MODULE-1: STRUCTURE OF MUSCLE

Learning objectives
- This module will introduce the learner to the structural pattern of muscle, the connective tissues associated with it.
- It will also enable the learner to understand the ultrastructure of muscle.
- It will also depict an overview of the organelles of muscle to the learner and also assist him to understand proteins of muscle from the perspective of meat sciences.

INTRODUCTION
- Meat is the post rigor aspect of muscle and the most abundant constituent of the carcass.
- Meat accounts for about 35-65% of carcass weight and 30 to 40% of live weight of meat animals, except in case of obese animals.
- Meat is primarily composed of skeletal muscle, but blood vessels present in muscle are composed of smooth muscle. However the ensuing discussion will be restricted to that of skeletal muscle.

GROSS STRUCTURE
- A meat animal possesses as many as 600 distinct muscles.
- Variations exist in respect of size and shape (triangular fan like or fusiform; long or short; broad or narrow) in the attachments (bones, cartilages, or ligaments); in blood or nerve supply; in association with other tissue; and in their action (fast, slow or intermittent) among muscles.
- These variations allow muscles to perform various type of movement ranging from gross as in the case of movement of limbs to very fine as in the case of eyes.
- However a basic structural pattern is common to every muscle, despite the variations listed above.
- Skeletal muscles are also known as striated muscles as they appear as parallel striations of alternating light and dark bands.
- Muscles are composed of individual cells referred to as muscles fibres, which in turn is made up myofibrils, which in turn is composed of myofilaments.

CONNECTIVE TISSUE ASSOCIATED WITH MUSCLE
- Muscles are composed of muscle fibre or muscle cells, the structural units of muscles.
- A connective tissue sheath, referred to as epimysium is the outermost layer of every muscle.
- A finer connective tissue, referred to as perimysium emerge from the epimysium, penetrate the muscle, and divide muscle into muscle fibre bundles by aggregating muscle fibres, and cover the muscle fibre bundles.
- A finer connective tissue framework known as the endomysium, emanates from the perimysium and covers each individual muscles fibres.
- Connective tissue networks act as channels for passage of blood vessels and nerve fibres.
- Endomysium is an amorphous, non-fibrous sheath and is collagenous in nature.
- The collagenous fibres of the endomysium are associated with the cell membrane of the muscle fibre, sarcolemma by means of the basement membrane
- Sarcolemma is similar to plasmalemma of any other animal cell in respect of structure, composition and function and is endowed with great elasticity to endure the great distortion it undergoes during muscular contraction and relaxation.
- The sarcolemma, basement membrane and endomysium though closely associated, are distinct entities.
**HISTOLOGICAL STRUCTURE - MYOFIBRE**

- Muscle fibres, or muscle cells are long un-branched thread like multinucleate cells that taper slightly at both ends.
- Muscles fibres may attain the length of many centimetres though only rarely do they extend the entire length of a muscle as in the case of sartorius muscles, but is only about 10-100 µm in diameter.
- Invaginations of sarcolemma, referred to as transverse tubules or T system form a network of tubules and run along the entire length and around the entire circumference of the fibre.
- Motor nerve fibre endings terminate on invaginations of the sarcolemma at the myoneural junction.
- The structures present at the myoneural junction form a small mound on the surface of the muscles fibre.
- The entire complex is called motor end plate.

**ORGANELLES OF THE MUSCLE FIBRE**

- The cytoplasm of the muscle is called as sarcoplasm, in which, as is the case of any other cell, organelles and colloidal substances are suspended.
- Sarcoplasm is composed of about 75- 80% water, and contain lipid droplets, glycogen granules, ribosome, numerous proteins, non-protein nitrogenous compounds and several inorganic constituents.
- The nuclei of the fibres are regularly distributed; about one every 5 µm, with increased numbers present at tendinous attachments and at myoneural junctions.
- Nuclei are located immediately beneath the sarcolemma in case of mammals, while they are centrally located in case of fishes.
- The nuclei are ellipsoidal in shape and their long axis is oriented parallel to the long axis of the fibre.
- The number and size of mitochondria in muscle fibres vary greatly.
- Mitochondria are relatively abundant at the periphery of the fibre near the poles of the nuclei and especially abundant at motor end plates.
- Mitochondria are located between myofibril, adjacent to Z disk, I bands or A – I junction (discussed below).
- Lysosomes are also present, as also are golgi bodies, plenty of which are found near the nuclei, though their total numbers are much less than in case of secretory cells.
- The endoplasmic reticulum is very well developed and is known as sarcoplasmic reticulum.
- Apart from these organelles, muscles fibres are principally composed of a unique organelle known as myofibril.
**MYOFIBRILS**

