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

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

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

Dairy industry Scenario in India

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

Topic 2 Milk constituents and Physico-chemical properties

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

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

Composition and Properties of Milk

- Water: 85-88%
- Total Solids: 12-15%
- Fat: 4-6%
- Proteins: 3.3% (Casein 82%, Whey Proteins 18%)
- Lactose: 4.9%
- Minerals and Vitamins: Includes calcium, potassium, and vitamins A, D, E, K.

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

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

Skim milk	0.5 max	8.7

Milk Fat:

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

The fatty acids in milk fat can be categorized as:

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

Milk fat can be divided into two main categories:

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

PROTEINS

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

- **Casein:**
  - Comprises about 3% of cow's milk and 4.3% of buffalo milk.
  - Found as a calcium caseinate phosphate complex.
  - Contains phosphorus and coagulates at a pH of 4.6.
- **Whey Proteins**:

- Do not contain phosphorus and remain soluble in milk at a pH of 4.6.
- The principle of coagulation at reduced pH is fundamental to cheese and curd formation.
- Additionally, riboflavin contributes to the color of whey proteins, while casein is responsible for the white color of milk.

Casein:

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

- **Composition of Casein Micelles**:
  - Consist of subunits from different types of caseins: **α, ß, and γ**.

- **ß-casein** is divided into two parts: **A1** and **A2**, differentiated by the 67th amino acid (A1 has histidine, while A2 has proline). A1 protein upon digestion produces beta casoporphin-7 (BCM-7) which has adverse health properties.

- **Characteristics**:
  - Casein micelles are spherical in shape and range from **0.04 to 0.3 µm** in diameter.
  - **Kappa casein** is the specific site where rennin acts during cheese-making.
- **Uses**:
  - The adhesiveness of milk, attributed to casein, makes it useful in glue production.

WHEY/ Serum Proteins:

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

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

Functions of Key Whey Proteins:

- **ß-lactoglobulin**: Acts as a carrier for **vitamin A**.
- **α-lactalbumin**: Plays a critical role in the synthesis of **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)**.

Protein Quality

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

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

Antimicrobial properties of Milk:

Specific antimicrobial agents: act by targeting specific pathogens:

➔ **Immunoglobulins**: These are antibodies that play a crucial role in identifying and neutralizing pathogens. In milk, secretory IgG is particularly important for mucosal immunity.

➔ **Complement**: A system of proteins that enhances the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promoting inflammation and attacking the pathogen's cell membrane.

➔ **Bifidus Factor**: This is associated with the growth of beneficial bacteria like *Bifidobacterium*, which can modulate immune responses and enhance specific immunity through the promotion of regulatory T cells and anti-inflammatory cytokines.

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

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

Topic 3. 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.

Topic 4 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.

Topic 5 Cooling and Transportation of milk

Bacteria Growth in Milk

- ➔ Common milk bacteria grow best between 20-40°C
- ➔ Bacteria develop faster in severely contaminated milk than in milk with a low bacterial count
- ➔ Under poor hygiene conditions, bacterial counts can reach half a million or more
- ➔ Bacterial growth is accompanied by deterioration in milk quality due to off-flavors, acidity, etc.

Cooling Milk Immediately After Milking

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

Materials for Dairy Equipment

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

LP System in milk:

- ➔ **Lactoperoxidase**: Lactoperoxidase is an enzyme naturally present in bovine milk at a concentration of approximately **30 µg/ml**. It plays a crucial role in the lactoperoxidase system's antimicrobial activity.
- ➔ **Thiocyanate:** Thiocyanate (SCN^-) is the substrate for the lactoperoxidase enzyme. It is naturally present in milk at low levels and can be supplemented to enhance the system's effectiveness.
- ➔ **Hydrogen Peroxide:** Hydrogen peroxide (H_2O_2) acts as a promoter in the lactoperoxidase system. It is not naturally present in milk but can be generated by the enzyme glucose oxidase or added exogenously.
- ➔ **Activation of the Lactoperoxidase System:** When sodium thiocyanate and hydrogen peroxide are added to milk in a ratio of **14:30 mg/litre**, respectively, the lactoperoxidase system is activated. This activation enhances the keeping quality of milk by inhibiting the growth of certain microorganisms.

The activated lactoperoxidase system exhibits:

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

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

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

Unit 2. Pasterization

Topic 1. 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

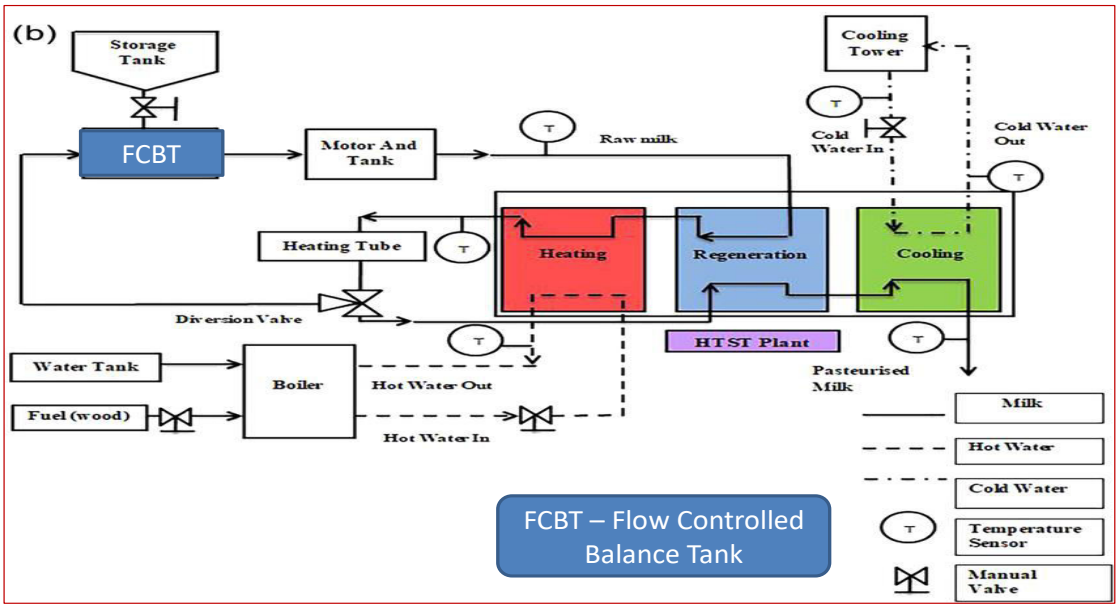
- ➔ **Cold raw milk** (4°C or 39.2°F) enters the pasteurization plant.
- ➔ The milk passes through the **regenerative heating section** of a plate heat exchanger. This section consists of stainless steel plates stacked together with spaces in between, forming chambers. Cold raw milk flows through the "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).

Topic 2 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.

Topic 3 Dairy microbiology

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

- ➔ When milk is drawn into a pail, the bacterial count increases significantly, reaching approximately **10,000 per ml**, compared to **500-1,000 per ml** in milk directly from the udder.
- ➔ The high temperature of freshly drawn milk, around **38°C (100.4°F)**, provides an ideal environment for bacterial growth.
- ➔ This temperature is within the optimal range for the proliferation of many types of bacteria commonly found in milk.
- ➔ To maintain the quality and safety of milk, it is essential to implement proper handling and storage practices, such as rapid cooling, to inhibit bacterial growth and minimize contamination.

Sources of Contamination

- ➔ **Interior of the udder:** bacterial count of milk varies between 500 and 1000/ml
- ➔ **Environmental:** bacteria accumulated on the surface of body get dislodged during the milking process and enter the pail contributing a load of 10,000 bacteria or more per ml. of milk
- ➔ **Milker or Handler**: typhoid fever, diphtheria, scarlet fever, septic sore throat
- ➔ Utensils
- ➔ Wholesaler, retailer and the vendor

➔ During transportation

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

Lactic acid Bacteria:

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

GRAS Status of LAB

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

Homofermentative vs Heterofermentative LAB

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

Specific Fermentations

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

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

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

milk curdles	**0.50 to 0.65%**

Ropiness Or Sliminess:

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

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

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

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

Sweet Curdling: curdling without pronounced acid production

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

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

- E.g. Pseudomonas

Gas forming bacterias: Coliaerogenus, Clostridium

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

Topic 4. Platform tests

➔ milk are essential quality assessments conducted primarily at milk collection centers and processing plants.

➔ These tests allow for the rapid evaluation of incoming raw milk to ensure it meets predetermined quality standards, which is crucial for maintaining the overall quality of milk products.

Types of Platform Tests

1. **Organoleptic Tests**: These are sensory evaluations where trained personnel assess the milk's appearance, smell, and taste. Observations include checking for cleanliness of containers, sediment, and any off-odors. This initial screening helps in identifying milk that may be spoiled or contaminated without the need for laboratory analysis.
2. **Clot on Boiling (COB) Test**: This test evaluates the heat stability of milk. A sample is heated, and if clotting occurs, it indicates that the milk is not suitable for processing due to high acidity or microbial contamination
3. **Alcohol Test**: This test checks the stability of milk proteins. A sample is mixed with alcohol,

and the formation of a clot indicates poor quality, suggesting the milk may spoil easily during processing.

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

5. **Alcohol-Alizarin Test:** The Alcohol-Alizarin test is similar to the Alcohol test but incorporates alizarin, a color indicator that changes based on the acidity level of the milk. After mixing milk with the ethanol solution, the color change can help determine the acidity level. This test provides a visual cue alongside the coagulation observation, making it a more informative method for assessing milk quality

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

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

Laboratory Tests:

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

Methylene Blue Reduction Test

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

Procedure

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

Interpretation of Results

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

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

Resazurin Reduction Test

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

Interpretation of Results

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

Standard Plate Count (SPC)

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

Key Features of Standard Plate Count

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

Procedure

➔ **Sample Preparation**: A diluted sample of milk is prepared to ensure that the number of colonies formed is countable.

➔ **Inoculation**: The diluted sample is spread on a suitable agar medium and incubated under specific conditions (usually at 30-37°C for 24-48 hours).

➔ **Counting Colonies**: After incubation, the colonies that develop on the agar plate are counted. Each colony is assumed to arise from a single viable microorganism in the original sample.

➔ **Calculating cfu/ml**: The number of colonies is multiplied by the dilution factor to calculate the concentration of viable microorganisms in the original sample, expressed as cfu/ml.

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

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

Direct Microscopic Count (DMC)

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

Key Features of Direct Microscopic Count

1. **Purpose:** The DMC provides a direct estimate of viable microbial growth in milk samples. It allows for the enumeration of bacterial clumps or somatic cells, which can be indicative of milk quality.
2. Procedure:

    - A small volume of milk (typically 0.01 mL) is spread over a defined area on a specialized slide (often a Petroff-Hausser counting chamber).
    - The slide is then stained using a reagent, such as the Levowitz-Weber (L-W) stain, which helps visualize the cells by dissolving the butterfat and staining the cells.
    - The sample is examined under a microscope, and the number of cells or clumps is counted in several fields of view.

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

Limitations:

- While the DMC can indicate the total number of bacteria, it does not differentiate between pathogenic and non-pathogenic organisms. Therefore, it may not provide a complete picture of milk safety.
- The method is also influenced by the presence of clumps, which can lead to underestimating the actual number of bacteria if they are not adequately dispersed.

Topic 5. 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

- Formulas- Richmond, Babcock, Fleischmann's

Unit 3 Milk Products

Topic 1 Concentrated Milk milk and Fermented milk
Topic 2. Cream,Butter,Ice cream,Cheese
Topic 3.Fermented Dairy Product and Desi Dairy Product
Topic 4.Defects in milk and milk products and Hazard Analysis and Critical Control Point (HACCP) System
Topic 5 Cleaning & Sanitation of Dairy plant and equipments and Milk-borne diseases:

Topic 1 Concentrated Milk milk and Fermented milk

- ➔ **Concentrated Milk**: A product obtained by evaporating part of the water from whole or skim milk, with or without the addition of sugar.
- ➔ **Condensed Milk**: Full cream sweetened milk that has had a portion of its water content removed and sugar added.
- ➔ **Evaporated Milk:** Full cream unsweetened milk that has been concentrated by evaporating about 60% of its water content.
- ➔ **Skimmed Milk Products**: Can be sweetened or unsweetened.
- ➔
- ➔ **Unsweetened Condensed Milk** - Equivalent to evaporated milk, which is concentrated without added sugar.

Concentration Ratios

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

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

Cane Sugar in sweetened milks: 40% (minimum)

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

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

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

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

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

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

- ➔ In spray drying, concentrated milk is atomized into fine droplets and dried by hot air, producing a fine milk powder.
- ➔ Roller drying involves applying a thin film of pre-concentrated milk onto heated rotating drums, where the milk forms a dry layer that is scraped off as powder.
- ➔ Spray drying is the more widely used method due to its ability to produce high-quality milk powders with good solubility and nutritional properties.

Fermented milk:

- ➔ **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)

Topic 2. Cream,Butter,Ice cream,Cheese

Cream

According to PFA 1976, minimum fat % - 25% (FSSR, 2011):

- ◆ Low fat cream: milk fat not less than 25.0 %
- ◆ Medium fat cream: not less than 40.0 %
- ◆ High fat cream: milk fat not less than 60.0 %

Classification:

based on end use

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

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

Cream can be separated by gravity method or centrifugal method.

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

Centrifugal Separation: In the centrifugal method of cream separation:

➔ **Skim Milk**: Moves to the **periphery** of the centrifuge.

➔ **Cream**: Collects in the **center**.

➔ **Cream Screw In**: Cream (higher fat content) is extracted from the center.
➔
➔ **Skim Milk Screw Out**: Skim milk (lower fat content) is removed from the outer edge.

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

➔ **Impact of Acidity**: High acidity in milk can precipitate casein, leading to clogging in the skimming bowl. This clogging decreases the efficiency of fat separation.

➔ **Homogenized Milk**: Skimming cannot effectively separate cream from homogenized milk due to the small size of fat globules and their stable dispersion.

Pasteurization Methods

➔ **LTLT (Low-Temperature, Long-Time)**: **Temperature**: 71°C for 20 minutes

➔ **HTST (High-Temperature, Short-Time)**: **Temperature**: 95-100°C for 5-16 seconds

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

Butter

- Balancing wheel of dairy industry
-
- Butter is defined under the Food Safety and Standards Regulations (FSSR) as a fatty product primarily composed of a **water-in-oil emulsion** derived exclusively from milk or milk products.

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 ºC.

Cheese

Cheese has been defined as a product made from the curd obtained from milk by coagulating the casein with the help of rennet or similar enzymes in the presence of lactic acid produced by added or adventitious microorganisms, from which part of the moisture has been removed by cutting and /or pressing which has been shaped in a mould, and then ripened by holding it at some time at suitable temperature and humidity.

Types of Cheese Based on Moisture Content

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

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

➔ 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.

