UNIT- VII: LIVESTOCK PRODUCTS TECHNOLOGY AND FOOD HYGIENE

• Composition of milk and its affecting factor, physio-chemical and nutritional characters of milk and milk products; processing of raw milk and production of market milk, Indian dairy products

• Defects in processing, packing, storing, distribution and marketing of milk and milk products and their remedial measures.

• Cleaning and sanitization of dairy equipments and plants, special milks, Methods of preparation of butter, ghee, khoa, lassi, curd, ice cream and cheese.

• Detection of adulterants in milk and milk product, utilization of byproduct of livestock produce.

• Ante mortem and Post mortem inspection, meat inspection, Abattoir practices, Meat Inspection Laws, quality control of meat and eggs and their products.

Composition of milk and its affecting factor, physio-chemical and nutritional characters of milk and milk products; processing of raw milk and production of market milk, Indian dairy products

1. Composition of milk and its affecting factor
2. physio-chemical and nutritional characters of milk and milk products
3. processing of raw milk and production of market milk
4. Indian dairy products

1. Composition of milk and its affecting factor

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 **l actose**.
- **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)**.

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.

2.physio-chemical and nutritional characters of milk and milk products

1.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.

3.processing of raw milk and production of market milk

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:

- **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.
- **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.

- **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.

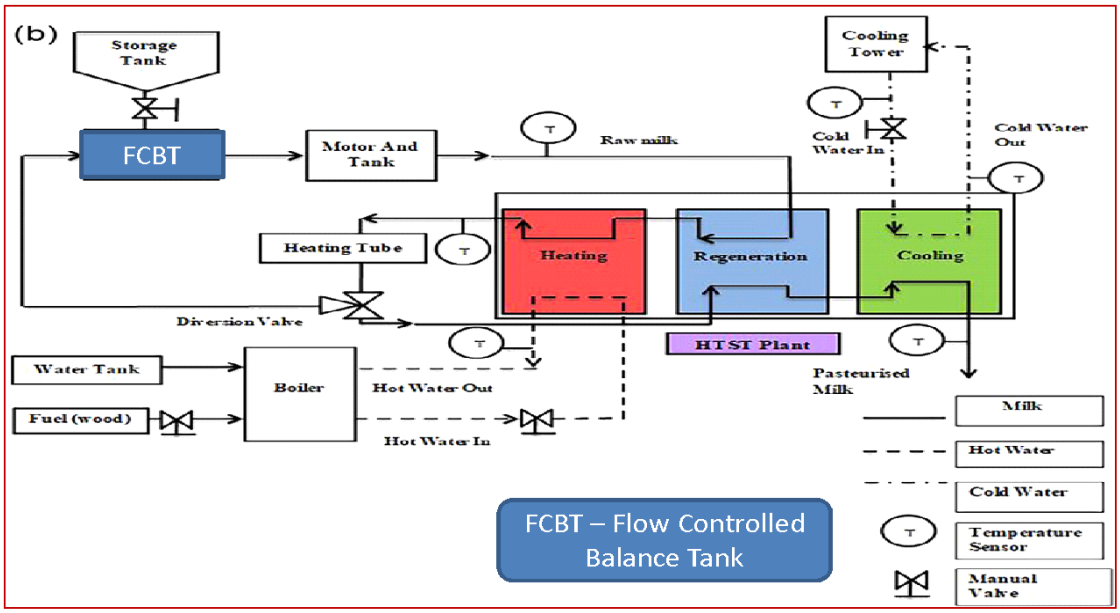
HTST Process

- **Cold raw milk** (4°C or 39.2°F) enters the pasteurization plant.
- 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).
- 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.
- The hot milk is held in a **holding tube** for about **15 seconds**, fulfilling the time requirement for HTST pasteurization.
- 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).
- 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

- **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.
- **Enhanced Shelf Life**: By effectively reducing microbial content, vacuum pasteurization extends the shelf life of cream and butter products.

- **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

- **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.
- **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.

- **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

- 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.

4.Indian dairy products

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

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

Chhana-based sweet

- Rasogolla
- Pantooa
- Sandesh

- Rasmalai
- Cham Cham
- Chhana-murki
- 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°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 °C and cooled to 70°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

Defects in processing, packing, storing, distribution and marketing of milk and milk products and their remedial measures.

1.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

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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

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.)

Cleaning and sanitization of dairy equipments and plants, special milks, Methods of preparation of butter, ghee, khoa, lassi, curd, ice cream and cheese.

1.Cleaning and sanitization of dairy 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

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
	Sodium meta-silicate	200 g.	utensils
	Wetting agent	150 g.	
3.	Tri-sodium phosphate	750 g.	For tinned uten-
	Sodium sulphite	100 g.	sils
	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

2.special milks

- **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:

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

- **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)

3.Methods of preparation of butter, ghee, khoa, lassi, curd, ice cream and cheese

ghee, khoa, lassi, curd refer indian dairy product

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.

Types of Butter

- **Table Butter:** Made from pasteurized cream.
- **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 ◦ C for 15 or 105-110◦C with no holding
- Cooling and ageing at 5-10 ◦ 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°C till desired an acidity is reached.

- **Churning of Cream**: Winters- 10-13°C Summers: 7-9°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°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

- Permitted stabilizers and emulsifiers not exceeding 0.5% 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.

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 ^{o}C.

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**
- Ripened principally by bacteria: Brick
- Ripened by bacteria and surface microorganisms: Limburger
- **Ripened principally by blue mould:**
    - External – Camembert (*Penicillium camemberti*)
    - 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:

- First stage is Souring /ripening
- Second stage is Clotting /coagulation by rennet
- Third stage is Cutting and drainage of whey.
- Fourth stage is Matting of the curd.
- 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 **30-31°C**.
- 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:

- To regulate the fat in the dry matter of cheese.
- 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.

Detection of adulterants in milk and milk product, utilization of byproduct of livestock produce.

1.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

- **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.
- **Starch**: Starch is sometimes added to thicken milk and give it a creamier texture.
- **Cane Sugar**: Sugar is added to enhance sweetness and mask the taste of spoiled milk.
- **Condensed Milk or Milk Powder**: These are sometimes mixed with fresh milk to increase volume and reduce costs.
- **Urea**: Urea is sometimes added to increase the apparent protein content of milk.
- **Detergents**: Detergents may be added to improve the foaming properties of milk. This is highly toxic and poses serious health risks to consumers.
- **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.
- **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

Milk by products

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

Ante mortem and Post mortem inspection, meat inspection, Abattoir practices, Meat Inspection Laws, quality control of meat and eggs and their products.