- Myofibrils are long thin, cylindrical rods, bathed by the sarcoplasm and usually 1-2 μm in diameter.
- A muscle fibre with a diameter of 50 μm from meat animals will have at least 1000 and could have as many as 2000 (or more) myofibrils.
- On microscopic examination, the myofibrils present an appearance of alternating light and dark bands.
- A cross-section of myofibrils reveals a well-ordered array of dots of two distinct sizes. These dots are actually the myofilaments with different sizes corresponding to the thick and thin filaments of the myofibril.
- The thin filaments are almost all completely made up of a protein actin (actin filaments), while the protein myosin (myosin filaments) is the sole constituent of the thick filaments.
- In longitudinal section, the thick filaments are aligned parallel to each other and are arranged in exact alignment across the entire myofibril. Similarly, the thin filaments are exactly aligned across the myofibril, parallel to each other and to the thick filaments.
- This arrangement of the myofilaments, and the fact that the thick filaments overlap in certain regions along their longitudinal axes, accounts for the characteristic banding or striated appearance of the myofibril.
- This banding effect, which takes the form of alternate light and dark areas, explains the use of the term striated muscle to describe skeletal muscle.
- The long axis of myofibrils in most muscles and in all mammals is parallel to the length of the muscle and extends the entire length of the muscle fibre.

**MYOFILAMENTS**

- Areas of different density are visible within the light and dark bands of the myofibrils.
- The light band is singly refractive when viewed with polarized light, owing to the fact it exclusively contains actin filaments only, hence it is described as being isotropic and is called the I band.
- The broad dark band is doubly refractive when viewed with polarized light, as it contains both actin and myosin filaments, hence it is described as being anisotropic, and thus referred to as the A band.
- The ‘A’ band is much denser than the ‘I’ band. Both the ‘A’ and ‘I’ bands are bisected by relatively thin lines. A dark thin band called the Z line bisects the ‘I’ band. A narrow dense band, known as the M line, bisects the centre of the ‘A’ band.
- The thick and the thin filaments differ in their dimensions, chemical composition, properties and position within the sarcomere. The thick filaments are approximately 14–16 nm (nanometres) in diameter (1 nm = one-billionth of a metre) and 1.5 μm long.
- The thick filaments constitute the ‘A’ band of the sarcomere. Since they consist almost entirely of protein myosin they are referred to as myosin filaments. They are held in transverse and longitudinal registers by thin cross bands located periodically along the length and by cross connections in the centre of the ‘A’ band.
- The alignment of these cross connections in the centre of the ‘A’ band corresponds to the transverse density characteristics of the M-line.
- The thin filaments are about 6–8 nm in diameter and they extend approximately 1.0 μm on either side of the Z line. These filaments constitute I band of the sarcomere. They consist primarily of the protein actin and are referred to as the actin filaments.

**SARCOMERE**

- The unit of the myofibril between two adjacent Z lines (an ‘A’ band and two half ‘I’ bands located on either side of the ‘A’ band) is called a sarcomere.
- The sarcomere is the repeating structural unit of the myofibril and it is also the basic unit in which the events of the muscle’s contraction–relaxation cycle occur. Thus, the sarcomere is the functional unit of myofibril.
- Sarcomere length is not constant and its dimensions, as well as those of I band, are dependent on the state of contraction at the time the muscle is examined.
- In the central region of the ‘A’ band, there is an area that has slightly less density than the remainder of the band. This lighter region is called the H zone which consists only of myosin filaments.
- Additionally, a region of relatively low density appears within the H zone on either side of the M line. This low-density region is referred to as the pseudo H zone, which comprises only the tail fraction of myosin.
- The H zone is less dense than the rest of the ‘A’ band because it is the centre region between the ends of the opposing actin filaments and contain only myosin heads. The pseudo H zone consists only of myosin tail.
- The width of the H zone varies with the state of contraction of the muscle.
- The densest area of the ‘A’ band is on the either side of the H zone, where both the actin and myosin filaments are present.
- Since I band contains only the thin actin filaments, it is the least dense band of the entire myofibril.
- The myosin filaments in the H zone region of the sarcomere are oriented in a definite hexagonal pattern — six thin filaments surround each thick filament.
- The H zone is completely obliterated when the muscle contracts fully, as the actin filaments are pulled towards itself by the myosin head, while the pseudo H zone is not obliterated by any amount of contraction.
In longitudinal section, an actin filament on one side of the Z line lies between two actin filaments on the opposite side of the Z line. This arrangement indicates that the actin filaments per se do not pass through the Z line.

