MEAT SCIENCE

Topics covered

- Prospects of meat industry in India
- Structure and composition of muscle
- Nutritive value of meat
- Muscle to meat conversion
- Abattoir standards

Prospects of meat industry in India

NIN guidelines: 180 eggs and 11 kg of meat per capita

Availability: 101 eggs and 7.1 Kg of meat

Rank of India: 8th in meat production and 3rd in egg production

Top Producing states: Uttar Pradesh(meat) & Andhra Pradesh (Egg)

Contribution of Livestock to Gross value addition: 5.73% of total and 30.19% to agriculture sector

Poultry -main sector contributing to total meat production (51%)

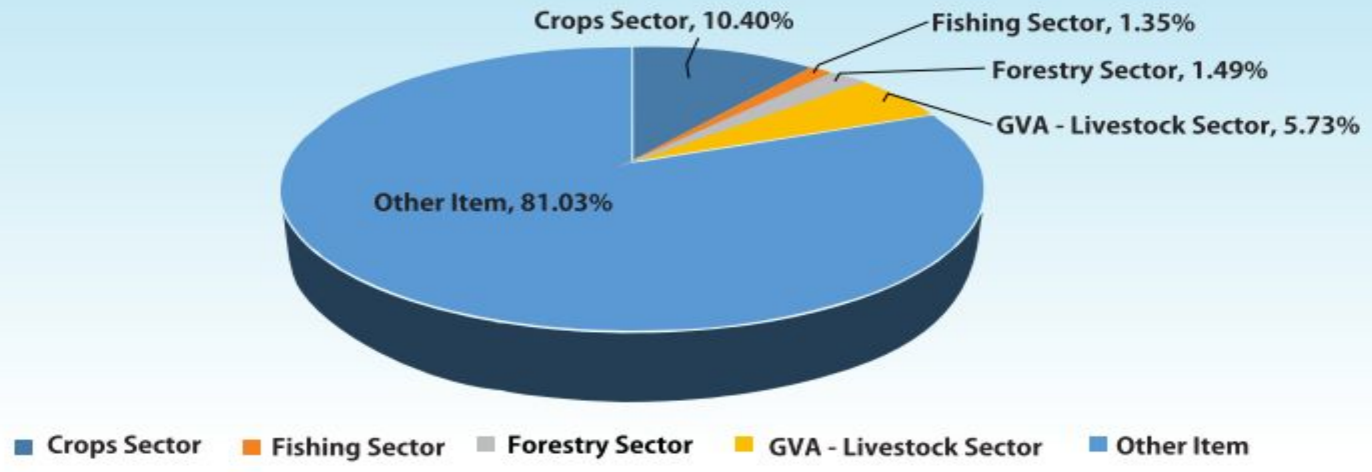
Buffalo meat share in total meat exports from India – 82%

3,900 licensed & authorized slaughter houses besides around 26,000 unauthorized slaughter houses

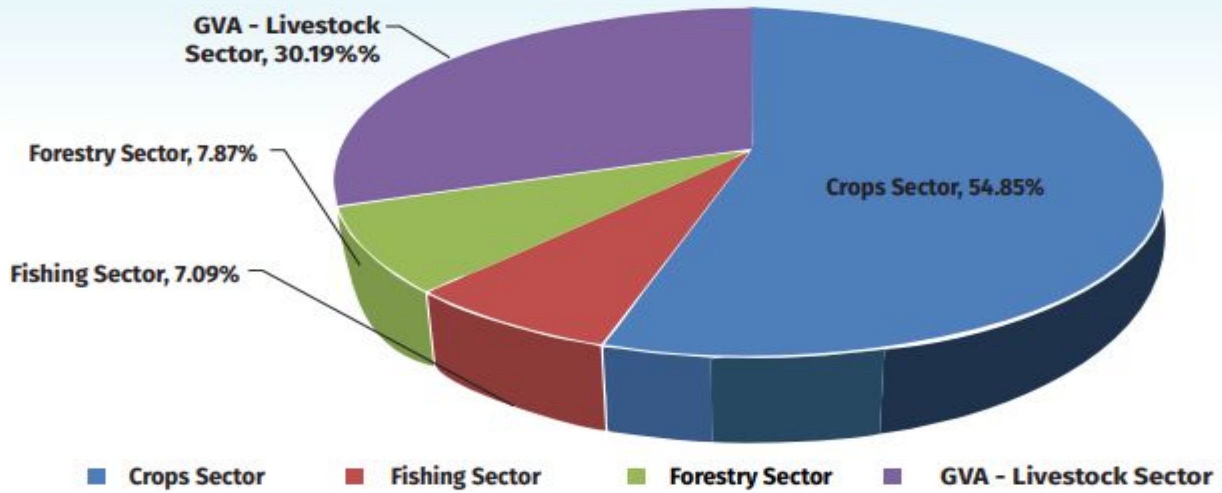
Registered Abattoirs cum meat processing plants with APEDA for export - 73

2.6.1 ITEM-WISE PERCENTAGE CONTRIBUTION IN AGRICULTURE & ALLIED SECTOR (A&AS) AND TOTAL GVA

Graph 2.31: (a) Item-wise % contribution total GVA at (Current Prices) 2021-22*

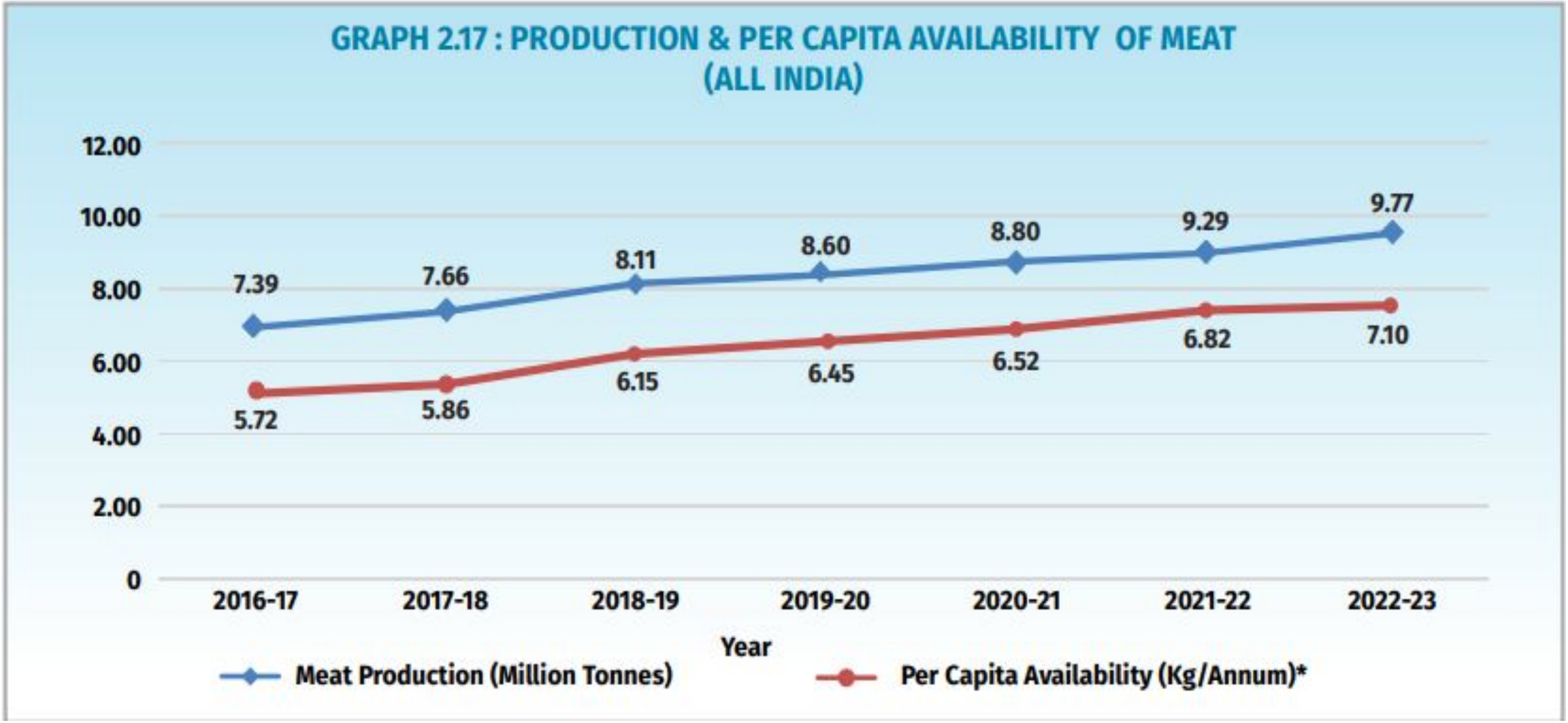


Graph 2.31: (b) Item wise % contribution Agriculture Sector at (Current Prices) 2021-22*

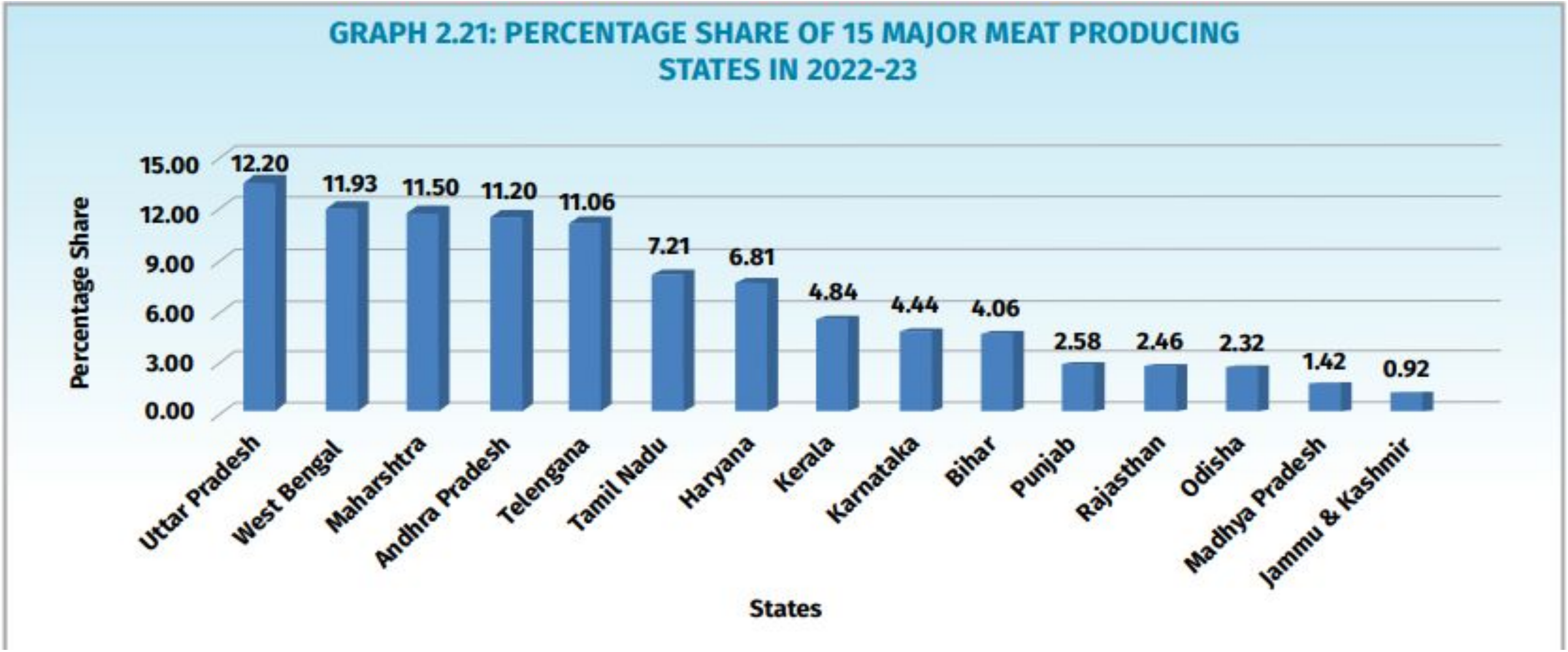


- The total meat production in the country is 9.77 million tonnes during 2022-23.
- India ranks 8th in the world in terms of total Meat production (Source: FAO).
- The meat production has increased by 5.13% as compared to previous year (2021-22).
- The meat production from poultry is 4.995 million tonnes, contributing about 51.14% of total meat production. The growth of poultry meat production has increased by 4.52% over previous year.
- The top 5 meat producing States are Uttar Pradesh (12.20%), West Bengal (11.93%), Maharashtra (11.50%), Andhra Pradesh (11.20%) and Telangana (11.06%). They together contribute 57.90% of total meat production in the country.