1.Ante-mortem inspection and Post-mortem inspection of meat animal

- main objective of meat inspection is to provide safe and wholesome meat for human consumption.
- professional examination of live animal before slaughter by a qualified veterinarian.

Objectives:

- **Public Health**: Separation of animals that may be suffering from zoonotic diseases and therefore may be a potential of infection for other animals and human.
- **Animal Health:** Certain diseases may be detected at the slaughter house and these have to be intimated to state veterinary services for protection of other animals.

- **Animal Welfare**: Ensures that only health animals are slaughtered and therefore prevent distress to injured animals.
- AM examination conducted in Lairage
- All animals that are to be slaughtered should be rested for at least 24 hrs before slaughter.
- They should not be fed for 12 hrs before slaughter but should be provided abundant water.
- The antemortem examination should be conducted on the day of arrival of the animal and should be repeated if slaughter is not carried out within 24 hrs of the examination.
- The inspection includes observing the animal at rest and in motion both individually and collectively

Categories/ Judgment

1. **Fit/ Passed:** If the animal is health and suffering from any disease condition.

2. **Unfit/ Discard/ Condemned:** unsafe for consumption.

3. **Slaughter under special conditions/ suspect**: symptoms or local lesions that require further investigation during PM examination before being passed as fit.

4. **Delayed:** The slaughter is delayed for a few days in case of animals that are fatigued, excited, suffering from transit sickness/ fever.

5. **Casualty slaughter:** animals that are not in acute pain or are not in any immediate danger of death but are suffering from a chronic condition. Some such conditions are obturator paralysis, post-partum paraplegia etc

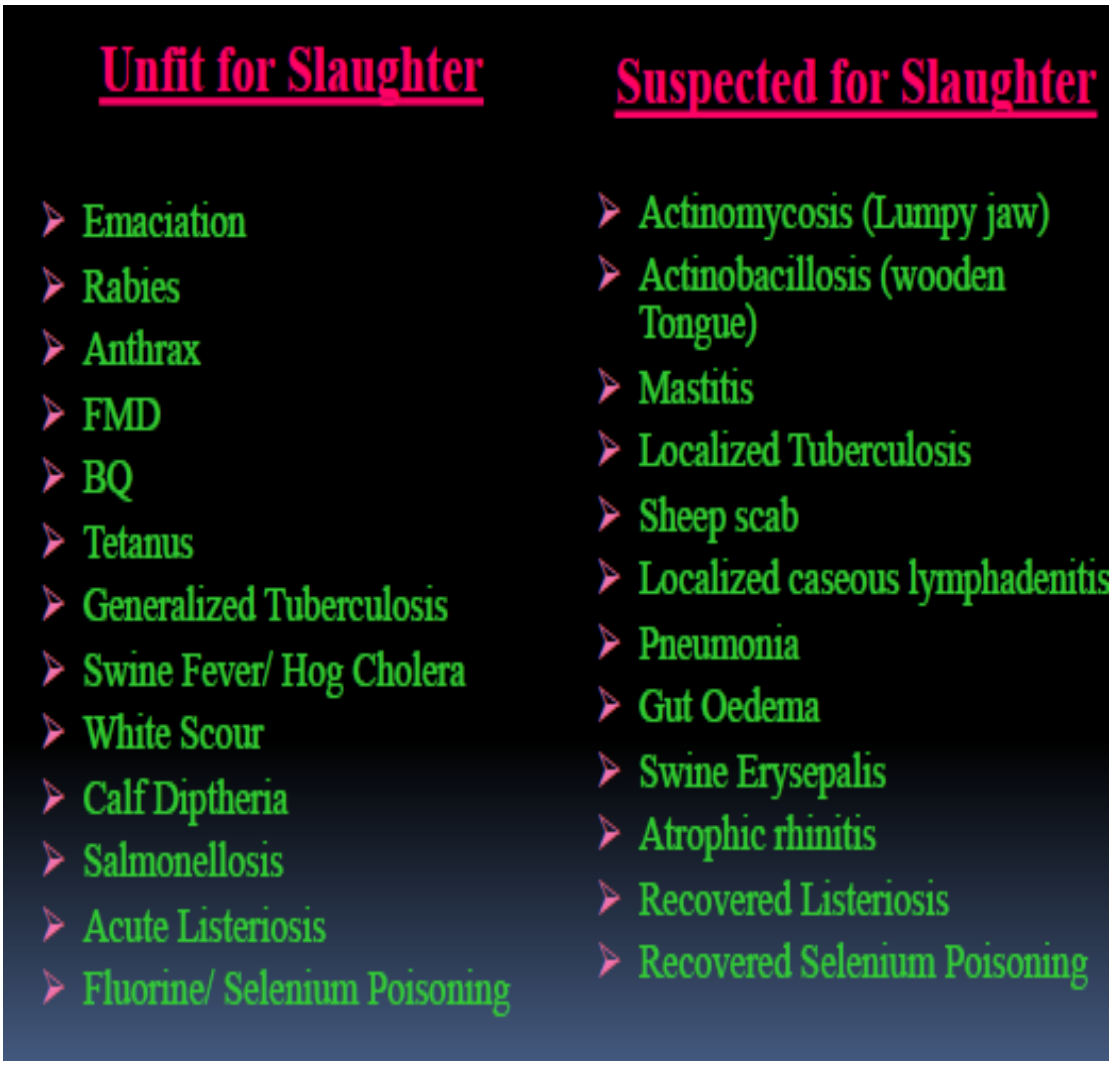
6. **Emergency slaughter:** This is required when the animal is in acute pain or suffering from a condition in which delay may cause distress to the animal. Such meat does not have any harmful effect on human health.

