup can affect the efficiency of the equipment, require regular maintenance, and potentially lead to contamination if not properly managed.

1. Batch or holding pasteurization (LTLT)	**63 ° C for 30 minutes**
2. High Temperature Short Time (HTST) pasteurization/ Flash pasteurization	72 ° C for 15 sec
3. Electric pasteurization	Using electricity for 15-20 sec

4. Vacuum pasteurization (vacreation)	under reduced pressure by direct steam
5. Ultra high temperature pasteurization	135 ° C to 150 ° C for no hold
6. In- bottle pasteurization	63-66 ° c for 30 minutes
7. Stassanization	74 ° c for 7 sec
8. Uperization/ultra – pasteurization	150 ° c for a fraction of a second

Batch Pasteurization Process

In batch pasteurization, milk is heated to a minimum temperature of **62.7°C** (approximately **144.9°F**) and held at this temperature for a minimum of **30 minutes**. After this holding period, the milk is rapidly cooled to **4°C** (39.2°F) or below to inhibit the growth of any surviving microorganisms.

Batch pasteurizers can be classified into three main types:

1. **Water-Jacketed Vat**: This type utilizes hot water that circulates around the vat to maintain the desired temperature. The design ensures even heating and effective thermal transfer.
2. **Water-Spray Type**: In this system, hot water is sprayed onto the milk container's exterior, providing rapid and uniform heating. This method is efficient for smaller batches.
3. **Coil-Vat Type**: This design features coils through which hot water flows, heating the milk directly as it passes through the coils. It allows for effective heat exchange and is commonly used in small-scale operations.

High Temperature Short Time (HTST) pasteurization is the most widely used modern method for pasteurizing milk. It involves heating milk to a minimum temperature of **72°C (161.6°F)** for at least **15 seconds**, followed by rapid cooling.

HTST Process

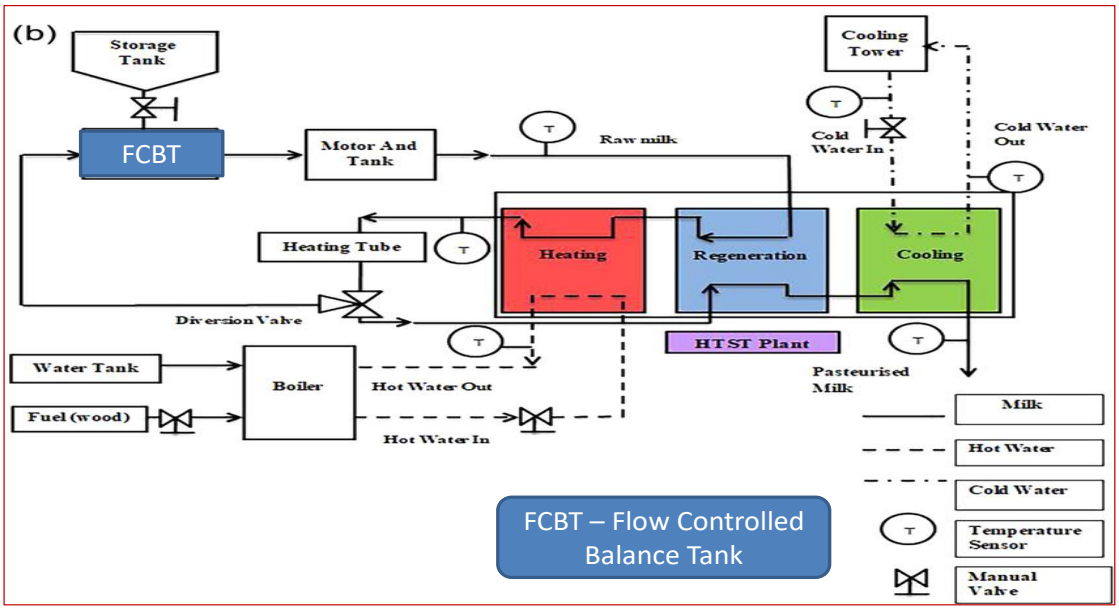
1. **Cold raw milk** (4°C or 39.2°F) enters the pasteurization plant.
2. The milk passes through the **regenerative heating section** of a plate heat exchanger. This section consists of stainless steel plates stacked together with spaces in between, forming chambers. Cold raw milk flows through the "A" chambers, while hot pasteurized milk flows through the "B" chambers. Heat from the hot milk is transferred to the cold milk through the steel plates, warming it to 57-68°C (134.6-154.4°F).
3. The partially heated milk then enters the **heating section**, where hot water or steam in the "B" chambers raises the milk temperature to at least **72°C (161.6°F)**, the minimum for HTST pasteurization.
4. The hot milk is held in a **holding tube** for about **15 seconds**, fulfilling the time requirement for HTST pasteurization.
5. After the holding tube, the **pasteurized milk** passes back through the regenerative section, where it warms the incoming cold raw milk, cooling itself to around 32°C (89.6°F).

6. Finally, the milk enters the **cooling section**, where chilled water or glycol further cools it to 4°C (39.2°F) or below before packaging.

Pressure Considerations

- **Pasteurized milk** is maintained at a pressure of around **15 psi** to prevent boiling.
- **Raw milk** pressure is slightly lower at **14 psi**.
- The **heating and cooling media** (water/steam/glycol) are maintained at 12-13 psi.

Regeneration Efficiency: The efficiency of the regenerative heating and cooling section is typically **85-90%**.



Pasteurization ensures **complete destruction of pathogens**, **negative alkaline phosphatase test** and least damage to the cream line.

Index organism for pasteurization: Coxiella burnetti

Keeping quality of milk after Pasteurization at 4°C: 4-7 days

Vacuum pasteurization, also known as **vacreation**, is a specialized method used primarily for pasteurizing cream under reduced pressure. This technique enhances the efficiency of heat treatment while preserving the quality of the cream. Here's an overview of the process and its parameters.

Vacuum Pasteurization (Vacreation)

Process Overview

- **Equipment**: The equipment used for vacuum pasteurization is called a **Vacreator**. This device operates under a vacuum to allow for effective pasteurization at lower temperatures, which helps retain the cream's flavor and quality.
- **Heating Method**: The cream is pasteurized by direct contact with steam while under reduced pressure. This method allows the cream to reach the required pasteurization temperature quickly without excessive thermal damage.

Benefits of Vacuum Pasteurization

1. **Improved Quality**: The vacreation method helps maintain the flavor and nutritional quality of cream better than traditional pasteurization methods, leading to higher quality butter production.
2. **Enhanced Shelf Life**: By effectively reducing microbial content, vacuum pasteurization extends the shelf life of cream and butter products.
3. **Flavor Preservation**: The lower temperatures used in vacuum pasteurization help preserve the delicate flavors of cream, which can be affected by higher temperatures in conventional pasteurization methods.

Thermization The milk is typically heated to a minimum of **62°C to 65°C** (approximately **144°F to 149°F**) for **15 to 20 seconds**. It helps reduce microbial load while preserving the sensory attributes.

Sterilization

Sterilization is a more intense heat treatment aimed at ensuring the long-term preservation of milk:

- **Temperature and Time**: Sterilization can involve heating to **115°C** (239°F) for **15 minutes** or **145°C** (293°F) for **3 seconds**. These conditions are designed to eliminate all viable microorganisms, allowing the milk to be stored at room temperature for at least **15 days**.
- **Quality Check**: Sterilized milk must pass a **negative turbidity test**, indicating that it is free from microbial contamination.