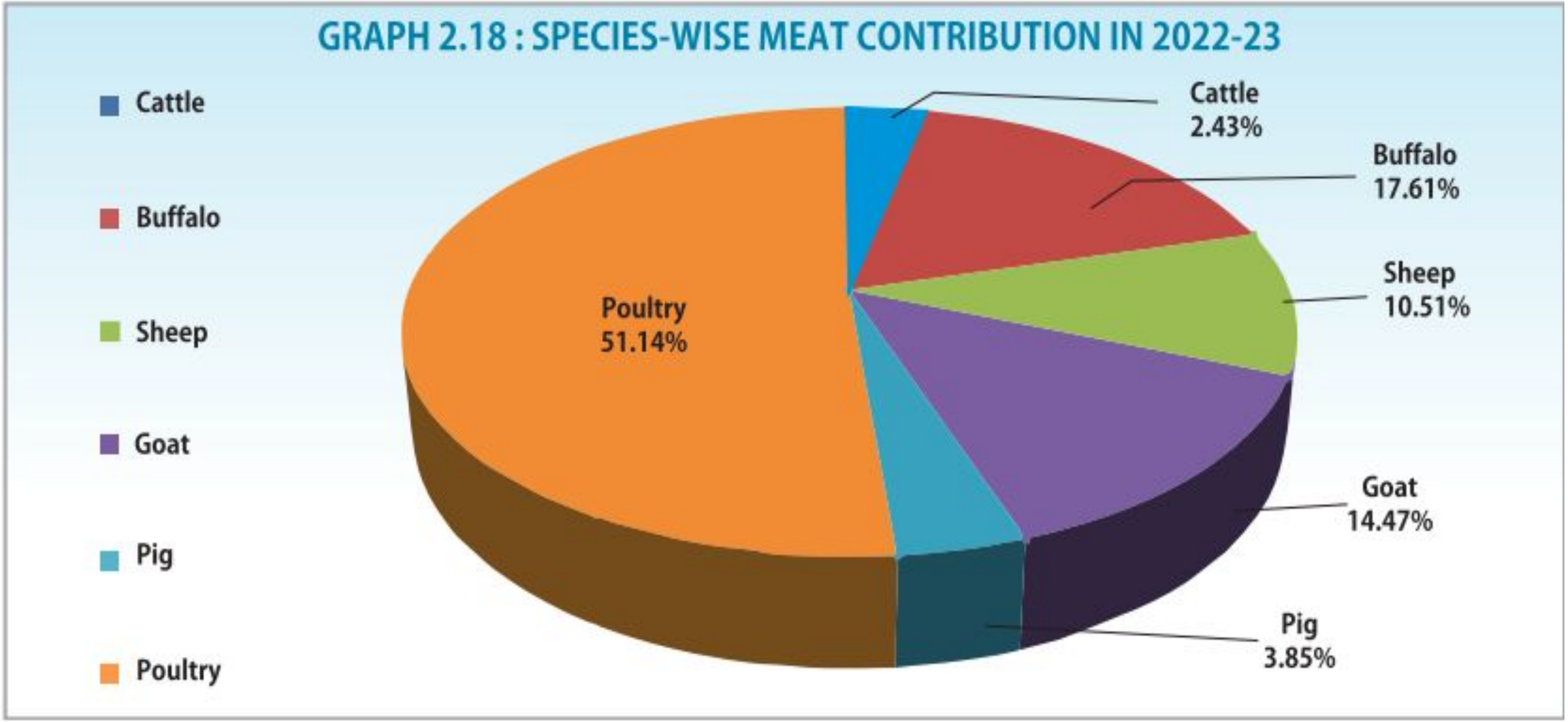
Production and availability



State wise Contribution



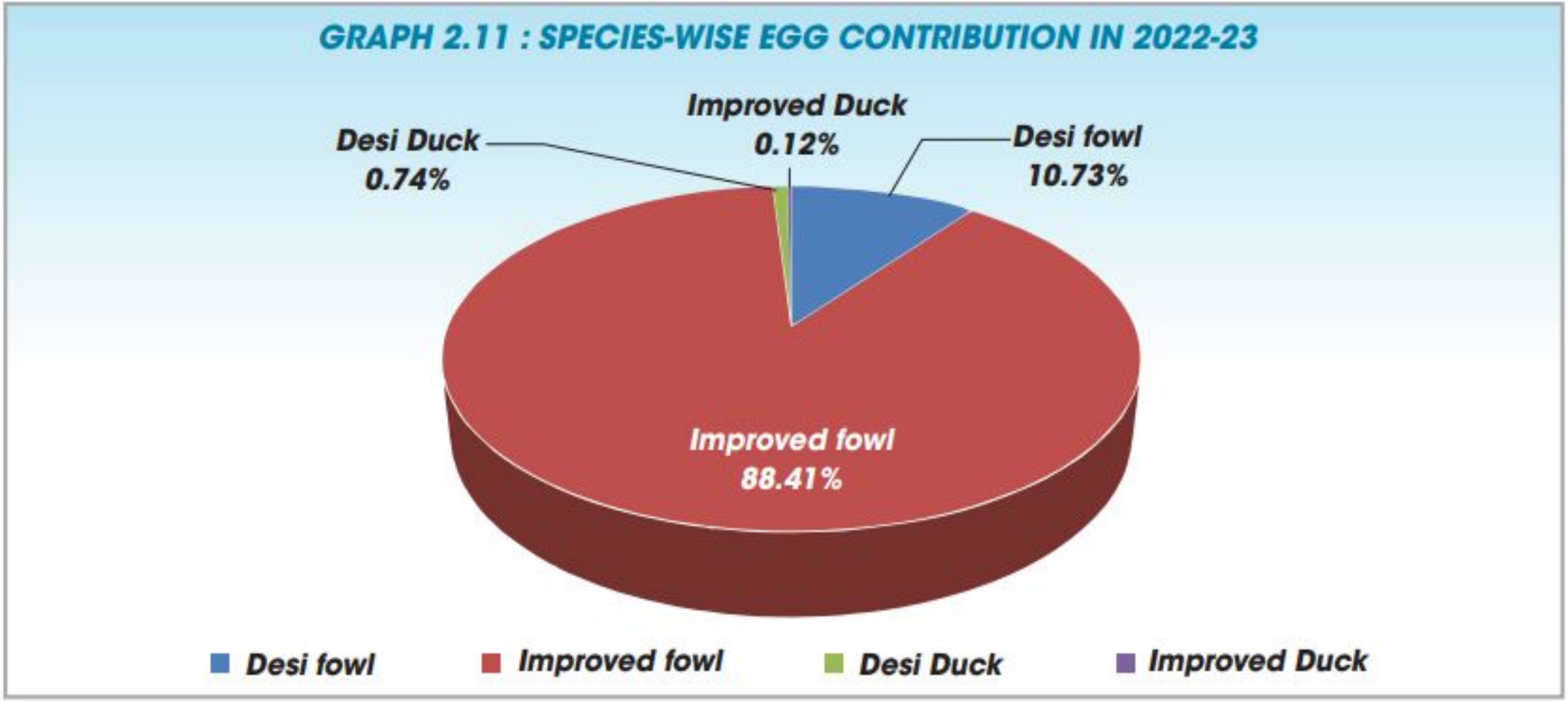
Species Wise Contribution



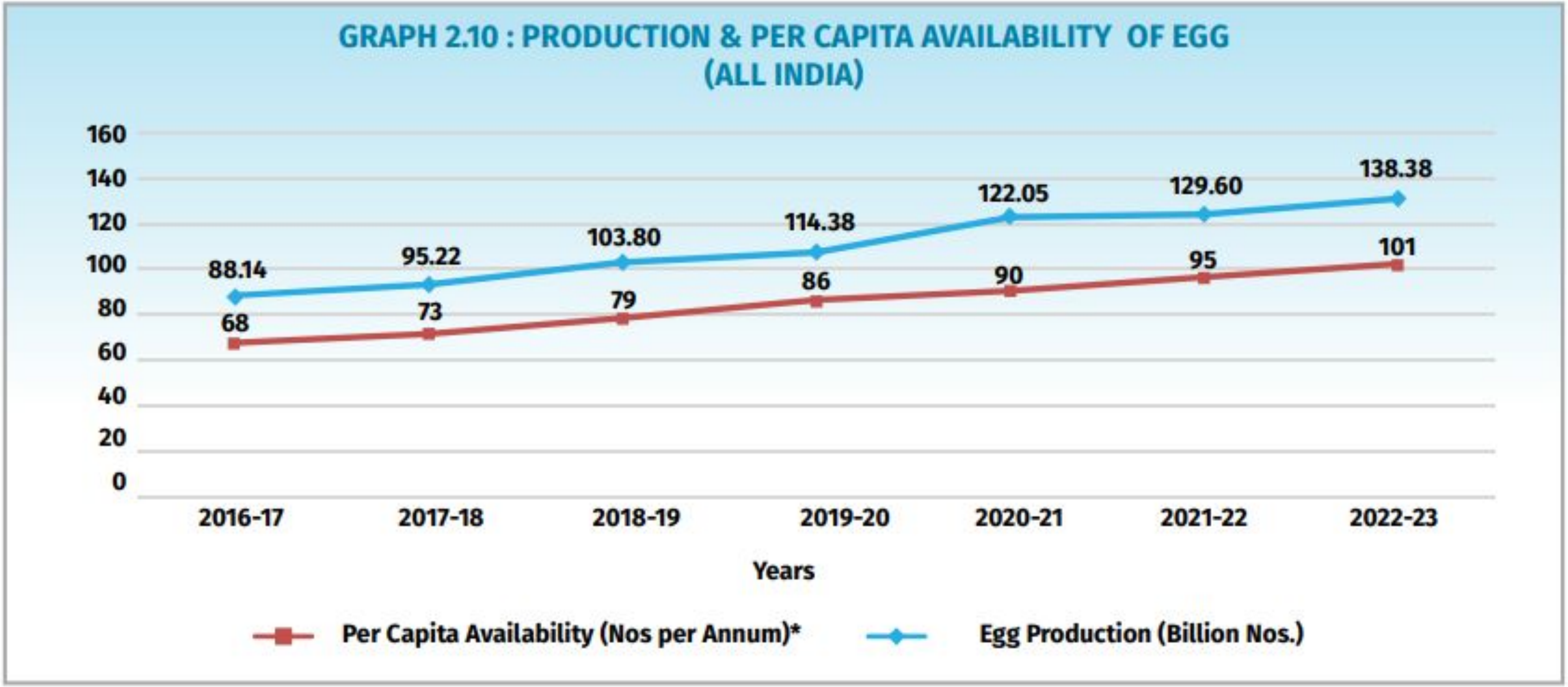
MAJOR HIGHLIGHTS OF EGG PRODUCTION

- The total egg production in the country is 138.38 billion numbers during 2022-23.
- India ranks 3rd in the world in terms of total Egg production (Source: FAO).
- The egg production has increased by 6.77% as compared to previous year (2021-22).
- The per-capita availability of egg is 101 eggs per annum.
- Top 5 egg producing States are Andhra Pradesh (20.13%), Tamil Nadu (15.58%), Telangana (12.77%), West Bengal (9.93%) and Karnataka (6.51%) They together contribute 64.93% of total egg production in the country.
- The total egg production from commercial poultry is 118.16 billion numbers and backyard poultry are 20.20 billion numbers contributing 85.40% and 14.60% of total production of egg respectively.

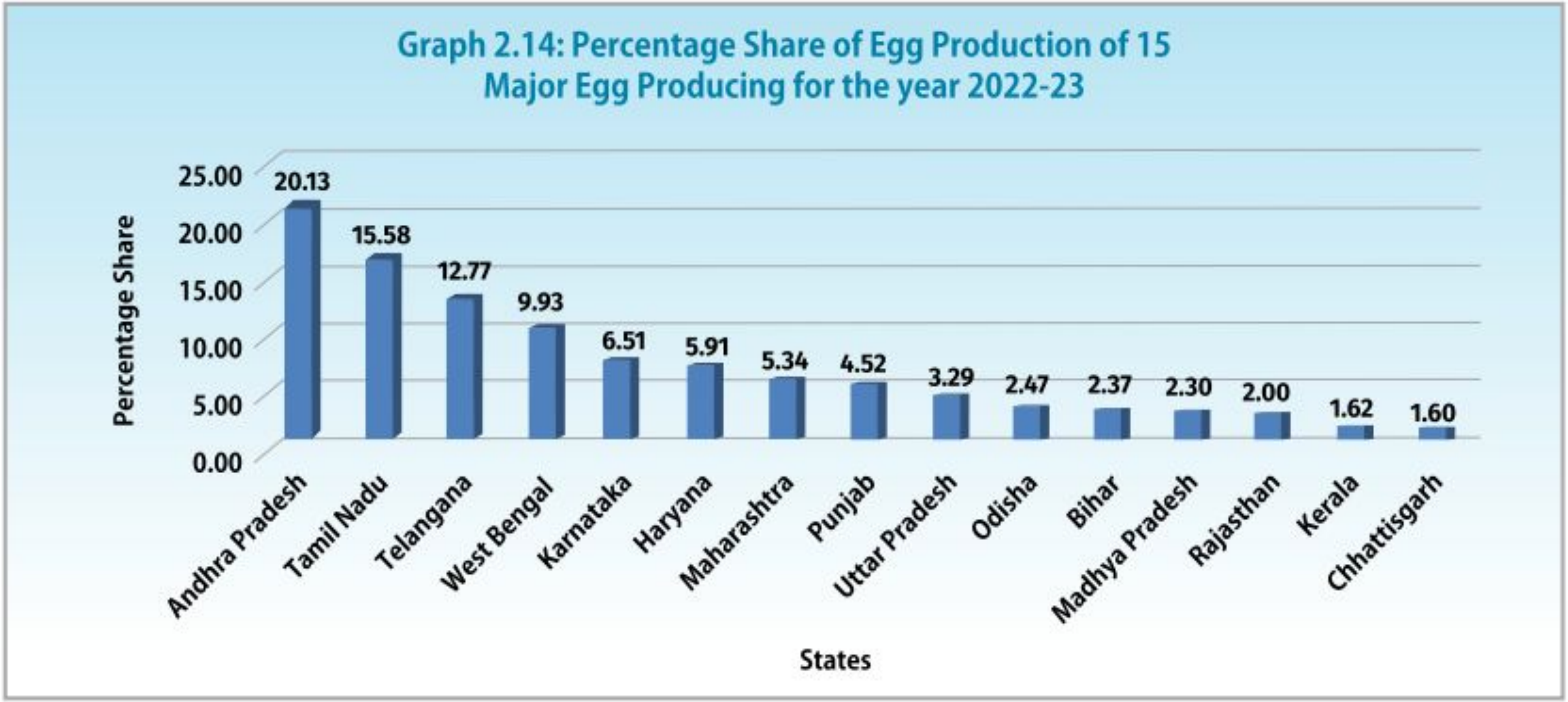
Species Wise Contribution



Production and availability



State wise contribution



20^{th} Livestock Census (DAHD, 2019)

Category	2012	**2019**	% Change (2012 to 2019)
Cattle	190.9	**192.52**	**0.85**
Buffalo	108.7	**109.85**	**1.06**
Yak	0.08	**0.06**	-25.00
Mithun	0.30	**0.38**	26.66
Bovines	299.98	**302.82**	1.00
Sheep	65.07	**74.26**	**14.13**
Goat	135.17	**148.88**	**10.14**
Horses & Ponies	0.63	**0.34**	-45.24
Mules	0.20	**0.08**	-57.09
Donkeys	0.32	**0.12**	-61.23
Camels	0.4	**0.25**	-37.05
Pigs	10.29	**9.06**	-12.03
Total livestock	**512.06**	**535.82**	**4.64**

Export of Animal Products for 2023-24 APEDA: Agricultural and Processed Food Export Development Authority

CATEGORY	Value (in crores Rs.)
Buffalo Meat	31010.10
Sheep/ Goat Meat	643.55
Poultry Products	1530.20
Dairy Products	2260.94
Animal Casing	399.21
Processed Meat	20.55
Albumin (Eggs & Milk)	173.06
Natural Honey	1470.84
TOTAL	37,665.51

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

Nutritive value of meat and poultry

- high quantity as well as quality of proteins, available supply of vitamin B complex, some minerals (Fe) and some essential fatty acids.
- **Water**: 75%
- **Protein:16-22% (18.5%). Meat contains all essential amino acids among which highest is lysine.**
- **Fat**: 3%

  Lipids: Most abundant fatty acid in meat is oleic acid> palmitic> Stearic acid

  Saturated fatty acids: stearic acid and palmitic acid.

  Cholesterol: lean meat 70-75mg/100g (liver and brain300-2000mg/ 100g)
- **CHO**: 1% or less (major glycogen)

Energy supplied by broiler: 151 cal/100 g

Inorganic substance: 1% minerals

- **Meat:** good source of all minerals except calcium. Max is K followed by P.
- **Vitamins:** good source of B complex but poor source of vitamin C (absent in lean meat)
- Lean pork has 5-10 times more thiamine than other meats

100 g serving of meat supplies:

- 10% of RDA of calories
- 50% of RDA of proteins (RDA of proteins is 56 g @ 0.8 grams/ kg BW).
- 35% of iron demand (**100% if serving is liver**)
- 25-60% of B complex vitamins

Skeletal muscles

- Water- 75% & Solids 25%
- Protein- 19%
- Lipids- 2.5%
- Carbohydrates- 1.2%
- Nitrogenous Subst.- 1.65%
- Inorganic Subst.- 0.65%
- Vitamins- traces

Water 75%	Protein 19%			Lipids 2.5%	Carb. 2.5%	Miscellaneous 2.3%		Vitamins Minute qu.	
	Myofibrillar 11.5%	**Sarcoplasmic 5.5%**	**Connective tissue 2.0%**	Neutral lipids	Glycogen	Nitrogenous subst.	Inorganic subst.	Water sol.	Fat Sol
	Myosin 50-55%	Haeme pigment (Myolobin)	Collagen			Creatinine	Macro Elements	Vitamin B complex	Vitamin A
	Actin 20-25%			Phospholipids	Glucose-6-phosphate				
	Tropomyosin 8-10%	Oxidative enzymes							
						Ionosine Phosphate	Micro Elements		Vitamin D
	Troponin 8-10%	Mitochindrial oxidative enzymes	Reticulin	Cerebrosides	Glucose				
	C protein 2-2.5%								
	M protein 4.0%	Lysosomal enzymes				Nucleostides	Trace Elements		Vitamin E
	Alpha actinin 2-2.5%	Nucleo-proteins	Elastin	Cholesterol	Lactic Acid	Carnosine			
	Beta Actinin 1-1.5%					Anserine etc.			Vitamin K

Structure and composition of muscle tissue

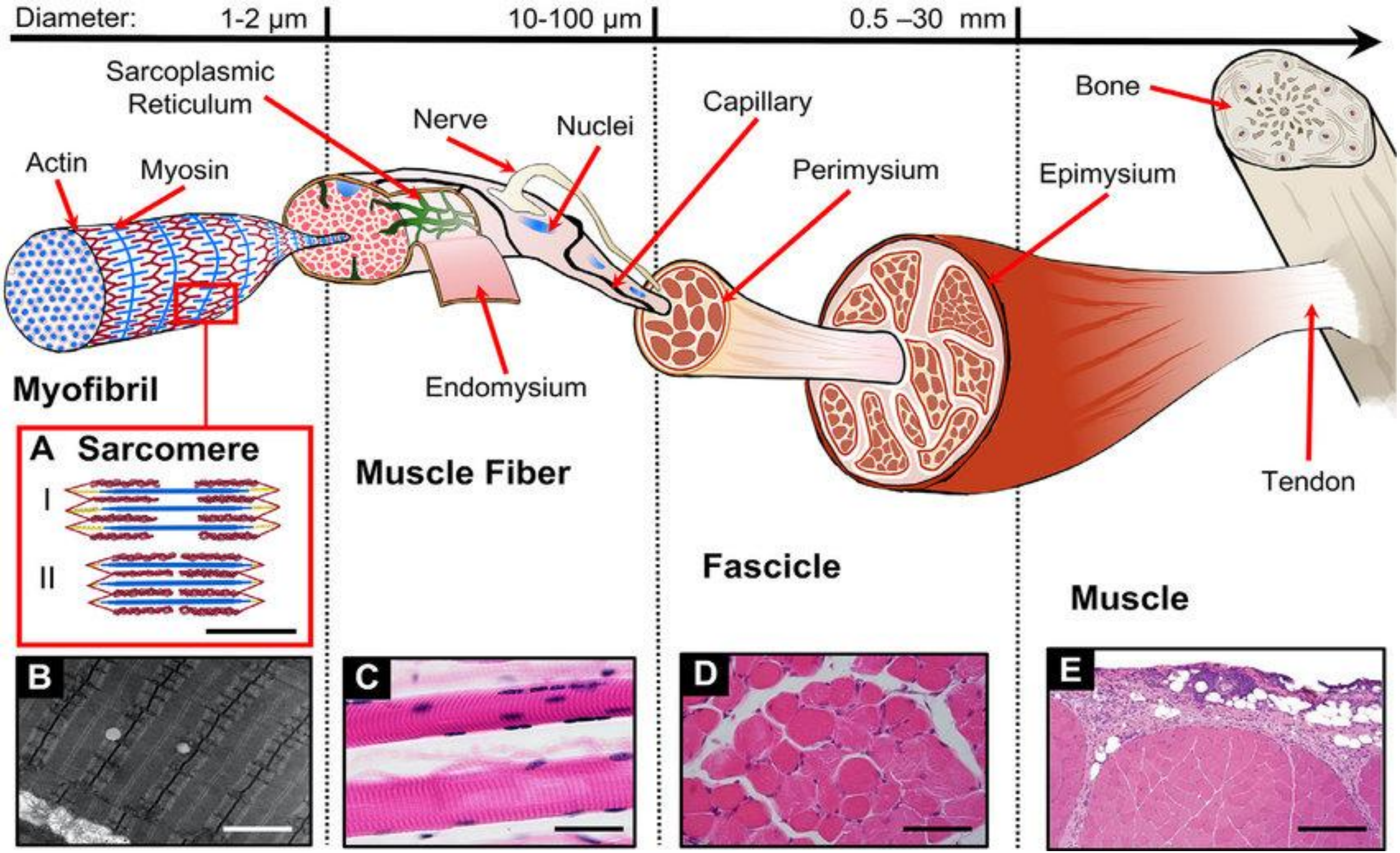
- Meat: animal tissue which are suitable for use as food.

Composition:

1. Muscle- skeletal muscles, smooth muscles and cardiac muscles
2. Connective tissue - adipose tissue, cartilage, bone, connective tissue proper.
3. Nervous tissue
4. Epithelial tissue

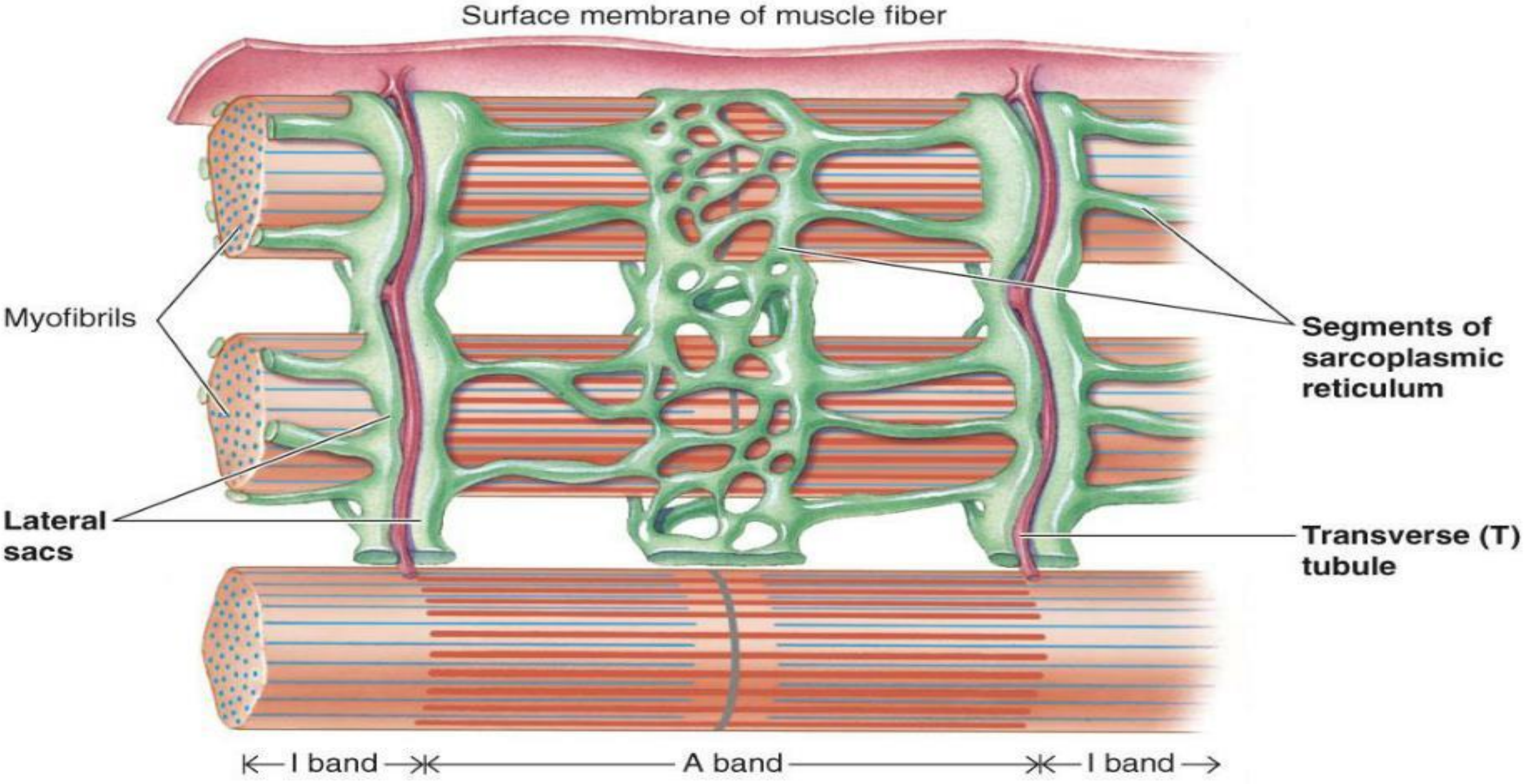
Skeletal muscles:

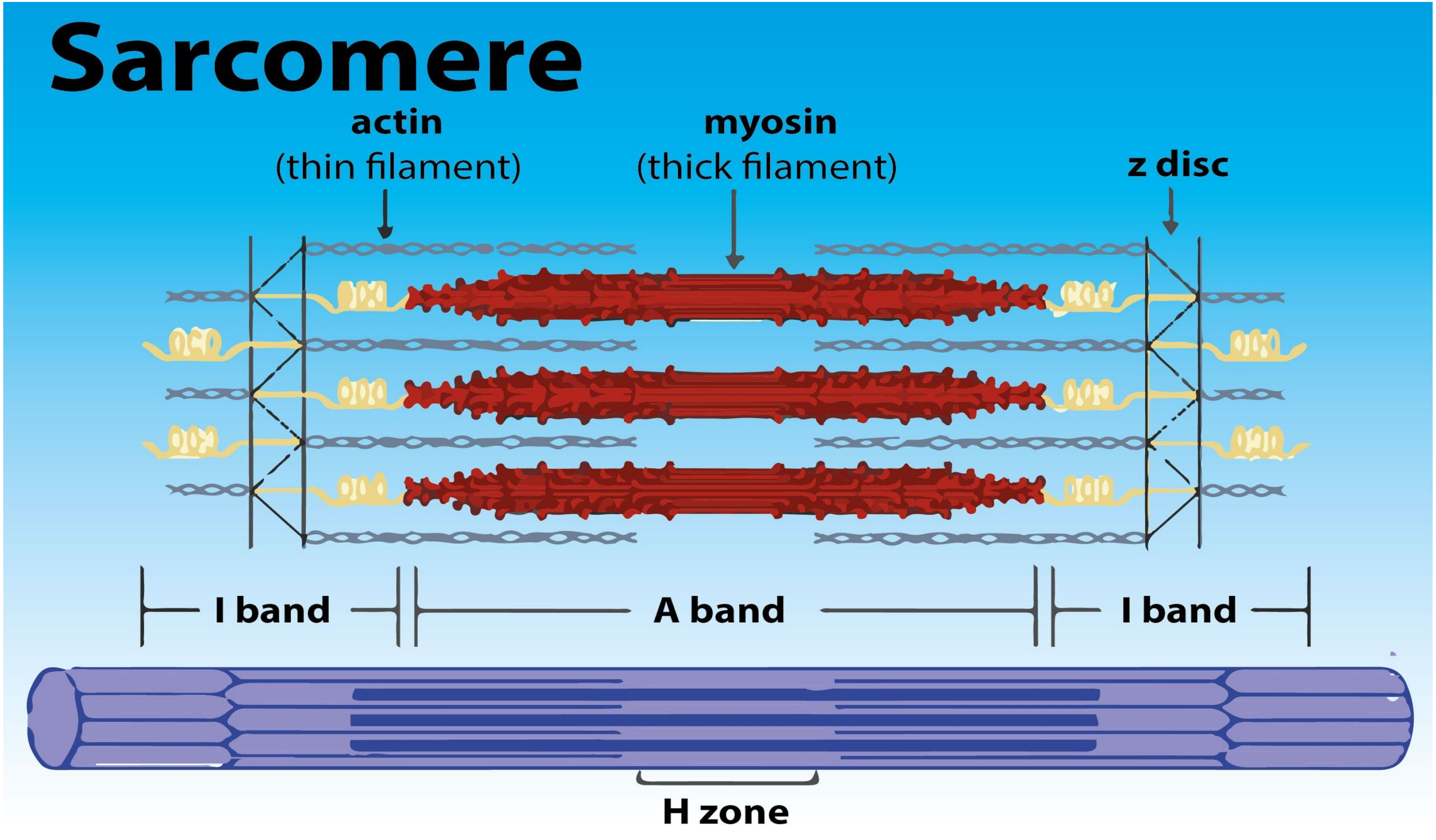
- Constitute bulk of carcass (35 to 65%)
- Covered with connective tissue
- **Epimysium:** Outermost covering of connective tissue surrounding a muscle.
- **Perimysium:** covering of Muscle bundles
- **Endomysium:** CT covering the muscle fibre.
- **Muscle fibre:** specialized cell □ structural unit of muscle & form 75-92% of total muscle volume. Have Diameter of 10 to 100 microns.
- **Sarcolemma:** membrane surrounding the muscle fibre.
- **Sarcomere:** basic contractile unit of muscle fibre.

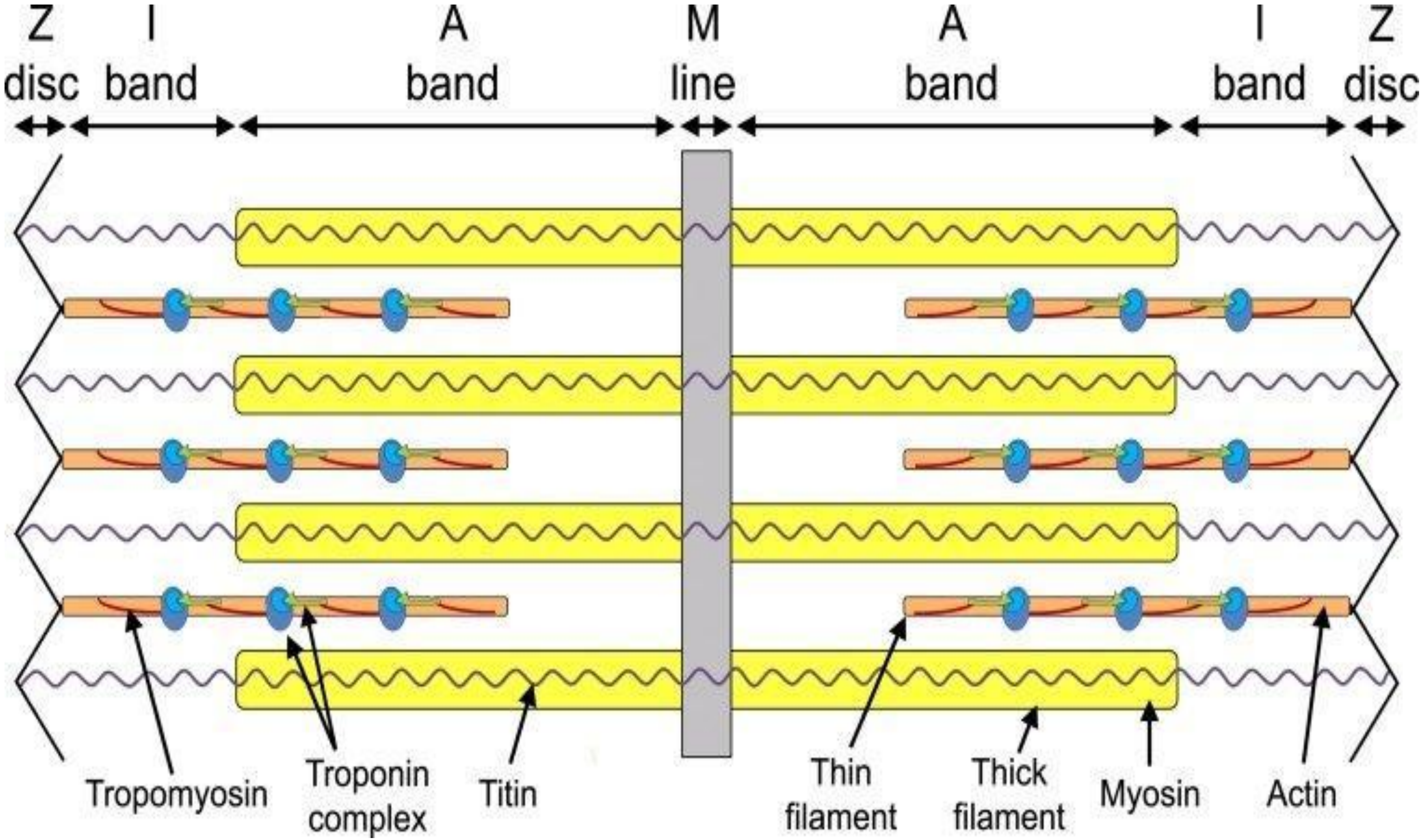


Diameter:
1-2 µm
10-100 µm
0.5 –30 mm
Sarcoplasmic
Reticulum
Nerve
Nuclei
Capillary
Bone
Actin
Myosin
Perimysium
Epimysium
Endomysium
Myofibril
A Sarcomere
I
II
Muscle Fiber
Tendon
Fascicle
Muscle
B
C
D
E

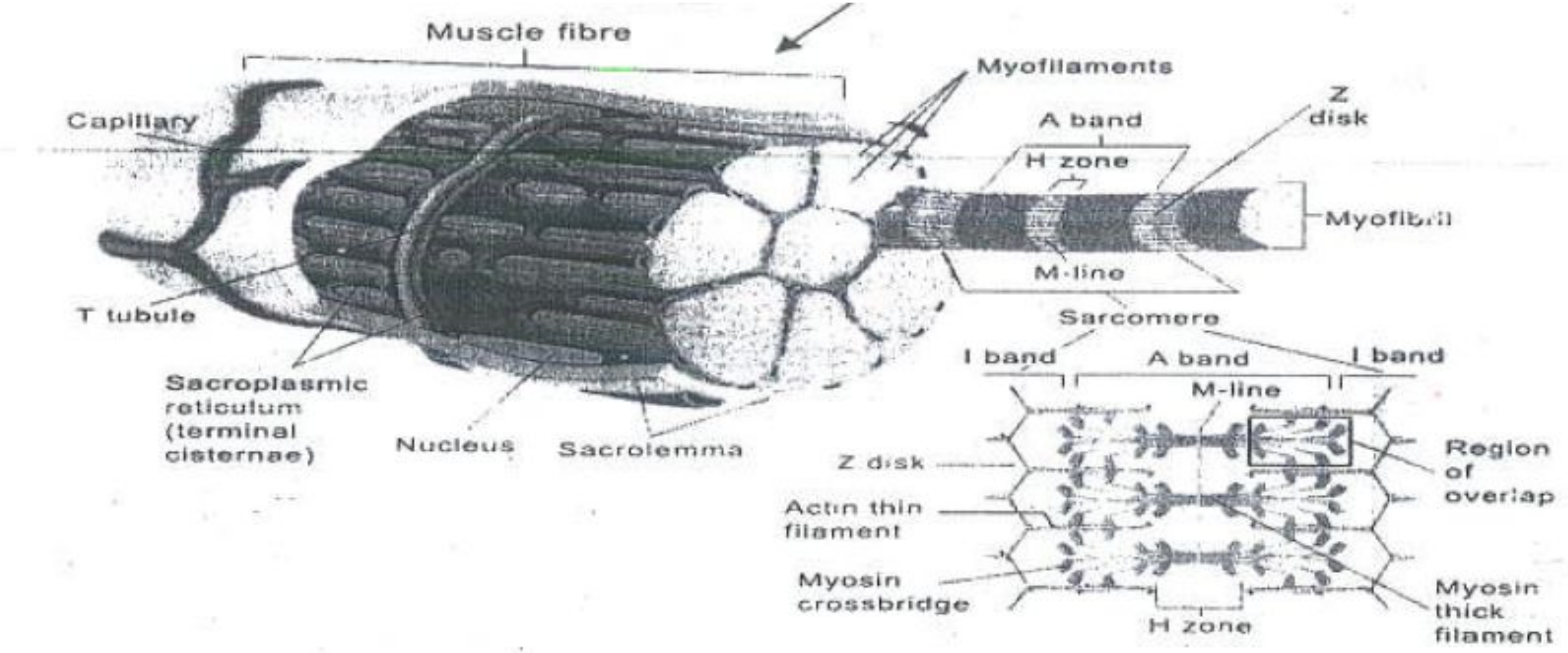
T Tubules and Sarcoplasmic Reticulum




Sarcomere
actin
(thin filament)
myosin
(thick filament)
z disc
I band
A band
I band
H zone


Z disc
I band
A band
M line
A band
I band
Z disc
Tropomyosin
Troponin complex
Titin
Thin filament
Thick filament
Myosin
Actin

- 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:**
  a. **Contractile-** action and myosin (75 to 80%)
  b. **Regulatory-** Z line proteins, tropomyosin, troponin.

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

Muscle proteins

- **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

Muscle proteins- (19.0%)

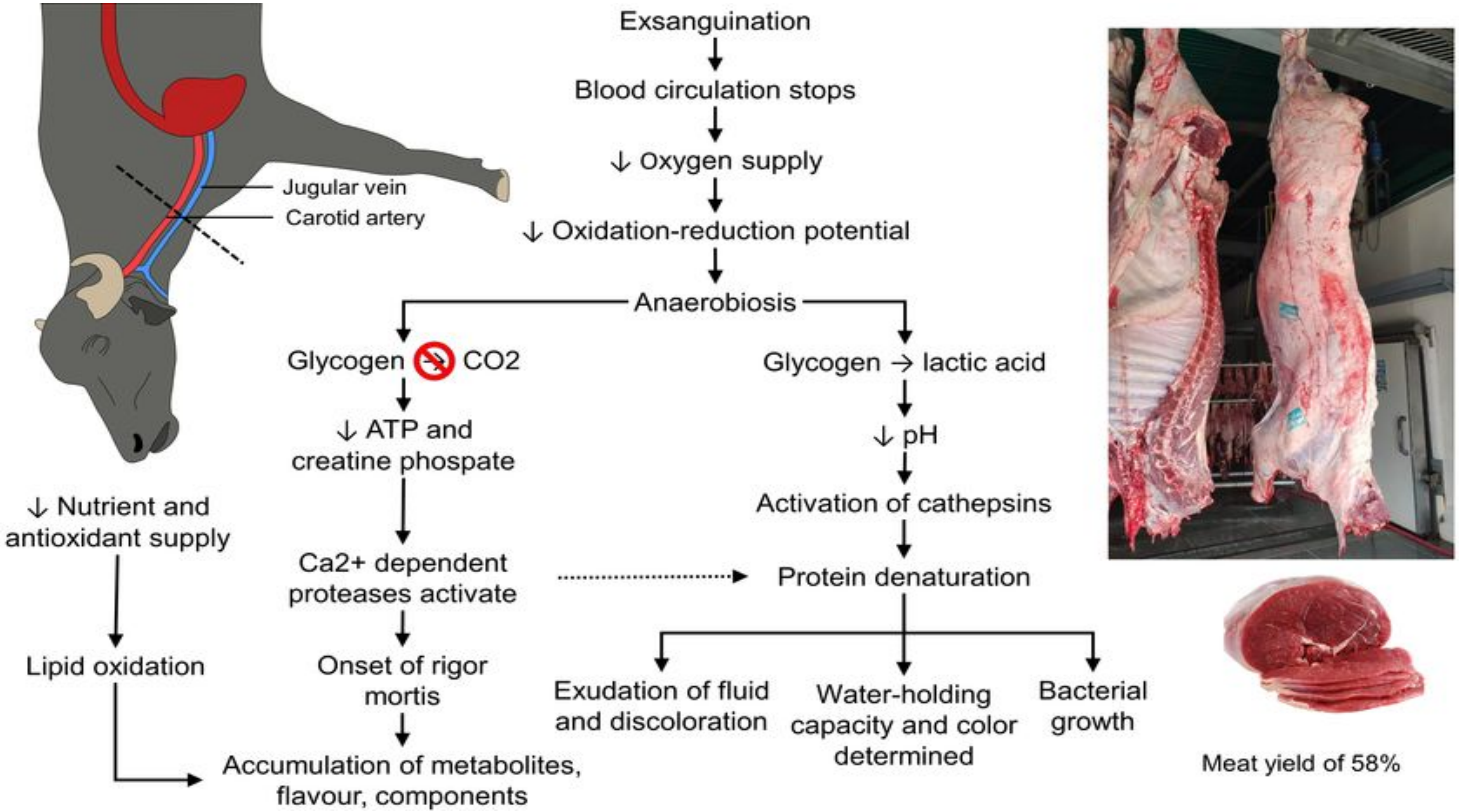
Myofibrillar (11.50%)	Sarcoplasmic (5.50%)	Connective Tissue (2.0%)
Myosin (5.5%)	Glyceraldehyde Phosphate Dehydrogenase (1.2%)	Collagen (1.0%)
Actin (2.5%)	Creatine Kinase(0.5%)	Elastin (0.05%)
Troponin (0.6%)	Aldose (0.6%)	Organelles(0.95%)
Tropomyosin (0.6%)	Glycolytic Enzymes (2.2%)	
Actinins (0.5%)	Myoglobin (0.2%)	
Nebulin (0.3%)	Hb and extracellular proteins (0.6%)	
Connectin (0.9%)		
M-line & C Proteins (0.2%)		
Miscellaneous (0.4%)		

Myoglobin

- Sarcoplasmic protein
- Gives red colour to muscle
- Content will be higher in red muscle fibre and low in white
- Carrier of oxygen to muscle fibre
- Oxymyoglobin: cherry red colour
- Metmyoglobin: Brownish red colour

Conversion of Muscle to Meat

- Post-mortem glycolysis and pH decline
- Rigor Mortis
- Loss of Protection from Invading Microorganisms
- Degradation due to proteolytic enzymes
- Loss of Structural Integrity
- resolution of rigor mortis.


Exsanguination
Blood circulation stops
↓ Oxygen supply
↓ Oxidation-reduction potential
Anaerobiosis
Glycogen → CO2
↓ ATP and creatine phospate
Ca2+ dependent proteases activate
Onset of rigor mortis
Accumulation of metabolites, flavour, components
Glycogen → lactic acid
↓ pH
Activation of cathepsins
Protein denaturation
Exudation of fluid and discoloration
Water-holding capacity and color determined
Bacterial growth
Jugular vein
Carotid artery
↓ Nutrient and antioxidant supply
Lipid oxidation
Meat yield of 58%

* **Loss of Homeostasis:** The homeostasis is controlled by nervous system, which ceases to function within 4-6 minutes after bleeding.