The actin filaments are believed to terminate at the Z line. Ultra-thin filaments, called Z filaments, constitute the material of the Z line and they connect with actin filaments on either side of it.

Near the Z line, each actin filament connects to four Z filaments that pass obliquely through the Z line.

Each of the four Z filaments then connects with an actin filament in the adjacent sarcomere. This structural arrangement of the Z line shows each actin filament of one sarcomere oriented in the centre of four actin filaments from the next sarcomere.

In longitudinal sections, this offset (or oblique) arrangement of the Z filaments results in the characteristic zigzag pattern of the Z line and explains why an actin filament on one side of the Z line appears to lie between two actin filaments of the apposing sarcomere.
PROTEINS OF THE MUSCLE

- Proteins of the muscle are classified based on their solubility characteristics as Sarcoplasmic proteins, which are soluble in water; Myofibrillar proteins, which are soluble in high ionic strength solutions and Connective tissue or Stromal proteins, which are insoluble in high ionic strength solutions, at low temperatures.
- Myofibrillar proteins, as the name indicates are associated with the myofibrils.
- Myofibrillar proteins are further classified into Contractile proteins, Regulatory Proteins and Cytoskeletal proteins.
  - Contractile proteins as called so as they are involved in muscle contraction and the contractile proteins include actin and myosin.
  - The proteins actin and myosin constitute approximately 65 percent of the protein in the myofibril.
  - Regulatory proteins are so named because of their direct or indirect regulatory functions on the adenosine triphosphate-actin-myosin complex.
  - The regulatory proteins include tropomyosin, troponin, two M proteins α-actinin, and β-actinin – listed in the decreasing order of concentration in the myofibril.
  - The cytoskeletal proteins are involved maintaining the myofibrillar proteins in register and include titin, nebulin, C protein, M protein, desmin, filamentin, synemin and vinculin.
- Actin is a globular molecule about 5.5 µm in diameter. This is referred to as G-actin (for globular actin) and it constitutes the monomeric (single molecule) form of actin.
  - The fibrous nature of the actin filament is due to the longitudinal polymerization (linking) of G-actin monomers to form F-actin (fibrous actin).
  - In F-actin, the G-actin monomers are linked together in strands, similar to beads on a string.
  - Two strands of F-actin are spirally coiled around one another to form a “super helix” that is characteristic of the actin filament.
  - The isoelectric pH (pH of minimum electrical charge and solubility) of actin is approximately 4.7.
  - Actin possesses a relatively low charge.
- Myosin constitutes approximately 50-55 percent of the myofibrillar protein and is characterized by a high proportion of basic and acidic amino acids, making it a highly charged molecule.
  - The isoelectric pH of myosin is approximately 5.4.
  - Myosin, with lower proline content than actin, has a more fibrous nature.
  - The structure of the myosin molecule is an elongated rod shape, with a thickened portion at one end.
  - The thickened end of the myosin molecule is usually referred to as the head region and the long rod-like portion that forms the backbone of the thick filament is called the tail region.
  - The portion of the molecule between the head and the tail regions is called the neck.
  - The head region of the molecule is double headed and it projects laterally from the long axis of the filament.
  - When myosin is subjected to the proteolytic (protein breakdown) action of the enzyme trypsin, it is split near the neck into two fractions that differ in molecular weight; light meromyosin and heavy meromyosin.
In the centre of the ‘A’ band, on either side of the M line, the myosin filament contains the tail portion of the myosin molecules without any of the globular heads. This region within the H zone, on either side of the M line, is called the pseudo H zone.