Loss of nutrients: In Pasteurization, 10% Vitamin B1 and 20% of Vitamin C is lost while in Sterilization 30-50% Vitamin B1 and 50% of Vitamin C lost.

Bactofugation: process of removal of microorganisms from milk using centrifugal force. Most of the microorganisms are inactivated by pasteurization. However, the highly heat resistant spores survive pasteurization. It is special form of separation of microorganisms (99%), mainly spore formers (Bacilli/Clostridia).

Homogenization of Milk

Homogenization is a mechanical process used in the dairy industry to create a stable emulsion by breaking down fat globules in milk into smaller sizes (typically less than **2 µm**) and distributing them evenly throughout the milk serum. This process prevents cream separation and improves the overall quality of milk.

Key Features

- **Increased Surface Area**: The homogenization process increases the surface area of fat globules by **four- to six-fold**, enhancing the texture and mouthfeel of the milk.
- **No Cream Separation**: after homogenization, cream can not be separated from the milk, ensuring a consistent product.

Principle of Homogenization

1. **High Pressure Application**: Milk is forced through a narrow valve at high pressure, typically between **150 to 200 bar** (15-20 MPa), with an additional **5-10 MPa** in a two-stage homogenization process.
2. **High Velocity**: The milk travels at velocities of **100 to 200 m/s**, generating:

- **High Shearing Stresses**: These stresses deform the fat globules.
- **Cavitation**: The formation and collapse of vapor bubbles contribute to the breakup of fat globules.
- **Micro-Turbulence**: Enhances mixing and distribution of fat globules.

3. **Deformation and Breakup**: The fat globules become deformed and wavy before breaking apart into smaller sizes.

Temperature Control

- **Inactivation of Lipase**: The process is conducted at temperatures of **65-70°C** to inactivate lipase enzymes, preventing rancidity and ensuring the stability of the milk.

Efficiency of pasteurizarion: Scharer Rapid Phosphatase Test is a method used to assess the effectiveness of pasteurization in milk and dairy products by detecting the presence of alkaline phosphatase, an enzyme naturally found in raw milk that is destroyed during proper pasteurization. The test involves adding a substrate that alkaline phosphatase can hydrolyze; leading to a color change to blue that can be measured. The intensity of the color produced correlates with the enzyme's activity, indicating the level of pasteurization.

Dairy microbiology:

Milk is considered sterile when secreted in the udder of a healthy cow. However, it quickly becomes contaminated with bacteria even before it leaves the udder due to the presence of bacteria in the teat canal and on the skin of the udder.

When milk is drawn into a pail, the bacterial count increases significantly, reaching approximately **10,000 per ml**, compared to **500-1,000 per ml** in milk directly from the udder.

The high temperature of freshly drawn milk, around **38°C (100.4°F)**, provides an ideal environment for bacterial growth. This temperature is within the optimal range for the proliferation of many types of bacteria commonly found in milk. To maintain the quality and safety of milk, it is essential to implement proper handling and storage practices, such as rapid cooling, to inhibit bacterial growth and minimize contamination.

Sources of Contamination

a) Interior of the udder: bacterial count of milk varies between 500 and 1000/ml

b) Environmental: bacteria accumulated on the surface of body get dislodged during the milking process and enter the pail contributing a load of 10,000 bacteria or more per ml. of milk

c) Milker or Handler: typhoid fever, diphtheria, scarlet fever, septic sore throat

d) Utensils

e) Wholesaler, retailer and the vendor

f) During transportation

Type of bacteria	Temp. range	Optimum growth temp.	Example
Mesophilic	**20 & 40°C**	**37°C**	**S. aureus, E. coli**
Thermophilic	**55-70° C**	**55° C**	Bacillus stearothermophilus
Thermoduric	**60-63° C**	**35-37°C**	**Micrococcus varians**
Psychrotopic (Cold loving)	**Can survive refrigerated temp.**	**15 - 20°C**	**Pseudomonas sp. Alkaligenes sp.**

Lactic acid Bacteria: Lactic acid bacteria (LAB) are a group of Gram-positive, catalase-negative, non-spore-forming bacteria that are generally recognized as safe (GRAS) for use in food and agriculture applications. Here are some key points about LAB:

GRAS Status of LAB

- LAB are considered safe due to their long history of use in food fermentation and their inability to produce toxins or cause infections in healthy humans.
- Members of the genera Lactococcus and Lactobacillus are most commonly given GRAS status, while some species in the genera Streptococcus and Enterococcus contain opportunistic pathogens.

Homofermentative vs Heterofermentative LAB

- **Homofermentative LAB**: Able to efficiently ferment lactose and other carbohydrates primarily to lactic acid. Examples include Lactobacillus acidophilus, L. delbrueckii, and L. helveticus.
- **Heterofermentative LAB**: Produce end products other than lactic acid, such as acetic acid, ethanol, and carbon dioxide, in addition to lactic acid. Examples include Lactobacillus brevis, L. fermentum, and L. reuter

Specific Fermentations

Souring/ curdling: due to the production of acidity (lactic acid from lactose) by lactic acid bacteria. Sour flavor is because of volatile acids, diacetyl and acetaldehyde.

e.g. Lactococcus, Lactobacillus, Leuconostoc, Streptococcus and Enterococcus.

normal acidity of fresh milk	**0.13 to 0.15%**
Milk sours	**0.20 to 0.25%**
milk curdles	**0.50 to 0.65%**

Ropiness Or Sliminess: growth of bacteria leading to change in consistency of the product that forms threads or viscous masses when poured. Ropiness is because of Polysaccharides and Mucins

E.g. **Alcaligenes viscolactis** – More common, B.cereus, B.subtlis, Coli aerogenus group

Proteolysis: casein or some insoluble casein derivatives are broken down to water soluble compounds through the action of microbes or their enzymes. E.g. Pseudomonas, Bacillus

- **Important for development of body and texture in Cheese**

Sweet Curdling: curdling without pronounced acid production

- Due to production of rennin like enzymes by bacteria which causes precipitation of casein without production of acid
- E.g. Bacillus cereus , B. subtilis, E.coli

Lipolysis: hydrolysis of milk fat by lipase resulting in to the accumulation of free fatty acids. Butyric & caproic are responsible for off flavors

- E.g. Pseudomonas

Gas forming bacterias: Coliaerogenus, Clostridium

- Coliaerogenus group – E.coli, Klebsiella, Enterobacter - possess the enzyme β-galactosidase, which is critical for lactose fermentation
- Stormy Fermentation: *Clostridium perfringens*

Platform tests for milk are essential quality assessments conducted primarily at milk collection centers and processing plants. These tests allow for the rapid evaluation of incoming raw milk to ensure it meets predetermined quality standards, which is crucial for maintaining the overall quality of milk products.

Types of Platform Tests

1. **Organoleptic Tests**: These are sensory evaluations where trained personnel assess the milk's appearance, smell, and taste. Observations include checking for cleanliness of containers, sediment, and any off-odors. This initial screening helps in identifying milk that may be spoiled or contaminated without the need for laboratory analysis.

2. **Clot on Boiling (COB) Test**: This test evaluates the heat stability of milk. A sample is heated, and if clotting occurs, it indicates that the milk is not suitable for processing due to high acidity or microbial contamination

3. **Alcohol Test**: This test checks the stability of milk proteins. A sample is mixed with alcohol, and the formation of a clot indicates poor quality, suggesting the milk may spoil easily during processing.