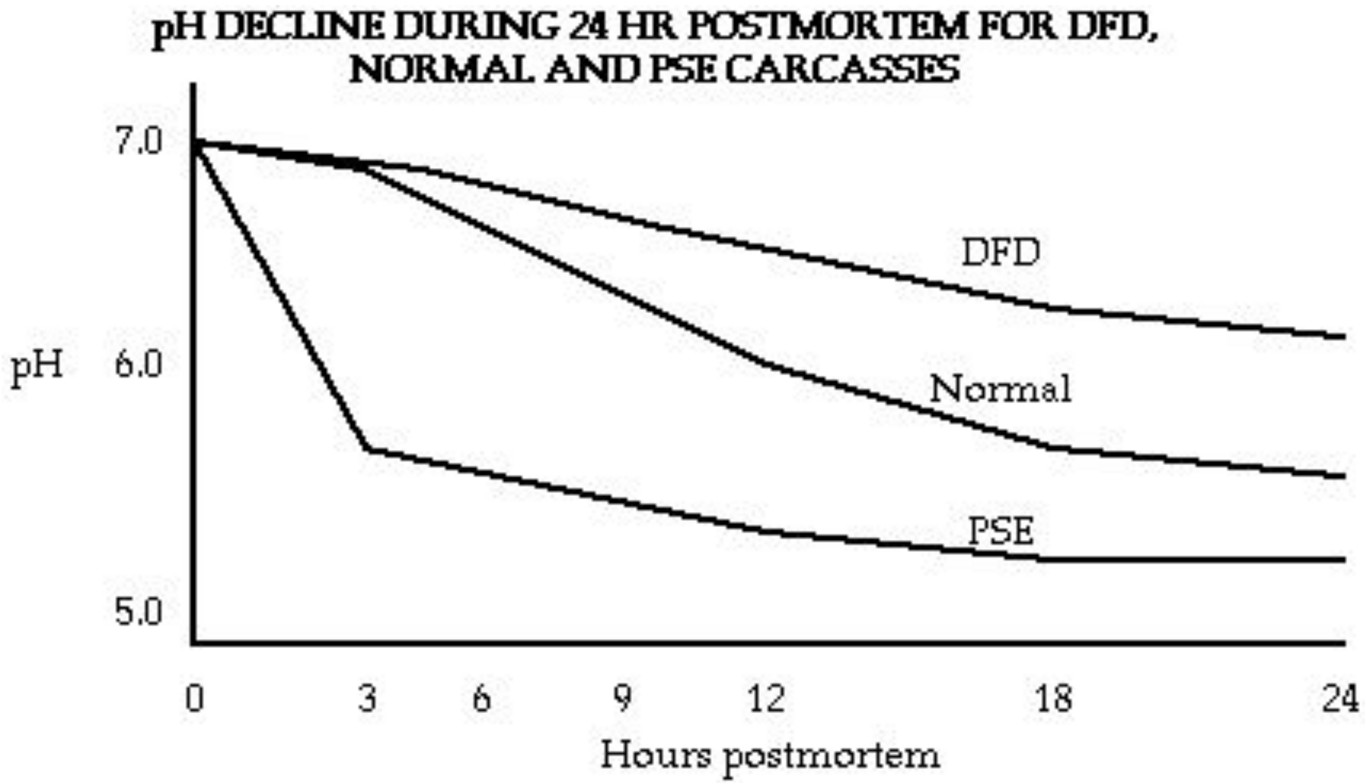
✓ In the absence of blood supply, there is loss of body heat and temperature starts declining.

✓ **Decline in pH:** In the absence of oxygen, anaerobic glycolysis leads to the formation of lactic acid, and thus decrease in pH.

✓ 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)

✓ 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



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

Rigor is characterized by three stages

1. **Delayed phase:** plenty of ATP in the muscle (complexed with Mg^{2+}), the muscle remains in the relaxed state
2. Onset phase: After the depletion of muscle glycogen, ATP level is maintained from rephosphorylation of adenosine diphosphate (ADP) by creatine phosphate (CP).
3. 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

1. Species of animal: onset faster in active animals. It is faster in horses and cattle than pigs.

2. Type of muscle: Active and well nourished muscles undergo rigor first.

3. 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.

4. 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.

5. Atmospheric temperature: High temperature is responsible for early onset and low temperature for delay in rigor.

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 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

1. Removal of blood □ exsanguination. If >50% retained □ less shelf life (excellent medium fro microbes) and meat is less appealing
2. Circulatory failure- anaerobic metabolism □LA
3. Decline in pH: 7 (neutral) to 5.6-5.8 (acidic) in 8 hr
4. Stress condition: DFD or PSE
5. PM heat dissipation: depending on muscle location and fat covering
6. Loss of protection from microbes
7. Loss of structure: z-line protein degradation
8. Physical changes: color□ oxymyoglobin– bloom
9. Water holding capacity: 65-80% water□ tenderness/ juiciness

   High pH: DFD□ High WHC And Low pH: PSE□ Low WHC
10. Rigor mortis: stiffness due to permanent acto-myosin complex cross-bridge.

    Normal muscle contraction: 20% site cross-bridge but in rigor mortis□ 100% binding site involved.

    Normal relaxation□ ATP binding with Mg^{+2}. But in rigor mortis□ z-line protein breakdown.

Abattoir

- 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.

Goat meat is known as

(A) Mutton

(B) Veal

(C) Chevon

(D) Pork

Fresh muscle (lean) tissue contains about percent of protein.

(A) 11

(B) 15

(C) 19

(D) 23

The intensity of light at all inspection points in an abattoir should not be less than

(A) 110 Lux

(B) 220 Lux

(C) 420 Lux

(D) 540 Lux

The characteristic and eye appealing bright red colour of the surface tissues of freshly cut meat is due to

a. Oxymyoglobin
b. Oxyhaemoglobin
c. Oxymyoglobin and oxyhaemoglobin
d. None

On slaughter of hunted animals, the onset of rigor mortis is usually:

(A) Very slow

(B) Very rapid

(C) Absent

(D) Not affected

Maximum fat present in which meat?

- (A) Carabeef
- (B) Beef
- (C) Pork
- (D) Rabbit

Protein content of white meat is:

- (A) Lesser than red meat
- (B) Higher than red meat
- (C) Equal than red meat
- (D) No comparison with red meat

- Brown colour of meat is due to:
- (A) Oxyhaemoglobin
- (B) Oxymyoglobin
- (C) Metmyoglobin
- (D) All of these

Carabeef is the meat which is obtained from:

- (A) Cattle
- (B) Sheep
- (C) Swamp Buffalo
- (D) Camel

Meat from sheep which is between the age of one month to one year is termed:

- (A) Mutton
- (B) Veal
- (C) Chevon
- (D) Lamb

Pork is rich in vitamin:

- (a) Niacin
- (b) Thiamine
- (c) Riboflavin
- (d) B2

- Rigor mortis in fowl is seen in hours.
- (a) 2-4
- (b) 4-8
- (c) 8-12
- (d) 12-24

- The unique amino acid present in elastin is:
- (a) Glycin
- (b) Proline
- (c) Demosine
- (d) Lysine

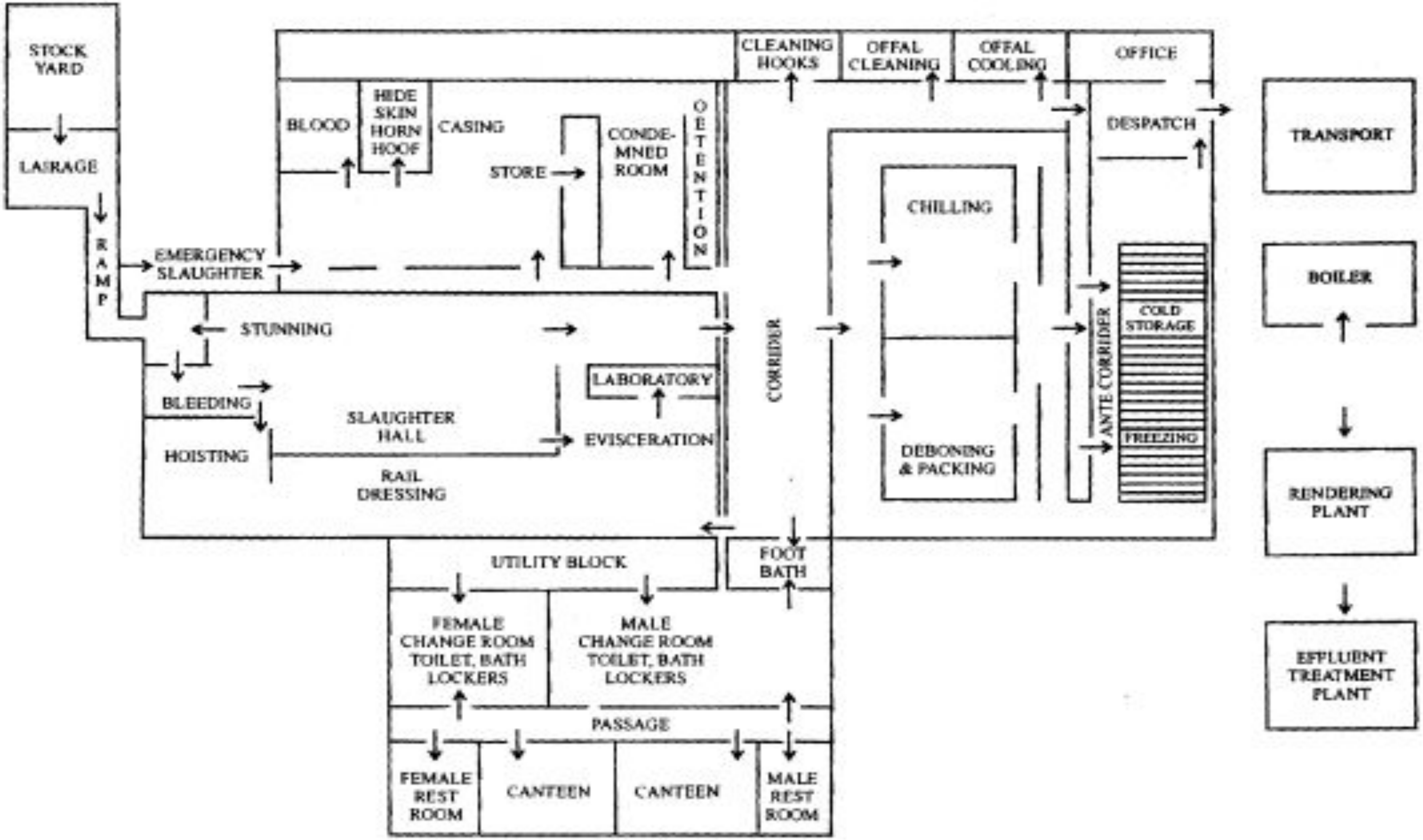
- Meat is poor source of:
- (a) Vitamin A
- (b) Vitamin B complex
- (c) Vitamin C
- (d) Vitamin D

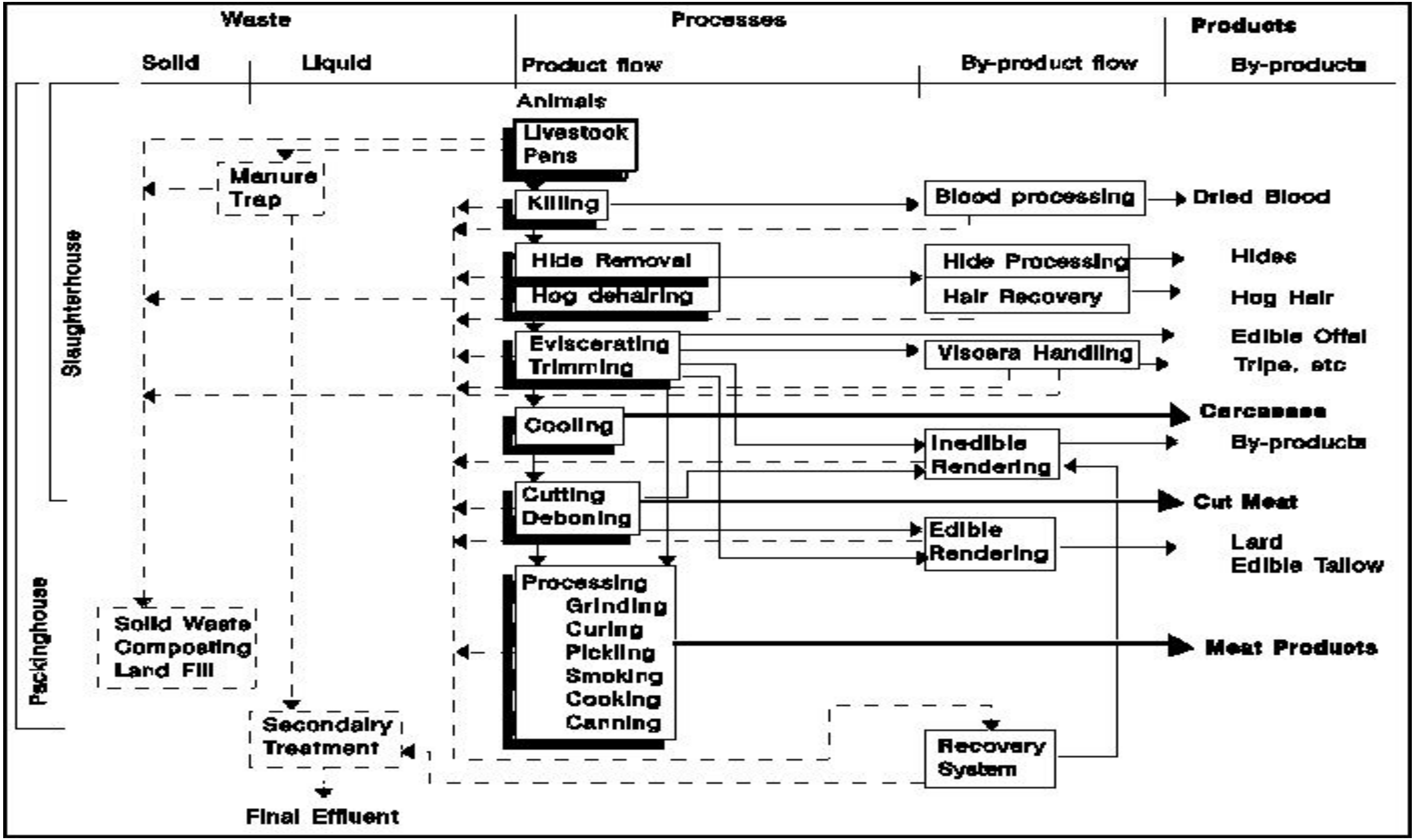
- The freezing point of meat lies between-----------------°C.
- (A) 3 & 4
- (B) 1 & 1.5
- (C) 0 & 1
- (D) -1 &-1.5

- The recommended light intensity at work rooms in an abattoir is
- (A) 10 foot candles
- (B) 20 foot candles
- (C) 30 foot candles
- (D) 40 foot candles

Topics covered

- Layout of Abattoir
- Transport of animals
- Ritual method of Slaughter
- Humane method of Slaughter
- Ante mortem examination
- Post mortem examination


STOCK YARD
LAIRAGE
RAMP
EMERGENCY SLAUGHTER
BLOOD
HIDE SKIN HORN HOOF
CASING
STORE
CONDE-MNED ROOM
DETENTION
CLEANING HOOKS
OFFAL CLEANING
OFFAL COOLING
OFFICE
DESPATCH
TRANSPORT
STUNNING
BLEEDING
HOISTING
SLAUGHTER HALL
RAIL DRESSING
LABORATORY
EVISCERATION
CORRIDOR
CHILLING
DEBONING & PACKING
ANTE CORRIDOR
COLD STORAGE
FREEZING
BOILER
RENDERING PLANT
EFFLUENT TREATMENT PLANT
UTILITY BLOCK
FOOT BATH
FEMALE CHANGE ROOM TOILET, BATH LOCKERS
MALE CHANGE ROOM TOILET, BATH LOCKERS
PASSAGE
FEMALE REST ROOM
CANTEEN
CANTEEN
MALE REST ROOM



Waste
Solid
Liquid
Processes
Product flow
By-product flow
Products
By-products
Animals
Livestock Pens
Manure Trap
Killing
Blood processing
Dried Blood
Hide Removal
Hog dehairing
Hide Processing
Hair Recovery
Hides
Hog Hair
Eviscerating
Trimming
Viscera Handling
Edible Offal
Tripe, etc
Cooling
Carcasses
Inedible Rendering
By-products
Cutting
Deboning
Cut Meat
Edible Rendering
Lard
Edible Tallow
Processing
Grinding
Curing
Pickling
Smoking
Cooking
Canning
Meat Products
Solid Waste
Composting
Land Fill
Secondary Treatment
Recovery System
Final Effluent
Slaughterhouse
Packinghouse

BUILDINGS IN A MODERN ABATTOIR

Lairage: rest area - Rest is to be given for 24 hours

- 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

Isolation block & Emergency slaughter house

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

- Stunning, bleeding, dressing, evisceration

Main hall where animals are slaughtered.