Topic 3.Fermented Dairy Product and Desi Dairy Product

1.Yoghurt

Fat and Total Solids Content

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

Starter Cultures

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

Incubation Temperature

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

Fermentation Time

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

Dahi/ Curd:

- ➔ Sweet Dahi with acidity < 0.7%
- ➔ Sour Dahi with acidity around 1%
- ➔ Sweetened Dahi: by adding 6.25% cane sugar

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

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

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

Sweetened Dahi: Misti Dahi or Lal Dahi:

- ➔ is a popular sweetened yogurt from the eastern region of India, particularly Bengal.
- ➔ This traditional dessert is characterized by its brown color and cooked, caramelized flavor, making it a favorite among many.
- **Color and Flavor**: Misti Dahi has a distinctive brown color due to the caramelization of sugar, which also imparts a cooked, rich flavor to the yogurt.
- **Sugar Content**: The recipe typically involves the addition of **6.25% cane sugar**, which contributes to its sweetness and enhances the overall taste.

Shrikhand:

- ➔ sweetened-dewatered dahi.
- ➔ This product is extremely popular Western and some parts of Southern India inoculated with culture containing **Str. lactis subsp. lactis and Lactococcus Lactis var. diacetilactis**
- Minimum fat % 8.5 and total solids 58% ; Titrable acidity not more than 1.4%

Indian Dairy product	Western counterpart

Kheer/ Basundi	Condensed milk
Khoa	Evaporated milk
Rabri	Clotted cream
Kulfi	Ice cream
Ghee	Butter oil
Lassi	Butter milk
Channa	Lactic coagulated green cheese
Paneer	Soft cheese

- ➔ 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

Milk by products

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

Curd	lassi

Packaging material for milk and milk poducts

Product	**Packaging Material**
Liquid milk	Glass bottles (obsolete) LDPE film Paper laminates for tetra packs
Milk Powder	Tin plate containers, nitrogen packed, and lacquered from outside. Flexible laminates such as metallized PET / BOPP / Aluminium foil / Poly laminates. Refill packs; lined cartons laminated with BOPP / PET, varnished on the outside. Bag-in-box; Powder filled in laminate and packed in cartons.
Butter	Duplex board with vegetable parchment paper Tin plate containers Aluminium foil
Cheese / Cheese spread	Tin plate containers lacquered from inside First packed in aluminium foil and then in duplex board carton Injection moulded PP / HDPE container
Ghee	Tin plate containers lacquered from inside Glass bottles HDPE film pouches
Ice cream	Thermoformed / Injection moulded plastic containers Duplex board carton (poly laminated) Laminates of BOPP (Biaxially Oriented Polypropylene) / PET
Indian Dairy Products	Injection moulded / thermoformed containers (shrikhand, gulab jamun) Stand up laminated pouches

APPENDIX

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

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

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

NS : Not specified

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

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

Bacteriological standards of cream (IS-3509-1966)

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

Bacteriological standards of butter (IS-3507-1966)

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

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

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

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

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

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

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

Bacteriological standards of indigenous dairy products.

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

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

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

Topic 4.Defects in milk and milk products and Hazard Analysis and Critical Control Point (HACCP) System

Flavor Profiles in Milk

1. **Bitty Flavor**: Caused by proteolytic microorganisms, particularly *Bacillus spp.* and *Pseudomonas spp.* These bacteria produce enzymes that break down proteins, leading to off-flavors.

2. **Potato Flavor**: Resulting from *Pseudomonas mucidolens* and *Pseudomonas graveolens*, these bacteria contribute to a flavor reminiscent of potatoes.

3. **Cooked Flavor**: Associated with the presence of sulfhydryl compounds, this flavor typically arises from overheating during processing.

4. **Cowy Flavor**: This flavor is linked to ketosis in dairy animals, primarily due to the presence of acetone, which imparts a distinct taste.
5. **Barny Flavor**: Often a result of poor ventilation during storage or processing, leading to a flavor reminiscent of barnyard conditions.
6. **Malty Flavor**: Caused by *Streptococcus lactis var. maltigenes*, this flavor adds a sweet, malt-like characteristic to the milk.
7. **Phenolic Flavor**: Associated with *Bacillus circulans*, this flavor can impart a medicinal or phenolic taste to the milk.
8. **Unclean Flavor**: Resulting from contamination with *E. coli*, this flavor indicates poor hygiene practices during milk handling and processing

Defects in Cream:

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

  i. Using sour milk for separation

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

Defects in Butter:

➔ **Gritty** - Undissolved coarse salt, incorrect salting

➔ **Grainy -** Incorrect neutralization of high acid cream with lime

➔ *Yeasty flavour and odour*: fermentation of the cream by Torula Cremoris and Torula sphaerica

➔ **Fishy flavor** - Hydrolysis of phospholipid to form trimethylamine is one of the reasons attributed for the 'fishy' flavor defect in butter

- ➔ **Skunk like odor**- P. mephitica
- ➔ **Apple taint** – P. fluroscrns

Defects in Ghee:

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

Defects in KHOA:

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

Defects in Cheese:

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

Hazard Analysis and Critical Control Point (HACCP) System -

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

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

The seven principles of a HACCP System are-

1. Analyze hazards

2.Determine critical control points

3.Establish limits for critical control points

4.Establish monitoring procedures for critical control points

5.Establish corrective actions

6.Establish verification procedures

7.Establish a record system

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

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

- Prevention of Food Adulteration (PFA) Act (1954) and Rules (1955)
- Agricultural and Processed Food Products Export Development Authority (APEDA) - Indian Apex-Export Trade Promotion Active government body
- Bureau of Indian Standards (BIS) – 1986
- AGMARK: Enforced by the Agricultural Produce (Grading and Marketing) Act, 1937 under Directorate of Marketing and Inspection (DMI)
- MILK AND MILK PRODUCT ORDER – 1992

Topic 5 Cleaning & Sanitation of Dairy plant and equipments and Milk-borne diseases:

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

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

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

- ➔ Some of the precipitates remains intact to equipment after cleaning and forms a film over equipment surface called **water stone**
- ➔ Heat denaturation of protein present on the equipment surface or absorbed by other components forms **milk stone** quickly over heated surfaces
- ➔ Milk stone – dried milk solids and salts from hard water and washing solution

cleaning modes - Manual, COP, CIP

Cleaning agents/ detergents:

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

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

Choice of detergents in organized dairies

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

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

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

Milk-borne diseases:

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

Bacterial Diseases –

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

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

Rickettsial disease- Q fever - Coxiella burnetti

Fungal intoxication - Aflatoxicosis - Aspergillus flavus

Viral Diseases

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

Parasitic diseases – Toxoplasmosis, Giardiasis

Milk borne toxi infections

- Bacillus cereus poisoning
- Clostridium perfringens poisoning

Milk borne intoxication:

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

Unit 4.Introduction to meat technology

Topic 1. Prospects of meat industry in India and Nutritional Composition of Meat
Topic 2. Structure and composition of muscle tissue and Conversion of Muscle to Meat
Topic 3. Rigor Mortis
Topic 4 Abattoir and Slaughter
Topic 5 Ante-mortem inspection and Post-mortem inspection of meat animal

Topic 1. Prospects of meat industry in India and Nutritional Composition of Meat

- **Per Capita Consumption**: The National Institute of Nutrition recommends a per capita consumption of **180 eggs** and **11 kg of meat** annually. Currently, the availability is **101 eggs** and **7.1 kg of meat**, indicating a gap that presents opportunities for growth.
- **Production Rankings**: India ranks **8th in meat production** globally and **3rd in egg production**, with Uttar Pradesh being the top meat-producing state and Andhra Pradesh leading in egg production.
- **Livestock Contribution**: Livestock contributes **5.73%** to the total Gross Value Added (GVA) and **30.19%** to the agricultural sector, highlighting its economic significance.
- **Meat Types**: Poultry is the main sector, contributing **51%** to total meat production. Buffalo meat accounts for **82%** of total meat exports from India.
- **Infrastructure**: There are approximately **3,900 licensed slaughterhouses** and around **26,000 unauthorized ones**. Additionally, there are **73 registered abattoirs** for meat processing aimed at export.

Growth Potential

➔ **Market Growth**: The meat industry is growing at a compound annual growth rate (CAGR) of **6%**, fueled by rising urbanization, increasing disposable incomes, and changing dietary preferences.

➔ **Employment**: The livestock sector provides livelihoods for about **20.5 million people** and contributes significantly to the income of rural households.

➔ **Export Opportunities**: India has a strong export potential, particularly in buffalo meat, although challenges such as disease management and competition exists.

➔ **Research and Development**: The National Research Centre on Meat in Hyderabad plays a crucial role in advancing meat production technologies and practices.

Meat of different animals:

- ➔ Goat: Chevon
- ➔ Sheep: Mutton
- ➔ Deer (game animals): Venison
- ➔ Pig: Pork
- ➔ Cattle: Beef
- ➔ Horse: Chevaline
- ➔ Buffalo: Carabeef
- ➔ Calf: Veal
- ➔ Bobby calves: calves slaughtered within a few days of birth

Nutritional Composition of Meat

- ➔ Water Content: Approximately 75% of meat is water.
- ➔ Protein: Ranges from 16-22%, with an average of 18.5% and contains all essential amino acids, with lysine being the most abundant.
- ➔ Fat: About 3% of meat.
    - ◆ Lipids: The most abundant fatty acids are:
        - Oleic acid
        - Palmitic acid
        - Stearic acid
- ➔ **Cholesterol:** Lean meat contains 70-75 mg of cholesterol per 100 g, while organ meats like liver and brain can have 300-2000 mg per 100 g.
- ➔ **Carbohydrates:** Less than 1%, primarily in the form of glycogen.
- ➔ **Energy**: Broiler meat provides **151 calories per 100 g**.
- ➔ **Minerals**: Meat contains about **1%** minerals. It is a good source of most minerals except calcium. The highest mineral content is **potassium (K)**, followed by **phosphorus (P)**.
- ➔ **Vitamins**: Meat is a good source of **B complex vitamins** but a poor source of **vitamin C**, which is absent in lean meat.
- ➔ **Lean Pork**: Provides **5-10 times more thiamine (vitamin B1)** than other meats.

Nutritional Contribution per 100 g Serving

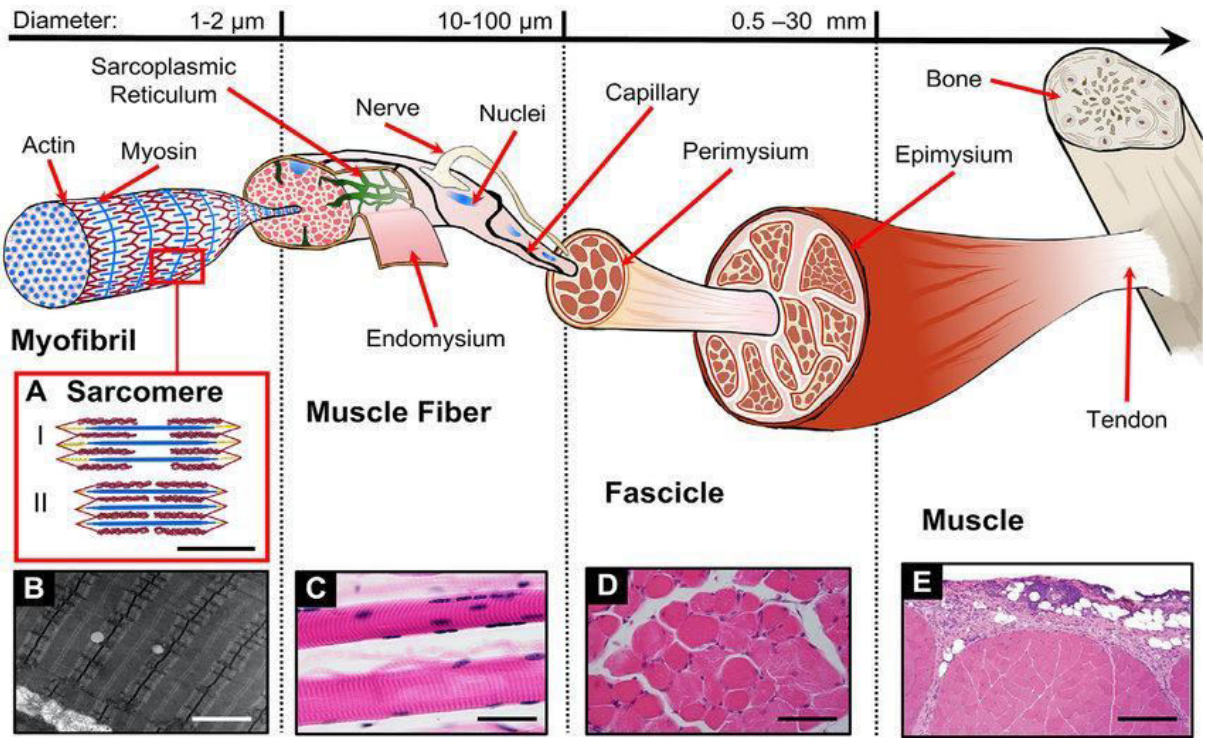
- ➔ **Calories**: A 100 g serving of meat supplies about **10%** of the recommended daily allowance (RDA) of calories.
- ➔ **Protein**: The same serving provides about **50%** of the RDA of proteins, assuming an RDA of 56 g (0.8 g/kg body weight).
- ➔ **Iron**: A 100 g serving of meat (except liver) supplies about **35%** of the iron demand. If the serving is liver, it can provide **100%** of the iron demand.
- ➔ **B Complex Vitamins**: A 100 g serving of meat can provide **25-60%** of the RDA for B complex vitamins.

Topic 2. Structure and composition of muscle tissue and Conversion of Muscle to Meat

- ➔ **Muscle**: **Skeletal Muscles**: Constitute **35% to 65%** of the carcass and are covered with connective tissue.
- ➔ **Connective Tissue**: Comprises adipose tissue, cartilage, bone, and connective tissue proper.
- ➔ **Nervous Tissue**: Present within the meat structure.
- ➔ **Epithelial Tissue**: Also found in meat.

Structure of Skeletal Muscle

- **Connective Tissue Coverings**:
  - **Epimysium**: The outermost layer surrounding the entire muscle.
  - **Perimysium**: Surrounds muscle bundles (fascicles).
  - **Endomysium**: Covers individual muscle fibers.
- **Muscle Fiber**:
  - Specialized cells that are the structural units of muscle, forming **75-92%** of total muscle volume.
  - Diameter ranges from **10 to 100 microns**.
- **Sarcolemma**: The membrane that surrounds each muscle fiber.
- **Sarcomere**: The basic contractile unit of muscle fibers, responsible for muscle contraction.



- ➔ T- tubules/T systems/transverse tubules: These are deep invaginations of sarcolemma. In skeletal muscle T tubule invaginations are typically located at the junction of A-I band of sarcomere. Thus a sarcomere has two T tubules.
- ➔ Sarcoplasm: It is the cytoplasm of muscle fibre. Sarcoplasmic reticulum (SR)- as reservoir for calcium ions
- ➔ **Nuclei:** Muscle fibres are multinucleated.