4. **pH Test:** The pH test measures the hydrogen ion concentration in milk, providing a direct assessment of acidity. Fresh milk typically has a pH around 6.6 to 6.7. As milk becomes more acidic, the pH decreases. This test is often performed using pH meters or strips, and a significant drop in pH can indicate spoilage or bacterial activity.

5. **Alcohol Alizarin Test:** The Alcohol Alizarin test is similar to the Alcohol test but incorporates

alizarin, a color indicator that changes based on the acidity level of the milk. After mixing milk with the ethanol solution, the color change can help determine the acidity level. This test provides a visual cue alongside the coagulation observation, making it a more informative method for assessing milk quality

6. **Lactometer test**: The lactometer test is a method used to assess the purity of milk by measuring its density, which helps in detecting the presence of added water. This test is based on the principle that the specific gravity of pure milk differs from that of water and other substances.

7. **Two minute Resazurin Test**: This colorimetric test assesses the microbial quality of milk. A Resazurin dye is added and the resulting color change indicates the level of bacterial contamination. The color grading ranges from blue (excellent) to white (very bad), guiding acceptance or rejection of the milk sample.

Laboratory Tests:

Test	Interpretation	Remarks
Dye reduction test	**extent of bacterial contamination**	**MB reduction test, Resazurin test**
Direct microscopic count	**type of microorganism**	**Both live and dead bacteria**
Standard plate count	**extent of bacterial contamination**	**Only live bacterias**
Freezing point	**adulteration of milk with water**	**Most sensitive test for detecting adulteration with water**
Coliform count	**faecal contamination**	**Should be less than 100cfu/ml in raw milk**

Methylene Blue Reduction Test

The Methylene Blue Reduction Test is a qualitative method used to estimate the relative number of bacteria present in a milk sample. This test relies on the ability of bacteria to reduce the dye, resulting in a color change. The duration of time it takes for the blue dye to decolorize serves as an indicator of microbial activity.

Procedure

1. **Preparation**: Collect a fresh milk sample in a clean container. Add a few drops of methylene blue dye to the milk sample.
2. **Incubation**: Place the sample in a warm environment (around 30-37°C) for a specific duration.
3. **Observation**: After the incubation period, observe the color of the milk sample.

Interpretation of Results

- **Very Good**: Not decolorized in 5 hours (indicates low bacterial count).
- **Good**: Decolorized in less than 3-4 hours (indicates moderate bacterial count).

- **Fair**: Decolorized in less than 1-2 hours (indicates high bacterial count).
- **Poor**: Decolorized in less than ½ hour (indicates very high bacterial count).

Resazurin Reduction Test

The Resazurin Reduction Test is another method used to assess the microbial quality of milk. Similar to the Methylene Blue Reduction Test, it measures the ability of bacteria to reduce a dye, but it provides results much faster.

Interpretation of Results

- **Blue**: Indicates low bacterial count (good quality).
- **Pink**: Indicates moderate bacterial count (acceptable quality).
- **Colorless**: Indicates high bacterial count (poor quality).

Standard Plate Count (SPC)

The **Standard Plate Count (SPC)** is a widely used microbiological test for assessing the quality of milk and other food products. It provides valuable information about the viable microbial population present in a sample.

Key Features of Standard Plate Count

1. **Estimation of Viable Microbial Growth**: The SPC gives a rough estimate of the number of viable microorganisms in a milk sample. This is crucial for evaluating the overall microbial load and determining the freshness and safety of the milk.
2. **Expression of Results**: All plate counts are typically expressed as **colony-forming units per milliliter (cfu/ml)**. This standardization allows for easy comparison between different samples and batches.
3. **Limitations**: While SPC provides an overall count of viable bacteria, it does not differentiate between pathogenic (harmful) and non-pathogenic (harmless) microorganisms. Therefore, a high SPC does not necessarily indicate the presence of pathogens, nor does a low count guarantee safety.
4. **Accuracy and Informative Nature**: The SPC is generally accepted as one of the most accurate and informative methods for testing the bacteriological quality of milk. It is a reliable indicator of hygiene and processing conditions, helping dairy producers ensure compliance with safety standards.

Procedure

1. **Sample Preparation**: A diluted sample of milk is prepared to ensure that the number of colonies formed is countable.
2. **Inoculation**: The diluted sample is spread on a suitable agar medium and incubated under specific conditions (usually at 30-37°C for 24-48 hours).
3. **Counting Colonies**: After incubation, the colonies that develop on the agar plate are counted. Each colony is assumed to arise from a single viable microorganism in the original sample.
4. **Calculating cfu/ml**: The number of colonies is multiplied by the dilution factor to calculate the concentration of viable microorganisms in the original sample, expressed as cfu/ml.

Bacteria CFU/ml	Grade
Up to 2 lakhs	**Very good**
2-10 lakh	**Good**
10-50 lakh	**Fair**
More than 50 lakh	**Poor**

SPC for pasteurized milk should not be not more than 30,000 cfu /ml

Direct Microscopic Count (DMC) is a method used to estimate the number of bacteria or somatic cells in milk. This technique is particularly valuable in the dairy industry for quality control and assessing microbial contamination.

Key Features of Direct Microscopic Count

1. **Purpose:** The DMC provides a direct estimate of viable microbial growth in milk samples. It allows for the enumeration of bacterial clumps or somatic cells, which can be indicative of milk quality.
2. **Procedure:**
    - A small volume of milk (typically 0.01 mL) is spread over a defined area on a specialized slide (often a Petroff-Hausser counting chamber).
    - The slide is then stained using a reagent, such as the Levowitz-Weber (L-W) stain, which helps visualize the cells by dissolving the butterfat and staining the cells.
    - The sample is examined under a microscope, and the number of cells or clumps is counted in several fields of view.

3. **Results:** The counts are usually expressed as the number of cells or clumps per milliliter of milk (cfu/mL). This provides a rough estimate of the microbial load in the sample.

4. **Limitations:**

    - While the DMC can indicate the total number of bacteria, it does not differentiate between pathogenic and non-pathogenic organisms. Therefore, it may not provide a complete picture of milk safety.

    - The method is also influenced by the presence of clumps, which can lead to underestimating the actual number of bacteria if they are not adequately dispersed.

Bacteriological standards of raw milk (IS-1479 PART III-1997)

Grades	Direct microscopic count per ml (lakhs)	Standard plate count per ml (lakhs)	Methylene blue reduction time (hr)	One hour resuzurin disc. (No.)	Presumptive coliform test (in 0.01 ml) i.e. 1 in 100
Very good	NS	< 2	> 5	NS	absent
Good	< 5	2-10	3-4	4 or higher	absent
Fair	5-40	10-50	1-2	3.5 to 1.0	absent
Poor	40-200	> 50	< 1/2	0.5 to 0	present
Very poor	> 200	NS	NS	NS	NS

NS : Not specified

Bacteriological standards of pasteurised milk (IS-6397-1971)

Test	Requirement
Standard plate count	Maximum 30000 cfu/ml
Coliform count	absent in 1:10 dilution
MBRT	more than 4 hr
Alkaline phosphatase	test negative

Adulteration of Milk

Adulteration refers to the practice of adding cheaper or inferior substances to milk or removing valuable constituents, such as fat, to increase profit margins. This not only compromises the quality and nutritional value of milk but can also pose health risks to consumers. Understanding common adulterants in milk is crucial for ensuring safety and quality.