- 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)

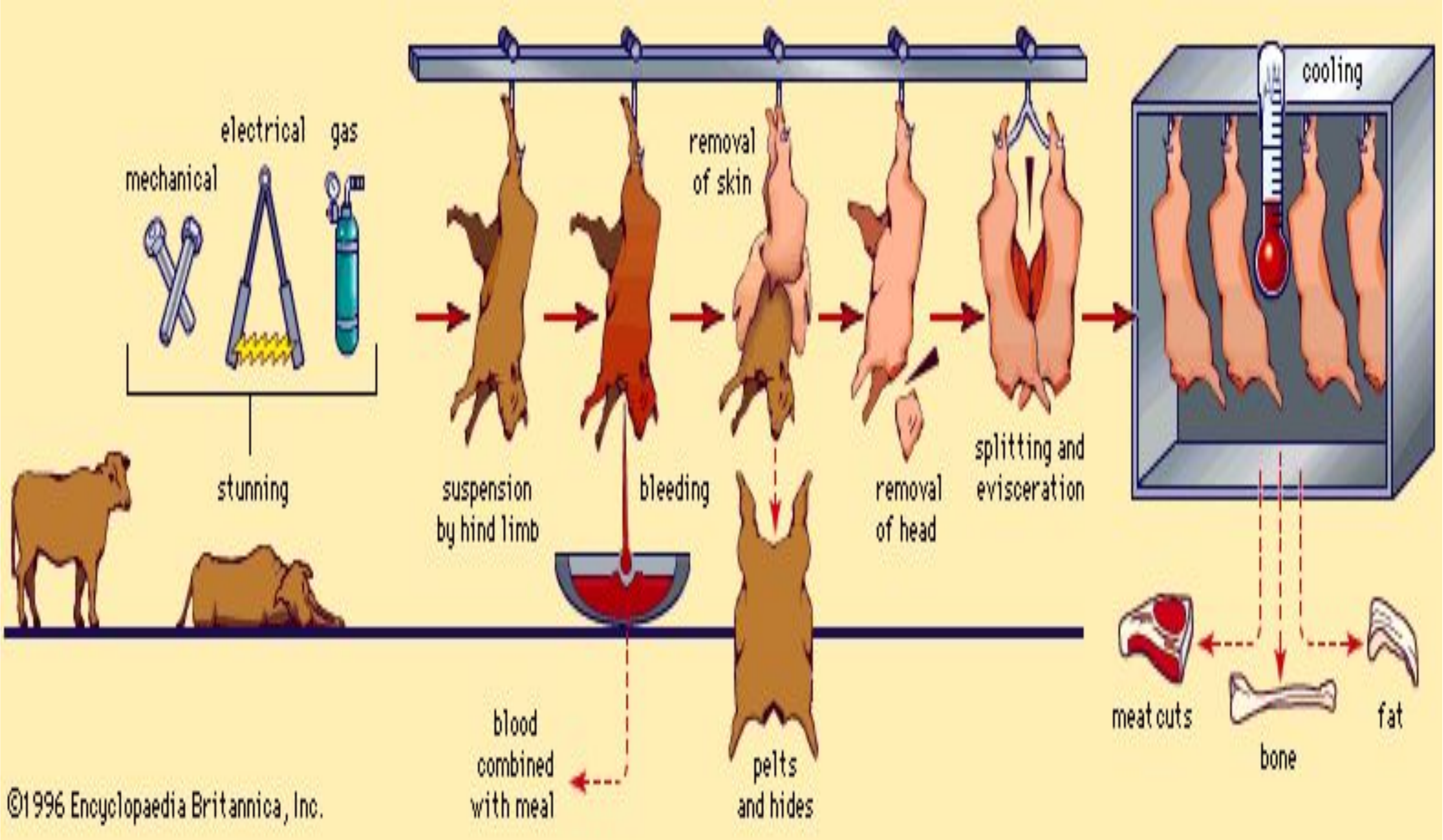
DRESSING SYSTEM

A. **Booth or Bed System**: slaughter is carried on floor by 1-2 persons; no person has specific work, Prevalent in India; Hygiene is poor

B. **Modified booth system:** facility for stunning and bleeding; booths with cradles and hoists;

C. **Cradle and Semi-line system**: stunning and bleeding; rail for breast opening, pluck removal and evisceration; Better hygiene

D. **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.



electrical
gas
mechanical
removal
of skin
cooling
stunning
suspension
by hind limb
bleeding
removal
of head
splitting and
evisceration
blood
combined
with meal
pelts
and hides
meat cuts
bone
fat

Types of Line or On-the rail dressing

a. Gravity rail system:

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

b. Intermittent Powered System:

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

c. **Continuous Power System:**

- Here dressing line will be in continuous motion
- More sophisticated instruments are used in the slaughter line (mechanical hide puller, etc.). Thus, the platform may be fixed or movable, elevated or lowered
- Carcass can be revolved to a full 360°
- Rate of slaughter 40-120 animals/hr

d. **Canpak System:**

- Continuous conveyor is used in which heavy trolleys or runners suspend the carcass from overhead rail
- Here everything is done systematically (mechanically)

Rate of slaughter 50-150 animals/hr

- Most Common in modern meat plants
- From arrival of animals till completely dressed the work is divided into 32 divisions (each work is carried out by one man).
- Developed and patented by the Canada Packers Ltd., Canada hence called Canpak system

- **Advantages**
- Time is saved
- Safer for operators
- More Hygienic
- A comfortable operative position is provided to the operator
- Increased output and enhanced value of carcass
- Less space per carcass is required
- **Possible Disadvantages**
- High standard of engineering maintenance is needed
- When break down occurs production ceases completely
- Trained personnel needed
- Meat inspection is sometimes more difficult and possibly less efficient

4. Chilling room:

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

5. Hide and skin store:

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

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

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

PIG SLAUGHTER HALL

- Pig slaughter should be carried out in a separate hall from that used for cattle, sheep. Facility for scalding, scraping and singeing are also provided in pig slaughter hall.
- Scalding is carried out by:

1. Scalding tank: Temperature of water is 60°C. This method is less hygienic as bacteria present in water may contaminate visceral organs like lungs.
2. Vertical scalding: is carried out in a double walled tunnel. Steam is blown over carcass for scalding and temperature is maintained at 61 to 64°C with the help of a thermostat. This method improves the hygienic quality of pig meat.

Transportation of meat animals

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

Loading/unloading: ramp should not be steeper than 30^{o}.

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.
- Response: Fight or flight syndrome 2 types

  Emergency/alarm reaction: immediate sympathetic N.S.

  General adaptation syndrome: long lasting ACTH – Corticosteroids, Gluconeogenesis, High Blood Glu.

Pre-slaughter Stress and Meat quality

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:

1. 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 with in 1 hr of death and 35°C.

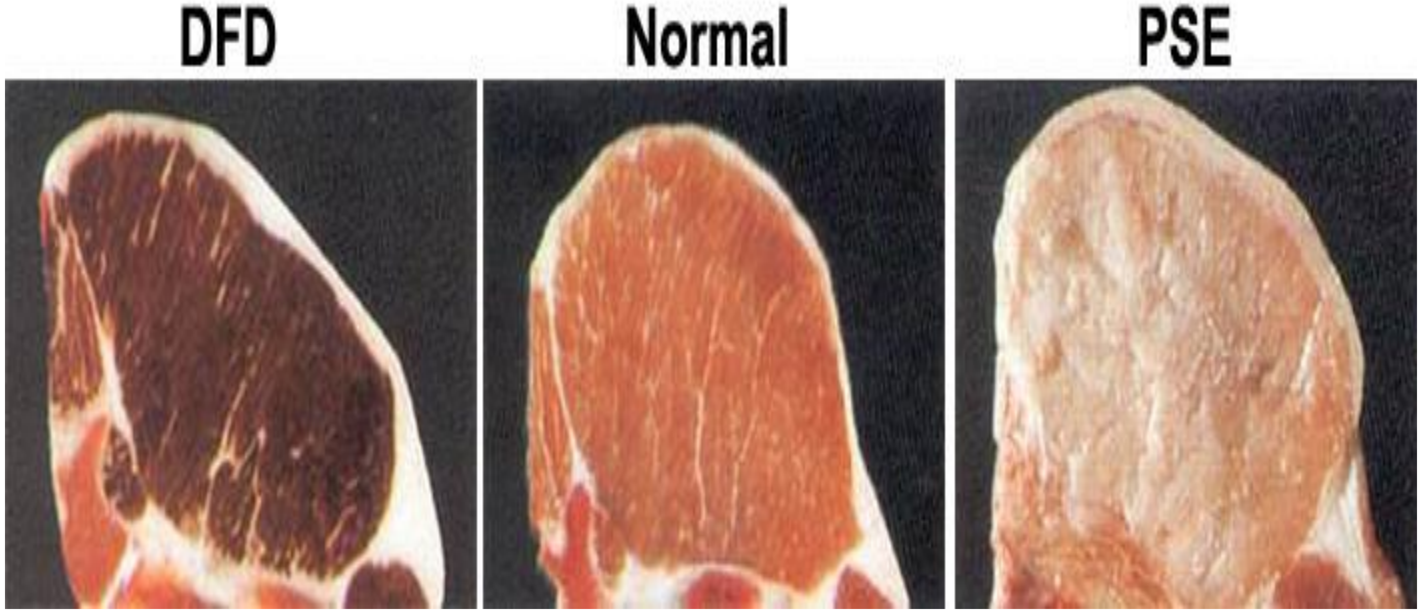
: Denaturation of proteins loss of protein solubility loss of water holding capacity loss of muscle pigment

: 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)


DFD
Normal
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 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

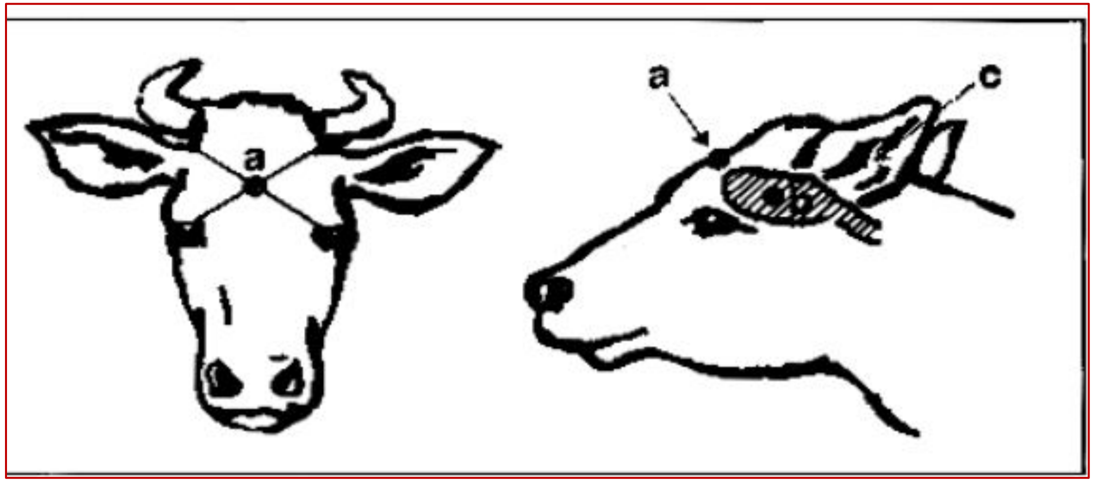
    - alter intracranial pressure

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

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

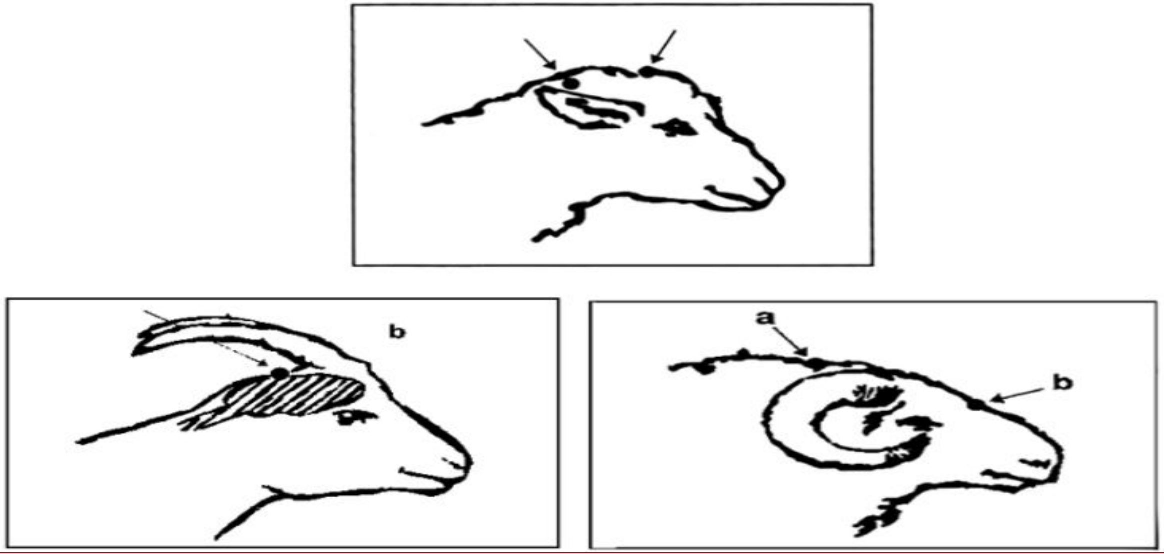
Site of shooting with captive bolt:

- 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



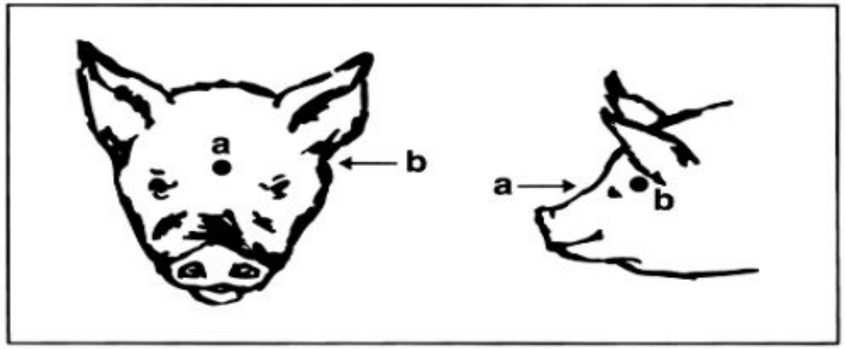
SHEEP & GOAT

- 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

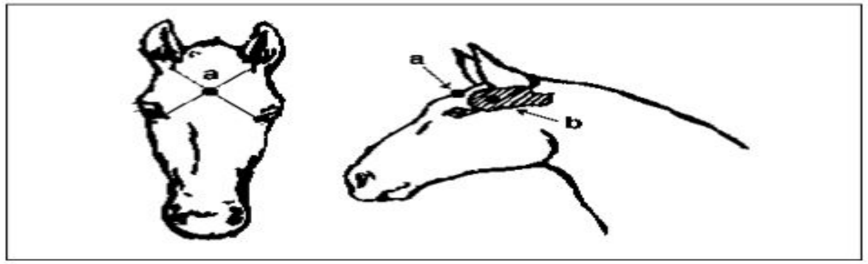


PIGS AND HORSES

- 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 employs 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 bcoz of wool- much CO_2 is wasted.

Equipment for CO_2 anesthesia

A. Oval tunnel: For pigs only, 600 pigs/Hr, conveyer of 10 compartments, one for each pig

B. Dip lift: pig/calf and sheep animal in cage descends vertically in to CO_2 pit.

C. Compact CO_2 immobilizer: Horizontally revolving apparatus of 4-8 compartments
: 300 pigs/Hr.

Adv. of CO_2 anesthesia: no harmful residues in meat
: carcass: relaxed better dressing
: less noise and labor req.
: 0.75% more bleeding compared to other methods stimulate resp.
: No muscular hemorrhages (as in electric method)
: Lower meat pH and PSE condition is reduced

Electrical stunning: Most widely used method

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

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

: massive depolarization of nerves

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

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

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

Signs of genuine electric shock:

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

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

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

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

Devices for electrical stunning

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

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

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

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

3. **Automatic stunning device:** line processing system.

Method of electrical stunning depending upon voltage applied:

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

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

Method of electrical stunning depending upon method of application:

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

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

BLEEDING

Spp	Incision	Bleeding time	Blood yield
Cattle	1. Bilateral carotid arteries & jugular vein by incision across throat caudal to larynx 2. Incision in jugular furrow at neck base with knife directed towards chest to incise brachiocephalic trunk and Ant. Vena cava.	6 min	Cattle: 13.6 kg Calf: 2.7 kg (Cow > bull of same age)
Sheep/goat	Jugular furrow close to head: cut both, carotid arteries and veins	5 min	1-2.5 kg
Pig	Middle of the neck at the depression in front of sternum, cut the anterior vena cava	6 min	Pigs: 2.2-3.0 kg Boar: 3.6 kg
Poultry	ventral neck cuts	2.25 – 3 min	30-50gm

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

PITHING

done in animals stunned by captive bolt

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

Ante-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.

Ante-mortem inspection

- 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.

Notifiable Diseases in India

1. Anthrax
2. Black Quarters
3. Foot and Mouth Disease
4. Haemorrhagic Septicemia
5. Rinderpest
6. Rabies
7. Johne's Disease
8. Tuberculosis
9. Glanders and Farcey
10. Epizootic Lymphangitis
11. Surra
12. Pourine

Unfit for Slaughter

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

Suspected for Slaughter

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

Post-mortem inspection

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

1. To detect and eliminate any abnormalities to ensure wholesome meat production.
2. Checking the efficacy of slaughter and carcass dressing technique.
3. Aids in animal health by identification of disease condition and thereby disease control.

Procedure for P.M.E.

Head → Viscera → Lungs → Heart → Liver → Kidney

↓

Uterus/ ← Urinary Bladder ← Stomach & Intestine ← Spleen

Ovaries/

Testicals

↓

Udder → Carcass (Muscles)

- ✓ After general inspection meat lymph nodes are checked.
- ✓ Judgment- Passed/ Totally Condemned/ Partially Condemned/ Conditionally Condemned

- **Head**
  - Tongue: FMD, Stomatitis, Actinobacillosis, Trichinellosis (Pig)
  - Masseter muscles: *Cysticercus bovis* (Measly Beef)
  - Lymph Nodes: Retropharyngeal, Sub-maxillary & Parotid (Tuberculosis & Actinobacillosis)
- **Lungs**
  - Pleurisy, Pnuemonia, Tuberculosis, Fasciolosis, Hydatid Cyst
  - Lymph Nodes: Bronchial & Mediastinal (Tuberculosis)
- **Heart**
  - Tuberculosis, Pericarditis, Petechial Haemmorhages, Cyst.

- **Liver**
  - Fatty Changes, Actinobacillosis, Abscess, Parasitic Infection, *Cysticercus bovis,* Fasciolosis, Hydatid Cyst, Oesophagostomum, Nematodes etc.
- **Spleen**
  - Anthrax and Tuberculosis
- **Stomach and Intestine**
  - Tuberculosis and Actinobacillosis
- **Uterus & Ovaries**
  - Septic Condition

- **Udder**
  - Mastitis, Abscess & Tuberculosis
- **Carcass**
  - Bruising & generalized Oedema (Dropsy)

✓ Pigs: Skin examined for lesions and conditions like Erysipelas, Urticaria, Swine Fever; External masseter muscle for *Cysticercus cellulosae* and base of tongue for *Trichinella sp*.

* Note: Never open a carcass, not even flaying without the consent of a veterinarian.

After general inspection meat lymph nodes are checked

Meat Lymph Nodes Inspected

Cattle & Buffalo	Sheep & Goat	Pig
Pre-scapular	Pre-scapular	Popliteal
Axillary	Popliteal	Pre-femoral
Pre-femoral	Pre-femoral	
Popliteal		
Ischiatic		

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.