Unfit for Slaughter

- Emaciation
- Rabies
- Anthrax
- FMD
- BQ
- Tetanus
- Generalized Tuberculosis
- Swine Fever/ Hog Cholera
- White Scour
- Calf Diptheria
- Salmonellosis
- Acute Listeriosis
- Fluorine/ Selenium Poisoning

Suspected for Slaughter

- Actinomycosis (Lumpy jaw)
- Actinobacillosis (wooden Tongue)
- Mastitis
- Localized Tuberculosis
- Sheep scab
- Localized caseous lymphadenitis
- Pneumonia
- Gut Oedema
- Swine Erysepalis
- Atrophic rhinitis
- Recovered Listeriosis
- Recovered Selenium Poisoning



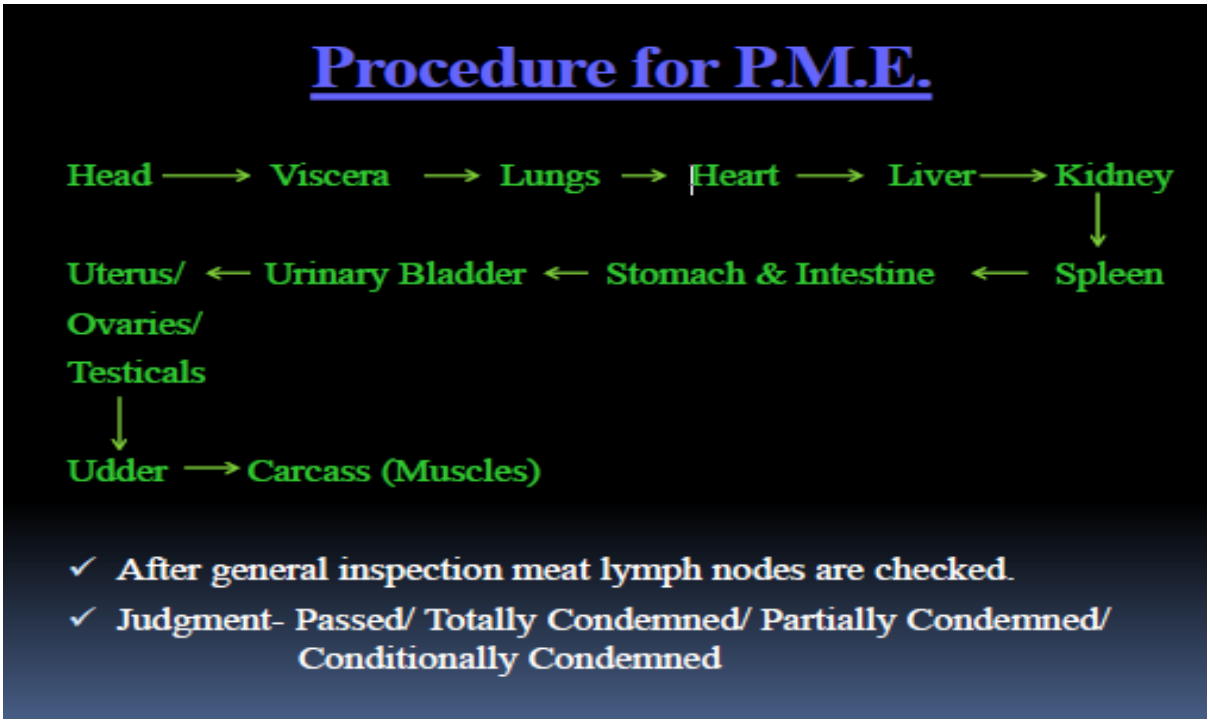
Post-mortem inspection:

- systematic examination of dressed carcass and their organs including blood by a meat inspector with the object of providing wholesome meat to consumers.
- The main objectives of this examination are:

1. To detect and eliminate any abnormalities to ensure wholesome meat production.

2. Checking the efficacy of slaughter and carcass dressing technique.

3. Aids in animal health by identification of disease condition and thereby disease control.



Entire carcass, organs, viscera should be rejected as unfit for human consumption if evidence of following disease conditions are seen:

Anaplasmosis Algal disease African swine fever Black leg, Bruising (extensive and severe) B.S.E., BVD Braxy, black leg Cysticercus bovis (Generalized) , Cysticercus cellulosae, cysticercus ovis, Emaciation (pathological), Actinobacillosis, Actinomycosis (generalised), Anthrax, FMD, Glanders

PM examination in animals		
Sl. No	**Condition**	**Judgment**
1.	Actinomycosis/ Actinobacillus	Condemn the affected part/ organ
2.	African horse sickness	Total condemnation
3.	Anthrax	Total condemnation
4.	Blue tongue	Depends on the type of lesion
5.	BVD	Total condemnation in acute cases Accepted after removing alimentary tract in chronic cases
6.	Brucellosis	Total condemnation or passed after heat treatment
7.	Campylobacter	Total condemnation
8.	Clostridial infections Black quarter Braxy Botulism Tetanus	 Total condemnation Total condemnation Total condemnation Total condemnation as poor keeping quality
9.	CBPP/ CCPP	Passed after removing affected organ
10.	FMD	Total condemnation or passed after heat treatment

11.	Glanders	Total condemnation
12.	JD	Total condemnation when emaciated, otherwise passed after removal of viscera & lymph nodes
13.	Leptospira	Total condemnation
14.	Listeria	Total condemnation
15.	HS	Total condemnation
16.	Pox	Total condemnation in acute cases, passed in recovered cases
17.	Rabies	Total condemnation
18.	RP	Total condemnation in febrile cases
19.	Salmonella	Total condemnation
20.	Swine fever	Total condemnation
21.	Tuberculosis	Total condemnation Passed when lesions not so severe
22.	Ringworm	Passed
23.	Cysticercosis	Total condemnation in generalized cases

		Passed is restricted to a part
24.	Hydatid	Passed after removal of affected organ
25.	Trichinosis	Total condemnation
26.	Toxoplasma	Total condemnation
27.	Emaciation	In the absence of disease condition approval after heat treatment.
28.	Fever	Total condemnation
29.	Improper bleeding	Total condemnation
30.	Tumor	Passed after removal Total condemnation when exetnsive

PM examination in poultry		
31.	Ranikhet Disease	Total condemnation
32.	Infectious Laryngotracheitis	Total condemnation
33.	Infectious-Coryza	Total condemnation
34.	Chronic Respiratory Disease	Total condemnation
35.	Ornithosis and psittacosis	Total condemnation
36.	Salmonellosis	Total condemnation
37.	Fowl Typhoid	Total condemnation
38.	Pullorum Disease	Total condemnation
39.	TB	Total condemnation
40.	Fowl Pox	Total condemnation
41.	Coccidiosis	Total condemnation
42.	Aspergillosis	Total condemnation
43.	Marek's disease	Total condemnation

- **Conditionally admissible meat**: meat affected with certain conditions which do not allow its unconditional sale and thus need to be treated before sending to market.
- Conditional basis of system: Friebank system to provide nutritious feed to economically weaker section of society.

Dressing percentage / Carcass yield: ratio of dressed carcass weight to the weight of the live animal, expressed as a percentage

Species	Dressing %
Cattle/ buffalo	43-54
Sheep	40-50
Goat	43-52
Pig	70-75
Poultry	65-70

2.Abattoir practices

Abattoir and Slaughter

- A place where animals are killed for their meat
- **Abattoir planning:** max. daily killing and disposal and treatment of edible and inedible byproducts.