Common Adulterants in Milk

1. **Water**: The most prevalent adulterant, water is often added to increase the volume of milk. It dilutes the nutritional content, reducing the levels of proteins, fats, and vitamins.

2. **Starch**: Starch is sometimes added to thicken milk and give it a creamier texture.

3. **Cane Sugar**: Sugar is added to enhance sweetness and mask the taste of spoiled milk.
4. **Condensed Milk or Milk Powder**: These are sometimes mixed with fresh milk to increase volume and reduce costs.
5. **Urea**: Urea is sometimes added to increase the apparent protein content of milk.
6. **Detergents**: Detergents may be added to improve the foaming properties of milk. This is highly toxic and poses serious health risks to consumers.
7. **Sodium Bicarbonate**: This is used to neutralize acidity and improve the shelf life of milk. Excessive use can lead to digestive issues and alter the taste of milk.
8. **Mixing of Cow and Buffalo Milk**: Mixing different types of milk can be done to increase fat content or reduce production costs. This can mislead consumers regarding the type of milk they are purchasing and can affect the quality and flavor

Test	Adulterant
Iodine solution Test	Starch adulteration in milk
Nitric acid	Skim milk powder
Bromocresol purple solution	Detergent in milk
p - dimethyl amino benzaldehyde	Urea adulteration in milk
Resorcinol	Cane sugar detection
Rosallic acid test	Sodium Carbonate
Storch's peroxidase test	Heated milk in fresh milk
Hansa Serum (Hansa Test)	Mixing of cow & buffalo milk
Picric acid solution/ Mercuric Nitrate	Gelatin in milk
Formalin	Milk powders
Conc. HCl	Calcium Chloride
Delvo kit test	Detect antibiotic and sulpha residues
Lactometer reading, freezing point, nitrate detection	Water in milk
Baudin test	Vegetable oil adulteration in ghee

Fat estimation: Gerber test (Fucoma Test), Babcock test, Rose Gottileb and Adam's test

Total Solids & SNF estimation: Gravimetric Method, Lactometer Method, Infrared Spectroscopy

- Formulas- Richmond, Babcock, Fleischmann's

CONCENTRATED MILK

Concentrated Milk: A product obtained by evaporating part of the water from whole or skim milk, with or without the addition of sugar.

Condensed Milk: Full cream sweetened milk that has had a portion of its water content removed and sugar added.

Evaporated Milk: Full cream unsweetened milk that has been concentrated by evaporating about 60% of its water content.

Skimmed Milk Products: Can be sweetened or unsweetened.

Unsweetened Condensed Milk - Equivalent to evaporated milk, which is concentrated without added sugar.

Concentration Ratios

- **Full Cream Products**: Ratio of concentration of milk solids is **1:2.5**.
- **Sweetened Condensed Skim Milk**: Ratio of concentration of milk solids is **1:3**

Type of milk	**Fat %**	**Milk Solids % (minimum)**
Evaporated milk	8% (minimum)	26
Condensed milk	9% (minimum)	31
Evaporated Skim milk	0.5% (maximum)	20
Condensed skim milk	0.5% (maximum)	26

Cane Sugar in sweetened milks: 40% (minimum)

Seeding: Crystallization of lactose by the addition of fine powder of lactose or small quantity of condensed milk from previous batch.

- Purpose: **forms very small crystals** in the supersaturated solution

Pilot Sterilization test: to determine the amount of chemical stabilizer to be added in evaporated milk

Dried milks/ Milk Powders: obtained by removing water from milk through various drying methods, resulting in a solid product with low moisture content. (less than 5%)

	Whole Milk powder (WMP)	Skim Milk powder (SMP)
Moisture % (max)	5	5
Fat %	26 (minimum)	1.5 (max)
Solubility index	15 if roller dried and 2 if spray dried	

Milk drying: Milk is commonly dried using either spray drying or roller drying methods.

In spray drying, concentrated milk is atomized into fine droplets and dried by hot air, producing a fine milk powder.

Roller drying involves applying a thin film of pre-concentrated milk onto heated rotating drums, where the milk forms a dry layer that is scraped off as powder.

Spray drying is the more widely used method due to its ability to produce high-quality milk powders with good solubility and nutritional properties.

Fermented milk:

1. **Acidophilus Milk:** Fermented milk developed using Lactobacillus acidophilus culture.
2. **Bulgarian Milk:** Made using the culture Lactobacillus bulgaricus.
3. **Kumiss:** Traditionally from Russia, originally made from mare's milk, now often made from cow's milk.
    - Composition: Fermented with lactic acid and alcohol, containing about 2.5% alcohol.
4. **Kefir:** A self-carbonated milk beverage.
    - Composition: Contains approximately 1% lactic acid and 1% alcohol.
5. **Filmjolk:** A Scandinavian sour milk product.

Functional milk products: specialized dairy items designed to provide additional health benefits beyond basic nutrition

- lactose-free milk - made by filtering regular milk to remove half the lactose and adding enzyme Lactase
- Filled milk: homogenized product prepared from refined vegetable oil & water.
- UHT processed milk: packed & aseptically sealed in pre-sterilized containers. can be stored Unrefrigerated for at least 3 months
- Designer milk: as per consumer requirement using biotechnology
- Irradiated milk: increased Vitamin D content by UV rays exposure
- Evaporated milk must be fortified with Vit. D
- Recombined Milk: product obtained when butter oil (also called anhydrous milk fat), skim milk powder and water are combined in the correct proportions to yield fluid milk.
- Reconstituted milk: dispersing milk powder in water
- Humanized milk: chemical composition modified to match human milk
- Imitation milk: milk of non dairy origin
- Vegetable toned milk: milk protein of SMP substituted by groundnut protein (MILTONE BY CFTRI , Mysore)

Cream:

According to PFA 1976, minimum fat % - 25%

(FSSR, 2011):

1. Low fat cream: milk fat not less than 25.0 %

2. Medium fat cream: not less than 40.0 %

3. High fat cream: milk fat not less than 60.0 %

Classification: based on end use

- Table cream, Light cream, Coffee cream : 20-25% milk fat
- Heavy cream Whipping cream: 30-40% milk fat
- Plastic cream: 65-85% milk fat

PRINCIPLE: Based on the fact that milk fat is lighter than skim milk portion

Cream can be separated by gravity method or centrifugal method.

Stokes' Law describes the velocity at which fat globules rise or fall in a fluid

Centrifugal Separation: In the centrifugal method of cream separation:

- **Skim Milk**: Moves to the **periphery** of the centrifuge.
- **Cream**: Collects in the **center**.
- **Cream Screw In**: Cream (higher fat content) is extracted from the center.
- **Skim Milk Screw Out**: Skim milk (lower fat content) is removed from the outer edge.

Skimming Efficiency: This refers to the percentage of fat recovered in the form of cream from milk. It is a critical measure of the effectiveness of the skimming process.

- **Impact of Acidity**: High acidity in milk can precipitate casein, leading to clogging in the skimming bowl. This clogging decreases the efficiency of fat separation.
- **Homogenized Milk**: Skimming cannot effectively separate cream from homogenized milk due to the small size of fat globules and their stable dispersion.

Pasteurization Methods

1. **LTLT (Low-Temperature, Long-Time)**: **Temperature**: 71°C for 20 minutes
2. **HTST (High-Temperature, Short-Time)**: **Temperature**: 95-100°C for 5-16 seconds

3. Vaceration Vaceration involves diluting cream, which can lower the fat percentage of the cream by up to **6-8%**.

Butter: Balancing wheel of dairy industry

Butter is defined under the Food Safety and Standards Regulations (FSSR) as a fatty product primarily composed of a water-in-oil emulsion derived exclusively from milk or milk products. Here are the key standards and specifications for butter as per FSSR:

Types of Butter

1. Table Butter: Made from pasteurized cream.
2. White Butter/Cooking Butter/ deshi butter: Typically has a lower fat content than table butter.