Myofibrils:

These are long, thin, cylindrical rods with diameter of 1 to 2 microns. They contain some filaments known as myofilaments which are called thick and thin myofilaments (striated appearance).

- ➔ **Thick filaments** (myosin): form A band which is broad dark band and bisected by M line.
- ➔ **Thin filaments** (actin): forms I band which is bisected by Z line.
- ➔ H zone: Contains only myosin filaments.
- ➔ Sarcomere: unit of myofibril between two adjacent Z-lines. Include A band and 2 half I bands.
- ➔ In transverse section, each myosin filament is surrounded by six actin filaments in hexagonal arrangement.

Proteins of myofilaments:

- Myofibrillar proteins: 11.5% - soluble in concentrated salt solution

  E.g. Myosin, Actin, Tropomyosin

- Sarcoplasmic Proteins: soluble in water and dilute salt solutions

  E.g. myoglobin, glycolytic enzymes

- Connective tissue proteins: Insoluble

  E.g. collagen, elastin, reticulin

Myosin: most abundant myofibrillar protein (50-55%)

- Ratio of length to diameter is 190:1.
- Strong affinity for Ca and Mg ions – ATPase activity stimulated by Ca and inhibited by Mg

Actin: 20-25%. G(globular) and F(fibrous) actin

Tropomyosin: 8-10% of myofibrillar proteins.

Troponin: 3 subunits

- ➔ **Troponin T:** binds to tropomyosin and troponin C
- ➔ **Troponin C**: binds with Ca ions
- ➔ **Troponin I:** inhibits acto-myosin ATPase complex

Connective tissue protein: collagen (rich in hydroxyproline & Proline but poor in lysine), elastin (desmosine & iso-desmosine) and reticulin.

Myoglobin: It is a Sarcoplasmic protein which gives red colour to muscle. Its content will be higher in red muscle fibre and low in white. It acts as carrier of oxygen to muscle fibre

- Oxymyoglobin: cherry red colour
- Metmyoglobin: Brownish red colour

Conversion of Muscle to Meat

- ✓ Conversion of Muscle to Meat – a series of biochemical events following sticking, culminating in resolution of rigor.
- ✓ Exsanguination leads to immediate loss of oxygen supply to the muscle, decreasing oxidation reduction potential, resulting in cytochrome system, thus ETC and TCA cycle inhibition.
- ✓ Depletion of creatinine phosphate soon follows.
- ✓ Hence, ATP re-phosphorylation aerobically ceases.

- ✓ Hence anaerobic glycolysis commences, lactic acid accumulation follows. Decline in pH follows suit.
- ✓ Resynthesis of ATP anaerobically inadequate to prevent actin-myosin formation.
- ✓ Onset of rigor

Cardinal changes in Conversion of Muscle to Meat

- ✓ Loss of Homeostasis
- ✓ Post-mortem glycolysis and pH decline
- ✓ Rigor Mortis
- ✓ Loss of Protection from Invading Microorganisms
- ✓ Degradation due to proteolytic enzymes
- ✓ Loss of Structural Integrity
- ✓ Thus the conversion of muscle to meat is a culmination of the above biochemical changes and ultimately the resolution of rigor mortis.

Loss of Homeostasis:

- ✓ Homeostasis mechanism, a system for the physiologically balanced internal environment which helps the body to cope up with the stresses of oxygen deficiency, extreme variation in temperature, energy supply, etc., is lost.
- ✓ The homeostasis is controlled by nervous system, which ceases to function within 4-6 minutes after bleeding.
- ✓ In the absence of blood supply, there is loss of body heat and temperature starts declining.

Decline in pH:

- ✓ In the absence of oxygen, anaerobic glycolysis leads to the formation of lactic acid, and thus decrease in pH.
- ✓ Rate and extent of pH decline influenced by species of food animal, various pre-slaughter factors environmental temperature, etc.
- ✓ pH drop steady in the first 5-7 hours, followed by little decrease in the next 15-20 hours to ultimate ph. (5.5 - 5.7 from 6.8 -7.2)

- ✓ The rate of pH decline is enhanced at high environmental temperature. A low ultimate pH is desired to have a check on the proliferating micro-organisms during storage.
- ✓ A sharp decline in post-mortem pH even before the dissipation of body heat through carcass chilling – PSE
- ✓ Contrary to this, muscles which maintain a consistently high pH during post-mortem conversion to meat - DFD

Topic 3. Rigor Mortis

- ➔ Stiffening of muscles after death
- ➔ ATP complexed with Mg++ at certain concentration required for breaking the actomyosin bond for relaxation of muscle
- ➔ ATP concentration decreases, permanent actomyosin cross bridges begin to form.
- ➔ Muscle gradually becomes less and less extensible under an externally applied force. This is delayed phase of rigor mortis
- ➔ Then actomyosin formation picks up and the muscle begins to loose extensibility rapidly. This phase is called the fast or onset phase of rigor mortis.
- ➔ When all the creatine phosphate (CP) is depleted, ADP can no longer be phosphorylated to ATP, muscle becomes quite inextensible and stiff.
- ➔ This stage marks the completion of rigor mortis

Stages of rigor mortis:

- ➔ **Delayed phase:** plenty of ATP in the muscle (complexed with Mg2+), the muscle remains in the relaxed state
- ➔ **Onset phase:** After the depletion of muscle glycogen, ATP level is maintained from rephosphorylation of adenosine diphosphate (ADP) by creatine phosphate (CP).
- ➔ **Completion phase:** No remaining creatine phosphate or glycogen for energy development. Actomyosin bond is formed from the permanent cross bridges of actin and myosin

Pattern of Rigor Mortis

- Begins in muscles of jaw neck downwards body trunk and extremities
- Time duration: Depend upon species, animal, post slaughter condition, physiological conditions and muscle
- Temperature (rapid at high temperatures than at low);

- pH of meat

  DFD → high pH→ minimal glycogen→ minimal re-synthesis of ATP

  PSE → low pH → LA → rapid consumption of ATP

- **Beef and lamb:** 6-12 hr after slaughter
- **Pork:** 5 min – 3 hr
- **Poultry:** 5 min – 1 hr

Factors affecting Rigor:

- **Species of animal**: The onset of rigor is faster in animals that are more active. It is faster in horses and cattle than pigs.
- **Type of muscle:** Active and well nourished muscles undergo rigor first.
- **Glycogen content:** Glycogen content is directly proportional to the fall in pH and the onset of rigor mortis. Higher glycogen content leads to more formation of lactic acid and a marked fall in pH. The low pH helps in maintaining the rigor for a long time. Maintenance of rigor for long is good for meat.
- **Initial level of ATP and creatinine phosphate:** In healthy animals the initial level of ATP is high therefore there is a delay in the onset of rigor. Creatinine phosphate is responsible for the synthesis of ATP from ADP therefore its level also affect the onset.
- **Atmospheric temperature:** High temperature is responsible for early onset and low temperature for delay in rigor. Therefore rigor is fast in summers and delayed in winters.

Loss of Protection against Invading Micro-organisms:

✓ During post-mortem period, body defense mechanism stops operating and membrane properties are altered.

✓ So, during conversion to meat, muscle is quite susceptible to invading micro-organisms.

✓ Except for low pH, most of the other post-mortem changes favour bacterial growth.

✓ Hence, utmost handling precautions are necessary to prevent contamination of meat.

Degradation due to proteolytic enzymes

✓ Several autolytic lysosomal enzymes called cathepsins, which remain inactive in a living muscle tissue, are activated as the muscle pH declines.

✓ These enzymes initiate the degradation of muscle protein structure.

✓ Cathepsin – B,D,H, L

- ✓ Calcium activated Sarcoplasmic factors (CASF)/ Calpains: enzymes activated by calcium and act above pH of 6 causing tenderization and important for tenderization
- ✓ Calstatin – antagonist of calpains

Loss of Structural Integrity

- ➔ Post-mortem alteration of membrane properties initiates the degradation of muscular proteins.
- ➔ There is a progressive disruption of myofibrillar structure.
- ➔ The resolution of rigor mortis is reported to occur due to disintegration of Z-line structure.
- ➔ A rapid decline in muscle pH also causes denaturation of collagenous connective tissue.

Ageing/ ripening/ Conditioning

- ✓ Ageing - the holding of carcasses just above its freezing point so as to obviate microbial spoilage and accompanied by an enhancement in tenderness and flavour of meat.
- ✓ The enhancement in flavour is mainly attributed to inosine (inosine monophosphate), a breakdown product of ATP(adenosine monophosphate).
- ✓ The breakdown of protein and fat during ageing resulting in formation of hydrogen sulphide, ammonia, acetaldehyde, acetone and diacetyl.
- ✓ An increase in free amino acids also adds to the development of characteristic meat flavour.
- ✓ The improvement in tenderness is on account of the subtle proteolysis that take place in the cytoskeletal proteins.
- ✓ Ageing period in different species of food animals
  Cattle : 14 days
  Sheep and Goats : 7 days
  Pigs : 5 days
  Chicken : 2 days

Topic 4 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:

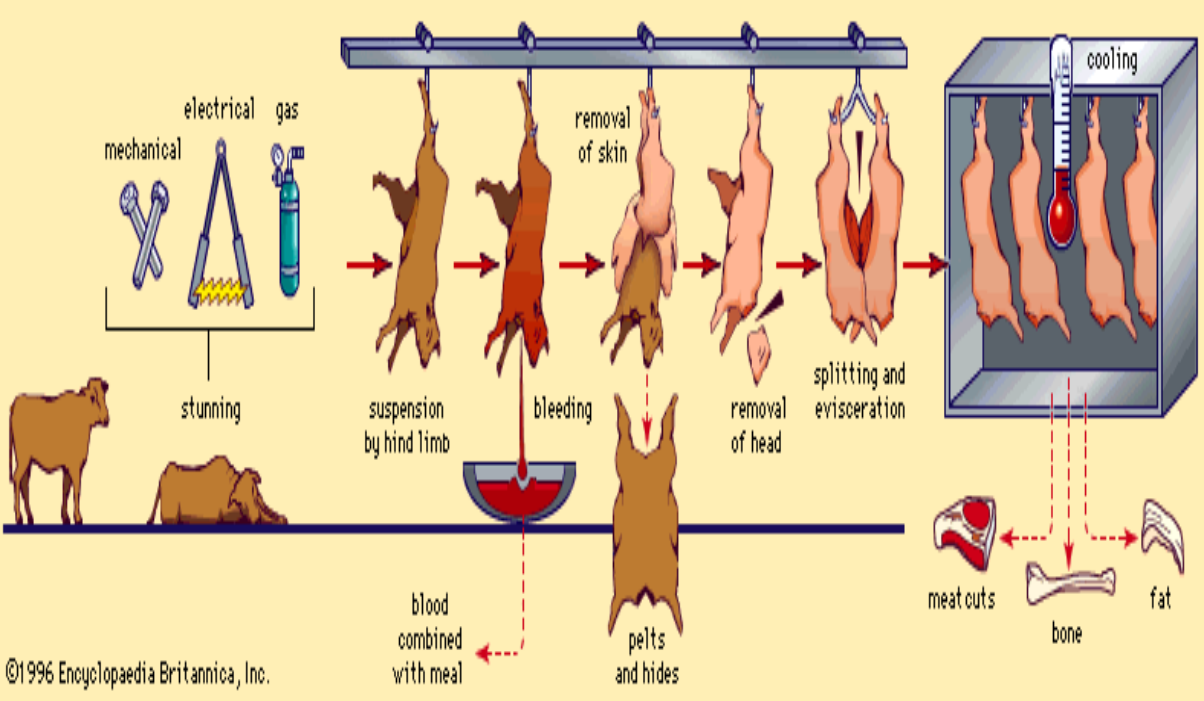
- ➢ carcass is suspended over a spreader(gambrel) and trolley
- ➢ moved mechanically on a level rails at an intervals by means of variable timing device
- ➢ Slaughter rate - 10-75 animals/hr

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^{o}
- 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 -1.5ºC to 4.5ºC.
- ➔ 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 30º.

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.

PSE and DFD meat:

Normal condition:

During Post-mortem glycolysis: Glycogen→ Lactic acid → lowering of muscle pH → 5.4 -5.6 (normal) → decreased enzyme activity → O_2 available for oxymyoglobin → attractive red color of meat

Stressed condition:

DFD: Dark Firm Dry meat → Dark cutting meat : Glycogen depleted- less Lactic acid → muscle pH → 6.5 – 6.8 → more Enz. Activity → O_2 consumption→ No oxymyoglobin formation

: Natural muscle water is tightly bound to proteins

: muscles are darker, firm and drier than normal

: Most common in cattle/ young bulls.

: Meat is fit for consumption but, less attractive, flavor and keeping quality

PSE: Pale Soft Exudative meat Watery pork

Rapid post-mortem Glycolysis high Lactic acid rapid fall in pH when the carcass is still hot pH 5.5 wit in 1 hr of death and 35°C.

Denaturation of proteins loss of protein solubility loss of water holding capacity loss of muscle pigment

: Pale, watery and unattractive

: mostly in Pork/ pigs

: Legs and loin area commonly affected

- *n* allele of the *RYR1* (ryanodine receptor gene) is the primary genetic factor responsible for the fast rate of postmortem pH decline in stress susceptible pigs, leading to the PSE meat defect. (nn More susceptible for PSE)

Religious/Ritual method of slaughter

➔ Slaughtering of animals while they are conscious

➔ based on tenets of a particular religion

➔ Animals are not stunned prior to slaughter.

➔ Most religion regard it as offering to god, therefore most pious and religious matter to them

Methods:

1. Jatkha Method/Hindu/Sikh Method
2. Jewish Method/Kosher Method
3. Halal/Muslim Method
4. Neck stab or evernazione method

Jatka Method/Hindu/Sikh Method:

- Followed by Sikhs and Hindu.
- Animals are decapitated by one stroke with a sword/axe.
- This kills animal immediately because the spinal cord is severed, and blood flow to the brain is stopped almost instantly, causing brain death within seconds.

- Less painful to the animal than other methods religious methods. Efficiency of bleeding is not good.

Halal Method: Muslim Method

- flesh of dead animals, blood, flesh of pig forbidden to eat
- Head of animal: turned towards Macca.Transverse and parallel to throat incision
- Zibah: killing an animal for the sole purpose of making its meat fit for human consumption.
- Cut esophagus/trachea/jugular vein without damaging spinal cord Complete bleeding Good quality meat.

- Requirements:
  - ➔ The animal should be healthy and without injuries.
  - ➔ The animal should be treated with respect and sympathy.
  - ➔ No animal should see another animal die.
  - ➔ The slaughter should be done by a practicing Muslim.
  - ➔ A blessing should be given before the cut

Jewish/Kosher Method

- **Shechita**: act of killing
- **Shochet:** person who performs Shechita/killing
- **Shomer:** assistant put Kosher mark on brisket and edible offal
- **Chalef:** knife used (twice the width of animal neck)
- **Kosher Meat**: Meat fit for Jewish consumption
- **Terefa/Treyf**: unfit meat
- **Talmud**: body of Jewish law which specifies ritual method.
- **Kashrut:** body of Jewish law dealing with what meat can or cannot be eaten certification for meat
- **Porging:** removed of major blood vessels of carcass fit for consumption prior to sale (mainly hindquarter).
- **Five rules:** neck incision shall be completed without pause, pressure, stabbing, slanting and tearing.