1. **Selection of site:**

- Proper water and electricity supply should be there
- Sewerage
- Availability of rail and road transport.
- Availability of labor.
- No pollution from other industries
- Good availability of stock near by
- Isolated from local housing.
- In general urban sites are avoided and nominated industrial area should be chosen

2. Water

- Potable water must be distributed to all parts of plant under adequate pressure.
- Pressure should be at least 20 Psi in main pipe lines.
- Hot water of at least 82°C should be available in plant for cleaning and disinfection of machinery and for scalding.
- Recommended water requirement:
    - 454 liters /day/pig
    - 272 liters /day/bovine
    - 45 liters /day/sheep

3. Electricity:

- industrial 3 phase electricity
- Generator for emergency

4. Area size

- Small abattoir up to 30,000 units/year - 1-2 acres
- Medium abattoir up to 50,000 unit/year - 2-4 acres
- Large abattoir up to 10,00,00 units/year – 4-6 acres
- For calculating of area size: 1 adult bovine (ALU) = 2 pigs = 3 calves = 5 sheep.

5. Lighting

- Adequate natural or artificial lighting must be provided throughout the meat plant.

- Intensity of lights is usually taken at levels of 0.9 m from floor except in inspection area where height is 1.5 m

Overall intensity should not he less than:

- **540 lux (50 foot candle) - at all inspection points.**
- 220 lux (20 foot candle) - in work rooms/ slaughter hall
- 110 lux (10 foot candles) - in other areas

6. Ventilation:

Must be adequate to prevent excessive heat steam and condensation, accumulation of odour.

7. Floor and wall finishes:

- Easily cleaned.
- Non-absorbent.
- Floor: Non-slip material.
- General Gradient: Floor slope towards drains should be 1:50 (least 2 cm per 100 cm)
- Drainage valleys under the dressing rail where the blood tends to collect, the gradient should be 1:25.
- One drainage inlet for every 36 m^2 of floor space.
- Ceiling height should be at least 5 m.
- Walls: covered with smooth impervious material like (tiles) up to 3 m.
- Doors should be wide enough to allow passage of workers, trolleys and carcasses (4.5 ft). Self closing and double action doors are preferable.

BUILDINGS IN A MODERN ABATTOIR

1. **Lairage: rest area -**

- Rest is to be given for 24 hrs
- Unrested animals after journey may suffer depletion of glycogen in muscles which results in black meat.
- It should have enough space to hold **2 days killing stock for large animals and one day stock for small animals**
- Distance of at least 10 m between lairage and slaughter hall
- holding pen is connected to the stunning pen through passages known as Race.
- Animals have to be kept off feed up to 12 hours before slaughter in lairage

Minimum space requirement in lairage:

- **Cattle loose** 2.3-2.8 m^2/ animal
- **Cattle tied** 3.3 m^2 animal
- **Pig (small)** 0.6 m^2/ animal
- **Heavy pig. calf, sheep and goat** 0.7 m^2

Cattle lairage:

- Horned animals should be separated from hornless animals.
- Large enough to hold 20-25 cattle
- Drinking water must be available
- Feeding of animal: twice a day except on day of slaughter.

Sheep lairage:

- Height of sheep pens should be 3 feet (0.9m) with passage 3 feet wide between pens
- Rails of the pens should not he more than 15 cm (6 inch) apart.

Pig lairage:

- Pig pens are preferably constructed with solid walls.
- If rails used: horizontal rails should not be more than 6 inches (15 cm) apart.
- In hot weather water spraying of pigs is useful to prevent fighting among them and it also improves quality of pork

2. Isolation block: It is actually a small abattoir and provided with a lairage, slaughter hall and hanging room.

- Situated near a suspected meat detention room and should have direct communication with byproducts department.

Emergency slaughter house

- For animal which are diseased or suspected are housed separately and slaughtered in isolation block.
- Conditions like - fracture of limbs, severe laceration and bruising, damage to pelvis, lightening strike, animal overlain and suffocated, lactation tetany, pregnancy toxaemia, enterotoxaemia etc.

SLAUGHTER HALL: Main hall where animals are slaughtered.

- Stunning, bleeding, dressing, evisceration
- A raised platform (killing floor) from lairage with an easy gradient is provided to facilitate the movement of animals on killing floor.
- Horizontal water sprays: along with path for cleaning of animals.

Size and type:

- It should be an open hall which is well ventilated and lighted.
- Sufficient natural or artificial light: intensity of 20 foot candle be provided (50 foot candle at meat inspection site)
- Gradient of slaughter hall/ work room floor: 2 inches in every 10 feet.
- Blood must be collected in shallow trays of 20 inches diameter and 4 inches deep. It is used for manufacture of black pudding(blend of onions, pork fat, oatmeal/barley, flavorings and blood)

DRESSING SYSTEM

- **Booth or Bed System**: slaughter is carried on floor by 1-2 persons; no person has specific work, Prevalent in India; Hygiene is poor
- **Modified booth system:** facility for stunning and bleeding; booths with cradles and hoists;
- **Cradle and Semi-line system**: stunning and bleeding; rail for breast opening, pluck removal and evisceration; Better hygiene
- **Line or On-the rail dressing**: conveying the carcass by gravity or power through overhead rail to various places after stunning and sticking. Also known as one man one job system. Men will be at different places carcass will reach them and they will attend to their allotted work. labor saving devices such as brisket cutter, hock cutter, hide puller etc. are used.