Composition Standards

- Table Butter:
    - Moisture: Maximum 16.0%
    - Milk Fat: Minimum 80.0%

- Milk Solids-Not-Fat: Maximum 2.0%
- Common Salt: Maximum 3.0%
- No preservative except common salt
- No coloring material except annato or carotene
- Flavoring agent – Diacetyl (not more than 4ppm)

- White Butter/Cooking Butter: Milk Fat: Minimum 76.0%

Theories for butter making:

- Fisher and Hooker's Phase reversal theory
- Rahn's Foam theory
- King's modern theory

Steps in butter making:

- Neutralization of cream: reduce the acidity of cream to 0.14-0.16%
- Standardization of cream: 33-40%
- Pasteurization of cream: 90- 95 ^{o}C for 15 or 105-110^{o}C with no holding
- Cooling and ageing at 5-10 ^{o}C
- Ripening of cream: by mixture of both acid producing (*Streptococcus lactis, S.cremories*) and flavour producing (*S.diacetylactis, Leuconostoc citrovorum* and/or *Leuc. Dextranicum,* Clostridium butyricum)
- Cream is incubated at about 21^{o}C till desired an acidity is reached.
- Churning of Cream: Winters- 10-13^{o}C Summers: 7-9^{o}C (Avg. 9-11)
- Salting & Working: Working of butter is a kneading process in which butter granules are formed into a compact mass
- Storage -23 to -29^{o}C

Overrun: increase in the amount of butter made from the given amount of fat caused by the presence of **moisture , curd, salt etc in butter. Maximum possible is 25%**

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 flavor, with or without stabilizers or color, and with the incorporation of air during the freezing process.

According to PFA, 1976

1. Permitted stabilizers and emulsifiers not exceeding 0.5% by weight.
2. The mixture must be suitably heated before freezing.
3. The product should contain not less than 10% milk fat, 3.5% protein, and 36% total solids.

Sr. No	Characteristics	Requirements
1.	weight (g./litre) min.	525
2	Total solids(%wt .min)	36.0
3.	Milk fat (% wt. Min.)	10.0 (Tentative)
4.	Acidity (% lactic acid max.)	0.25
5.	Sucrose (%wt. Max.)	15.0
6.	Stabilizers/emulsifiers(%wt. Max)	0.5
7.	Standard plate counts (per g.)	Not more than 2,50,000
8.	Coliform count (per g.)	Not more than 90
9.	Phosphatase test.	Negative.

Stabilizers: prevent the formation of objectionable large ice crystals in ice cream, especially during storage. Sodium alginate, methyl cellulose, gelatin

Emulsifiers: improve upon and provide a uniform whipping quality of the mixture. Egg yolk, sorbitol, propylene glycol esters

- Ice cream without Hardening process: Soft serve or Softy
- overrun due to air - Maximum 100%

- Sandy Texture: caused by Lactose crystals which do not dissolve readily and produce a rough or gritty sensation in the mouth
- Whipping quality: reduced air cell sizes and a homogeneous distribution of air in the ice cream
- The ageing temperature should not exceed 5 ºC.

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.

Types of Cheese Based on Moisture Content

Cheese can be classified into different categories based on its moisture content:

- **Very Hard Cheese (Less than 25% moisture):** These cheeses have an extremely low moisture content, resulting in a hard, dry texture. The low moisture and high salt content inhibit microbial growth, allowing these cheeses to be aged for extended periods. Examples: Parmesan, Romano
- **Hard Cheese (25-36% moisture):** Hard cheeses have a firm, sliceable texture. The moisture content is higher than very hard cheeses, but still relatively low. Examples: Cheddar, Swiss
    - Cheddar is ripened by bacteria and does not have eyes (holes).
    - Swiss cheese is also hard, but is ripened by propionibacterium shermanii, which produce the characteristic holes or "eyes".
- **Semi-hard- 36 to 40 % moisture**

a) Ripened principally by bacteria: Brick

b) Ripened by bacteria and surface microorganisms: Limburger

c) Ripened principally by blue mould:

   i) External – Camembert (*Penicillium camembert*i)

   ii) Internal – Gorgonzola, Blue, Roquefort (*Penicillium roqueforti* and *Penicillium Glaucum*)

- **Soft Cheese (>40% moisture):** These fresh cheeses are not aged and have a high moisture content, resulting in a soft, spreadable texture. Unripened soft cheeses: Cottage cheese
- Ripened soft cheeses (40-80% moisture): Example: Neufchatel

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

Withania coagulans, also known as Indian rennet or Paneer doddi, is a plant that serves as a natural rennet substitute in cheese production. It contains a rennet-like protease that can coagulate milk, making it a viable alternative to traditional animal-derived rennet.

Steps in cheese making:

1. First stage is Souring /ripening
2. Second stage is Clotting /coagulation by rennet
3. Third stage is Cutting and drainage of whey.

4. Fourth stage is Matting of the curd.
5. Fifth stage is Maturing /curing

CHEDDAR CHEESE:

Hard cheeses are characterized by their low moisture content and firm texture. The production process typically involves specific starter cultures, rennet, and careful monitoring of various parameters.

Starter Culture: The starter culture usually contains **Streptococcus lactis** and/or **Streptococcus cremoris**. These lactic acid bacteria are essential for acidification and flavor development during the cheese-making process.

Coagulation Process: **Rennet**: The coagulation of milk is achieved using rennet, which consists of **rennin (clotting enzyme)** and **pepsin (proteolytic enzyme)**. The typical addition rate is **15-25 ml per 100 liters of milk**.

- The **hot iron test** is conducted to determine the end of the cheddaring process, which is crucial for achieving the desired texture.

Temperature and Culture Addition: The starter culture is added at a rate of **0.5-1% of the milk volume** at a temperature of **30-31ºC**. This temperature supports optimal bacterial activity for fermentation.

Color and Salting: For coloring, **30-200 ml of colorant per 1000 kg of milk** may be used, depending on the desired hue of the final product. Salting is typically done at a rate of **1-2%**, which helps in flavor enhancement, preservation, and texture development.

Standardization: In cheese making standardization refers to adjustment of the casein/fat ratio in cheese to 0.68 to 0.70.

Objectives:

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

Addition of calcium chloride: Excessive heat treatment of milk causes the precipitation of a part of calcium salts in milk. It results in slower renneting action and a weaker curd which can be corrected by the addition of **0.001 to 0.003 %** calcium chloride to milk.

Yoghurt:

Fat and Total Solids Content

- **Fat percentage**: Yogurt can have a fat content ranging from **0% (non-fat)** to **5%** (full-fat).
- **Total solids**: The total solids content in yogurt typically ranges from **9% to 20%**, which includes fat, protein, lactose, and other milk solids.

Starter Cultures

- **Lactobacillus bulgaricus** and **Streptococcus thermophilus** are the two main bacterial cultures used in yogurt production.
- These cultures grow symbiotically, meaning they support each other's growth and activity during fermentation. Together, these cultures are responsible for the fermentation process that converts lactose into lactic acid, resulting in the characteristic flavor and texture of yogurt.
- **L. bulgaricus** produces lactic acid, which creates an acidic environment favorable for **S. thermophilus**. **S. thermophilus** produces formic acid and carbon dioxide, which stimulate the growth of **L. bulgaricus**.