- The term "Kosher" is related to

a) Muslim method of slaughter
b) Sikh method of slaughter
c) Mexican method of slaughter
d) Jewish method of slaughter

- Pork ban in Muslim religion is an example of
- (a) Norms
- (b) Monkeys
- (c) Folkways
- (d) Taboos

Carcasses are dressed by

a. Booth system.
b. Cradle and semi line system.
c. On rail system.
d. All of the above

- Canpak system of line dressing can process the number of cattle/hour:
- (A) 50-75
- (B) 50-150
- (C) 100-200
- (D) 100-250

- Which of the following statement is not correct during slaughtering and PM Examination of animals?
- a. Slaughtering is not to be limited to certain specified hours.
- b. There should be sufficient time and light.
- c. The animal should be blead completely.
- d. Veterinarian must be present during PM Examination.
- Options:
- 1. All are correct
- 2. Only a is correct
- 3. Only b and c are correct
- 4. Only c and d are correct

- Stunning by captive bolt pistol is considered to be the most effective in:
- (A) Cattle
- (B) Bull
- (C) Sow
- (D) Boar
- In cattle during transport, the shrink rate is maximum in a period of:
- (A) 0-12 h
- (B) 12-24 h
- (C) 24-36 h
- (D) 36-72 h
- Prior stunning is always forbidden in the following method of slaughter of animals:
- (A) Halal
- (B) Jhatka
- (C) Jewish
- (D) All of the above

- Captive bolt system of stunning is less effective in:
- (A) Cattle
- (B) Sheep
- (C) Pigs
- (D) Goats

- The concentration of C02 gas and period of exposure used for making pigs unconscious prior to slaughter :
- (1) 70% C02 and 60 seconds (2) 65% C02 and 40 seccnds
- (3) 80% C02 and 45 seconds (4) 70% C02 and 45 seconds

- With reference to postmortem examination of Ranikhet disease, which of the following statement(s) is/are correct ?
- 1. Carcasses with systemic involvement are unfit for food.
- 2. If lesions are localized, only affected parts are condemned, rest are passed for food.
- Select the correct answer using the code given below.
- Code:
- a. Only 1
- b. Only 2
- c. Both 1 and 2
- d. Neither 1 nor 2

In Kosher slaughter, rejected meat termed as:

a) Spoiled meat

b) Wholesome meat

c) Terefa

d) Culled meat

Topics Covered

- Dressing percentages
- Meat Storage and Preservation
- Meat packaging
- Meat by products
- Carcass Disposal

Dressing percentage

- is the 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

Poultry slaughtering: On-line system

- Pre-slaughter resting: off feed for 4 hr (not >12 hr)
- Shackling: hanging by hock joint
- Stunning:

  Electrical (mostly): 120 mA current

  Gas: 90% argon alone or Mixture of 25-30% CO_2 + 60% argon
- Bleeding: 1.5 min in chicken and 2 min turkey
- Scalding: water or spray (hygienic but expensive)

  Soft scalding: 50-51°C for 3-3.5 min

  Hard scalding: 56-58°C for 2-2.5 min
- Defeathering: plucking machines (wax stripping for ducks)
- Washing
- PM examination
- Carcass, Edible and inedible/ offal separation
- Edible viscera: Giblets: heart, liver and Gizzard

Meat storage & preservation

- Aim: inhibition of microbial, enzymatic activities to maintain quality of meat
- 3 methods:
- Temperature control
- Moisture control
- Direct microbial inhibition.

Methods of Preservation

- 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 MICRO ORGANISM

- Moisture content -water activity (a_w) of the food
- spoilage and pathogenic bacteria in meat require a water activity in equal to more than 0.9
- most tolerant bacteria is *Staphylococcus aureus* which continues to grow at a a_w of 0.86.
- spoilage yeasts require a a_w of 0.88, while spoilage moulds 0.80.
- If foods are dried to a final a_w of 0.60 or lesser, the product becomes shelf stable.

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. by low 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; <u>about 70% is removed at 3.5°C and 94% at -10°C.</u>

- 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

- -23°C (-15 to -29°)

- **Zone of crystal formation**: temp. below freezing point where extra cellular ice crystal formation occurs. **-0.5 to -3.8°C: Zone of Maximum crystal formation**

- **Slow freezing: large ice crystals** **more Drip loss** (AA,Vit) as compared to fast

METHODS OF FREEZING

slow freezing	quick-freezing
cabinet freezer-	blast freezers
72 hours	completed in 30 minutes
freezing proceeds slowly from the exterior to the interior.	
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.

METHODS OF FREEZING

1. Still air freezing: -10 to -20°C, no air circulation (home freezer), convection
2. Plate freezing: -10 to -30°C, conduction.
3. Blast freezing: -10 to -40°C, air (30-1070 m/min for red meat and 1300-1500 ft/min for poultry), **Best: 760 m/min @ -30°C**
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 -10°C and-40°C, 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.

UNDESIRABLE CHANGES IN FREEZER STORAGE OF MEAT

- Freezer burn
- Surface desiccation and discolored 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 5°C in 8 hr)	Chilling	Beef/pork/lamb/veal: □ - 4 to 0°C Poultry and fish□ 0 - 5°C R.H. □ 82-92%
	Below freezing point (excellent method)	Freezing	Fast: -23°C (-15 to -29°)/ 30 minutes Slow: -1.5 to -3.8/ 72 hours
Thermal process	Pasteurization	Moderate heat	58-75°C
	Sterilization	Severe heat	100°C□ 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%)

Thaw rigor: when pre-rigor meat is frozen cold induced Ca^{2+} release extensive rigor mortis 60% (up to 80%) shortening and removal of juices

Cold shortening: when meat is chilled at 0-15°C just after slaughter. It is less than thaw rigor shortening.

Water loss from

- Fresh uncooked meat – weep
- Thawed uncooked meat - drip
- Refrigerated meat - sweating

Ageing of meat

- **Ageing:** In absence of microbial spoilage, holding of unprocessed meat above freezing point (0-3°C) make muscle tender and juicy.
- Also called: conditioning, tenderizing, ripening or maturing of meat.
- Important for beef and buffalo meat and not pork and lamb.
- Types of Aging:

  Dry aging: traditional process of placing an entire carcass or wholesale cut without covering or packaging in a refrigerated room for 21 to 28 days at 32-34°F and 85% RH with an air velocity of 0.5 to 2.5 m/sec.
- **Wet aging:** aging in vacuum bags under refrigerated conditions of 32-34°F. It is predominant method.

Meat packaging

- 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

- Ham: meat of thigh of pigs
- Bacon: meat from sides and back of pigs

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**

Diaphragm: Skirt

Tripe: rumen & reticulum

Spleen: Melt

Book/bible/farthing/manyplies: Omassum

Pancreas: Gut (sweet) bread

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 mesentry

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**
Skin of **Large Animal**	Skin of **Small Animal/** young calf
Large, Thick and Heavy	Small, Thinner and Tighter
Av. yield 7.0% of live wt.	Av. Yield 11.0% of live wt.
75-80%: Fallen Animals	**80 %: Slaughtered animals**
20-25 %: Slaughtered animals	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)**; Calf Skin (immature calf, 9-15); Kip Skin (calf, 15-25); Heifer Skin (25-30); Cow Hide (>30); Light Cow Hide (<53); Heavy cow Hide (> 53); Extreme Light Hide (steer 32-48); Light Steer Hide (48-58); Heavy Steer Hide (> 58); Bull Hide (60-100).
- ✔ 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

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 110-116°C 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

- Which of the following compounds from smoke contribute to smoky flavour of meat:
- a) Phenol
- b) Alcohol
- c) Formaldehyde
- d) Caproic acid

- Meat curing refers to
- (1) Production of thermally stable pink pigments.
- (2) Chilling
- (3) Freezing
- (4) Smoking

- Fat from pig carcass after it has been tendered is known as:
- (A) Gammon
- (B) Lard
- (C) Ham
- (D) All of the above

- Acid treatment of collagen produce:
- (A) Collagen
- (B) Elastin
- (C) Gelatine
- (D) Reticulin

- Shelf life of vacuum packaging cuts for lambs is:
- (A) 10 days
- (B) 2 weeks
- (C) 3 weeks
- (D) 8-10 weeks

- Which is bactericidal in smoking?
- (A) Choloform
- (B) Phenol
- (C) Both (A) and (B)
- (D) Saw dust/hard wood

- Brine, which can be used to marinate fish and meat, is a concentrated solution of:
- (A) Sodium sulphate
- (B) Calcium chloride
- (C) Sodium chloride
- (D) Sodium bromide

- Lyophilisation of food is also referred to as:
- (A) Smoking
- (B) Curing
- (C) Freeze drying
- (D) Moist heating

- The term mountain oysters refer to cooked:
- (A) Testicle of lambs
- (B) Kidneys of calf
- (C) Brain of goats
- (D) Pancreas of birds

- Non muscular parts of carcass of beef, mutton or pork which are either consumed as food or used to in production of other food:
- (A) Offal
- (B) Waste
- (C) Viscera
- (D) Offense

- The dressing percentage in broiler chicken is usually around:
- (A) 20-30%
- (B) 40-50%
- (C) 90-100%
- (D) 60-75%

- Ham is:
- (A) Which comes from back and join
- (B) Which comes from sides
- (C) Comes from loin and sides
- (D) Comes from rear quarters

- In freezing dried meat the moisture level is reduced to_____________ %.
- (a) 50
- (b) 2
- (c) 65
- (d) 10

- When fat content of meat is increases, there will be reduction in
- (a) Water
- (b) Protein
- (c) Ash
- (d) Vitamins

- Nitrates act as flavouring agent at, ppm.
- (a) 10
- (b) 50
- (c) 100
- (d) 150

- Most commonly used humectant is:
- (a) NaCl
- (b) Glycerol
- (c) Both (a) and (b)
- (d) None of the above

- Skin in pig is called:
- (a) Hide
- (b) Rind
- (c) Kip
- (d) Slunk

- Liquid smoke used to avoid the carcinogenic compound present in smoke is:
- (a) Hydrocarbons
- (b) Acetic acid
- (c) Phenol
- (d) Benzypyrin

- D value is more important in preservation method:
- (a) Chilling
- (b) Freezing
- (c) Drying
- (d) Canning

- Irradiation is ineffective in destroying:
- (a) Bacteria
- (b) Parasite
- (c) Both (a) and (b)
- (d) Endogenous enzymes

- Food preservative to be avoided in processed food is:
- a) Sodium Chloride
- b) Potassium Bromate
- c) Sodium Benzoate
- d) None of the above

- Bacterial spoilage in chilled meat is due to:
- a) Psychrophilic bacteria
- b) Thermophilic bacteria
- c) Mesophilic bacteria
- d) Microaerophilic bacteria

- Casings are prepared from layer of intestine.
- (A) Mucosal
- (B) Sub-mucosal
- (C) Muscular
- (D) Serosal

- The dressing percentage in lambs is
- (1) 30 — 45 % (2) 40 — 50 % (3) 55 — 60 % (4) 60 — 65 %
- Which is the black meat producing breed of chicken ?
- (1) Aseel (2) Chittagong (3) Kadaknath (4) Miri
- Which of the following parts of a dressed broiler is not included in the giblets ?
- (1) Heart (2) Gizzard (3) Kidney (4) Liver

1. Casings prepared from small intestines of sheep are called as

a) Weasand

b) Middles

c) Bungs

d) Rounds

1. Lard is

a) Beef fat

b) Pork fat

c) Chevon fat

d) Carabeef fat

1. Pluck means in pig, sheep and calf consists of following organ

a) Larynx, Trachea, Heart, Liver, Spleen

b) Larynx, Trachea, Lungs, Heart, Liver

c) Larynx, Trachea, Lungs, Liver, Spleen

d) None of the above

Scalding

- For poultry-
- Soft scalding: 50-51 °C x 180-220 sec.
- Semi/ Slack scalding- 50-53 °C x 60-180 sec.
- Sub scalding – 54-58 °C x 60-120 sec.
- Hard Scalding- 59-61 °C x 45-90 sec.

Meat preservation

- Cold shortening avoided by keeping meat above 14 °C
- At -18 °C storage life of beef, carabeef, mutton, chevon – 6 months
- Pork and poultry – 4 months
- Cured and salted meat products – 2 months
- At 4 °C : 5-7 days
- Permitted levels of nitate and nitrites: 500 and 200ppm
- GRAS preservatives: Citric acid, propionic acid, benzoic acid, sorbic acid – mold inhibitors
- Acetic and lactic acid – prevent bacterial growth
- Hurdle concept: combination preservation technique in balanced manner

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

Meat Quality parameters

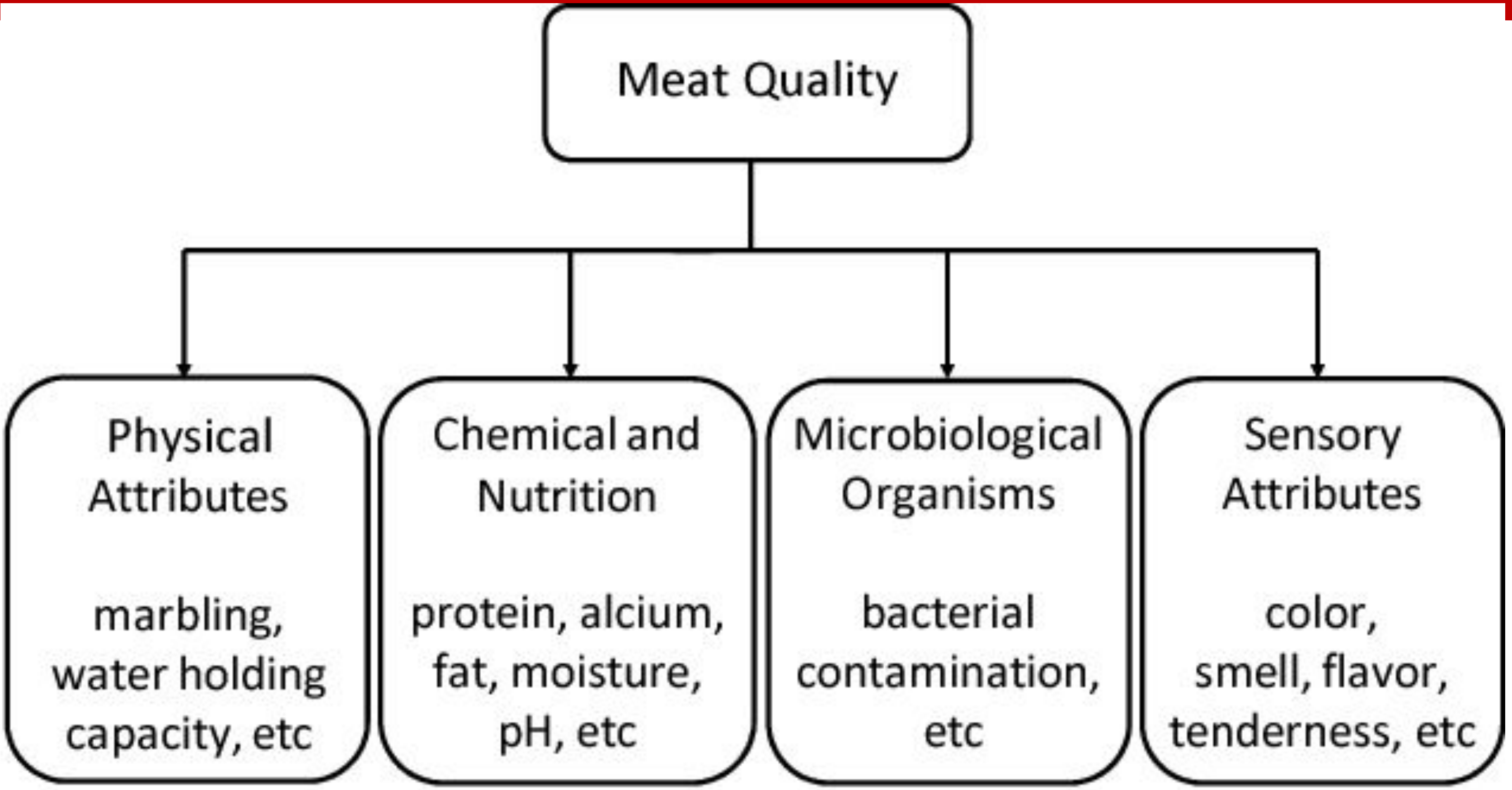


Figure 1. Quality attributes of meat in general

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. [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

Bureau of Indian Standards

Grading done on basis of

1. Length of the carcass
2. Thickness of back
3. Fullness of legs and flank
4. Amount of fat in intercostal muscles.

Types

Prime Grade

Choice Grade

Utility Grade

Cull Grade

Raw Meat Grading and Marking Rules (1977)

For export quality control of chilled and frozen meats

Types

Choice Grade

(Dressed wt. not less than 8 kg.)

Standard Grade

(Similar to choice grade but slightly poorer in body conformation and trimmable fat)

X Grade

(As agreed between the purchaser and exporter against firm order)

Evaluation of Buffalo Carcass

Bureau of Indian Standards	Raw meat Grading & marking rules
Grading done on basis of Conformation, finish and quality of the carcass	For export quality control of chilled and frozen meats
Types Prime Grade Choice Grade Good Grade Commercial Grade Utility Grade Cutter and Canner Grade	**Types** Choice Grade Good Grade Commercial Grade X Grade (As agreed between the purchaser and exporter against firm order)

Evaluation of Swine Carcass

Based on

1. Carcass length- Edge of first rib to front of aitch bone.
2. Dressing %- (Ratio of carcass wt. to live wt.) X 100.
3. Yield- Average of four lean cuts (Ham, Loin, Boston Butt & Picnic Shoulder)
4. Loin Eye Area- Proportional to muscle (*Longissimus dorsi*) development in carcass.
5. Back Fat Thickness- Average of back fat on first rib, last rib and last lumbar vertebra.
6. Meat color- Pinkish red > Greyish Red > Pale
7. Firmness- Very Firm > Reasonably Firm > Soft and Watery
8. Marbling- Small/Moderate > Slight > No Visible Marbling

Meat spoilage

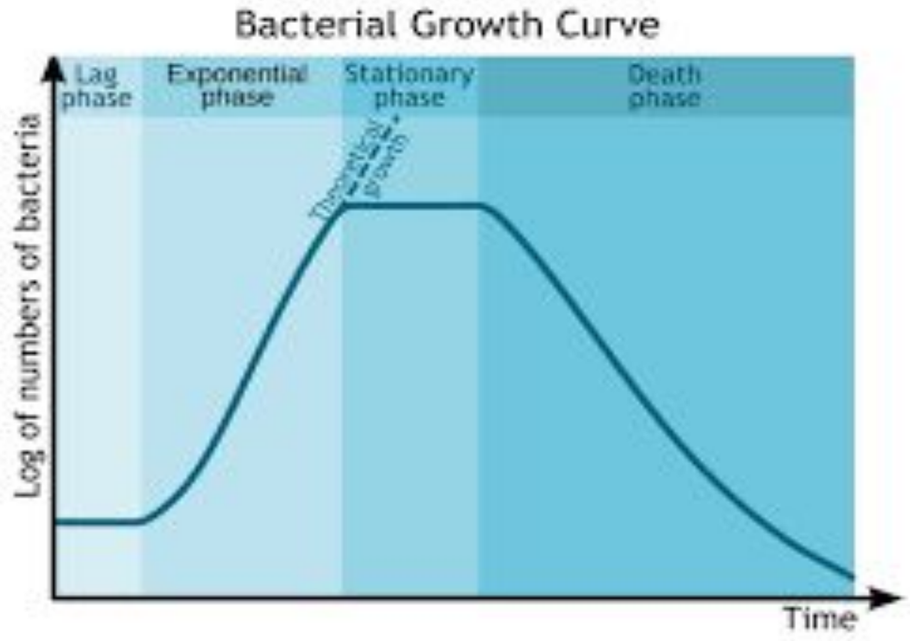
Phases of growth of micro-organisms in meat-

A. Lag phase: adaptation

B. Log phase: exponential growth phase

C. Stationary phase: growth ceases but cells

D. Decline or death phase



Identification of meat spoilage

1. 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)
2. Off flavor: oxidation of lipids
3. Extract release volume: rapid test for detecting incipient spoilage inversely proportional to extent of spoilage
4. Dye reduction test: total aerobic and psychrotrophic bacterial counts Resazurin dye
5. Increase pH , WHC, Microbial count
6. High TBA (degree of oxidative rancidity) and peroxide value (reactive oxygen contents).

Meat spoilage

- 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

Designer meat products

1) nutritionally enhanced, 2) value added, and 3) added processing.