The polarity of the myosin filaments is such that the heads on either side of the bare central region of the A band are oriented at an oblique angle away from the M line.

The protruding heads are the functionally active sites of the thick filaments during muscle contraction, since the myosin heads form cross bridges with actin filaments.

During muscle contractions each myosin head attaches to a G-actin molecule of the actin filament.

The formation of cross bridges through this interaction of actin and myosin filaments produces the chemical complex known as actomyosin.

- The formation of actomyosin results in a rigid and relatively inextensible condition in the muscle.
- Actomyosin is the major form of the myofibrillar proteins that is found in postmortem muscle and the rigidity associated with rigor mortis is largely due to this complex.
- It is a transient compound in the living animal, since the cross bridges between the actin and myosin filaments are broken during the relaxation phase of the contraction cycle. (Cross bridges are almost nonexistent in muscle when it is at rest.)

Tropomyosin constitutes 8-10 percent of the myofibrillar protein and like myosin, is highly charged molecule with a high content of acidic and basic amino acids.

- The isoelectric point of tropomyosin occurs at a pH of about 5.1.
- Tropomyosin has a very low proline content, that contributes to its fibrous nature.
- Tropomyosin molecules, consisting of two coiled peptide chains, attach end to end to one another and thus form long, thin filamentous strands.
- In the actin filament, one such tropomyosin strand lies on the surface of each of the two-coiled chains of F-actin.
- The tropomyosin strands lie alongside each groove of the actin super helix.
- A single tropomyosin molecule extends the length of 7 G-actin molecules in the actin filament.

Tropomin, a globular protein with relatively high proline content, also constitutes 8-10 percent of the myofibrillar protein.

- Like tropomyosin, troponin is present in the grooves of the actin filament where it lies astride the tropomyosin strands.
- It is also probably present near the end of the tropomyosin molecules.
- The troponin units shows a periodic repetitiveness along the length of the actin filament.
- There is one molecule of troponin for every 7 or 8 G-actin molecules along the actin filament.
- Troponin is a calcium-ion-receptive protein and calcium ion (Ca^{2+}) sensitivity is its major function in the actomyosin-tropomyosin complex.
• α-actinin has proline content comparable to that of actin and it too is a globular molecule.
  o α-actinin is present in the Z line and constitutes about 2-2.5 percent of the myofibrillar protein.
  o It has been suggested that α-actinin functions as the cementing substance in the Z line.
• B-actinin, which is also a globular protein, is located at the ends of actin filaments and is believed to regulate their length by maintaining a constant length of about 1µm in each half sarcomere.
  o In the absence of β-actinin, actin filaments in vitro attain lengths of 3-4 µm or more.
• Sarcoplasmic proteins include all the enzymes involved in glycolysis, TCA cycle and also myoglobin, which is the pigment responsible for the colour of meat.
• Connective tissue proteins include collagen, reticulin and elastin.