Incubation Temperature

- The optimal incubation temperature for yogurt production ranges from **41°C to 43°C**.
- At this temperature range, the starter cultures can thrive and efficiently convert lactose into lactic acid, leading to the desired acidity and coagulation of the milk proteins.
- Maintaining a consistent incubation temperature is crucial for ensuring a uniform and high-quality product.

Fermentation Time

- The fermentation process typically takes **4 to 6 hours** at the specified incubation temperature.
- During this time, the pH of the yogurt drops as lactic acid is produced, causing the milk proteins to coagulate and form a gel-like structure.

Dahi/ Curd:

- Sweet Dahi with acidity < 0.7%
- Sour Dahi with acidity around 1%

- Sweetened Dahi: by adding 6.25% cane sugar

Starter culture for sweet dahi*: Streptococcus lactis, Str. cremoris, Str. diacetalactis*

Starter culture for sour dahi*:* same as above along with *Lactobacillus bulgaricus and Str. Thermophilus*

Flavor due diacetyl (obtained from mother compound acetyl methyl carbinol)

Sweetened Dahi: Misti Dahi or Lal Dahi, is a popular sweetened yogurt from the eastern region of India, particularly Bengal. This traditional dessert is characterized by its brown color and cooked, caramelized flavor, making it a favorite among many.

- **Color and Flavor**: Misti Dahi has a distinctive brown color due to the caramelization of sugar, which also imparts a cooked, rich flavor to the yogurt.
- **Sugar Content**: The recipe typically involves the addition of **6.25% cane sugar**, which contributes to its sweetness and enhances the overall taste.

Shrikhand: sweetened-dewatered dahi. This product is extremely popular Western and some parts of Southern India inoculated with culture containing Str. lactis subsp. lactis and Lactococcus Lactis var. diacetilactis

- Minimum fat % 8.5 and total solids 58% ; Titrable acidity not more than 1.4%

Indian Dairy product	**Western counterpart**
Kheer/ Basundi	Condensed milk
Khoa	Evaporated milk
Rabri	Clotted cream
Kulfi	Ice cream
Ghee	Butter oil

Lassi	Butter milk
Channa	Lactic coagulated green cheese
Paneer	Soft cheese

1. Cultured/ fermented milk products: curd, lassi, Dahi, Chakka, Shrikhand
2. Acid coagulated milk products- Channa, panner
3. Acid and Rennet coagulated milk products- Cheese
4. Heat dessicated/ dehydrated(concentration and coagulation) - Rabri, Basundi, Khoa, Khurchan (23.6%fat)

Chhana-based sweets i. Rasogolla ii. Pantooa iii. Sandesh iv Rasmalai v. Cham Cham vi. Chhana-murki vii. Chhana podo

Channa: milk solids obtained by the acid coagulation of boiled hot milk and subsequent drainage of whey. 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

Preparation:

- Boiling of milk in karahi.

- Reducing the temperature of milk to 80^{o}C and required quantity of coagulants is added slowly till the coagulation.

- The strength of the coagulating acid solution is 1-2%.

- Coagulants are lactic (for rosogolla) and citric acid (for sandesh).

- Contents of vessel emptied over a piece of muslin cloth.

- No pressure is applied

Yield of channa:

- Cow milk is 16-18%.

- Buffalo milk is 22-24%

Cow milk preferred for channa making, because it has open texture – yields smooth textured and smooth body product. Used for making sweets like rosogulla, Sandesh

Paneer: Heat acid coagulated milk solid heated at 82 ^{o}C and cooled to 70^{o}C

- moisture 60-70%
- Total solids 30-40% (milk fat not less than 50% of DM basis)
- pressure is applied for removal of whey while in Channa hanged over a hook wrapped in cloth
- Buffalo milk preferred –whitish, sweetish

Khoa/ Mawa: Khoa is a partially dehydrated, heat-coagulated whole milk product that is prepared by continuously heating and stirring milk over a direct fire until it reaches a semi-solid consistency.

Production Process

- Milk, preferably buffalo milk, is heated in a karahi (a type of pan) over a direct fire.
- The milk is constantly stirred and scraped while heating to prevent scorching and promote even cooking.
- The heating and stirring continue until the milk reaches a semi-solid consistency, typically taking several hours.

Milk Fat Content: The milk fat content in Khoa should not be less than 20 percent.

Preference for Buffalo Milk

- Buffalo milk is preferred over cow milk because it yields a higher quantity of Khoa with a better quality.
- Buffalo milk Khoa has a soft, smooth body and a granular texture compared to cow milk Khoa.

Overrun and Yield

- The overrun in Khoa is primarily due to the presence of moisture.
- The yield from cow milk is typically 17-19 percent, while for buffalo milk, it ranges from 21-23 percent.

Type of milk	**Composition of khoa**					
	Moisture	**Fat**	**Protein**	**Lactose**	**Ash**	**Iron(ppm)**
Cow	25.6	25.7	19.2	25.5	3.8	103
Buffalo	19.2	37.1	17.8	22.1	3.6	101

Three main varieties are "**pindi**" for burfi, "**dhap"** for gulabjamun, pantooa etc., and "**danedar**" used for kalakand

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

Constituents	Khoa type		
	Dhap	Pindi	Danedar
TS (%) min	55	65	60
Fat (% dmb) min	37	37	37
Protein (% dmb) min	37	37	37
Ash (%dmb) max	6	6	6
Titrable acidity (% LA) max	0.6	0.8	0.9
End uses	Gulabjamun, milk cake	Burfi, peda Pantua	Kalakand,

- keeping quality of *khoa* at room temperature-5 days and 10 weeks at 4°C
- **Generally 4 kg of buffalo milk or 5 kg of cow milk yield one kg of *khoa***
- ***Pantua, Kala jamun manufactured from both Khoa and channa***

Ghee: Clarified butter fat prepared chiefly from cow or buffalo milk.

- Milk fat - 99 to 99.5%
- Moisture Not more than 0.5 %
- Buffalo milk preferred being richer in fat content and gives larger yield of ghee
- Flavor of Ghee is because of Lactones

Properties:

- Specific gravity: 0.93-0.94
- Refractive index 40-45
- RM number: min. 28 (cotton seed feeding areas 20)
- Polenske number: min. 2 (------do→1.5)
- Solidifying point 28 to 15° C
- Iodine value : 26 to 38
- Saponification number: 220
- Melting point: 28-44° C
- Granularity in Ghee: presence of high melting saturated FA e.g Stearic, Palmitic acid
- buffalo: white color with greenish tinge due to Biliverdin
- cow- golden yellow due to carotene
- Natural antioxidants: Tocopherol, carotene
- Synthetic: BHA, BHT, hydroquinone, gallic acid esters
- BHA level should not exceed 0.02% in Ghee (PFA, 1976)

Ghee may contain BHA not more than 0.02% as antioxidant

Table 4: Agmark standards of *Ghee*

Sr. No.	Tests	All India	Winter regional	Summer
1.	B audouin	Negative	Negative	Negative
2.	Phytosterol acetate	Negative	Negative	Negative
3.	B.R. reading (40°C)	40.0-43.0	41.5-44.0	42.5-45.0
4.	R.M.value (Minimum)	28	23.0	21.0
5.	Polenske value	1.0-2.0	0.5-1.2	0.5-1.0
6.	Moisture (%)	Maximum	0.3	
7.	Free fatty acids (as % Olic acid)			
	Special grade (Red label)	Not more than	1.4	----------
	General grade (Green label)	Not more than	2.5	
	Standard grade (Chocolate label)	Not more than	3.0	----------