- Shochet carries out PM examination by making an incision to Xyphoid process to detect adhesions in thoracic cavity.
- **According to Kashrut:** eat animal that has cloven hooves and chews cud.
- Meat of birds cannot be eaten with dairy.
- **Camel and pig:** are not Kosher.
- **Diseased animal:** forbidden.
- Animal must be alive at the time of slaughter.
- Consumption of blood, spleen, heart, liver : prohibited.
- Animals that lie quietly and cannot rise must not be slaughtered according to Jewish ritual.

Other traditional methods:

- **The Evernazione/ neck –** stab method: Spain, Italy, Mexico
- Cattle are slaughtered by neck-stab with a double edged knife (puntilla) plunged into the occipito-atlantal space: severing medulla oblongata

Humane slaughter of meat animals

- Humane slaughtering To prevent cruelty to animals in slaughter house Stunning unconsciousness
- Stunning: process of making animals unconscious prior to slaughter to make the killing painless, without adverse effects on condition of meat/offal.

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	• Bilateral carotid arteries & jugular vein by incision across throat caudal to larynx • 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

Topic 5 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.

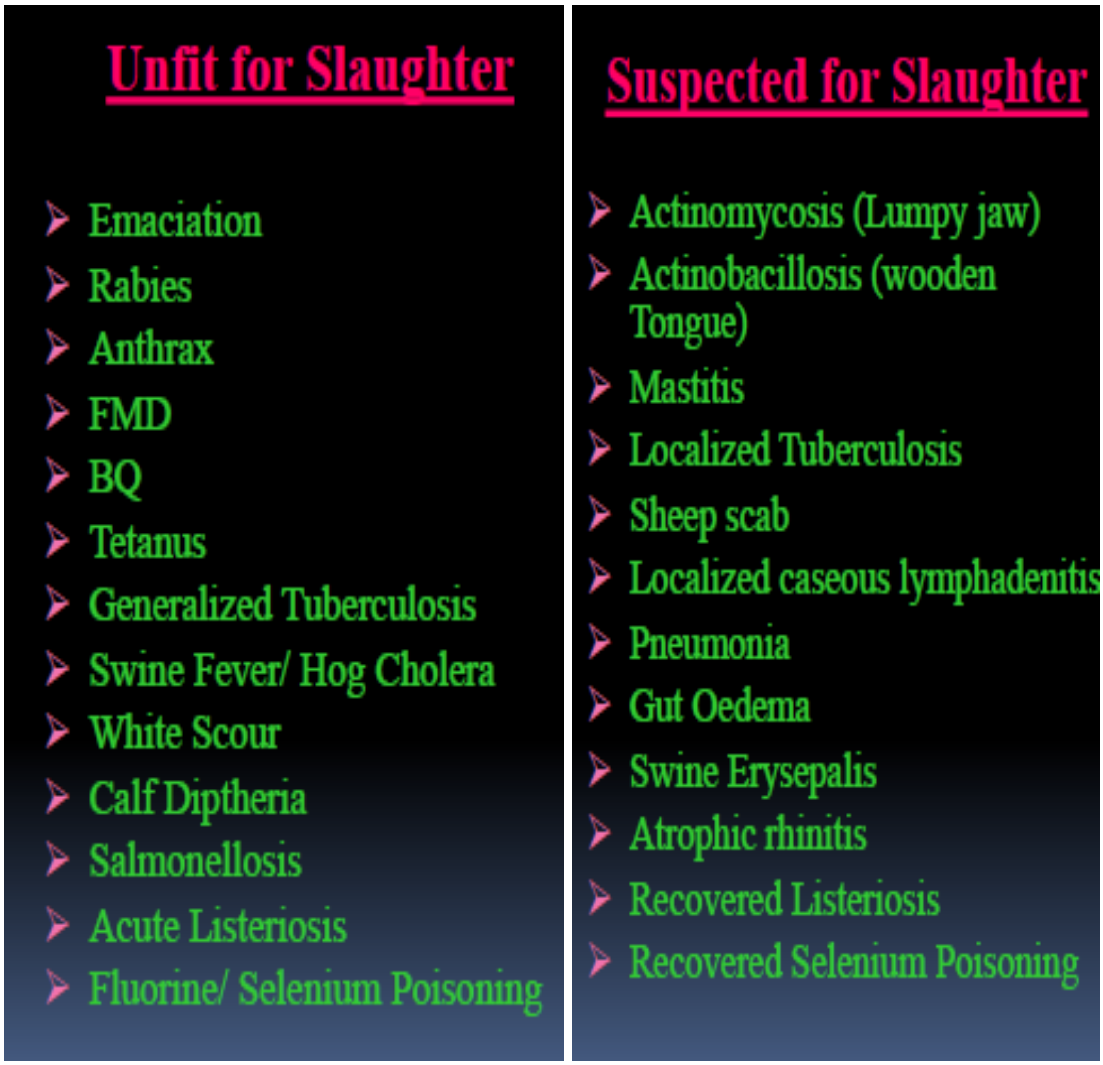
2. **Unfit/ Discard/ Condemned:** unsafe for consumption.

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

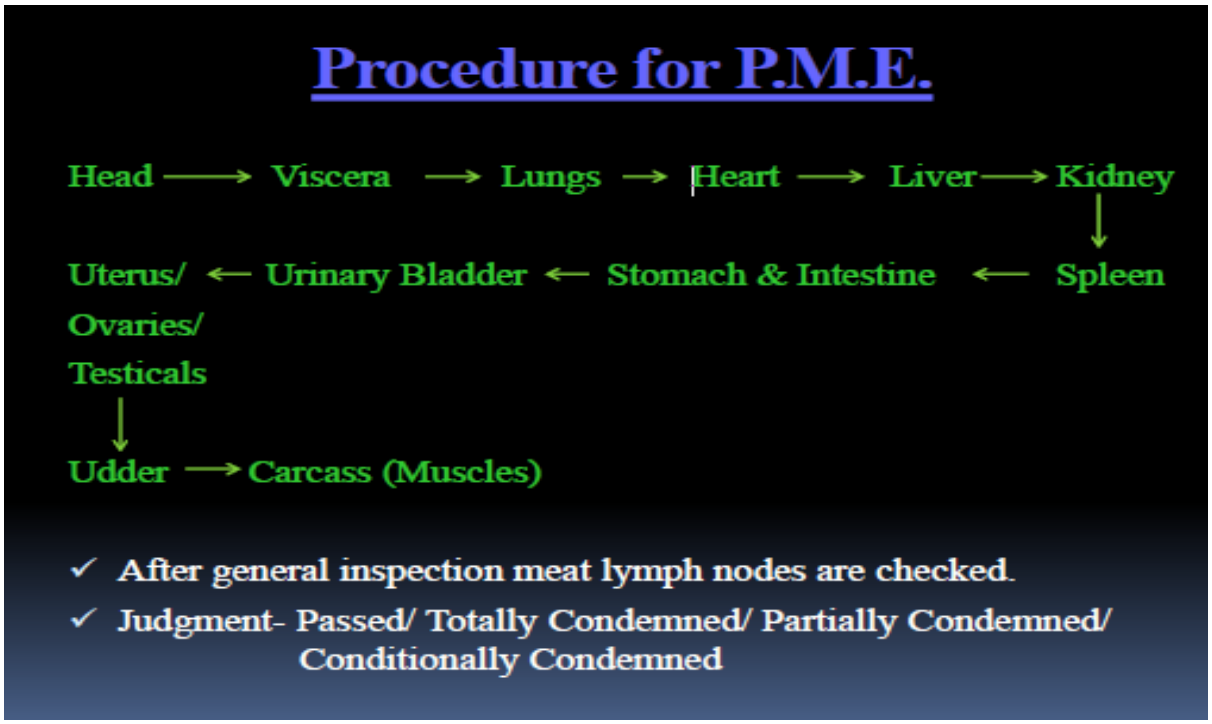
6. **Emergency slaughter:** This is required when the animal is in acute pain or suffering from a condition in which delay may cause distress to the animal. Such meat does not have any harmful effect on human health.



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

Unit 5 Meat Products

Topic 1. Poultry slaughtering and Food Preparation
Topic 2. Meat packaging,Casings,Meat byproduct
Topic 3.Carcass disposal, Quality Evaluation of Meat Products and Evaluation of Carcass
Topic 4. Meat spoilage and Fraudulent substitution/ adulteration of meat
Topic 5. Abattoir Effluent Treatment,Standards in meat industry and Meat borne diseases

Topic 1. Poultry slaughtering and Food Preparation

Pre-Slaughter Resting

- Animals should be rested for a minimum of 4 hours and not exceeding 12 hours before slaughter. This resting period is essential to reduce stress and improve meat quality.
- During this time, animals should be off feed for at least 4 hours, but not more than 12 hours, while fresh water is allowed to keep them hydrated.

Shackling: The birds are shackled by the hock joint, which is a common practice to prepare them for stunning and subsequent processing. Proper handling during shackling is crucial to minimize stress and injury to the animals.

Stunning: Stunning is performed primarily using electrical methods, applying a current of 120 mA. Alternatively, gas stunning can be employed, using either 90% argon alone or a mixture of 25-30% CO2 and 60% argon. These methods are designed to render the animals unconscious before slaughter, thereby reducing suffering.

Bleeding: After stunning, the bleeding process is initiated. For chickens, this process typically lasts about 1.5 minutes, while for turkeys, it takes approximately 2 minutes. Effective bleeding is vital for meat quality and hygiene, as it helps to remove blood from the carcass

Scalding: Scalding is performed using either water or spray methods, which are hygienic but can be costly. Two types of scalding are utilized:

- **Soft Scalding**: Water temperature is maintained at 50-51°C for 3-3.5 minutes.
- **Hard Scalding**: Water temperature is set at 56-58°C for 2-2.5 minutes.

The choice of scalding method affects the ease of defeathering and overall meat quality.

Defeathering: Defeathering is achieved using plucking machines, with wax stripping being an alternative method specifically for ducks. This step is critical for preparing the carcass for further processing.

Washing and Post-Mortem Examination: After defeathering, the carcasses are washed to remove any contaminants. A post-mortem examination is conducted to ensure the meat's safety and quality. This examination assesses both the carcass and the edible and inedible parts, including offal separation.

Edible Viscera: The edible viscera, commonly referred to as giblets, include the heart, liver, and gizzard. These parts are often processed and sold alongside the carcass, contributing to overall meat utilization and reducing waste.

Meat storage & preservation:

Aim: inhibition of microbial, enzymatic activities to maintain quality of meat

- ➔ 3 methods:
- ➔ Temperature control
- ➔ Moisture control
- ➔ Direct microbial inhibition.

Preservation by Moisture Control

- ➔ Drying
- ➔ Intermediate Moisture Foods
- ➔ Freeze Drying or Lyophilisation
- ➔ Salting
- ➔ Curing and smoking

Preservation by Temperature Control

- ➔ Preservation by Low Temperature
- ➔ Chilling
- ➔ Freezing

Preservation by High Temperature

- ◆ Canning
- ◆ Preservation by Direct Microbial Inhibition
- ◆ Irradiation
- ◆ Antibiotics
- ◆ Chemicals

Factors Influencing Growth Of Microorganism

Moisture Content and Water Activity (aw)

- **Moisture Content:** This refers to the amount of water present in a food product, expressed as a percentage of the total weight.
- **Water Activity (aw)**: This is a measure of the availability of water for microbial growth in food. It is expressed on a scale from 0 to 1, with pure water having an aw of 1.0.

Importance of Water Activity

- Water activity is a critical factor influencing the growth of microorganisms.
- Different types of bacteria, yeasts, and molds have specific water activity requirements for growth:

Microbial Growth and Water Activity

Pathogenic Bacteria

- **General Requirement:** Most spoilage and pathogenic bacteria, including common pathogens found in meat, require an aw of greater than 0.9 to grow effectively.
- **Staphylococcus aureus:** This is one of the most tolerant bacteria, capable of growing at an aw of 0.86. This characteristic makes it particularly concerning in food safety, especially in improperly stored or handled foods.

Spoilage Microorganisms

- **Spoilage Yeasts**: These organisms typically require an aw of 0.88. Yeasts can lead to fermentation and off-flavors in food products.
- **Spoilage Molds:** Molds generally require a lower aw of 0.80 to grow. They can spoil food and produce mycotoxins, which are harmful to human health.

Shelf Stability through Reduced Water Activity

- **Dried Foods**:
  - ➔ If foods are dried to a final aw of 0.60 or lower, they become shelf-stable.
  - ➔ At this level of water activity, the growth of spoilage and pathogenic microorganisms is significantly inhibited, allowing for extended shelf life without refrigeration.

PRINCIPLES OF FOOD PRESERVATION

Preservation or delay of microbial decomposition

- By keeping out microorganisms (asepsis)
- By removal of microorganisms e.g. by filtration.
- By hindering the growth and activity of microorganisms e.g. bylow temperature, drying, anaerobic conditions or chemicals.
- By killing the microorganisms e.g. by heating or irradiation.

Preservation or delay of self-decomposition of the foods

- By destruction or inactivation of food enzymes e.g. by blanching.
- By prevention or delay or purely chemical reactions e.g. prevention of oxidation by means of an antioxidant.

PRESERVATION BY LOW TEMPERATURE

- The failure of bacteria to grow at or below freezing depends mainly on the removal of the available water as ice; about 70% is removed at 3.5°C and 94% at –10°C.
- The surface growth of mould on meat is controlled not only by the temperature but also by the relative humidity of the atmosphere.
- For the prevention of mould, the temperature and relative humidity must therefore be kept as low as possible.

CHILLING

➔ Holding of meat above freezing point

➔ Method of short-term preservation

➔ Initial chilling of warm carcasses, sides, or quarters is carried at 7°C and offals at 3 °C

➔ mean air speed of 0.75m/s

➔ while in the terminal stages of chilling temperature must be maintained between -1°C and 2°C

➔ Relative Humidity 85-90%

➔ Rapid chilling – leads to cold shortening

PHYSICAL CHANGES IN CHILLED MEAT

➔ **Shrinkage:** loss of weight occurs as a result of evaporation of water from meat surface. (usually, 1.5 to 2.0% of weight by evaporation during the first 24 hours of hanging)

➔ **Sweating**: condensation of water vapour on meat brought from a cold store into ordinary room temperature.

➔ **Loss of bloom**: Bloom is defined as the colour and general appearance of the carcass surface when viewed through the semi-transparent layer of connective tissue, muscle and fat, which form the carcass surface.

COLD SHORTENING

- ➔ undesirable change associated with quick chilling, when pre- rigor muscles, (i.e. while the pH of muscle was still above 6.2 and ATP was still present) were subjected to a temperature of below 10°C
- ➔ A pH of above 6.2 and presence of ATP is a pre-requisite for cold shortening to occur.