SARCOPLASMIC RETICULUM AND "T" TUBULES
• The endoplasmic reticulum of the muscle, the Sarcoplasmic reticulum (SR) is very well developed and is a membranous system of tubules and cisternae (flattened reservoir for Ca²⁺) that forms a closely meshed network around each myofibril.
  o Periodically along the length of the muscle fibre, and around its entire circumference, invagination of the sarcolemma forms the network of tubules that are called transverse tubules. These are usually called as T system or as T tubules.
• Thus SR and transverse tubules (t-tubules) are two separate distinct membrane systems and the t tubules are associated with the sarcolemma while the SR is intracellular in nature.
• The reticulum membranes of the SR are the storage sites of Ca²⁺ in resting muscle fibres.
• The SR consists of several distinct elements.
  o Thin tubules oriented in the direction of the myofibrillar axis, constitute the longitudinal tubules of the reticulum.
  o In the H zone region of the sarcomere the longitudinal tubules converge forming a perforated sheet that is called a fenestrated (window-like opening) collar.
  o At the junction of the A and I bands the longitudinal tubules converge and join with a pair of larger, transversely oriented, tubular elements called terminal cisternae.
  o The longitudinal tubules extend in both directions from the fenestrated collar to the terminal cisternae.
  o The two tubular elements comprising the terminal cisternae lie parallel to each other with one tubule of the pair transversing the A band and the other transversing the adjacent I band, of the sarcomere.
  o A "T" tubule also runs transversely across the sarcomere, at the A-I band junction and lies between the two tubular elements of the terminal cisternae pair.
  o The central "T" tubule and the two tubular elements of the terminal cisternae collectively form a structure known as the triad.
  o Each sarcomere has two triads, one in each half sarcomere at the A-I band junction.
  o The triads encircle each myofibril at the A-I band junction of mammals, birds and in some fish.
  o In some species the triads are located at the Z lines.
• The SR volume varies from one muscle fibre to another, but it is estimated as constituting approximately 13 percent of the total fibre volume.
• The T tubules on the other hand, comprise only about 0.3 percent of the fibre volume.
MITOCHONDRIA
- Mitochondria are oblong organelles located in the sarcoplasm. They are frequently referred to as the “power house of the cell” because they “capture” the energy derived from carbohydrate, lipid and protein metabolism and then provide the cell with a source of chemical energy.
- They contain the enzymes that the cell uses in the process of oxidative metabolism.
- There exists a considerable variation in mitochondrial numbers and size in muscle fibres.
- Skeletal muscle mitochondria are relatively abundant at the periphery of the fibre near the poles of the nuclei and are especially abundant at the myoneural junctions.
- Additionally, a number of mitochondria are located between the myofibrils, adjacent either to the Z lines, the I bands or to the A-I band junctions

LYSOSOMES
- Lysosomes are small vesicles, located in the sarcoplasm, that contain a number of enzymes collectively capable of digesting the cell and its contents.
- These lysosomal enzymes contain a group of proteolytic enzymes known as the cathepsins.
- Several cathepsins have proteolytic effects on some of the muscle proteins.

GOLGI COMPLEX
- Golgi complex is located in the sarcoplasm near the nuclei.
- They consist of flattened vesicles, which apparently function as the “concentrating” and “packaging” apparatus for the products from the metabolic “production line” of the cell.
- The muscle fibre, being multinucleated, has numerous Golgi complexes.
- The vesicles of the Golgi complex resemble the membranes of the sarcoplasmic reticulum.

SMOOTH MUSCLE
- Smooth muscle is present in the greatest quantity in the walls of arteries, lymph vessels and in gastrointestinal and reproductive tracts.
- It is involuntary in nature.
- Smooth muscle fibres are long, unevenly thickened in the centre and tapering on both the sides.
- The myofibrils are homogenous and do not show alternating dark and light bands like those of skeletal muscle.
- There are no Z or M-lines.
- The SR is also not much developed. Smooth muscle is poorly supplied with blood.

CARDIAC MUSCLE
- Cardiac muscle possesses the unique property of rhythmic contractility, which continues from early embryonic life until death.
- Cardiac muscle has properties that resemble characteristic properties of both skeletal and smooth muscle.
- It is also involuntary.
- The muscle fibres are rounded to irregular in shape and give off branches, which get mixed up with those of nearby fibres.
- The nucleus is placed in the centre of the fibre.
- Myofibrils depict striations similar to skeletal muscle.
- The sarcoplasm shows numerous and much more mitochondria than the skeletal or smooth muscle.
- The intercalated discs are present at the position of Z-lines.

MODULE-2: DEVELOPMENT OF MEAT INDUSTRY
Learning objectives
At the end of this module the learner will gain a bird’s eye view of the presstatus of the meat industry in India, its historical development and the issues that deter its development, and the way forward.

INTRODUCTION
The meat production and processing industry is slowly getting organised to meet the ever-increasing demand for meat with the growing human population.
But the word “MEAT” is considered as a taboo in our country and this social prejudice is the root of all the problems that this age old-industry faces in its healthy growth, scientific improvement and contribution to the speedier growth of Livestock Industry.
Today the consumers are in the process of changing their meat eating habits from fresh to frozen meat and processed items.