Ghee is prepared by five methods, namely,

- Desi
- Creamery butter
- Direct cream
- Pre-stratification method
- Continuous method – industrial method

Pre-stratification method:

- a top layer of floating denatured particles of curd,
- a middle layer of fat,
- a bottom layer of buttermilk

Test for adulteration:

- Valenta test: animal fat adulteration

- Halphens test: for cotton seed oil
- Nitric acid test, Baudin test, Phytosterol test: vegetable oil adulteration

Panir: indian variety of rennet coagulated small sized soft cheese e.g. surati panir, bandal cheese

Kheer/ basundi: partial dehydation of whole milk in karahi

Khurchan: concentrated, sweetened whole milk product prepared by simmering without stirring in karahi and have fat % of 23.6

Rabri: concentrated and sweetened milk product containing several layers of clotted cream and have 20% fat

Milk by products

Main product	**By product**
Cream	**skim milk**
Butter	butter milk
Ghee	**ghee residue**
Channa/paneer/cheese	**whey**
Curd	lassi

Packaging material for milk and milk poducts

Product	**Packaging Material**
Liquid milk	Glass bottles (obsolete) LDPE film Paper laminates for tetra packs
Milk Powder	Tin plate containers, nitrogen packed, and lacquered from outside. Flexible laminates such as metallized PET / BOPP / Aluminium foil / Poly laminates. Refill packs; lined cartons laminated with BOPP /

	PET, varnished on the outside. Bag-in-box; Powder filled in laminate and packed in cartons.
Butter	Duplex board with vegetable parchment paper Tin plate containers Aluminium foil
Cheese / Cheese spread	Tin plate containers lacquered from inside First packed in aluminium foil and then in duplex board carton Injection moulded PP / HDPE container
Ghee	Tin plate containers lacquered from inside Glass bottles HDPE film pouches
Ice cream	Thermoformed / Injection moulded plastic containers Duplex board carton (poly laminated) Laminates of BOPP (Biaxially Oriented Polypropylene) / PET
Indian Dairy Products	Injection moulded / thermoformed containers (shrikhand, gulab jamun) Stand up laminated pouches

APPENDIX

Bacteriological standards as prescribed by Bureau of Indian Standards (BIS)

Bacteriological standards of raw milk (IS-1479 PART III-1997)

Grades	Direct microscopic count per ml (lakhs)	Standard plate count per ml (lakhs)	Methylene blue reduction time (hr)	One hour resuzurin disc. (No.)	Presumptive coliform test (in 0.01 ml) i.e. 1 in 100
Very good	NS	< 2	> 5	NS	absent
Good	< 5	2-10	3-4	4 or higher	absent
Fair	5-40	10-50	1-2	3.5 to 1.0	absent
Poor	40-200	> 50	< 1/2	0.5 to 0	present
Very poor	> 200	NS	NS	NS	NS

NS : Not specified

Bacteriological standards of pasteurised milk (IS-6397-1971)

Test	Requirement
Standard plate count	Maximum 30000 cfu/ml
Coliform count	absent in 1:10 dilution
MBRT	more than 4 hr
Alkaline phosphatase	test negative

Bacteriological standards of cream (IS-3509-1966)

Type of Cream	Type of count	Level in Cfu/ml or g (lakhs)	Grade
Raw Cream	Standard plate count	< 4	Very good
		4-20	Good
		20-100	Fair
	Coliform count	100	Poor
		< 100	Satisfactory
Pasteurised	Standard plate count	< 60000	Satisfactory
	Coliform count	< 10	Satisfactory

Bacteriological standards of butter (IS-3507-1966)

Yeast & Mold count/ml	Quality
< 20	Good
21-50	Fair
51-100	Poor
> 100	Very poor

Bacteriological standards of ice cream (IS-2802-1964)

Test	Limit
Standard plate count (per g)	not more than 2,50,000
Coliform count (per g)	not more than 90
Phosphatase test	negative

Bacteriological standards of condensed milk (IS-1166-1973)

Characteristics	Full cream	Skim milk
Bacterial count (cfu/g. maximum)	500	500
Test for Coliforms	Negative	Negative
Yeast and Mold count (cfu/g. maximum)	10	10

Bacteriological standards of milk powder (IS-1165-1975)

Types	WMP and extra grade SMP	Standard grade SMP
Total bacterial count, max, cfu/g	40,000	50,000
Coliform count	absent in 0.1 g	absent in 0.1 g
Salmonella	absent in 25 g	not specified
Staph aureus (coagulase positive)	absent in 0.1 g	not specified
Shigella	absent in 25 g	not specified

Bacteriological standards of indigenous dairy products.

Product	Standard plate count max (cfu/g)	Coliform count, max (cfu/g)	Yeast and mold count, max (cfu/g)	ISI Manual Reference No.
Khoa	NS	90	50	IS-4883-1980
Burfi	30,000	NS	10	IS-555-1970
Paneer	5,00,000	100	250	IS-10984-1983
Kulfi	2,50,000	100	NS	IS-10501-1983
Chakka	NS	10	20	IS-9532-1980
Shrikhand	NS	10	50	IS-9532-1980
Canned Rasogolla	500	Nil	NS	IS-4079-1967

Microbiological standards for assessing the sterility of utensils/equipments as prescribed by BIS (cited from *Fundamantals of Dairly microbiology* by Prajapati p:44.)

	Rinse method Colony count per liter capacity of can	Swab method Colony count per 900 sq.cm. area of equipment surface
Satisfactory	< 1000	< 5000
Fairly satisfactory	1000 to 5000	5000 to 25,000
Unsatisfactory	> 5000	> 25,000

Defects in milk and milk products

Flavor Profiles in Milk

1. **Bitty Flavor**: Caused by proteolytic microorganisms, particularly *Bacillus spp.* and *Pseudomonas spp.* These bacteria produce enzymes that break down proteins, leading to off-flavors.
2. **Potato Flavor**: Resulting from *Pseudomonas mucidolens* and *Pseudomonas graveolens*, these bacteria contribute to a flavor reminiscent of potatoes.
3. **Cooked Flavor**: Associated with the presence of sulfhydryl compounds, this flavor typically arises from overheating during processing.
4. **Cowy Flavor**: This flavor is linked to ketosis in dairy animals, primarily due to the presence of acetone, which imparts a distinct taste.