FREEZING

- ➔ reduction of the internal temperature of meat below its freezing point of, -1.5 ⁰ C and further storing it at temperatures of less than its freezing point.
- ➔ Method of choice for long term preservation
- ➔ **Principle:** Reducing water availability by ice crystal formation and Temperature reduction to retard microbial growth
- ➔ -23ºC (-15 to -29º)
- ➔ **Zone of crystal formation:** temp. below freezing point where extra cellular ice crystal formation occurs. -0.5 to -3.8ºC: Zone of Maximum crystal formation
- ➔ **Slow freezing:** large ice crystals more Drip loss (Amino Acids, Vitamins) as compared to fast.

METHODS OF FREEZING

slow freezing	**quick-freezing**
cabinet freezer-	blast freezers
72 hours	completed in 30 minutes
Extracellular water freezes more rapidly than intracellular water due to its lesser solute concentration.	Numerous small ice crystals with filament like appearance are formed both intra- and extracellularly at approximately the same speed.
Long periods of crystallisation exist in slow freezing, producing numerous large extracellular masses of ice crystals that are easily lost as drip during thawing.	Most of the water inside the muscle fibre freezes intracellularly, so drip losses during thawing are considerably lower than in slow frozen meat.

Slow freezing also might result in mechanical damage to muscles, due to volume changes, associated with formation of large ice crystals	In addition, smaller and numerous ice crystals formed in quick freezing reflect more light from meat surfaces, resulting in lighter colour than in slow frozen meat.

1. **Still air freezing:** -10 to -20ºC, no air circulation (home freezer), convection
2. **Plate freezing:** -10 to -30ºC, conduction.
3. **Blast freezing:** -10 to -40ºC, air (30-1070 m/min for red meat and 1300-1500 ft/min for poultry), Best: 760 m/min @ -30ºC
4. **Liquid immersion/ spray:** Poultry, Sod. Chloride brine, Glycerol & Propylene glycol.
5. **Cryogenic freezing:** Liq. Nitrogen and CO_2

BLAST FREEZERS

- ➔ This is the most commonly used commercial Method
- ➔ Method for freezing meat and is either undertaken in rooms or tunnels in which cold air blast is provided.
- ➔ The medium of heat transfer in a blast freezer is also air, but air is forced to circulate rapidly by means of fans, hence rate of heat transfer and thus freezing rate is markedly increased.
- ➔ The temperature range of commercial blast freezers fall between -10ºC and-40ºC, while the air velocities range from 0.5 m/sec to about 18m/sec.
- ➔ High air velocities increase the cost of freezing and also the risk of freezer burn.

PHYSICO-CHEMICAL CHANGES DURING FROZEN STORAGE OF MEAT

Weep or drip

- ➔ Weeping denotes the presence of a watery, bloodstained fluid, which escapes from frozen meat when thawed.
- ➔ It is caused partly by the rupture of the muscle cells and tissues by large crystals of ice, and partly by the permanent irreversible change in the muscle plasm, which prevent frozen muscles from reabsorbing water on thawing.

Rancidity

- ➔ Oxidative process in general is slowed, but in case of prolonged storage of meat in freezer,
- ➔ oxidative changes occur, with fat breaking down into free fatty acids and glycerine.

Freezer burn

- ➔ Surface desiccation and discoloured meat
- ➔ The meat or offals have a brown withered discolouration
- ➔ Freezer burn is attributed to loss of moisture from the outer tissues; it may be seen where a carcass is stored close to opening of a cold air duct.

Bone darkening:

- ➔ develops when young poultry is frozen and thawed as more haemoglobin is present in the bone marrow of young, rapidly growing birds.
- ➔ Incomplete calcification of the bones allows the haemoglobin to escape from the marrow cavity and stain the surrounding tissue dark.

THAW RIGOR

- ➔ When pre rigor meat is frozen, a severe type of rigor mortis ensues during thawing.
- ➔ The shortening so produced may be 60 to 80% of the original length of the unrestrained muscle.
- ➔ results in tough meat and heavy drip losses.

EFFECTS OF FREEZING ON MICRO-ORGANISMS AND PARASITES

- ➢ destroys some bacteria but the temperature is merely inhibiting their growth and multiplication until conditions favorable to their growth appear.
- ➢ valuable method for the treatment of certain parasitic infestation and pork affected with *Cysticercus cellulosae* can be rendered safe if held for 4 days at -10.5 to -8˚C.
- ➢ Carcass of beef affected with *Cysticercus bovis* can be rendered safe by holding for 3 weeks at a temperature of not exceeding -6.5˚C or by holding for 2 weeks at a temperature of not exceeding -10.5˚C.
- ➢ *Trichinella* cysts in pork are destroyed by holding the carcasses for 20 days at -15˚C or by quick freezing for 24 hours at -18˚C.

Temp. control			
Refrigeration	Above freezing point (below 5ºC in 8 hr)	Chilling	Beef/pork/lamb/veal: - 4 to 0ºC Poultry and fish 0 - 5ºC R.H. 82-92%
	Below freezing point (excellent method)	Freezing	Fast: -23ºC (-15 to -29º)/ 30 minutes Slow: -1.5 to -3.8/ 72 hours
Thermal process	Pasteurization	Moderate heat	58-75ºC
	Sterilization	Severe heat	100ºC shelf life is 1-2 years

Humectants:

- ➔ Additives employed for lowering the water activity of foods
- ➔ low molecular weight and chemically inert compounds, which are easily soluble in water.
- ➔ Eg Glycerol, Propylene glycol, Sodium chloride, Polyhydric alcohols (e.g. sorbitol), Sugars (e.g. sucrose, dextrose, corn syrup etc)
- ➔ Intermediate moisture meat (IMM): 30-50% moisture and 0.6 -0.85 water activity
- ➔ use of antimycotic agents like potassium sorbate, sodium benzoate, propylene glycol etc. is a must in the semi-moist meats because 0.6 to 0.85 water activity ranges specifically permits the growth of moulds.

Thermal processing

- Thermal death time: how long it takes to kill a specific bacterium at a specific temperature.
- D-value: time in minutes at a specific temp to destroy 90% (one decimal bacterial population)

- F-value: time in minutes required to destroy stated no. of micro-organisms at a defined temperature. At 121°C (250°F)- called as F_o
- F value for Clostridium botulinum: 2.45 minutes
- 12 D concept: heat treatment to resduce Clostrdium botulinum spores by 10^{12}
- Pasteurization and sterilization of meat

Canning/ Appertization

➔ first done by Nicholas Appert

➔ In most canning process, the effect of heating on spoilage organisms is to destroy them and the permanent sealing of the container preventing the re- infection of the food by further organisms

➔ Temp. 121°C

➔ Shelf life – 2 years

➔ **Head space**: portion of can not filled with product. 6-10% of can volume : protect color, flavor, prevent rancidity etc.

Spoilage in canned meat

➔ **Swell or blower** - a can with its end bulged due to positive internal pressure due to gas generated by microbial activity (Clostridium botulinum)

➔ **Flipper** - flipper has a normal appearance. Its one end flips out when the can is struck against solid object and it snaps back to normal under light pressure.

➔ **Springer** - can in which one end is bulged. It can be forced back to normal position where another end bulges.

➔ Flipper and springer gives early signs of can spoilage.

➔ **Leaker** - It is a can with a hole through which air or infection may enter or its contents may escape.

➔ **Overfilled cans -** the ends are convex due to overfilling.

➔ **Flat sours -** caused by thermophilic organisms - B. coagulans, B. stearothermophilus., B. circulans. These are highly heat resistant and attack carbohydrate. Produces acid but no gas.

➔ **Hydrogen swell** - due to formation of hydrogen gas in the can due to internal corrosion.

➔ **Purple staining-** it occurs on the inner surface of the cans. May occur in all fish and meat products especially liver, kidney and tongue. It is due to the breakdown of Sulphur containing

proteins in high temperature processing by the thermophilic Clostridium nigrificans (sulphur stinker).

➔ **Hydrogen sulphide** is liberated and a thin layer of tin sulphide is formed on the inside of the can. There is light pink to dark discoloration. Food surface is not discolored. But if hydrogen sulphide reacts with the steel base of can, than iron sulphide is formed. This results in blackening of inside of can and surface of canned product.

Moisture control

Dehydration	**Sun drying**	**Spoilage**
	Dehydrator **(moisture < 5%)**	Cost, shrinkage, case hardening
Freeze drying/ lyophilization	Sublimation- solid to vapor Triple point: 0°C + 4 mmHg Microwave for heating up to 43°C at 1-1.5 mm Hg	**Moisture ~ 2%** No shrinkage, good rehydration
Curing and smoking	Salt, nitrate, sugar, ascorbic acid, MSG, cold & hot smoke	Enhance flavor, color and shelf life

Curing of meat

- addition of salt, sugar and nitrate or nitrite to the meat, which results in conversion of the meat pigments into the characteristic cured meat pigments.

Curing Ingredients

- Sodium chloride
- Sodium or potassium nitrate or Sodium nitrite
- Monosodium glutamate
- Sugar
- Acetic acid
- Vinegar and

- Spices

Salt: most imp. curing ingredient dehydration, anti-microbial and flavoring agent

➔ **Disadvantage**: dry, harsh and grainy product, changed texture.

➔ **Acceptable limit:** 2-3%.

Sugar: Give flavor and softens the product by counteracting the harsh effect of salt and prevent excess moisture removal with mild preservative action.

- **Maillard's reaction-** between amino acids and reducing sugar gives desirable color.
- **Limit**: 2%

Phosphate: sodium tripolyphosphate (STPP), sodium hexametaphosphate (SHMP), Pyrophosphate, Orthopshophate. Maximum limit - 0.5 %.

Ascorbic açids: In practice, sodium ascorable and sodium erythorbate are used. It is used to accelerate and stabilize color development. Prevent discoloration by reducing MetMb to Myoglobin.

- Acceptable level: 100 to 1000 ppm

Monosodium glutamate (MSG): flavor enhancer @ 0.05% - Aginomotto

Nitrates and nitrites

➔ Nitrates are first reduced to nitrites and than to nitric oxide in presence of reducing conditions such as presence of meat, microbes, ascorbic acid or erythrobate.

➔ Cured meat before heat processing Myoglobin reacts with nitric oxide and is converted to nitrosomyoglobin / nitric oxide myoglobin that has attractive bright red color.

➔ Heat processed cured meat On cooking the nitrosomyoglobin is converted into stable pigment, nitrosyl-hemochrome/ nitroso-haemochromogen which gives characteristic pink color to cured meat products.

➔ Nitrate or nitrite alone or in combination of both shall not be more than 200 ppm in finished products as it is toxic

➔ Excess nitrite – bind with amines to form nitrosamine carcinogenic

Smoking of meat

Smoking and curing go hand in Hand

➔ Active compounds in smoke

➔ **Phenol:** antioxidant, smoky flavor, bacteriostatic

➔ **Alcohol:** bacteriostatic and carrier of other volatile compounds

➔ **Organic acids:** preservative e.g. formic, propionic, acetic, valeric, caproic etc.

➔ **Carbonyls:** acetone, butanol smoky flavor

➔ **Aldehyde:** formaldehyde – bactericidal

➔ **Hydrocarbons**: carcinogenic in nature benzopyrene

➔ **Types:** Cold smoking: for already cooked meat 35-40°C for 8-16 hr

: Hot smoking: for raw meat 70°C (155°F)

- **Temperature:** 155°F (68°C) internal
- **Weight loss:** max. 5-10%
- The chief bacteriostatic and bactericidal substance in wood smoke is formaldehyde.

Direct microbial inhibition

1. **Radappertization(radiation sterilisation)**. - commercial sterility 20 -30 kGy (2-3 Mrad). After application, no spoilage or toxicity of microbial origin is subsequently detectable, irrespective of duration or conditions of storage. Wet Dog Hair odour
2. **Radurization (radiation pasteurisation):** - enhancement of shelf life of a food by causing substantial reduction in the number of viable specific spoilage organisms by radiation. Levels of radiation are 1- 10 kGy
3. **Radicidation** - It refers to reduction of number of viable specific non-spore forming pathogens, other than virus, so that none is detectable by any standard method. Levels of radiation used are less than 1kGy

❖ Preservation of meat without raising temperature, hence referred to as cold sterilisation.

Direct microbial inhibition		
Ionizing radiations (rad)	Cold sterilization (beta nad gamma rays)	Radiation pasteurization: 1 lakh rads Sterilization: 4.5 meg rads no refrigeration

Non- Ionizing radiations	Microwave, UV and infrared rays	Heating
Antibiotics	IV pre-slaughter /spray Rarely used alone Resistance problem	➔ 0.5 – 2ppm chloramphenicol or tetracycline ➔ Canned food/ thermal processed – tylosin, subtilin and nisin (heat stable)
Chemicals	Antibacterial agents	NaCl (2%), Nitrite, Nitrate, CO_2 (25%)

Topic 2. 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

Topic 3.Carcass disposal, Quality Evaluation of Meat Products and Evaluation of Carcass

Burial of Carcass

- ➢ Carcass buried in 2m deep pit
- ➢ Highest part of carcass 1.5 m below ground.
- ➢ Left over feed, bedding, excreta etc. all dumped in pit.
- ➢ Top 5 cm of soil where animal lived/died also buried in pit.
- ➢ Skin slashed and drenched with crude phenol.
- ➢ Carcass covered on all sides with lime.
- ➢ Pit filled with mud and covered with concrete object.
- ➢ Anthrax affected cases, all orifices plugged with cotton and body covered with bag, all soaked in 5% cresol No PM

Incineration of Carcass

- ➔ Incinerators operated at 600-800°C.
- ➔ Suitable for all micro-organisms including *B. anthracis* (anthrax).
- ➔ If incinerator absent, 0.5m deep pit is dug and filled with wood. Animal burnt in such a manner that it remains hung/suspended on the iron bars. No touching the ground or any supportive surface.

Pyre Burning System

- ➢ Open system of burning carcasses on site with fuel.
- ➢ Well established procedure, requires no transportation.
- ➢ Environmentally hazardous and time taking.

- ➢ No verification of pathogen destruction.
- ➢ Less acceptable by public

Chemical Disposal of Carcass

- ➢ Practiced when animal dies from a disease which do not pose potential health hazard.
- ➢ Alkali like Sodium hydroxide or Potassium hydroxide under heat and pressure digest the carcass tissues. The resulting effluent has a pH level of 11.4-11.7 and in most cases it can be discharged into the municipal sewage system.
- ➢ Requires specialized expensive equipment.
- ➢ Limited application in diseased outbreaks.

Rendering

process of recovery of fat from animal materials by heating process

- ➔ Processing of animal by-product materials for production of tallow (sheep/cattle) and lard (pork), grease, and high-protein meat (crackling) and bone meal (processing speed: 12 tonnes/hr)
- ➔ Carcass crushed into small uniform pieces and heated under pressure.
- ➔ Discouraged in prion infected carcasses.