Types of Line or On-the rail dressing

a. Gravity rail system:

- In this method the carcass will be suspended from a spreader and single wheel trolley or runner, gravitated to each station and stopped by manually operated stop on the overhead rail
- The system is used for lower slaughter **rates 10-40 animals/ hr**
- Most compact and economical
- Less chance of breakdowns with consequent loss of production
- Adequate ceiling height is necessary because of the pitch of the rail to gravitate the carcass

b. Intermittent Powered System:

- carcass is suspended over a spreader(gambrel) and trolley
- moved mechanically on a level rails at an intervals by means of variable timing device
- Slaughter rate - 10-75 animals/hr

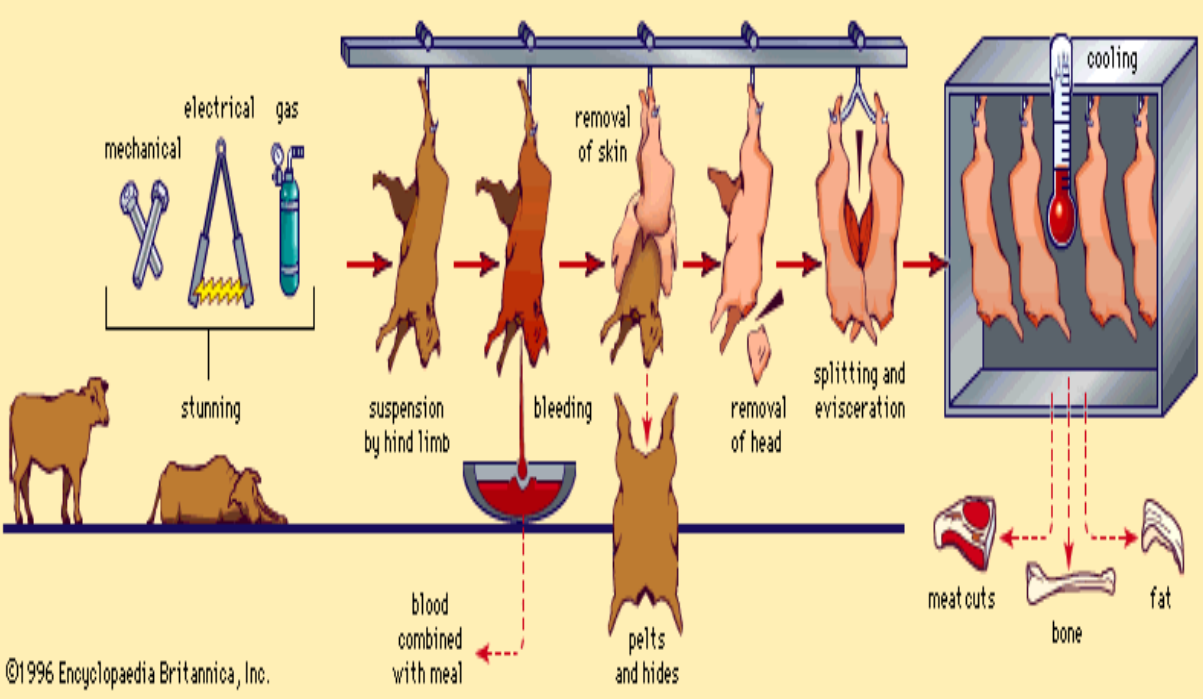
c. Continuous Power System:

- Here dressing line will be in continuous motion
- More sophisticated instruments are used in the slaughter line (mechanical hide puller, etc.). Thus, the platform may be fixed or movable, elevated or lowered
- Carcass can be revolved to a full 360°

- Rate of slaughter 40-120 animals/hr

d. Canpak System:

- Continuous conveyor is used in which heavy trolleys or runners suspend the carcass from overhead rail
- Here everything is done systematically (mechanically)
- Rate of slaughter 50-150 animals/hr
- Most Common in modern meat plants
- •From arrival of animals till completely dressed the work is divided into 32 divisions (each work is carried out by one man).
- Developed and patented by the Canada Packers Ltd., Canada hence called Canpak system



Advantages

- Time is saved
- Safer for operators
- More Hygienic
- A comfortable operative position is provided to the operator
- Increased output and enhanced value of carcass
- Less space per carcass is required

Possible Disadvantages

- High standard of engineering maintenance is needed

- When break down occurs production ceases completely
- Trained personnel needed
- Meat inspection is sometimes more difficult and possibly less efficient

4. Chilling room:

- Rapid cooling of carcass immediately alter slaughter is must.
- Chilling space should be enough for storing at least 2 days slaughter.
- **Temp:** between -1.5°C to 4.5°C.
- Chilling temperature should be less than 7°C for meat and less than 3°C for offal.
- Minimum space between carcass on rails should be 0.3 to 0.4 m.
- Minimum space between rails should be 0.9 m for beef, 0.7 m for pig and 0.5 m for lamb.

5. Hide and skin store:

- A separate room for keeping the skins, salting and piling up should be provided.

6. Guttery and tripery: Gut scraping unit, tripe (stomach of cattle and sheep) room, stores and byproduct plants. They should be away from main building for sanitation point of view.

7. Others: Offices, laboratory, dispatch room, effluent treatment plant, First aid room, toilets, staff canteen are essential in a modern slaughterhouse.

Transportation of meat animals

- Driving on hoof: short distance of 8-10 km and 4-5 Hrs.
- Transport by road truck: up to 500 km and 12-15 Hrs; animals should face in the direction of vehicle movement
- Transport by rail: > 500 km; break in journey after 1000 km
- Transport by sea: very expensive and time consuming, high mortality.
- Transport by air: mainly companion and zoo animals.

Loading/unloading: ramp should not be steeper than 30°.

Transit of animals (Road and rail) order, 1975

- **Schedule 1:** general provisions for road and rail vehicles and receptacles
- **Schedule 2**: Separation of animals during transportation
- **Schedule 3:** Cleaning and disinfection of vehicles

Transport rule: Welfare of animal during transport order, 1994

- For >50 km.
- Feed and rest at every 8 Hrs. interval

Considerations for planning a journey

- **Species of animals**
- **Health check up**: e.g. dipping in sheep 10 days before transport
- **Interstate and abroad transport**: vaccination history, breed, age, heath status
- **Space req.:**

  Railway wagon: (21.1 m^2) → 10 adult cattle/ 15 calves/ 3-6 horse/ 70 S/G per wagon

  By road truck: 4-6 Cattle/ horses

Weight loss during transportation: Shrinkage → water, urine, feces, carcass protein & fat loss during first few hours of transport

- E.g. Pigs: 2.2-5.4 kg during 24 hr journey and Sheep: 3.6 kg.
- **Disease induced by transportation:**
- Transit/ Shipping fever: in cattle with poor condition travelled long distance without food especially in cold climate.
- Transit tetany: in advanced pregnant cows and ewes. Similar to milk fever → Ca therapy.