- addition of different health promoting components like antioxidants, minerals, omega fatty acids, vitamins, and various non- nutrient additives.
- less cholesterol and saturated fat
- an added bonus of increased vitamin E and omega-3 fatty acids.

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	-	-

are as follows:

	Beef muscle	Buffalo meat	Goat meat	Mutton muscle	Sheep liver	Pork muscle
Moisture	74.3	78.8	74.2	71.5	70.4	77.4
Protein	22.6	19.4	21.4	18.5	19.3	18.7
Fat	2.6	0.9	3.6	13.3	7.5	4.4
Minerals	1.0	1.0	1.1	1.3	1.5	1.0

The intramuscular fat in sheep is higher than in other animals and could be used as a method of identification. Calcium and potassium contents are higher in mutton muscle. Vitamin A is present in beef and mutton but not in buffalo, goat or pig meat.

Species	Per cent of bone
Mutton	25
Bobby calves	50
Veal calves	25
Pork	12-20
Bull	15

(b) Ribs on the thorax: Ribs on the thorax vary in number i
species of animals:

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 (H2SO4) water
- color of beef varies from light red to dark red

Horse meat

- meat of horse is dark red in colour
- Horseflesh contains large quantities of glycogen and linoleic acid.

Fraudulent substitution/ adulteration of meat

- **Two types:**

1. Substitution of inferior quality meat to superior quality (maximum cases)
2. 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.

Dentition of different animal species

Species	**Temporary**	**Permanent**
Cattle/ sheep/ goat/ buffalo	2(0030/ 3130) = 20	2(0030/ 3133)= 32
Pig	2(3130/3130)= 28	2(3143/3143)= 44
Horse	2(3030/3030)= 24	2(3133/3133)= 40

Vertebrae of different species

Species	**Vertebrae**
Cattle/ Buffalo	C7T13L6S5Cy18-20
Sheep/ Goat	C7T13L6S4Cy16-18
Horse	C7T18L6S5Cy15-21
Pig	C7T14-15L6-7S4Cy20-23
Poultry	C15-17T7L+S14Cy5-6

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
- Agar gel precipitation test, Counter current immunoelectrophoresis and ELISA

Abattoir Effluent Treatment

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°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 (Screening of solids and Removal of fats)

↓

Stage II (Biodegradation of Organic Matter)

↓

Stage III (Sedimentation and Disinfection)

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	-

HACCP

- Hazard Analysis Critical Control Point
- Quality & safety regulating system to avoid production of defective item
- **Hazard:** unacceptable contamination of microbial/chemical/physical nature
- **Hazard analysis**: identification of potential hazards at all stages
- **Control points:** Point in a process where hazard/ risk exist and get entry in product
- **Critical control point:** points at which control can be applied and hazard is prevented/ eliminated (CCP I) or reduced (CCP 2) to acceptable limit.
- **Critical limit:** Max or min. value to which a hazard must be controlled at a CCP.
- **Principals of HACCP:**
  - ✔ Identify hazard
  - ✔ Determine CCP
  - ✔ Critical limit establishment
  - ✔ System of testing
  - ✔ Corrective action
  - ✔ Verification
  - ✔ Keeping records

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

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 (Woolsorter'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

- With reference to the Designer Meat Products consider following statements:
- (1) They are low in sodium, fat and calories.
- (2) They are high in sodium and high in calories.
- (3) They are low in calcium.
- (4) They are low in fibres and natural antioxidants.

- For antemortem and postmortem inspections of meat animals (First Revision), is the mandatory code of practice in India.
- [A] IS: 1723-1973
- [B] IS: 1981-1978
- [C] IS: 1982-1971
- [D] None of the above

- Protein content of white meat is:
- (A) Lesser than red meat
- (B) Higher than red meat
- (C) Equal than red meat
- (D) No comparison with red meat

- Which is firm meat?
- (A) Pork
- (B) Chevon
- (C) Mutton
- (D) Chicken

- Which meat has cherry red colour?
- (A) Mutton
- (B) Pork
- (C) Chevon
- (D) Beef

- Meat is firmer:
- (A) In older animal
- (B) During chilling
- (C) Both (A) and (B)
- (D) In younger animal

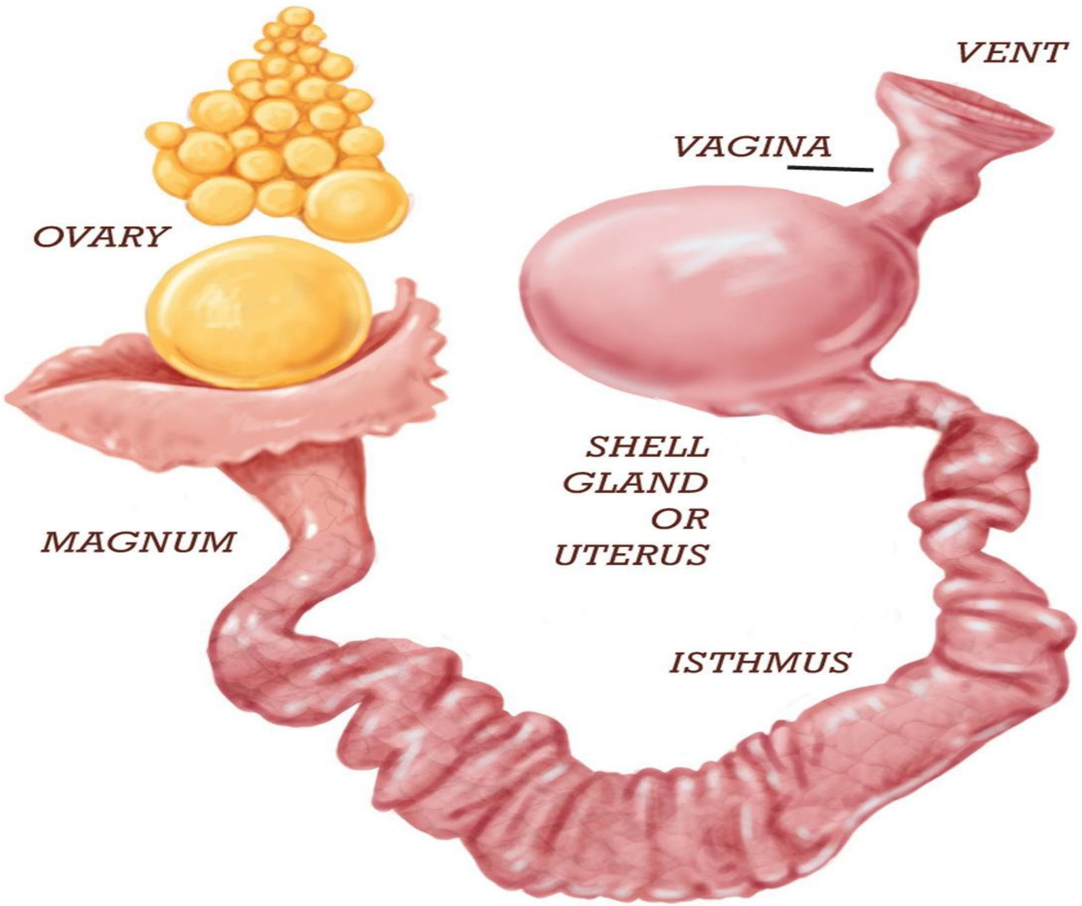
- The primary constituent of a sheep carcass is:
- (A) Skin
- (B) Bones
- (C) Fat
- (D) Meat

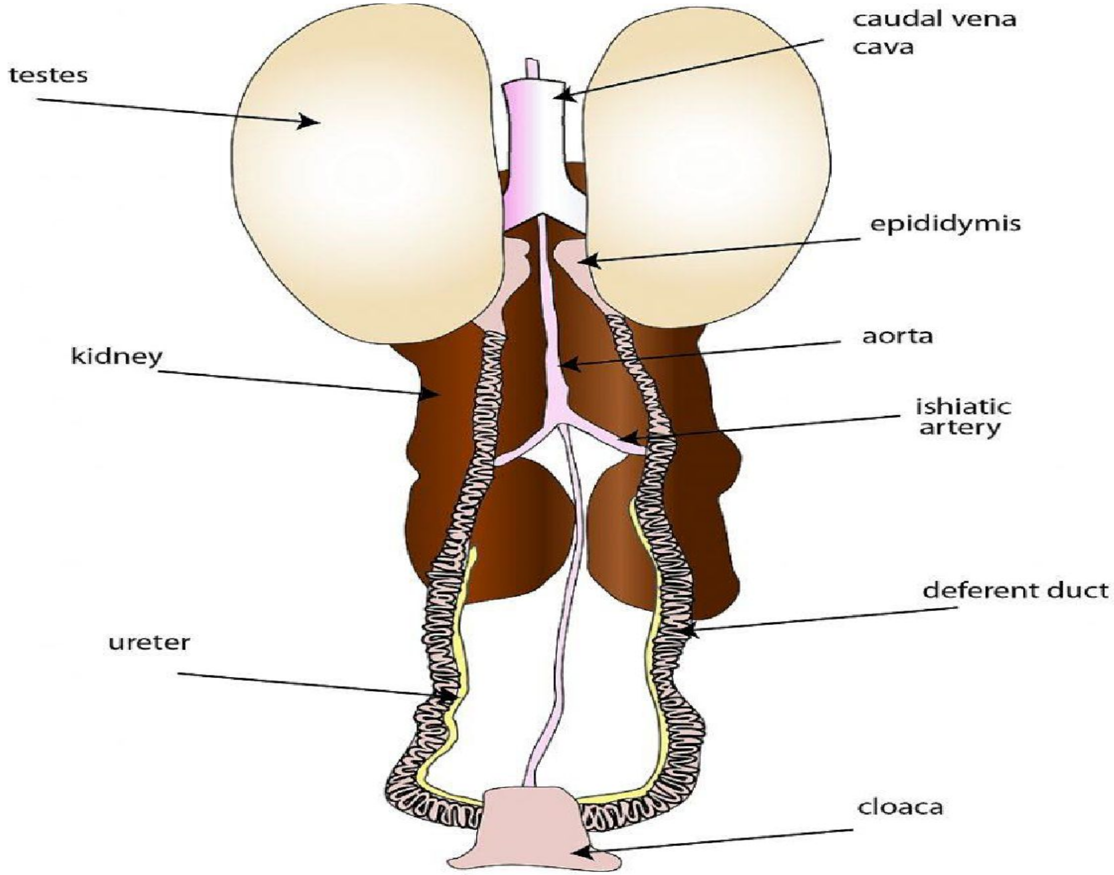
- Lamb carcass (less than one year age) is usually graded as:
- (A) Prime, Choice, Good, Utility
- (B) Prime, Good, Cull, Utility
- (C) Choice, Very good, Good, Discard
- (D) Choice, Good, Discard, Cull

- During decomposition of meat, a pronounced repulsive odour and an alkaline reaction takes place due to liberation of:
- (A) CO_2
- (B) NH_3
- (C) H_2S
- (D) CH_4

- The white fat deposition in between groups of muscles is a characteristic feature of meat of which of the following species?
- (A) Horse
- (B) Camel
- (C) Fish
- (D) Sheep

REPRODUCTIVE SYSTEM OF POULTRY





Urinary and Reproductive Organs of the Male

FEMALE REPRODUCTIVE SYSTEM

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

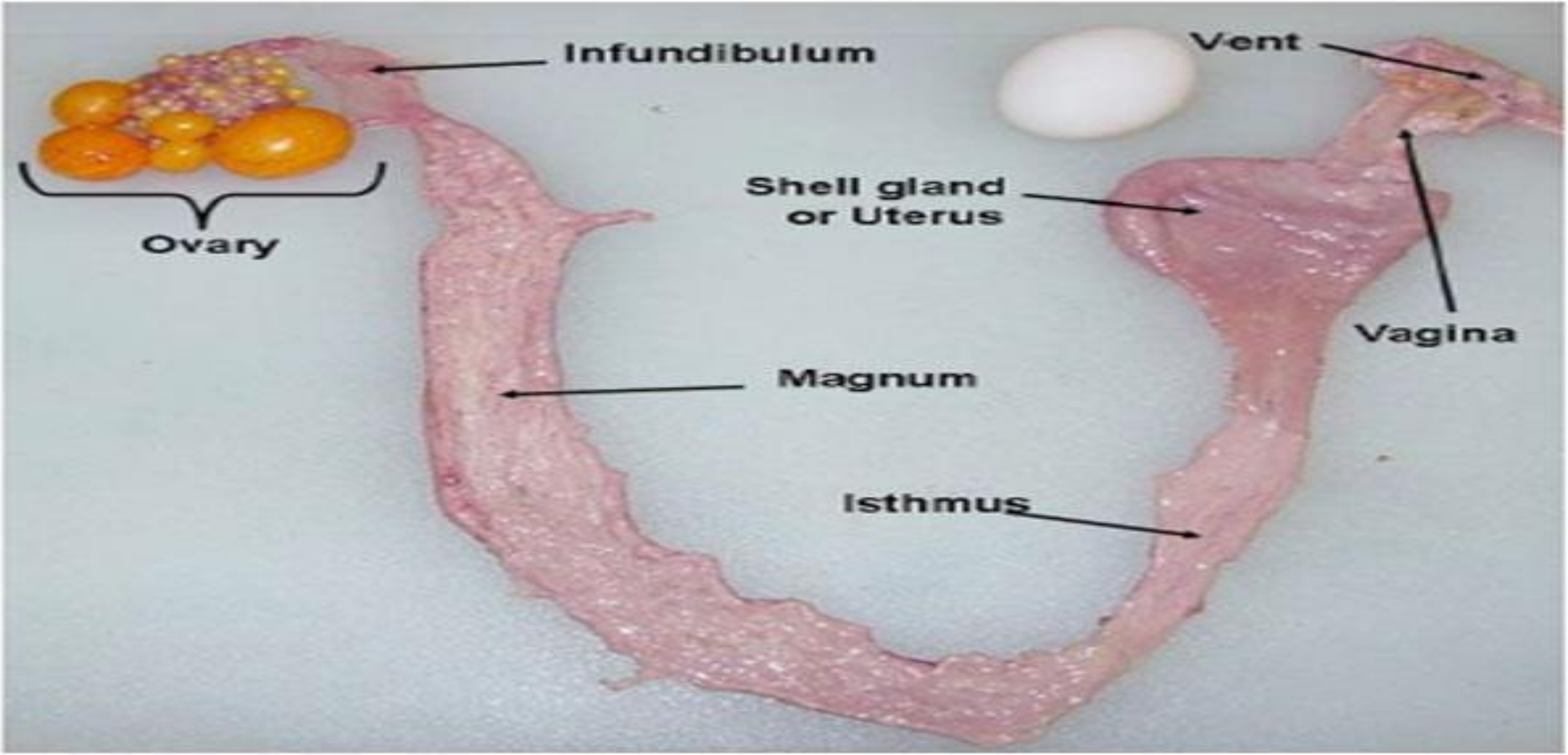


Figure 1 Figure showing different parts of the poultry reproductive system, starting from ovary, infundibulum, magnum, isthmus, uterus, vagina and vent

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

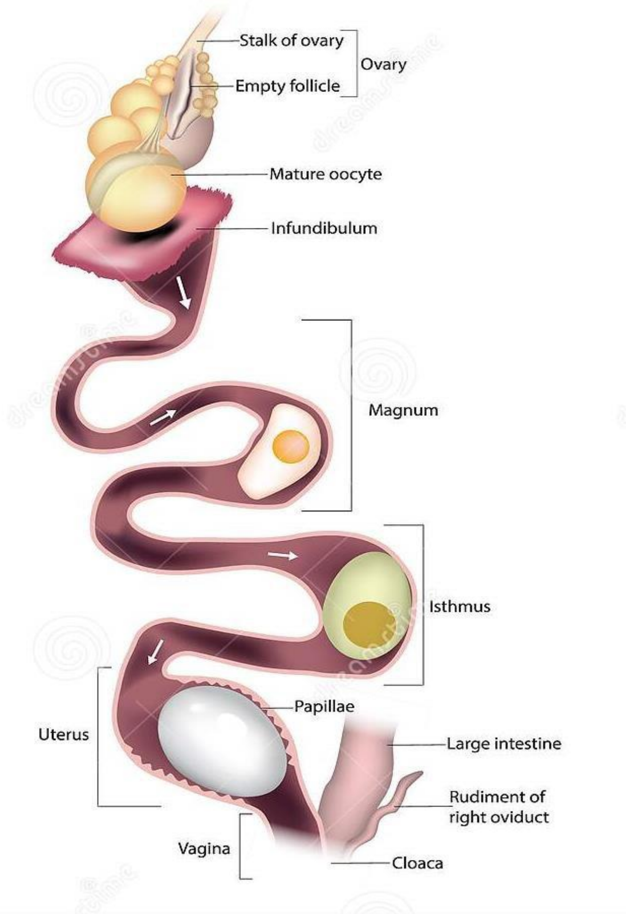
- Color of yolk is yellow comes due to yellowish fat soluble pigment called as Xanthophyll
- Hens fed yellow maize or allow to range on grass , typically have dark yellow yolk
- Hens fed on diets with white maize , sorghum, millet or wheat typically have pale yolk
- Color of yolk can be improved by adding 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