5. **Barny Flavor**: Often a result of poor ventilation during storage or processing, leading to a flavor reminiscent of barnyard conditions.
6. **Malty Flavor**: Caused by *Streptococcus lactis var. maltigenes*, this flavor adds a sweet, malt-like characteristic to the milk.
7. **Phenolic Flavor**: Associated with *Bacillus circulans*, this flavor can impart a medicinal or phenolic taste to the milk.
8. **Unclean Flavor**: Resulting from contamination with *E. coli*, this flavor indicates poor hygiene practices during milk handling and processing

Defects in Cream:

- Oxidized/oily/Metallic/Tallowy: Fat oxidation due to direct contact of milk with copper or iron, exposure of milk or cream to sunlight, etc.
- Rancid: Fat hydrolysis due to lipase action in milk or cream
- Bitterness and thinning: Bacillus subtilis
- Highly acid/sour

  i. Using sour milk for separation

  ii. Acid development in cream
- Bitty cream: lecithinase enzyme of *Bacillus cereus* var *mycoides*

Defects in Butter:

- Gritty - Undissolved coarse salt, incorrect salting
- Grainy - Incorrect neutralization of high acid cream with lime
- *Yeasty flavour and odour*: fermentation of the cream by Torula Cremoris and Torula sphaerica
- Fishy flavor - Hydrolysis of phospholipid to form trimethylamine is one of the reasons attributed for the 'fishy' flavor defect in butter
- Skunk like odor- P. mephitica
- Apple taint – P. fluroscrns

Defects in Ghee:

- Rancidity: lipase action (incidence is low), oxidation of fat (more chances) through exposure to light and contact with metal ions e.g. Cu, Fe, etc.
- Dark/Burnt color: Excessive high temperature (> 120 C for some period) of clarification of ghee can lead to 'dark brown' colored ghee

Defects in KHOA:

- At room temperature (24-30°C) a rancid flavor is developed on *khoa*
- low temperature (5-10°C) a stale and sour flavor is observed and there is mould growth on the surface

Defects in Cheese:

- Rind rot – excessive acidity or moisture in cheese before curing
- Gassiness/ Late blowing in cheese: Clostridium tyrobutyricum
- Fish eyes/yeast holes: Contamination with yeasts (Torula sp.)

Hazard Analysis and Critical Control Point (HACCP) System - In order to enhance food safety, every stage of the food production (from purchasing, receiving, transportation, storage, preparation, handling, cooking to serving) should be carried out and monitored scrupulously.

- The HACCP system is a scientific and systematic approach to identify, assess and control of hazards in the food production process.

The seven principles of a HACCP System are-

1. Analyze hazards

2.Determine critical control points

3.Establish limits for critical control points

4.Establish monitoring procedures for critical control points

5.Establish corrective actions

6.Establish verification procedures

7.Establish a record system

Food Safety and Standards Authority of India (FSSAI) is an autonomous body established under the Ministry of Health & Family Welfare, Government of India.

- The FSSAI has been established under the Food Safety and Standards Act, 2006 which is a consolidating statute related to food safety and regulation in India.
- FSSAI is responsible for protecting and promoting public health through the regulation and supervision of food safety.
- The FSSAI has its headquarters at New Delhi.

Prevention of Food Adulteration (PFA) Act (1954) and Rules (1955)

Agricultural and Processed Food Products Export Development Authority (APEDA) - Indian Apex-Export Trade Promotion Active government body

Bureau of Indian Standards (BIS) – 1986

AGMARK: Enforced by the Agricultural Produce (Grading and Marketing) Act, 1937 under Directorate of Marketing and Inspection (DMI)

MILK AND MILK PRODUCT ORDER – 1992

Cleaning & Sanitation of Dairy plant and equipments

Cleaning is the process in which complete removal of soil (unwanted matter on food-contact surfaces) is accomplished using appropriate detergent chemicals under recommended conditions from the internal and external surface of the equipment

Sanitation: It involves effective bactericidal treatment with chemical/thermal agents to reduce the bacterial count including pathogens to a safe level on the utensils and equipment.

Most frequently used dairy sanitizers include steam, hot water and chemical sanitizers. Chemicals include – iodophores, chlorine, Iodine, acids, quaternary ammonium compounds

Some of the precipitates remains intact to equipment after cleaning and forms a film over equipment surface called **water stone**

Heat denaturation of protein present on the equipment surface or absorbed by other components forms **milk stone** quickly over heated surfaces

Milk stone – dried milk solids and salts from hard water and washing solution

cleaning modes - Manual, COP, CIP

Cleaning agents/ detergents:

- strong alkali: Sodium hydroxide (caustic soda) potassium hydroxide (caustic potash) – corrosive
- mild alkali: Sodium carbonate and sodium silicates, Trisodium phosphate (TSP) - commonly used
- Mild Acids- phosphoric, tartaric, citric, gluconic acid
- Strong acids- Nitric acid- 1% for stainless steel, HCL, Sulphuric acid
- Polyphosphate and chelating chemicals: tetra phosphate, hexametaphosphate
- Surface active/ wetting agents: Teepol, Acinol – N, common soaps

Material	Cleaning	Sanitization
Tinned steel/ copper	Weak alkalis, together with sodium sulphite as inhibitor, should be used.	All sanitizers may be used.
Bronze	-do-	-do-
Galvanized	-do-	-do-
Aluminium alloy	Weak alkalis, together with sodium silicate as inhibitor, should be used.	-do- -do-
Glass	All alkalis and acids may be used.	-do-
Vitreous enamel	Weak alkalis, together with sodium silicate as inhibitor, should be used.	-do-
Plastics	Cleaning temperatures should not be above the softening point of plastic.	Only chemical sanitizers should be used.
Rubber	Strong alkalis should be used to remove any fatty material stuck to the surface.	-do-

Choice of detergents in organized dairies

S. No.	Ingredients	Quantity	Remarks
1.	Tri-sodium phosphate	850 g.	For general use
	Wetting agent	150 g.	
2.	Tri-sodium phosphate	650 g.	For aluminium utensils
	Sodium meta-silicate	200 g.	
	Wetting agent	150 g.	
3.	Tri-sodium phosphate	750 g.	For tinned utensils
	Sodium sulphite	100 g.	
	Wetting agent	150 g.	

CIP (Clean In Place) has been opted in milk industry for good cleaning and sanitation.

- The cleaning cycle in dairy comprises following steps-
- Recovery of product residue by scrapping, drainage with water or compressed air.
- Pre- rinsing with water to remove dirt.
- Cleaning with 0.15-0.6% alkaline detergent
- Rinsing with clean water.
- Cleaning with acidic detergent.
- Rinsing with clean water (Hardness not exceeding 112mg/L)
- Sodium Hypochlorite/ Chlorine: 200ppm
- Iodophores:25mg/L QUATS: 200mg/L

Milk-borne diseases:

- Food infection: ingestion of viable pathogenic bacteria along with the food
- Food intoxication: Ingestion of toxins already produced by microorganisms in the food
- Toxi-infection: A certain group of organisms which can infect intestines when ingested along with the food and produce toxins in situ to bring about symptoms of poisoning.

Bacterial Diseases –

- Anthrax: Bacillus anthracis
- Brucellosis: Brucella abortus B. melitensis B. suis
- Campylobacteriosis: Campylobacter jejuni
- Diphtheria: Corynebacterium diphtheriae
- Listeriosis: Listeria monocytogenes
- Salmonellosis: Salmonella typhi S. paratyphi S.enteritidis
- Shigellosis: Shigella dysenteriae

- Streptococcosis: Streptococcus pyogenes
- Tuberculosis: Mycobacterium tuberculosis M.bovis M.avium
- Vibrio parahaemolyticus infection
- Yersiniosis: Yersinia enterocolitica

Rickettsial disease- Q fever - Coxiella burnetti

Fungal intoxication - Aflatoxicosis - Aspergillus flavus

Viral Diseases

- Polio myelitis- Polio virus
- Infectious hepatitis - Hepatitis A virus
- Tick borne encephalitis - Group B Arbo virus
- FMD

Parasitic diseases – Toxoplasmosis, Giardiasis

Milk borne toxi infections

- Bacillus cereus poisoning
- Clostridium perfringens poisoning

Milk borne intoxication:

- Botulism
- Cholera
- E.coli poisoning
- Staphylococcal poisioning