Pre-slaughter practices

- Avoid unnecessary stress to animal
- Adequate rest at lairage
- Fasting and plenty of drinking water- better bleeding and dressing; less chances of bacterial contamination from intestine
- Feeding of easily digestible CHO like sugar especially to pigs after long journey – replenish glycogen

Stress: journey, feed, hunting, weather, fear etc.→ non-specific response in animal to adapt to maintain homeostasis

Types of Stunning:

- 1. Percussive stunning devices: Captive bolt– power operated or pneumatic
- 2. Free bullet method
- 3. Use of CO_2 anesthesia
- 4. Electrical stunning

Mechanical stunning/ Captive bold method:

Bolt is captive and cartridge is blank- bolt recoils back into barrel

- Bolt- 2 types
  - Blunt/ mushroom head - work by concussion – sudden jerk

- used when brain is kept edible- Claves

- Sharp head- Penetrate frontal bone

  - alter intracranial pressure

  - Brain trauma

  - used in cattle/ sheep but not in Pig and bulls (Thick frontal bone)

- Pneumatic captive bolt stunning device: pressure 80-120 psi

Site of shooting with captive bolt:

- Cattle: gun placed at right angle to the intersection of line joining the horns with median canthus of opposite eyes
- Calves: Slightly lower to the point of intersection
- Bull and old animals: 15 mm to the side of ridge which runs down the centre of forehead
- Sheep/goat (Hornless): pistol at the top of head aimed towards gullet
- Sheep/goat (Horned): Behind the ridge between the horns and aimed towards gullet
- Pigs: 2.5 cm above level of eyes and fired upward in cranial cavity
- Horse: 1 cm above the intersection of lines joining opposite ears to median canthus. Bolts are heavier and longer.

Water jet stunning:

This method emp loys a fine jet of water to penetrate the skull and mechanically destroy the brain by the induction of laceration, crushing or shockwaves to such an extent that immediate unconsciousness is induced.

Free bullet method: use of rifle at the site same for captive bolt method

Disadvantage: Brain destroyed non-edible and chance of injury to operator

Use of CO_2 anesthesia

- Mostly used for pigs
- Blocks nerve impulse
- Minimum CO_2 conc. 70%
- Low conc.: improper stunning
- High conc.: stiffening and poor bleeding
- Proper exposure pd.: 45 sec
- Longer exposure: superficial congestion/ bluish, convulsion and cardiac arrest

Note : Bleeding s/b done with 30 sec. otherwise recovery occurs in 1.5 min.

: For Sheep – uneconomical method because of wool- much CO_2 is wasted.

TYPES:

- **Oval tunnel**: For pigs only, 600 pigs/Hr, conveyer of 10 compartments, one for each pig
- **Dip lift**: pig/calf and sheep animal in cage descends vertically in to CO_2 pit.
- **Compact CO_2 immobilizer**: Horizontally revolving apparatus of 4-8 compartments

: 300 pigs/Hr.

Adv. of CO_2 anesthesia: no harmful residues in meat

: carcass: relaxed better dressing

: less noise and labor req.

: 0.75% more bleeding compared to other methods stimulate resp.

: No muscular hemorrhages (as in electric method)

: Lower meat pH and PSE condition is reduced

Electrical stunning: Most widely used method

Electrode: kept in brine, positioned such that current pass through thalamus and cortex chief sensory centers of forebrain

: Animal s/b dry (otherwise current passes over surface and not through brain)

: massive depolarization of nerves

: Mostly for pigs and poultry, but also for sheep and calves

: not satisfactory for adult cattle/buffalo: insulating hairs on head

: Low caloric intake and good state of hydration: better passage of current

Signs of genuine electric shock:

Cattle: eyes wide open with no corneal reflex, hind legs stretched, head bent backward and ceased respiration temporarily.

Poultry: feather spread, extended wings, tail feathers turned over back

Sheep/goat: flexion of forelimbs, closing of eye and extension of hind limbs.

- Effective bleeding in electrical stunning: increased blood pressure due to vasoconstriction and muscular contraction.
- Bleeding should be done immediately after electrical stunning. Otherwise: increased arterial blood pressure causes blood splashing in muscles (Blood splashing/ Muscle splashing) due to rupture of smaller arterioles and blood vessels muscular hemorrhages
- If voltage is high, it causes cardiac arrest and animal dies and whole blood remains in the body.

- **Missed shock:** If voltage is low or electrodes are poorly positioned, animal is paralyzed but fully conscious.

Devices for electrical stunning

1. **Hand stunning device:** for small animal and slow rate of killing.

   : 70 volt for 1-3 sec fowl and 90 volt for 9-10 sec for turkey

2. **Elther apparatus:** Rapid and complete bleeding with no blood splashing

: 285 watt for 1 sec. for cattle and 198 watts for 1 sec calf, sheep and fowl.

3. Automatic stunning device: line processing system.

Method of electrical stunning depending upon voltage applied:

a. **Low voltage**: less than 150 volts and minimum 7 seconds less effective

b. **High voltage:** 300 volts or more and minimum 3 seconds more effective

Method of electrical stunning depending upon method of application:

a. Head only: applied on head only. Min. 400 mA for pigs and 250 mA for sheep & lambs

b. Head to back stunning: High voltage current applied simultaneously to head a& legs/back.

BLEEDING

Spp	**Incision**	**Bleeding time**	**Blood yield**
Cattle	1. Bilateral carotid arteries & jugular vein by incision across throat caudal to larynx 2. Incision in jugular furrow at neck base with knife directed towards chest to incise brachiocephalic trunk and Ant. Vena cava.	6 min	Cattle: 13.6 kg Calf: 2.7 kg (Cow > bull of same age)
Sheep/goat	Jugular furrow close to head: cut both, carotid arteries and veins	5 min	1-2.5 kg
Pig	Middle of the neck at the depression in front of sternum, cut the anterior vena cava	6 min	Pigs: 2.2-3.0 kg Boar: 3.6 kg

Poultry	ventral neck cuts	2.25 – 3 min	30-50gm

- Malachite Green test – to check efficiency of bleeding
- Sticking – process of severing neck for bleeding
- Back bleeding/ oversticking – contamination of lungs due to improper sticking
- Splash – appearance of petechial haemorrhages in s/c tissue in pigs

PITHING: done in animals stunned by captive bolt

- A long rod is inserted in brain to destroy medulla oblongata to minimize reflex muscular activity
- Length of rod: not more than 0.6 m splanchnic nerve damage: main for vasoconstriction of abdominal cavity congestion in liver, kidney, intestine etc.
- Slaughter spleen: improper pithing spleen congested and enlarged

3.Quality control of meat and eggs and their products.