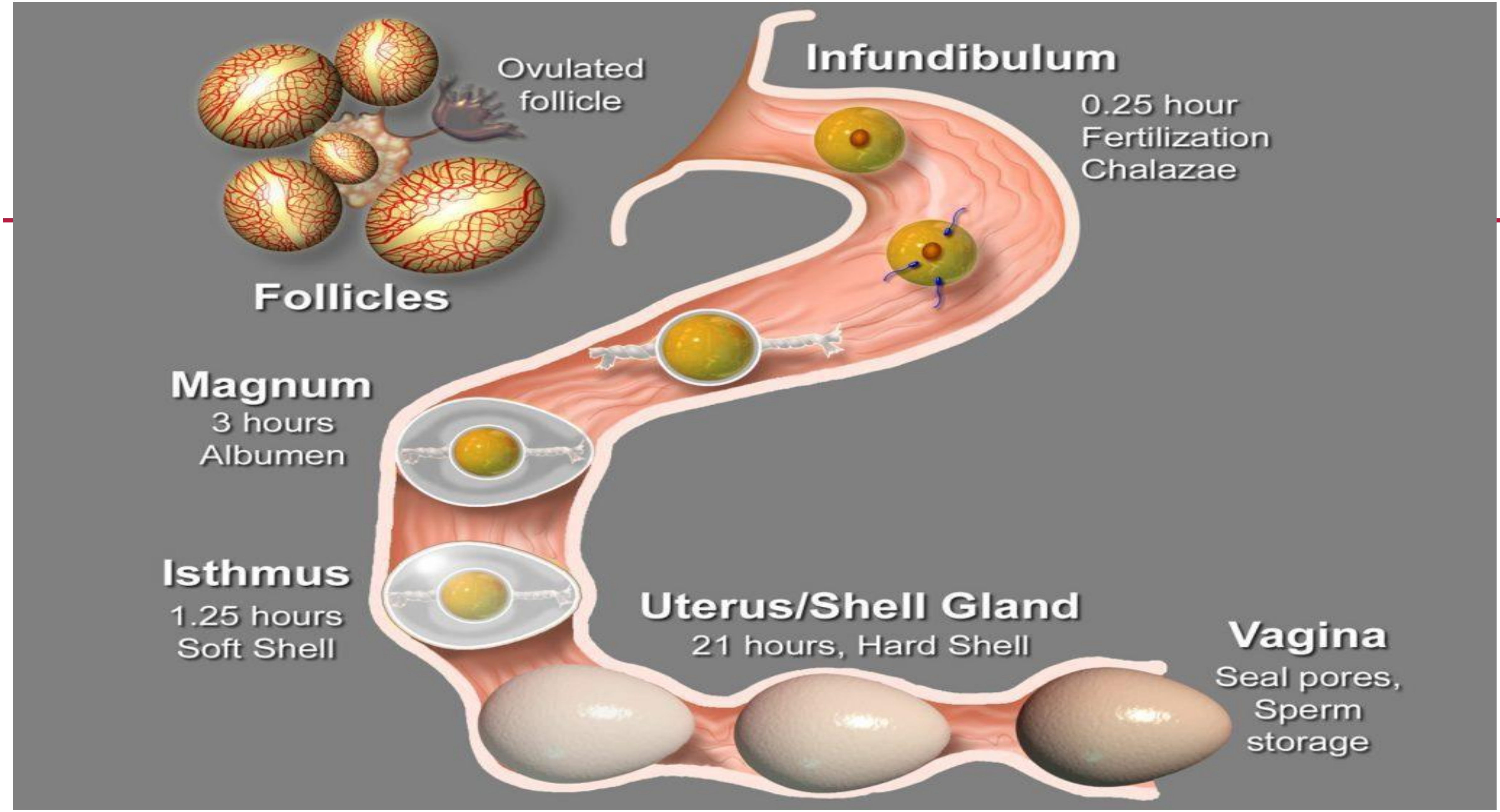
OVIDUCT

- 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



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	


Ovulated
follicle
Infundibulum
0.25 hour
Fertilization
Chalazae
Follicles
Magnum
3 hours
Albumen
Isthmus
1.25 hours
Soft Shell
Uterus/Shell Gland
21 hours, Hard Shell
Vagina
Seal pores,
Sperm
storage

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 Ca CO3 = 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 104-106^0 F
- There is synchronisation between ovulation and oviposition
- Next ovulation occur 30 min after oviposition

Egg structure

- Four major structures from outside to inside
- <u>Shell</u>
- <u>Shell membrane</u>
- <u>Albumen</u>
- <u>Yolk</u>

Egg shell

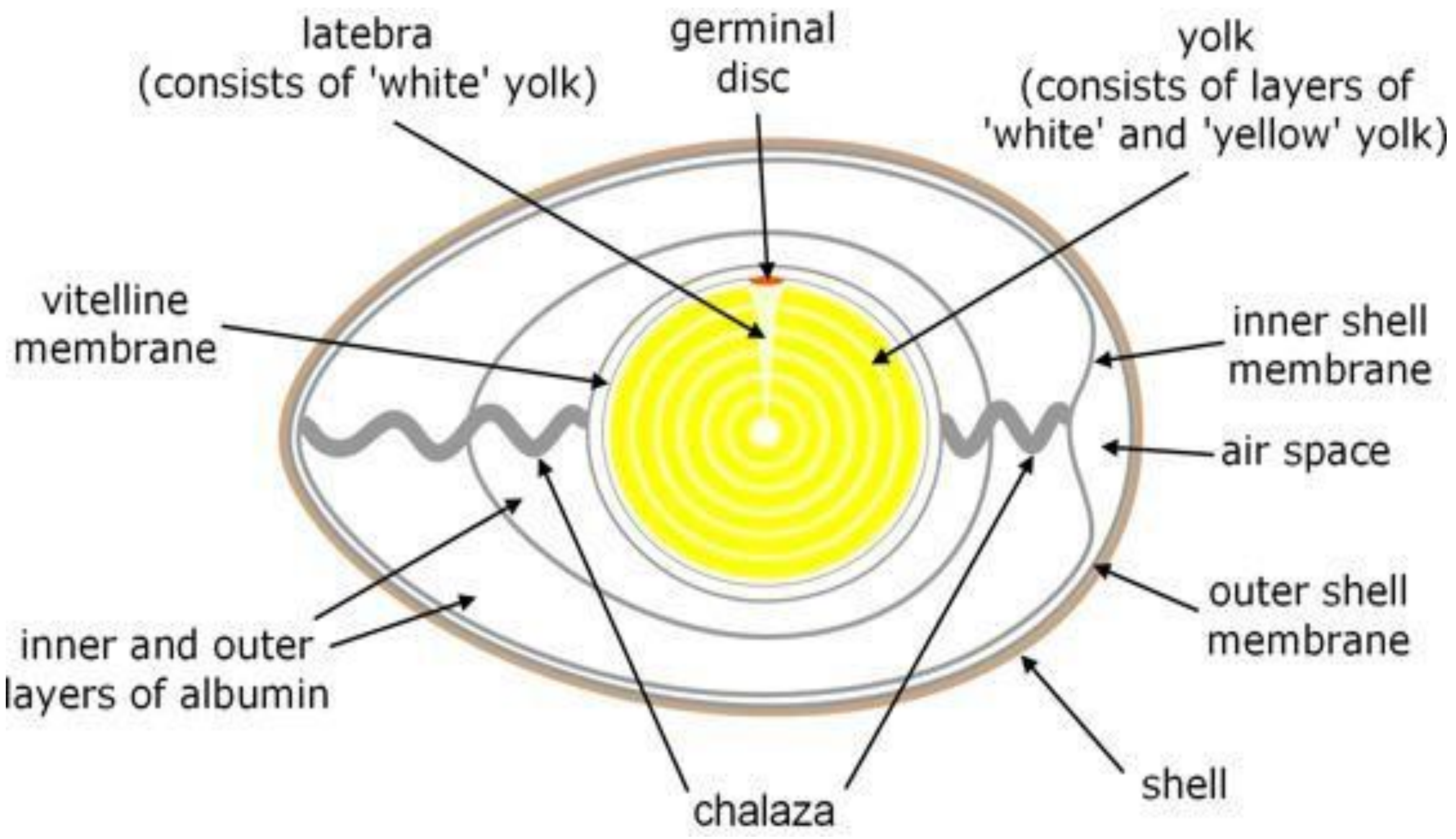
- outer covering of an egg which consist of pores & Constitutes 9-11% of the egg weight.
- The pores in the egg shell allow the exchange of air which allows the embryo to breath.
- There are approximately 7500 pores per egg. The size of the pores is big at the broader end.
- At the time of laying the 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.

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.


latebra
(consists of 'white' yolk)
germinal
disc
yolk
(consists of layers of
'white' and 'yellow' yolk)
vitelline
membrane
inner shell
membrane
air space
outer shell
membrane
inner and outer
layers of albumin
chalaza
shell

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.

Composition of egg of various species

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

Component (Unit)	Amount	Component (Unit)	Amount
Egg shell (%)	10.5	Calcium (mg)	56.0
Egg yolk (%)	31	Magnesium (mg)	12.0
Egg white (%)	58.5	Iron (mg)	2.1
Water (g)	74.5	Phosphorus (μg)	180.0
Energy (Kcal)	162	Zinc (mg)	1.44
Protein (g)	12.1	Thiamine (mg)	0.09
Carbohydrates (g)	0.68	Riboflavin (mg)	0.3
Lipids (g)	12.1	Niacin (mg)	0.1
Saturated fatty acids (g)	3.3	Folic acid (μg)	65.0
Monounsaturated fatty acids (g)	4.9	Cyanocobalamin (μg)	66.0
Polyunsaturated fatty acids (g)	1.8	Pyridoxine (mg)	0.12
Cholesterol (mg)	410	Retinol equivalents (μg)	227.0
Iodine (μg)	12.7	Potassium (mg)	147
Tocopherols (μg)	1.93	Carotenoids (μg)	10
Selenium (μg)	10	Cholecalciferol (μg)	1.8

Quantities represent an edible portion of about 100 g.

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

- 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

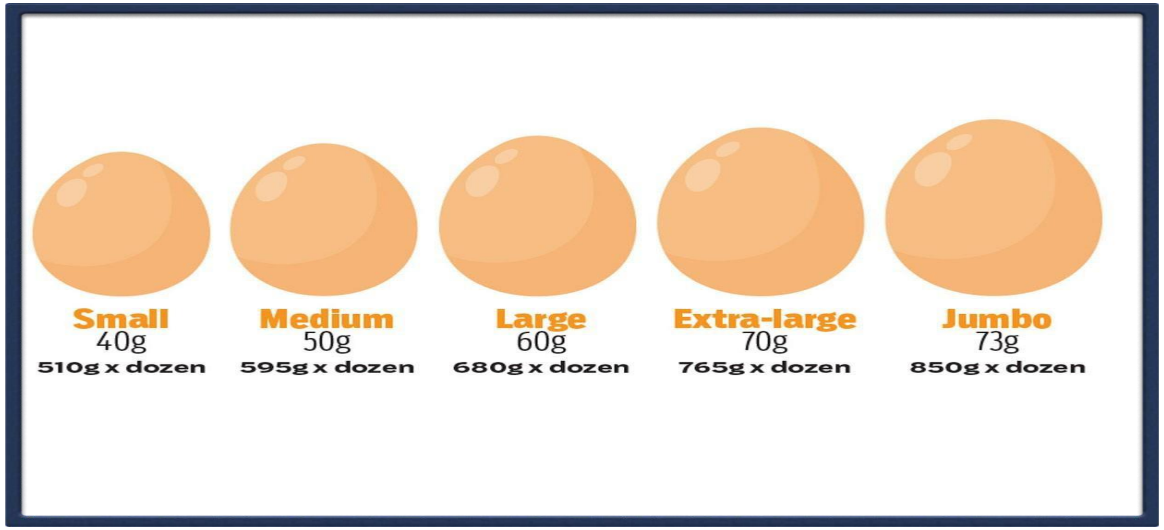
GRADING OF EGG

- The 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, rating.
- $HU = 100 \times \log10 (h - 1.7w_{0.37} + 7.6)$

HAUGH UNIT

- 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:
- <u>Grade AA: HU unit of 72or more</u>
- <u>Grade A: 71 to 60</u>
- <u>Grade B: 59 to 31</u>
- <u>Grade C: 30 or less</u>

- In India eggs are graded according to the weight. There are 5 grades.



Physico-Chemical properties

- 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 CO2 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

- Designer eggs are 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

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.


©YourHobbyFarm.com
8.5.20 = 20 eggs

WATERGLASS

- For Long term storage.
- 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 CO_2 from the egg content.
- 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 WARAPPING

- 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.

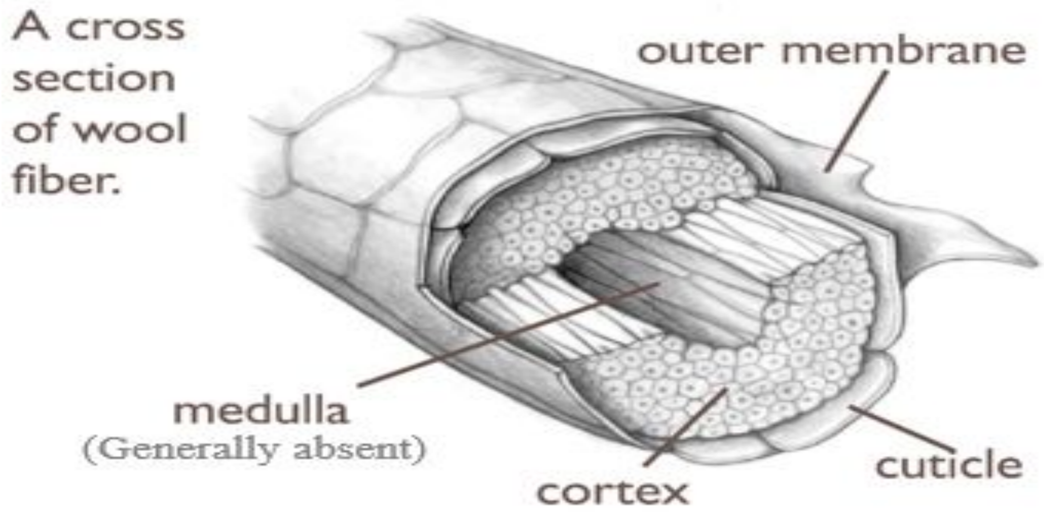
Filler trays

- 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.
- A standard tray carries 36 eggs. A standard box carries 5 trays hence carrying 180 units of egg.

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.

Wool science

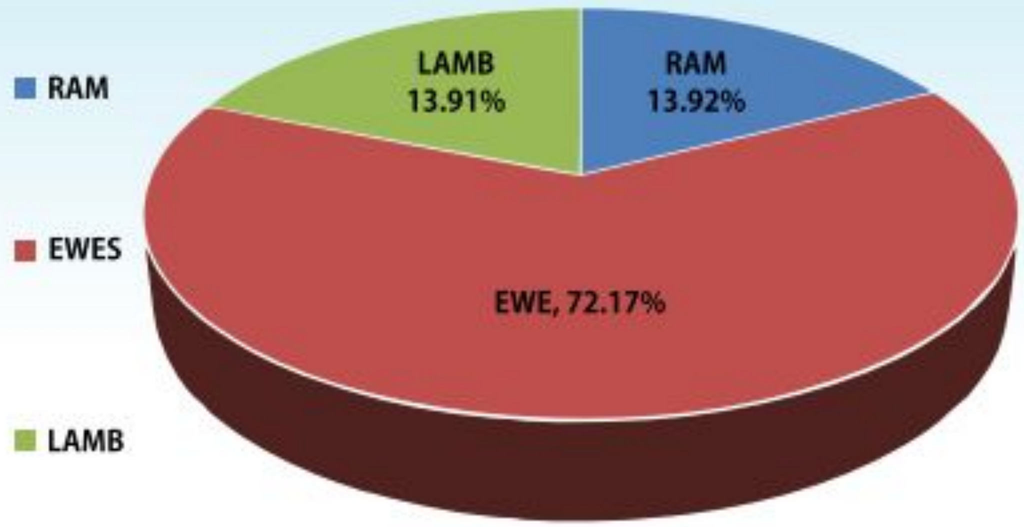


MAJOR HIGHLIGHTS OF WOOL PRODUCTION

- 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

GRAPH 2.24 SPECIES-WISE SHARE IN WOOL PRODUCTION IN 2022-23



- **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.

Wool Glossary/ Terminology

1. Fleece: Fibre coat that covers a sheep
2. Lock: A group of fibres clinging together in fleece
3. Suint: natural greasy substance in sheep's wool Secretions of sudoriferous glands.
4. Lanolin/ Wool wax: Secretions of the sebaceous glands of the skin.
5. Greasy wool: Shorn wool with grease and wax before removal of impurities.
6. Wool Yolk: Wool wax with suint in raw wool is known as yolk.
7. Kemp: A coarse, weak and brittle wool fibre with irregular medulla
8. Crimp: Natural waviness/curliness of a wool fibre.
9. Staple Length: Length of a wool fibre without disturbing its natural waviness.

10. Fibre Length: Length of the fibre in stretched condition.
11. Burr: Vegetable matter present in wool
12. Scouring: removal of impurities detergent (sodium carbonate)
13. Carbonization: removal of burr with chemical treatment of wool
14. Shearing/ Clipping: Removal of fleece from body of sheep
15. Skirting: Removal of objectionable parts and stains from body of fleece after shearing
16. Pelt: undressed skin along with it's hair/wool/fur.
17. 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.

18. 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.

19. Fellmongering: removal of wool from sheep skin through use of chemical applications (sodium sulphide or thallium).

20. Felting: ability of textile material to undergo irreversible increase in bulk density when subjected to friction and pressure under suitable physical conditions.

21. Yarn: thread made from wool in the form of a loosely twisted collection of fibers

22. Count: It is an index of thickness or diameter of yarn.

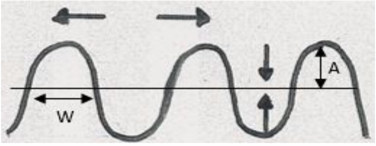
23. Hank: a coiled or wrapped unit of yarn

24. Warp: longitudinal section of fabrics arranged in form of sheet
25. Weft/ woof: transverse section of fabrics
26. Weaving: technology in which two distinct sets of yarns/threads are interlaced at right angles to form a fabric or cloth
27. Scale: A cuticle of flattened cells protecting the cortex of fibres.
28. Keratinization: Hardening of previously soft plastic fibrous protein.

29. Gare: Partially medullated mohair fibre which at sometimes also arise from some secondary follicles.

30. Crimp width: The distance between the mid point of the successive valleys of the projected crimp wave image.

31. Crimp amplitude: It refers to crimp wave and is half the total depth from crest to trough.



32. Rise in wool: Seasonal increase in flow of wax.

33. 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.**
    a. Fine
    b. Medium
    c. Long
    d. Cross bread
    e. Mixed

S.no.	Grading	Length (cm)	Diameter (micron)	Count
1	Fine	3.2-10	10-30	60^s-90^s
2	Medium	5-20	20-40	40^s-60^s
3	Long	12.5-35.5	35-50	35^s-50^s
4	Cross bread	7.5-15.5	20-40	50^s-60^s
5	Mixed	Different Wools are mixed		

- **Coarse wool** fibre: (25–70 µm diameter): carpets
- **Fine** merino fibre: (10–25 µm): apparels

- The Carbonisation of wool refers to
- (1) Grading of wool
- (2) Removal of vegetable matter from wool
- (3) Drying and baking of wool
- (4) Shearing

- Eggs can be commercially stored at the temperature of:
- (a) 0°C
- (b) +0.5°C
- (c) -0.5°C
- (d) -1.5°C

- Green rot in egg is caused by:
- (a) Proteus
- (b) Pseudomonas
- (c) Cladosporium
- (d) Aspergillus

- supplementation of laying hen diets at concentration of less than 1 ppm, lowers egg cholesterol and also improve egg interior quality, leading to Designer egg.
- (1) Cobalt (2) Zinc (3) Chromium (4) Selenium

- What is the normal value of shape index for chicken egg ?
- (1) 54 (2) 64
- (3) 74 (4) 84

- As per ICMR (Indian Council of Medical Research) recommendation how many eggs should be consumed per person per day ?
- (1) 1/2
- (2) 1
- (3) 1 1/2
- (4) 2

- Which organization regulates wholesale price of eggs in most of the states and towns of the country ?
- (1) NAFED (2) NE CC (3) PFI (4) PDMC

- In which year the National Egg Co-ordination Committee (NECC) was established ?
- (1) 1972 (2) 1982 (3) 1992 (4) 2002

- What is the energy content of an average sized (58g) chicken egg ?
- (1) 70 kcal (2) 90 kcal (3) 110 kcal (4) 130 kcal

- Sheep wool fibres contain high content of following amino acid:
- Alanine
- Glycine
- Cystine
- Aspartic acid

- Mohair wool is obtained from
- Angora goat
- Angora rabbit
- Pashmina
- Fur wool