Types of rendering:

Dry rendering: crackling/ greaves production 110-116ºC 20% higher yield

Wet rendering: Tankage/slush production - 130-140°C for 3.5 hr

Technical fat is also recovered in this process (Technical fat: the animal fat obtained from animals, which are not incorporated into feed or food chain but are used for other technical purpose like soap making)

Tallow:Tallow is referred to as the rendered fat of cattle and sheep

Lard: Lard is the rendered fat of the hog

Scalding: Scalding in poultry processing is a critical step that involves treating carcasses with hot water or steam to facilitate the removal of feathers. This process is essential for ensuring the quality and cleanliness of the meat.

Process of Scalding

- ➔ **Purpose:** The primary goal of scalding is to loosen feathers from the skin, making them easier to remove during the defeathering process.
- ➔ **Methods:** Scalding can be performed manually or automatically. In smaller operations, birds may be immersed in a tank of hot water, while larger facilities often use continuous systems where birds are suspended and passed through multiple scalding baths.
- ➔ **Temperature and Time**: The effectiveness of scalding is highly dependent on the temperature and duration of exposure. Common practices include:
  - ◆ **Soft Scalding:** Typically involves temperatures of 50–51°C (122–130°F) for about 2 to 3 minutes, which helps retain the skin's integrity and produce yellow-skinned birds.
  - ◆ **Hard Scalding:** Involves higher temperatures (59–61°C) for shorter durations (around 1.5 minutes), which is often used for birds destined for freezing, resulting in a white appearance of the skin.
  - ◆ Semi/ Slack scalding- 50-53 °C x 60-180 sec.
  - ◆ Sub scalding – 54-58 °C x 60-120 sec.

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

Topic 4. Meat spoilage and Fraudulent substitution/ adulteration of meat

Phases of growth of micro-organisms in meat-

A. Lag phase: adaptation

B. Log phase: exponential growth phase

C. Stationary phase: growth ceases but cells remain metabolically active

D. Decline or death phase

Identification of meat spoilage

- **By physical observation:**
    - Discoloration: oxidation of ferrous forms of myoglobin
    - Slime formation: *Lactobacillus* and *Leuconostoc* spp.
    - Stickiness: Aerobic mold
    - Whiskers (white cottony growth of mold)
  - Off flavor: oxidation of lipids
    - **Extract release volume:** rapid test for detecting incipient spoilage inversely proportional to extent of spoilage
    - **Dye reduction test:** total aerobic and psychrotrophic bacterial counts Resazurin dye
    - Increase pH , WHC, Microbial count
    - High degree of oxidative rancidity and peroxide value (reactive oxygen contents).

➔ **Whiskers** : white growth caused by mucor. Rhizopus

➔ **Black spot**: cladosporium herbarum

- ➔ **White spot:** sporotrichum carnis, geotrichum
- ➔ **Green patches:** penicillium expansum, p. Asperulum
- ➔ Cadaverine and putrescine smell like rotting flesh
- ➔ Hydrogen sulfide smells like rotten eggs
- ➔ Dimethyl disulfide and trisulfide have a foul, garlic-like odor

Processing of Meat and Meat Products

Any treatment: physical and chemical changes in the natural state of meat.

Basic Processing Procedures

- ◆ **Comminution:** (size reduction)
- ◆ **Emulsification:** (oil-in water emulsion)
- ◆ **Meat Extension**: non-meat protein substances, increase bulk
- ◆ **Pre-blending:** Mixing of ingredients/preservatives with meat
- ◆ **Hot Processing:** processing of meat prior to chilling
- ◆ **Fermentation:** *Lactobacillus, Staph.* and *Micrococcus:* Salami, Sucuk, chorizo.
- ◆ **Cooking:** Dry Heat (Broiling; Roasting and Frying), Moist Heat (Pressure Cooking; Stewing; Simmering and Braising), Microwave.

Advanced Processing Procedures: Smoking; Curing/ Salting; Canning.

Sausages

- ➔ Meat product prepared from minced meat and formed in to cylindrical shape by casings
- ➔ Coarse ground type: Fresh pork sausages
- ➔ Cured, emulsion type: Frankfurters
- ➔ Fresh, emulsion type: Salami
- ➔ Coarse ground, fermented, semi dry: Thuringer summer sausages
- ➔ Coarse ground, fermented, dry: Pepperoni
- ➔ Emulsion type prepared from meat of old animals: Bologna
- ➔ Spicy sausage usually made in weasand: Hot dog

➔ Dry sausage prepared in cattle bladder: Mortadella

Other meat products

➔ **Luncheon**: canned meat product prepared from pork not less than 80%

➔ **Meat patties**: emulsion based product contain less than 30% fat

➔ **Meat loaves:** red to eat comminuted meat products prepared from coarse ground meat or meat emulsion or combination of both

Species differentiation

Meat	Colour	Consistency	Odour
Beef	Dark red with slight brownish tinge	Firm and cut surfaces are shiny	-
Buffalo meat	Dark red	Firm	-
Veal	Pale grey to grayish red	Firm	-
Chevon	Light red and paler than mutton	Very firm	Goaty odour
Mutton	Dark red	Firm and dense	Ammonical
Pork	Grayish white to light red	Very soft	Urine like
Poultry meat	White	Firm	-
Horse meat	Dark red with bluish tinge	Firm with prominent fascia	-
Camel meat	Red	Fairly firm	-
Dog meat	Dark red	Firm	Disagreeable and repulsive
Rabbit meat	Pale, grey to grey red	Firm	Pronounced
Venison	Dark red to brownish red	-	-

Fat Characteristics

Fat	Colour	Consistency	Fat type	Bone marrow characteristics	Remark
Beef	Yellowish white	Firm	Intramuscular fat	Pure white to reddish yellow	-
Buffalo fat	Pure white	Slightly firm	No Intramuscular fat	-	-
Veal	Reddish yellow to white	Loose and greasy	No Intramuscular fat	Pink red	-
Chevon	Pure white	Hard , firm and brittle	No intermuscular fat	Firm and slightly red	-
Mutton	Pure white	Hard , firm and brittle	Abundant intermuscular fat	Firm and slightly red	-
Pork	White	Soft and greasy	Subcutaneous but	Pink red and soft intramuscular also	On boiling it turns to whitish grey
Poultry fat	Yellow	Loose	Mostly subcutaneous	-	-
Horse fat	In young-light gold to yellow In mature -white	Soft and greasy	No intramuscular fat	Waxy, yellow, greasy and soft	On exposure to air turns to blackish
Dog fat	White to whitish grey	Oily and greasy	Slight intramuscular	-	-
Rabbit fat	Whitish yellow	Loose	Fat is absent in muscle and confined to body cavity	-	-

Fat %

- ➔ Mutton 13.3%
- ➔ Pork 4.4%
- ➔ Chevon 3.6%
- ➔ Beef 2.6%
- ➔ Buffalo 0.9%

CHARACTERISTICS OF MEAT

- ➔ The odour of the buffalo meat and fat are always strikingly musky and if boiled in strong acidified (H_2SO_4) water
- ➔ color of beef varies from light red to dark red
- ➔ meat of horse is dark red in colour
- ➔ Horseflesh contains large quantities of glycogen and linoleic acid.

Fraudulent substitution/ adulteration of meat:

- **Two types:**

➔ Substitution of inferior quality meat to superior quality (maximum cases)

➔ Substitution of spoiled meat to fresh meat.

Common substitutes:

➔ Horse meat for beef

➔ Goat meat for mutton

➔ Mutton for venison

➔ Cat flesh for rabbit

➔ Rabbit for poultry

➔ Replacement of steer and heifer meat of high quality with low quality cow and bull beef.

Methods to judge type of substitution

1. **Physical methods:** Recognition of meat by anatomy, bones, color of flesh, fat, odor and internal organs. It could be carried out only when carcass is available.

➢ **Beef**- light red to dark red in color, attractive, well marked fat (marbling). In Young bulls, Flesh is light red but in old bulls it becomes dark and coarse. Surface becomes dried and very dark. Less marbling and good water binding ability. Fat is yellowish/ yellowish white due to carotene content. Firm in consistency. More yellowish in older animals.

➢ **Veal**- few days old veal flesh is pale in color and watery in consistency. Fat is white and jelly like. In milk fed calves, fat becomes white and firm and flesh becomes white.

➢ **Buffalo meat-** more dark color than beef. Less tender and less juicy than beef. Marbling is very less. It is lean and contains less cholesterol. Buffalo fat is firm and white in color and contains no cholesterol.

➢ **Sheep meat (Mutton)**: flesh is light to dark red and has fine, firm muscle fibre, fine texture and marbling. In well nourished animals fat deposits are present between muscles. Fat is firm, white and odorless. Fat contains white SFA.

➢ **Goat meat (Chevon)** flesh resembles mutton but kidney fat is abundant. There is no fat between muscles. Subcutaneous fat is sparse. It is more lean, dry and firm. Typical goat odor is present.

➢ **Pig meat (Pork)** - color of muscles varies depending upon age, nutrition, and part of body. Of all food animals, pork is least firm. Color varies from whitish grey to red. In case of boars, it becomes very dark red especially in back muscles. There is marked deposition of subcutaneous fat which is white, sol and greasy in texture. On cooking pork becomes white. Has boar odor.

➢ **Horse-** flesh is dark red or even bluish on cutting and sometimes almost black. Odor is sweet and repulsive. Connective tissue fascia is more strongly developed. Marbling is absent. Fat is yellow, soft and greasy but can change to firm texture depending on the type of feed.

2. Chemical tests

- HPLC method most widely used

- Content of glycogen in flesh

- percentage of linoleic acid in fat

- melting point of fat

- Iodine number of unsaturated fatty acids in fat

- refractive index of fat

Glycogen & Linoleic acid

➔ The horseflesh is richer than the flesh of other food animals in glycogen in horsemeat as compared with other kinds of meat

➔ Horse – 0.5 to 1.0 % • Beef - 0.0 to 0.5% • Pork and mutton - nil

➔ Linoleic acid content: Horse fat contains 1-2% linoleic acid. Linoleic acid content in other animals' fat is not more than 0.1%.

➔ Thus adulteration of lard or beef and mutton fat with horse fat can be identified by estimation of the linoleic acid concentration.

Iodine value:

is the amount of iodine absorbed by the unsaturated fatty acid present in the fat

The iodine value of the fat from various food animals is:

➔ Horse - 71-86

➔ Ox (cattle) - 38-46

➔ Sheep - 35-40

➔ Lard - 66

Refractive index

➔ Horse - 53.5

➔ Ox - less than 40

- ➔ Pig - not above 51.9

Myoglobin content

- ➔ Beef - 0.30 to 1%
- ➔ Pork - 0.06 to 0.40%
- ➔ Poultry - 0.02 to 0.18%

Other Tests

- ➔ Iso-electric focusing
- ➔ SDS-PAGE
- ➔ Agar gel precipitation test, Counter current immunoelectrophoresis and ELISA

Topic 5.Abattoir Effluent Treatment,Standards in meat industry and Meat borne diseases

Effluents: liquid, solid/ semi-solid wastes (treated/ not treated) which are passed through a plant's sewer pipe, to be discharged into water bodies. All components of effluents have a potential to pollute natural waters.

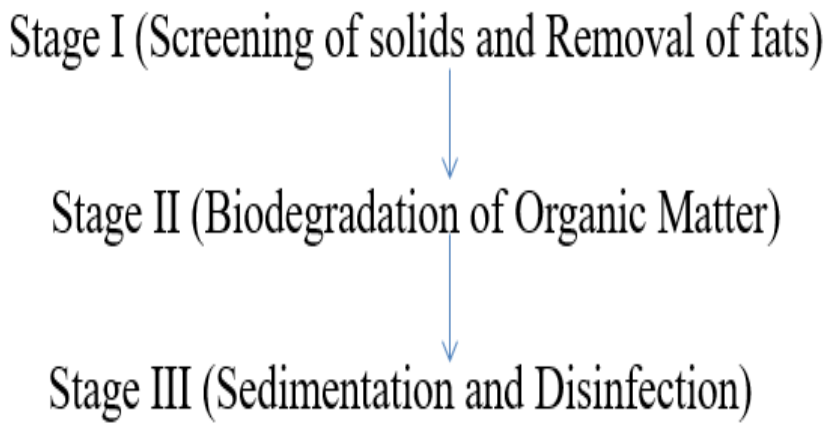
Composition:

- ➔ Abattoirs & Meat Plants: Elevated level of concentrated nutrients including FOGs, organic matter, micro-organisms, suspended solids and detergents 10% solid
- ➔ **Treatment:** Direct discharge into water bodies causes depletion of Dissolved Oxygen as well as disturbs the pH of the environment in which the aquatic organisms thrive.
- ➔ **Quality of Waste water: BOD & COD**
- ➔ **Chemical Oxygen Demand:** amount of dissolved oxygen required for the chemical oxidation of total organic matter in water. A chemical oxidation process.
- ➔ **Bio-chemical Oxygen Demand:** amount of dissolved oxygen which is consumed by bacteria while decomposing organic matter for first 5 days under aerobic conditions at $20^{o}C$. A biological oxidation process.
- ➔ **COD > BOD**

BOD of effluents produced in abattoirs and meat plants:

- **Poultry Meat Plant** : 1000-1200 ppm
- **Pig Meat Plant** : 1500-2000 ppm
- **Cattle & Sheep Meat Plant** : 1400-3200 ppm
- **Fish Processing** : 1000-3000 ppm
- **Dairy Plant** : 600-1300 ppm

Steps of Effluent Treatment



Stage I of Effluent Treatment

Primary Filtration

(Effluent passed through strong steel mesh)

↓

Secondary Filtration

(Re-filteration by vibrating screen with a fine mesh arranged at an angle)

↓

Fat Separation

(Water agitated and air pumped, Fat rises upwards which is skimmed)

↓

Equalization

(Activated sludge, a biological stimulant added in small quantity)

****65% of solids & 90% of fat is removed reducing the BOD by 35%**

Stage II of effluent treatment biological oxidation

Aerobic Process

- Occurs in open areas.
- Pond of 1 m depth filled with waste water and is agitated in presence of ample air supply

Anaerobic Process

- Occurs in closed areas.
- Deep tank having 4-5 m depth is filled with waste water and is agitated.
- Results in 60% reduction in BOD of treated water.

*** For meat plants a combination of both used**

Stage III of effluent treatment Sedimentation and Disinfection

Sedimentation:- The un-oxidized organic matter and other suspended material is removed through gravitational force and supernatant fluid is directed towards the disinfection tank or the sewer line.

Disinfection:- The supernatant is then disinfected with chlorine treatment UV treatment etc. and then discharged to water bodies through sewer lines.