Meat packaging,Casings,Meat byproduct

- **Function:** protection from physical damage, chemical changes & microbial contamination

Fresh meat: oxygen permeable film recommended

1. **Overwraps:** Low density polyethylene (most widely used), PVC, nylon-6,11.
2. **Tray with overwraps**: polystyrene trays
3. **Shrink packaging:** polypropylene, PVDC, irradiated polyethylene irreg. cuts
4. **Vacuum packaging:** long term storage PVDC, nylon, polythene (meat-purple)
5. **Modified atmosphere packaging(MAP):** O_2(color),CO_2(bacteriostatic),N_2 (Filler).

ensure retention of meat quality for a period of at least 8 weeks in fresh meat and 10 weeks in case of cured meat at a refrigerated storage of 0°C

Frozen meat: Low density polyethylene, cellophane, polyester moisture proof

Cured meat: polyethylene, PVC, nylon-6,11, PVDC

Dehydrated meat: metal foil/plates/laminates moisture and O_2 proof

Thermo-processed meat: tin cans/ laminates

Meat byproducts (products other than dressed meat)

Poultry byproducts: 1kg bird 25-30% waste = 35 g blood; 80 g feather, 30g head, 40 feet and 90 viscera

Feather meal: 85% CP with 80% digestibility

Manure: high Nitrogen

Casings

- Prepared from sub-mucosa of the small intestine
- Measured in Hanks
- Used for stuffing sausage
- Rounds: casings from sheep and goat/ Pigs
- Runner: small intestine of cattle
- Middle: large intestine of cattle
- Bung: caecum of cattle
- Weasand: Esophagus of cattle
- Maws: pig stomach
- Chitterling/ black gut: colon (LI)
- Cap: caecum
- Paunch: stomach

Term	**Corresponding Organ/Part**
Diaphragm	Skirt
Tripe	Rumen & Reticulum
Spleen	Melt
Book/Bible/Farthing/Manyplies	Omasum
Pancreas	Gut (Sweetbread)

Weasands/Roll/Gullet	Oesophagus
Thymus	Sweetbread
Rapes/Runnes/Ropes	Small intestine of cattle
Reed	Abomasum
Buff/Lites	Lungs
Rind	Skin of pig
Caul/Crup Fat	Omental fat
Web	Ox mesentery
Cod Fat	Scrotal fat
Crow/Crown Fat	Mesenteric fat of pig

Use of meat byproducts:

- **Offal:** part other than the carcass
- **Variety meat:** Tongue, brain, sweetbread, heart, kidney, liver, Chitterlings
- **Lamb fries/ mountain oyster**: cooked testicles of lambs and calves
- Tripe, blood and pig stomach: sausage (tube-like case containing meat)
- Ox-tail: soups
- Bone: bone meal (21% Ca and 10% P), Bone china, Bone char
- Blood: 80-90% CP, lysine & Fe rich
- Neats foot oil: hoof/ feet of cattle lubricant

Pharmaceutical byproducts

- Adrenal gland: epinephrine
- Pancreas: insulin
- Pineal: melatonin
- Thyroid: thyroxin
- Beef fat: ointment base

- Stomach: **pepsin (Rennet from unweaned calf stomach (4th):** milk dig/ cheese)
- Gelatin: capsule, ice-cream
- Glue: adhesive
- Catgut: mucosa and submucosa of small intestine of sheep

Hide and Skin: one of the most important by-products

Hide

- Skin of **Large Animal**
- Large, Thick and Heavy
- Av. yield 7.0% of live wt.
- **75-80%: Fallen Animals** and 20-25 %: Slaughtered animals

Skin

- Skin of **Small Animal**/ young calf
- Small, Thinner and Tighter
- Av. Yield 11.0% of live wt.
- **80 %: Slaughtered animals** and 20%: Fallen Animals

Flaying: Process of skin removal from dead animal

Processing: Drying/Curing Conditioning Tanning Leather (Product)

Fallen animals: Coagulated blood capillaries stain the hide: inferior leather

Classification (wt, lb): Slunk Skin (Unborn Calf);

Classification (Weight, lb)	**Description**
Slunk Skin	Unborn Calf
Calf Skin	Immature Calf (9-15 lb)
Kip Skin	Calf (15-25 lb)
Heifer Skin	Heifer (25-30 lb)
Cow Hide	Cow (> 30 lb)
Light Cow Hide	Light Cow (< 53 lb)

Heavy Cow Hide	Heavy Cow (> 53 lb)
Extreme Light Hide	Steer (32-48 lb)
Light Steer Hide	Steer (48-58 lb)
Heavy Steer Hide	Steer (> 58 lb)
Bull Hide	Bull (60-100 lb)

Bristles of pig: stiff wiry hairs of pigs: making of brushes

Tanning: Process of conversion of hides/ skins to insoluble and non-putrescible leather without destruction of original structure.

- Types:
  - Vegetable Tanning
  - Chrome Tanning

Glue and Gelatin

- Bone constitute almost 15% of the weight of dressed carcass
- Bone collagen (ossein) is main organic constituent
- bone collagen or ossein, which is the mother substance for gelatine and glue.
- **Gelatin:** Gelatin can be obtained by boiling ossein or by boiling degraded bones in water acidified with Hydrochloric acid, which separates the gelatinous substances.

Glue: Glue is the inferior gelatin

Quality Evaluation of Meat Products

Physico-chemical qualities

1. pH: 6.1-6.7 (fresh meat: 5.5 to 6.2)

2. Emulsion stability: ability to maintain moisture, fat

3. Water Holding Capacity (WHC)

4. Cooking Yield (CY)

5. Shear Force Value: to measure meat tenderness Warner–Blatzler device

Microbiological Qualities

1. SPC

2. Coliform count

3. Yeast and Molds count

Color:

- **Meat color:** main pigment responsible for meat color is myoglobin (role of hemoglobin negligible)
- **Bloom:** bright red color of meat due to oxymyoglobin
- meat with a higher proportion of red fibers has a higher concentration of myoglobin
- **Beef and Carabeef:** bright cherry red
- **Mutton and chevon:** light to dark red
- **Pork:** grayish pink
- **Poultry:** grayish white to dull red
- **Veal**: brownish pink

Water holding capacity

- ability of meat to hold its own or added water during the application of external forces such as cutting, heating, grinding and pressing
- Related to juiciness of meat along with texture and color
- DFD has high WHC while low in PSE
- A decrease in WHC can be seen through fluid exudation called weep in unfrozen raw meat; or drip in frozen meat which is thawed, folds in cooked meat

Marbling

- The intramuscular fat visible within the meat, which is a key determinant of flavor and tenderness, especially in beef.
- Solidification of fat during chilling contributes to firmness

Tenderness/ Shear force

- Most important sensory attribute
- Warner–Blatzler device/ Penetrometer to measure meat tenderness
- Higher the whc – more will be tenderness
- Meat tendering Enzymes from plant: papain (papaya), bromelain (nanas), and ficin (ficus)