ECONOMIC IMPORTANCE
Livestock sector is an important component of the Indian agriculture, ranking in importance after crop production, from the viewpoint of its contribution to the Gross National Product (GNP) as well as the employment potential in rural areas.
The share of the livestock product is estimated a 5.21% of GDP in 2007-2008.
National sample survey has reported that in India livestock activities are carried out by over 90% of small cultivators and low wage earners to supplement their income.
The value of output of the Livestock and Fisheries Sector in 2009-10 amounted to Rs. 4,08,386 crores at current prices – about 29.7% share in the agriculture and allied activities sector.

LIVESTOCK RESOURCE
India has the largest livestock population in the world.
There are 226.1 million cattle, 96.9 buffaloes, 59.0 million sheep, 124.50 million goats and 18.5 million pigs and 842 million chickens in the Country (FAO, 2004)BAHS to be used instead of FAO.
Our country shares about 50% of the buffaloes and nearly 15% each of cattle and goat population of the world.
India ranks the first in the world in buffalo population, second in cattle and goat, third in sheep and fifth in chicken.
This is in contrast to the concept of large sized livestock farms in the developed countries.
It is also noteworthy that 75% of our livestock population does not conform to the specific breed characteristics and has significantly low in production potential.
Animals that are generally used for production of meat are cattle, buffaloes, sheep, goats, pigs and poultry.
Mithun is also slaughtered for meat in North East and Sikkim.
Rabbit, quail, duck and turkey meat are also used as a specialty in Kerala, Andhra Pradesh, Karnataka and some other states.
Recently emu and ostrich have also been introduced in Andhra Pradesh, Tamil Nadu and Pondicherry.
For long time meat industry has remained confined to a very small section of people in our country.
These people had little knowledge of wholesome meat production and effective utilisation of valued slaughterhouse by-products.
The scene is now changing.
However, industry is still largely based on spent animals except for pigs and farm poultry.
Most animals are utilised for meat production after loosing their economic viability in the primary field.
Cow slaughter is banned in our country except in West Bengal and Kerala states.
The concept of meat type animals is yet to take roots in our country, although an awakening in this regard is discernible.
Of late, particularly due to export potential, buffalo is emerging as a prospective meat animal at the end of its productive or working life.
This is a factor favouring meat export as the buffalo carcass compares favourably in terms of conformation, fat content and weight, with international term.
Besides, buffalo meat has the advantage of low primary cost. Mutton occupies a distant second position in terms of value of exports.

MEAT PRODUCTION
Meat is an important livestock product, which in its widest sense includes all those parts of the animals that are used as a food by man.
Though meat has a very high biological value, its production and processing has always been the subject of social prejudice.
This factor has adversely affected the growth of meat industry.
In many cases, social resistance and ignorance have resulted in inordinate delay and determent of abattoir modernization schemes.
• An important milestone in this area was the establishment of a modern abattoir (Deonar Abattoir) at Govandi, Mumbai in 1973.
• This has a capacity to slaughter two million sheep and goats and one hundred thousand each buffaloes, bullocks and pigs in a year.
• Further, in the fourth five-year plan, eight bacon factories (in 1970) were established with the foreign assistance.
• A few meat corporations were also formed to take up the development of slaughterhouses.
• Meat production increased almost five times during the last fifteen years and was estimated at 4.9 million tonnes in 1998 and an annual growth rate of 4.1% achieved during the last decade as compared to 4.7% for eggs and 4.3% for milk. APEDA data to be incorporated.
• ICMR recommended 34 g of meat/capita/day.
• Actual consumption is as low as 14 gms/capita/day.
• Per capita meat production in India increased from 4.6 Kg/annum in 1991 to 4.9 Kg/annum in 2000.
• The total consumption of meat in 1981 was 38.28 lakh metric tonnes, which has increased to 45.49 lakh metric tonnes in 2000 showing an annual growth rate of 1.7%.
• During the year 2004 the quantity of meat produced in recognized slaughterhouses in Tamil Nadu was 43 million Kgs with the value of meat at Rs.410 crores.
• At present, almost 91.01 million animals are slaughtered annually yielding 4.9 million tones of meat.
• From this 60.6% is contributed by the sheep and goats and 15.6% by cattle and buffaloes.
• Nearly, 99% pig population is slaughtered annually contributing 9.9% of the total meat production.
• Poultry with a population of 467 million contribute 0.44 million tones of meat (10.7% of total meat production).
• There has been an impressive rise in the share of poultry and pig meat over the years and the same trend is likely to continue in future also.
• The traditional form of meat industry is characterized by unorganized sector in the hands of butcher-workers with very little knowledge of personal hygiene.
• There are about 3600 licensed slaughterhouses in the country, which includes 128 in Tamil Nadu.
• A large number of them are outdated and substandard according to the present production and processing technology specifications.
• These slaughterhouses operate as service abattoirs where butchers slaughter the animals for a fee and both edible and non-edible parts of the carcasses are delivered to the butchers.
• Most of them need modernization with facilities for lairage, slaughter hall, chilling room, rendering plant, etc.
• While it is imperative to have all these facilities in big cities, a semi-modern approach with mechanical hoist facility is the workable proposition for modern and small sized towns