Recommended (minimum) effluent standards

	BOD (mg/l)	Faecal coliform (per 100 ml)	Algae (per ml)
Effluent to be discharged into surface water	<25	<5000	<100,0000
Effluent to be used for restricted Irrigation	-	<5000	-
Effluent to be used for unrestricted Irrigation	-	<100	-

Standards in meat industry

- BIS standards
- IS:4393-1979 – basic requirements for abattoir
- IS:1982-1971 – Code of practice for AM and PM inspection of meat animals (first revision)
- IS: 6659- 1972 - Code of practice for AM and PM inspection of poultry
- IS:8182- 1976 – code of hygienic condition for processed meat products

Meat Food Products Order

➔ MFPO, 1973

Categories

- ➔ **A-** includes those manufacturers or licensees of meat products who possess their own slaughter house
- ➔ **B-** includes those manufacturers of meat products who purchase meat from approved slaughter house
- ➔ **C**- includes those manufacturers of meat products who purchase raw meat from any other source

Schedules

- ➔ **The first schedule:** deals with application of license or renewal of license
- ➔ **The second schedule**: deals with minimum sanitary requirements
- ➔ **The third schedule:** deals with hygienic requirements who slaughter animals in their factory
- ➔ **The fourth schedule**: deals with packaging, marking and labeling of containers of meat products

Limits for poisonous elements as per MFPO

- Lead – 2.5ppm
- Arsenic – 2ppm
- Copper- 20ppm
- Zinc -50 ppm
- Tin – 250 ppm
- MFPO replaced by FSSAI, 2006

Rabbit farming: multipurpose animal

- ➔ Meat- low fat white meat
- ➔ Wool: Angora (shearing every 10-11 weeks- 400gm per year)
- ➔ Fur (pelts)
- ➔ Laboratory
- ➔ Pets
- ➔ Show
- ➔ Manure
- ➔ Meat breed: Californian, New Zealand white

Note:

1. No estrus cycle (induced/ spontaneous ovulator)
2. Gestation pd: 30 days
3. Litter- 1-14 (avg 8)
4. Litter per year: 4-8

Occupational injuries and infections

Anthrax

- ➔ Cutaneous form (Malignant pustule, Hide porter's disease)
- ➔ Pulmonary form (Wool sorter's disease)
- ➔ Intestinal form
- ➔ Brucellosis
- ➔ Contagious pustular dermatitis: CPD or orf is caused by virus of the genus parapox
- ➔ Erysipeloid: Erysipelothrix rhusiopathiae
- ➔ Leptospirosis Weil's disease
- ➔ Listeriosis
- ➔ **Lyme disease:** The disease is caused by a spirochete of the genus Borrelia burgdorferi and is transmitted by hard tick Ixodes ricinus
- ➔ **Q fever/ Query fever/ Abattoir fever:** The disease is caused by Coxiella burnetii.
- ➔ **Tularemia/ Deerfly fever/ Rabbit fever:** The disease is caused by Francisella tularensis and is found in human in contact with tick or rabbits.
- ➔ Fungal infections

Meat borne diseases

Viral infections

- ➔ Enterovirus
- ➔ Small gastroenteritis virus: rotavirus, astrovirus, calicivirus, small round structured viruses like Norwalk like virus etc

Bacterial infections:

- ➔ -Salmonellosis

- ➔ Clostridial infections: Clostridium perfringens & Clostridium botulinum
- ➔ Staph aureus, E.coli, Bacillus cereus, Listeria monocytogenes, Campylobacter jejuni, Yersinia enterocolitica

Parasitic infections:

- Cryptosporidiasis
- Sarcocystosis
- Taeniasis
- Trichinosis
- Toxoplasmosis

Unit 6. Egg and Wool

Topic 1. Female Reproductive System and Process of egg Formation
Topic 2. Egg structure and Nutritive Value
Topic 3.Designer eggs and Egg Preservation
Topic 4 Wool science and Wool processing
Topic 5.Wool Glossary/ Terminology and Wool grading

Topic 1. Female Reproductive System and Process of egg Formation

Two parts

1) ovary

2) oviduct

- ➔ At time of early embryonic development two ovaries and two oviducts are present
- ➔ Only left pair ovary and oviducts are persist in all species of adult bird
- ➔ Except in kiwi both ovaries develops but only left oviducts remain functional

OVARY

- ➔ Before maturity size is small
- ➔ Mature ovary consist of numerous developing follicle appears like cluster of grape
- ➔ Attached to abdominal wall by help of mesovarium ligament
- ➔ A pullet chick have 10,000- 20,000 potential eggs

- ➔ Most of them never developed to point of ovulation
- ➔ During ovulation each ovum is surrounded by a vitelline membrane
- ➔ As ovum develops yolk is added
- ➔ Color of yolk is yellow comes due to yellowish fat soluble pigment called as Xanthophyll
- ➔ Hens fed yellow maize or allow to range on grass , typically have dark yellow yolk
- ➔ Hens fed on diets with white maize , sorghum, millet or wheat typically have pale yolk
- ➔ Color of yolk can be improved by adding marigold petal (xanthophyll)
- ➔ Liberation of ovum from follicle is called ovulation
- ➔ Ovulation normally occur 14-75 minutes after oviposition (laying of fully formed egg)
- ➔ Yolk size in the egg – up to 40 mm in diameter
- ➔ On distal surface of mature follicle has a area which is devoid of blood vessels called as stigma from where follicle splits to release yolk in to oviduct
- ➔ If follicle splits from place other than stigma numerous blood vessels will rupture and result in blood spot in eggs

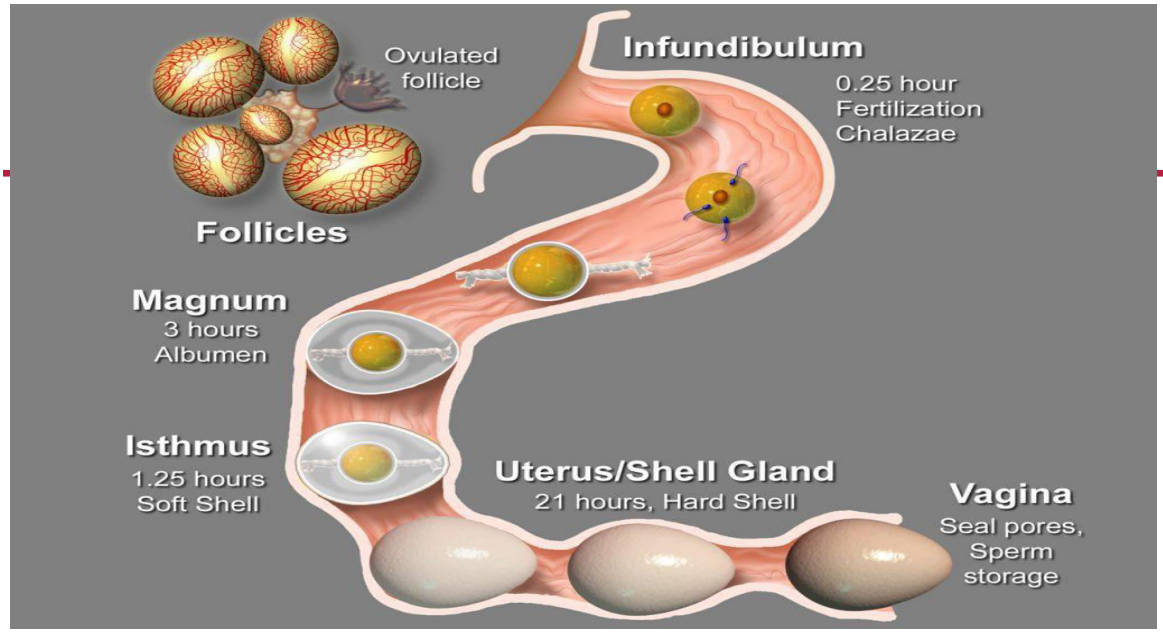
OVIDUCT

- ➢ Is a long zig zag tube (25-27 inches long)
- ➢ Consist of glandular and muscular part
- ➢ Oviduct extend from ovary to cloaca

5 parts

- ➢ Infundibulum (9cm)
- ➢ Magnum (33cm)
- ➢ Isthmus (10 cm)
- ➢ Uterus (10-12 cm)
- ➢ Vagina (12 cm)

Part	Length	Time spend	Function
Infundibulum	9 cm	18 min	Reservoir for spermatozoa and fertilisation
Magnum	33 cm (longest part)	2 hr 54 min	Thick white or albumen is added
Isthmus	10 cm	1hr 15 min	Some albumen and inner and outer shell membrane is added
Uterus or shell gland	10-12 vm	20 hr 40 min	Shell Ca CO3 over egg 47% calcium from her bone , pigment deposition (porphyrin – brown color)
Vagina (muscular part)	12 cm		Cuticle is added help in easy oviposition
Total	74 cm	25-26 hr	



PROCESS OF EGG FORMATION

- ➔ Yolk is not true reproductive cell
- ➔ When female attain sexual maturity (FSH) mature ovum rapidly inside graffian follicle
- ➔ Yolk weight also increases 7 day prior to ovulation due to deposition of yolk material over the ovum in alternate layer of white and yellow
- ➔ White layer – night time
- ➔ Yellow layer – day time
- ➔ The nucleus of infertile egg called as germ spot and nucleus of fertile egg is called as germ disc
- ➔ FSH - growth of maturity of grafian follicle
- ➔ LH- release ovum by rupturing of graffian follicle (Ovulation)
- ➔ Oviposition (broad end first comes out)
- ➔ In emu one egg formation required 3 days
- ➔ Albumin = magnum
- ➔ Inner and outer shell membrane and water = isthmus
- ➔ Egg shell $CaCO3$ = uterus
- ➔ Tubular gland of uterus add water content to albumin also
- ➔ Shell pigment (porphyrin- brown color) are added 5 hour before oviposition
- ➔ Laying of egg occur through contraction of uterus
- ➔ Oxytocin and vasotocin are required for oviposition
- ➔ Complete shell formation takes 24-26 hours to complete
- ➔ Hens body temp during egg formation $104\text{-}106^0$ F
- ➔ There is synchronisation between ovulation and oviposition
- ➔ Next ovulation occur 30 min after oviposition

Topic 2 Egg structure and Nutritive Value

Four major structures from outside to inside

- ➔ Shell
- ➔ Shell membrane
- ➔ Albumen
- ➔ Yolk

Egg shell

- ➔ outer covering of an egg which consist of pores & Constitutes 9-11% of the egg weight.
- ➔ The pores in the egg shell allow the exchange of air which allows the embryo to breath.
- ➔ There are approximately 7500 pores per egg. The size of the pores is big at the broader end.
- ➔ At the time of laying the outer surface of the shell is covered with cuticle which seals the pores. It protects the egg from outside temperature and prevents carbon dioxide to escape from the egg.
- ➔ Egg shell has two shell membranes, the outer egg shell membrane and inner shell membrane.
- ➔ air cell is formed between the two shell membranes and it is usually present at the broader end of the egg.
- ➔ Composed of Calcium carbonate 94.0%

Albumen

- Constitutes 58-60% of the egg weight.

- Consist of 4 layer

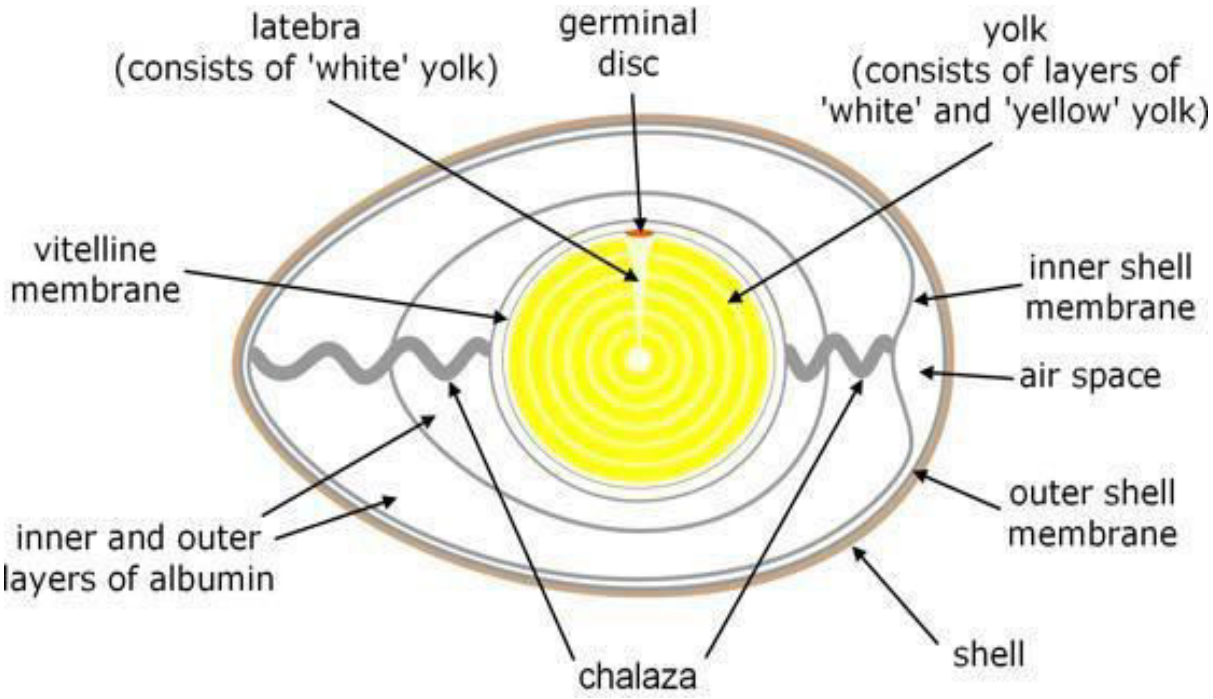
  - ➔ **Outer thin albumen layer** (23%)
  - ➔ **Inner thin albumen layer** (17%)
  - ➔ **Outer thick or dense albumen** (57%)
  - ➔ **Chalaza or inner thick albumen** (3%)

- It consists of a chalaza which is attached to the chalaziferous layer, around the yolk.
- Chalaza plays an important role in keeping the yolk in a fixed place.

Yolk

- ➔ constitutes around 31% of the egg weight

- ➔ The yolk consists of the germinal disc,dark yolk layer, light yolk layer, the vitelline membrane (yolk membrane) and the latebra (white yolk).
- ➔ The germinal disc is known as the blastoderm in a fertile egg and as blastodisc in an infertile egg.
- ➔ The latebra or the white yolk is the structure which connects the germinal disc to the centre of the yolk.
- ➔ The germinal disc is located in a cone like portion of the latebra, known as the nucleus of pander. Fertilization of the egg takes place here.



S. No.	Birds	Egg weight (g)	Yolk (%)	Albumin (%)	Shell (%)
1.	Chicken	50	31	58	11
2.	Quail	10	32	48	20
3.	Turkey	65	32	56	12
4.	Duck	72	35	53	12
5.	Pigeon	18	18	74	8

Composition of an Egg

	%	% Water	% Protein	% Fat	% Ash
Whole Egg	100	65.5	11.8	11.0	11.7
Albumen	58	88	11.0	0.2	0.8
Yolk	31	48	17.5	32.5	2.0

NUTRITIVE VALUE OF EGG

- ➔ The white or egg albumen contains more than half the egg's total protein, niacin, riboflavin, chlorine, magnesium, potassium,sodium, and sulfur and all the egg's zinc.
- ➔ yolk contains all of the fat in the egg and a little less than half of the protein. It also contains the fat-soluble vitamins A, D, and E.
- ➔ Egg yolks are one of the few foods naturally containing vitamin D.