Firmness

- Collagen in muscle tissue determine the toughness
- Firmness more in old animals than young

- Although collagen content high in young animals but that is more heat labile and convert to gelatin on heating causing tenderness
- Firmness increases during carcass chilling due to loss of extensibility

Evaluation and grading of dressed carcasses

- Carcass evaluation is a broader term which gives idea about carcass yield, meat processing character, palatability and overall quality of meat.
- **Carcass Yield:** calculated by dividing the chilled carcass weight by the live weight and multiplying by 100.
- **Carcass Length:** Forward edge of the first rib to the forward edge of the pubic bone.
- **Back fat Thickness:** back fat deposited opposite 1st rib, last rib, and last lumbar vertebra for pork and 12-13th rib for beef/lamb.
- **Loin Eye Area (LEA):** cross section of longissimus dorsi muscle between 12-13th rib (ruminants) and 10th -11th rib (pork) for muscle development.
- **Fat Depth:** Using a back fat probe measure the fat depth including the skin at the rib eye/streak (6th rib onward).
- **Ribbing of Carcass:** opening the carcass by a cut made perpendicular to the length of carcass just below the 11th rib.
- Meat cutting room: temp. 15-20°C & RH 80%

Grading

- It is process of segregating meat and meat products on the basis of palatability, yield or other economically important traits into standardized group with minimum common characteristics.

Generally: two types of grades:

1.Quality Grade: based on the factors related to the palatability and acceptability of meat and meat products to the consumers.

2. Quantity grade /Yield Grade: As assigned to the carcass based on the yield of trimmed retail cuts and are established only for beef, pork and lamb carcasses.

Factors used to establish grades:

1. Conformation - Morphology of animal

2. Quality – firmness/ texture, tenderness. palatability, color, juiciness, odor, water holding capacity, etc.

3. Finish - quantity, amount, colour and distribution of fat. This includes:

- External: Subcutaneous fat (Blubber in marine animals)
- Intramuscular fat (between bundles- perimyseal CT): **Marbling** juiciness

- Intermuscular fat: Seam fat
- Feathering: fine streaks of fats in inter-costal muscles
- Flank streaks: streaks of fat in epimysium of flank muscles

Evaluation of Sheep & Goat Carcass

Grading done on basis of (BIS)

- Length of the carcass
- Thickness of back
- Fullness of legs and flank
- Amount of fat in intercostal muscles.

Types

- Prime Grade
- Choice Grade
- Utility Grade
- Cull Grade

Evaluation of Buffalo Carcass

Grading done on basis of

Conformation, finish and quality of the carcass

Types

- Prime Grade
- Choice Grade
- Good Grade
- Commercial Grade
- Utility Grade
- Cutter and Canner Grade

Evaluation of Swine Carcass

Based on

- **Carcass length-** Edge of first rib to front of aitch bone.
- **Dressing %-** (Ratio of carcass wt. to live wt.) X 100.
- **Yield-** Average of four lean cuts (Ham, Loin, Boston Butt & Picnic Shoulder)
- **Loin Eye Area**- Proportional to muscle (*Longissimus dorsi)* development in carcass.
- **Back Fat Thickness-** Average of back fat on first rib, last rib and last lumbar vertebra.
- **Meat color-** Pinkish red > Greyish Red > Pale

- **Firmness-** Very Firm > Reasonably Firm > Soft and Watery
- **Marbling**- Small/Moderate > Slight > No Visible Marbling

Egg Preservation

- Recommendation for production of quality egg on farm
- 3 time egg collection daily
- Carefully handling while keeping in filler flats
- Quickly cooling of egg to 50 °F or less @75-85% relative humidity
- Marketing of egg twice a week
- Additionally lose of water content also responsible for spoilage of egg
- Methods are used to counteract it and increase shelf life of egg

Methods Of Preservation

- Refrigeration/ Cold storage
- Immersion liquids
- Thermo stabilization
- Egg shell treatment
- Overwrapping
- Radiation

Immersion liquids

- Lime water: For Long term storage (2-3 months).
- 0.5 Kg of lime dissolve in 1 litre of boiling water, the solution is kept over night and the supernatant is poured in a jar. In this solution 2.5 litres of cold water is added and the entire solution is then filtered with a muslin cloth.
- NaCl may be added @ 112 gms/litre of the supernatant solution.
- Eggs are kept dipped in this solution for 24 hrs, they are then dried and packed.

WATERGLASS

- 10% sodium silicate solution prepared in hot water.
- Eggs are then immersed in this cooled solution and stored in areas where temperature does not rise above 70 ^{0}F.
- Eggs preserved by this method are usually punctured before boiling so that the shell does not break while boiling and the shell peels of easily.

Shell Sealing Method

- It involves use of oil which seals the egg shell pores, thus preventing the escape of moisture and CO2 from the egg content.

- Thin albumen layer below shell membrane get coagulated
- Types: Oil Coating & Oil Water Emulsion
- Technique: Dipping or Spraying.
- Using color less odorless oil
- Cotton seed, linseed and ground nut oil are prefered

Thermostablisation

- Good for fertile egg as it killed embryo
- Known as defertilisation method
- Eggs are immersed in hot water at different time temperature combination
- 130 °F X 15 minutes
- 142 °F X 2 minutes
- 212 °F X 5 seconds
- Remain edible for a month

Over Wrapping

- Eggs stored in cartons which are then over wrapped in cellophane
- This technique is effective in maintaining egg albumen quality.
- Reduction in evaporation rate and maintaenace of low albumen pH.
- Over-wrapping cannot replace refrigeration but should be used in conjugation with it.
- Compared to oil coated eggs, eggs stored under plastic overwrap peel easily.

Cold Storage

- Best method of storage
- Temp : 30-32°F or 0 °C and 85-90% RH for 5-10 month
- Temp : 50-55 °F and 60-70% RH for 2-3 month

Radiation

- Shell egg irradiation dose starts at 1.0 kGy upto 5.0 kGy
- Radiation destroys the ovomucin protein of the albumin
- The gel-like structure of the albumen is lost on irradiation.

Packaging

- Wooden Boxes, Cardboard Boxes, Plastic Boxes, Plastic Trays

- Aluminum Trays, Paper Boards
- Moulded Pulp Cartons
- Boxes made from Straw/Organic fibres.

Filler trays

- Filler trays are made up of wood pulp or cardboard or plastic.
- They are moulded/constructed in such a way that they can be stacked one on top of the other and they can also be placed in boxes for transport.