- ➔ The yolk also provides vitamin B 12 and folic acid, and the minerals iron, calcium, copper and phosphorus.
- ➔ Eggs have biological value of 93.79 %
- ➔ Cholestrol content: 210-250mg/egg
- ➔ Energy from chicken egg: 143kcal/100gm

Nutrient (unit)	Whole Egg
Weight	60g
Water (percentage)	65-68.5
Calories (kcal)	70
Protein (g)	6.3
Carbohydrate (g)	0.36
Total fat (g)	4.8
Polyunsaturated fat (g)	1
Monounsaturated fat (g)	1.8
Saturated fat (g)	1.6
Cholesterol (mg)	185
Choline (mg)	126
Vitamin A (IU)	270
Vitamin D (IU)	41
Vitamin E (mg)	0.5

EGG PROTEINS

- **Ovalbumin**: phospho glycoprotein & 55% of the proteins of egg white
- **Conalbumin**:13% protein of the egg albumin. It binds metals specially iron
- **Ovamucoid:** It is a glycoprotein & 10% of the egg white proteins
- **Ovomucin:** This protein is responsible for the jelly like character of egg white and the thickness of the thick albumen. It contains 2% of the egg white.
- **Avidin -**Avidin is 0.05% of the egg white protein. It binds biotin and makes the vitamin unavailable.
- **Ovoglobulin-** It is a protein consisting of two components G1 and G2 and both are excellent foaming agents.
- **Ovoinhibitor-** capable of inhibiting trypsin and chymotrypsin

Anti bacterial factors in egg

- Lysozyme and conalbumen
- Lysozyme causes lysis of cell wall of gram positive bacterias

- Conalbumen chelates Iron and make it unavailable for bacterial growth

Egg quality parameters

➔ Haugh unit

➔ Yolk index: gives idea about yolk quality and value for standard egg is 0.5

➔ Egg shape index (ESI) = Maximum width/ max length *100

- Chicken egg – 74, Duck egg – 72, Quail egg 78

➔ Shell Strength: measured by screw gauge (0.3-0.5micron)

➔ Specific gravity: 1.060-1.090

Haugh unit is a measure of the internal quality of an egg.

➔ It is considered to be one of the most significant measures of egg quality, next to other measures such as eggshell thickness and eggshell strength.

➔ measure the height of the thick albumen that immediately surrounds the yolk.

➔ micrometer - determine the height of the thick albumen (egg white).

➔ The height, correlated with the weight, determines the Haugh unit, or HU

➔ value ranges from 0 – 130

➔ The higher the number, the better the quality of the egg. Eggs can be ranked according to their HU rating:

➢ **Grade AA**: HU unit of 72or more
➢ **Grade A:** 71 to 60
➢ **Grade B:** 59 to 31
➢ **Grade C:** 30 or less

Physico-Chemical properties

pH

➔ **newly Laid Egg**: pH Albumen: 7.6-8.5 & pH Yolk: 6.0

➔ **During Storage**: pH Albumen: 9.7 (max) pH Yolk: 6.4 - 6.9

➔ pH of albumen and yolk rises due to loss of CO_2 through the egg shell pores.

Viscosity

- ➔ On storage, with time, first the viscosity of the albumen increases
- ➔ After certain amount of time as the pH of the albumin increases from7.8-9.5 the albumen starts to liquefy and become thin and viscosity decreases

Freezing Point

- ➔ The freezing point of egg white is -0.45 °C
- ➔ The freezing point of egg yolk is -0.58 °C
- ➔ In shell, the egg contents may be cooled to a temperature of -3.0 °C, without becoming frozen.
- ➔ Egg is reported to freeze at -6.0 °C
- ➔ Designer eggs ar**Topic 3.Designer eggs and Egg Preservation**
- ➔ e those in which the content has been modified from the standard egg in terms of high vitamin and minerals, lower cholesterol, high omega fatty acids and added pharmaceutical compounds.
- ➔ For this purpose the bird's feed is modified.
- ➔ Chromium supplementation to laying hen diets at concentrations of less than 1 ppm have been shown to lower egg cholesterol and also improve egg interior quality.

Egg Spoilage

Type of rot	Changes in egg	Organisms
Green rot	Albumen becomes green	Pseudomonas fluorescens
Black rot type 1	Faecal odor	Proteus
Black rot type 2	Green albumen but black yolk with cabbage odr	Pseudomonas
Red rot	Albumen stained red	Serratia
Fungal rot	Pink spots	Sporotrichum

	Black spots Yellow or green spots	Cladosporium Penicillium

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.

National Egg Coordination Committee

- ➔ Founder(s)Dr. Banda Vasudev Rao
- ➔ Established: May 1982
- ➔ NECC's role in the Indian egg industry mainly focuses on egg pricing.
- ➔ After fulfilling its original purpose, NECC expanded its scope of activities to achieve the following
- ➔ Determining egg price based on fair return for farmer, decent margin for middleman, and reasonable cost for customer.
- ➔ Monitoring, managing and, regulating the stocks from surplus to deficit regions.
- ➔ Market intervention through Agrocorpex India Limited.

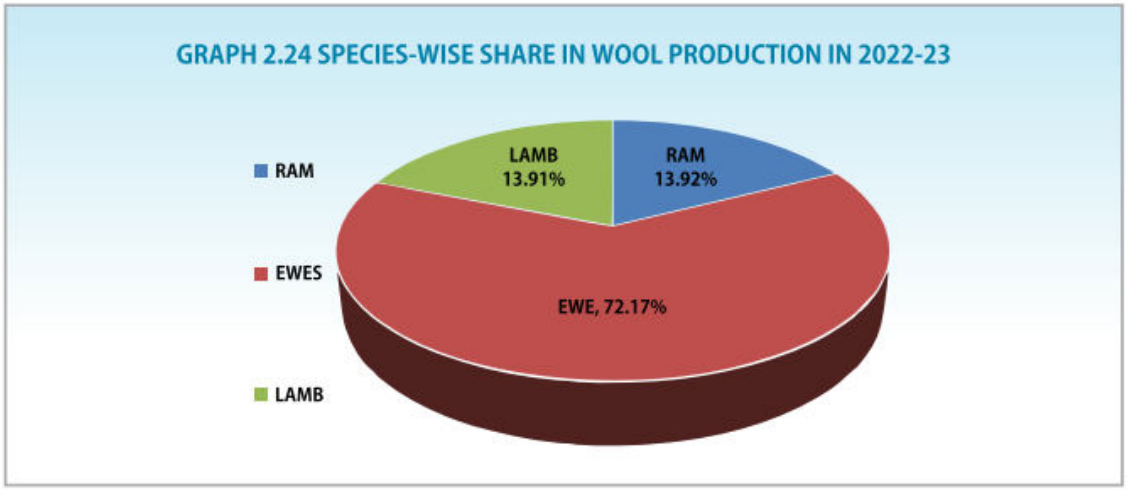
- ➔ Having a dependable and close network of marketeers that use multi level marketing to sell the products.
- ➔ Promoting egg trade, egg farm, and egg exports.
- ➔ Making technology and information available for increased production of eggs.

Topic 4 Wool science and Wool processing

MAJOR HIGHLIGHTS OF WOOL PRODUCTION

- ❖ The total wool production in the country is 33.61 million Kgs.
- ❖ The Wool production has increased by 2.12% as compared to previous year.
- ❖ The top 5 wool producing States are Rajasthan (47.98%), Jammu & Kashmir (22.55%), Gujarat (6.01%), Maharashtra (4.73%) and Himachal Pradesh (4.27%). They contribute 85.54% of total wool production in the country.

2.4.1 SPECIES-WISE SHARE OF WOOL PRODUCTION



- **Wool:** is a natural fibre of animal origin consists of a cortex and cuticle, it is devoid of a medulla & Obtained from sheep, goat, yak, camel, etc.
- **Hair**: tend to be sleeker, straighter, more diameter and less crimpy than the wool fibers. consists of cuticle, cortex and medulla.
- **Mohair:** Natural fibre obtained from Angora goats and has high lustre and sheen, devoid of medulla and less developed scales unlike wool.
- **Fur**/pelage: A synonym for non-human hair (similar to hair); consists of cuticle, cortex and medulla.

Structure of Wool

➔ Fibrous Protein: keratin (Cysteine links, Ionic links, Hydrogen bonds)

➔ Sulphur containing AA: cysteine.

➔ **Cuticle:** Outer most protective layer of scales.

➔ **Cortex:** Internal cells of fibre, contributes 90% of the fibre.

➔ **Medulla:** hollow central core found in coarse and medium wool fibre consist of cells separated by gaps of air.

Wool development

Follicles appear in the second month of gestation

Primary follicles: developed earlier coarse fibres

Secondary follicles : developed later fine fibre Merino – majority

- ❖ S:P ratio of follicles determine types of fleece produced

Properties of Wool

- ➔ Flexible
- ➔ Resilience: restore their original shape after removing the external loading
- ➔ Elastic: stretch up to 30% of its normal length
- ➔ Crimpiness: 2-12/cm curliness
- ➔ Hygroscopic: 18-50% of own weight
- ➔ Specifc gravity: 1.304 and refractive index: 1.553- 5.00
- ➔ Water proof and non-inflammable

Wool processing

1. **Sorting**: Raw wool bought to the mill and is sorted
2. **Opening & Dusting**: Clumps are opened
3. **Scouring**: removal of impurities hot water (45°C-120°C) and soap/sodium carbonate
4. **Burr picking**: **carbonization**: Vegetable content is removed (NaOH solution)
5. **Oiling**: lubrication with oil to reduce breakage and maximise cohesion.
6. **Carding**: wool fibers are untangled and aligned in one direction. The wool fibre are bundled into strips known as “Roving/Sliver”.
5. **Spinning**: twisting to give yarn strength and size.
6. **Weaving**: intertwining the yarns into desired product
9. **Dyeing** : permanent colour into the wool fibres.
10. **Finishing**: improves the appearance. Steps involved:

    ✓ **Milling**: Shrinkage of the fabric to the required degree in order to thicken it and give it a desired appearance.

    ✓ **Carbonization**: Chemically burr is removed by treating the finished product with dilute acid at high temperature.

    ✓ **Raising**: lifting out of wool from the body of the fabric.

    ✓ **Shearing**: levelling of raised out wool fibres.

11. Testing: assesses the quality, value, defect and other characteristics of the end product.

Wool Quality Parameters

1. **Fibre-fineness**
2. **Length (cm):** Determines spin-ability of the fibre
3. **Crimp frequency**- crimps per unit length of the fibre (Merino: up to 100 crimps per inch)
4. **Moisture Content:** % proportion of water absorbed in undried specimen
5. **Medullation Percentage:** Volume occupied by medulla in a fibre: 5%-99%. Medullated fibres are hollow & cause serious problems in dying process hocks and briskets of sheep.
6. **Scouring Yield:** The process of cleaning of wool is called scouring.
7. **Burr Content:** Types: Low Burr 3%; Medium Burr: 3-5%; Heavy Burr >5%

8. Colour: near white to shades of cream and yellow. Intense yellow discoloration **canary stain**: fleece under the influence of moisture, temperature and bacterial activity.

9. Lustre: coarse wools have higher lustre than fine types.

Topic 5.Wool Glossary/ Terminology and Wool grading

- ➔ **Fleece**: Fibre coat that covers a sheep
- ➔ **Lock:** A group of fibres clinging together in fleece
- ➔ **Suint:** natural greasy substance in sheep's wool Secretions of sudoriferous glands.
- ➔ **Lanolin/ Wool wax:** Secretions of the sebaceous glands of the skin.
- ➔ **Greasy wool:** Shorn wool with grease and wax before removal of impurities.
- ➔ **Wool Yolk:** Wool wax with suint in raw wool is known as yolk.
- ➔ **Kemp:** A coarse, weak and brittle wool fibre with irregular medulla
- ➔ **Crimp**: Natural waviness/curliness of a wool fibre.
- ➔ **Staple Length:** Length of a wool fibre without disturbing its natural waviness.
- ➔ **Fibre Length**: Length of the fibre in stretched condition.
- ➔ **Burr**: Vegetable matter present in wool
- ➔ **Scouring**: removal of impurities detergent (sodium carbonate)
- ➔ **Carbonization**: removal of burr with chemical treatment of wool

- ➔ **Shearing/ Clipping:** Removal of fleece from body of sheep
- ➔ **Skirting:** Removal of objectionable parts and stains from body of fleece after shearing
- ➔ **Pelt:** undressed skin along with it's hair/wool/fur.
- ➔ **Sweating:** process of removal of wool by bacterial digestion (proteolytic enz.) of pre-keratinous region of fibre root or by application of depilatory agent to the under surface of pelt.
- ➔ **Rooing:** Plucking of fleece of indigenous sheep having double coat under going loosening of the fibre. Natural break in the growth of the wool in spring. This causes the fleece to begin to peel away from the body, and it may then be plucked by hand without cutting.
- ➔ **Fellmongering:** removal of wool from sheep skin through use of chemical applications (sodium sulphide or thallium).
- ➔ **Felting:** ability of textile material to undergo irreversible increase in bulk density when subjected to friction and pressure under suitable physical conditions.
- ➔ **Yarn**: thread made from wool in the form of a loosely twisted collection of fibers
- ➔ **Count**: It is an index of thickness or diameter of yarn.
- ➔ **Hank:** a coiled or wrapped unit of yarn
- ➔ **Warp**: longitudinal section of fabrics arranged in form of sheet
- ➔ **Weft/ woof**: transverse section of fabrics
- ➔ **Weaving:** technology in which two distinct sets of yarns/threads are interlaced at right angles to form a fabric or cloth
- ➔ **Scale:** A cuticle of flattened cells protecting the cortex of fibres.
- ➔ **Keratinization:** Hardening of previously soft plastic fibrous protein.
- ➔ **Gare**: Partially medullated mohair fibre which at sometimes also arise from some secondary follicles.
- ➔ **Crimp width:** The distance between the mid point of the successive valleys of the projected crimp wave image.
- ➔ **Crimp amplitude**: It refers to crimp wave and is half the total depth from crest to trough.
- ➔ **Rise in wool:** Seasonal increase in flow of wax.
- ➔ **Hunger Finess:** Wool of under nourished sheep as of nutritional scarcity producing lighter but finer fleece.

Wool grading

1. Blood system of grading: based on the percentage of Merino blood e.g. fine, 1/2-blood, 3/8-blood, 1/4-blood, low 1/4-blood followed in USA

2. Numerical system: based on no. of yarns made from one pound of scoured wool

3. Based on the length and diameter of the wool grading is done.

- ➔ Fine
- ➔ Medium
- ➔ Long
- ➔ Cross bread
- ➔ Mixed

Coarse wool fibre: (25–70 μm diameter): carpets

Fine merino fibre: (10–25 μm): apparels