<table>
<thead>
<tr>
<th>S.No</th>
<th>Kind of animal</th>
<th>Number of heads slaughtered (in lakhs)</th>
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<tbody>
<tr>
<td>1.</td>
<td>Sheep</td>
<td>11.29</td>
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<td>2.</td>
<td>Goat</td>
<td>0.71</td>
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<tr>
<td>3.</td>
<td>Buffaloes</td>
<td>0.50</td>
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<tr>
<td>4.</td>
<td>Pigs</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>26.30</strong></td>
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**Quantum of Meat Production in Tamil Nadu (In lakh Kgs) for the Year 2004**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Species</th>
<th>Quantity (In lakh Kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mutton</td>
<td>12.35</td>
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<tr>
<td>2.</td>
<td>Chevon</td>
<td>16.63</td>
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<tr>
<td>3.</td>
<td>Beef</td>
<td>7.21</td>
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<tr>
<td>4.</td>
<td>Buffalo</td>
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<tr>
<td>5.</td>
<td>Pork</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>42.54</strong></td>
</tr>
<tr>
<td>6.</td>
<td>Broiler</td>
<td>42.49</td>
</tr>
</tbody>
</table>

By- Manuprabh, Naveen, Pradeep
The meat industry in India is really concentrated in U. P and Western regions.

There are about 12 large meat processing plants in India whose turnover ranges from Rs. 10 crores to Rs. 30 crores and about 50-60 small meat processing industries located in these regions.

Most of these processors depend upon the slaughtering of the cattle at the local municipal slaughterhouses.

The Asia’s largest slaughterhouse is at Deonar-Greater Mumbai.

Since many of our slaughterhouses are not properly managed and organised on modern scientific lines, the slaughter of large number of livestock and proper utilisation of all the by-products profitably is very difficult to get the competitive price to fight the global competition.

During the last decade, ten modern abattoir complexes have come up in public sector.

An equal number have become functional in private sector also.

Eight new projects on modern mechanized abattoirs were initiated in 1990-91.

In the Eighth Plan, five private sector export abattoirs are nearing completion.

These developmental activities are necessary to improve the image of the Indian meat sector.

Among the large players in the field of meat industry in our country are Allanasons, Alkabeer and Hind Industries - all of them are major export houses.

Meat industry in India belongs to a handful of business houses in small and medium sectors particularly dominated by one religious group.

Large corporate houses did not venture in this business at all.

The only major venture from corporate sector in meat processing was from Brooke Bond.

In seventies, Brooke Bond had set up a large modern processing plant for export at Aurangabad in Maharashtra.

The plant had a capacity of handling 500 buffaloes per day and was equipped with the processing facilities to produce blood meal, bone meal, etc.

The project failed mainly for three reasons –

- Non - availability of required number of buffaloes everyday.
- Higher cost of production and therefore difficulty in marketing the same and
- Marketing problems of by-products

The plant was finally sold to Allanasons, who are organised well in selling chilled and frozen meat in the Middle East through their own retail outlets located there.

Out of the total meat produced in our country, less than 3% of the meat produced is sold as processed meat. In developed countries 65-80% of the meat produced is sold in the processed form.

Under MFPO 1973, 220 licensed manufacturers produce 22,000 tonnes of processed meat comprising 50% of cured products, 20% sausages and 20% canned products.

Lately, however, Indian dynamics is changing in favour of processed meat products especially in metropolis and big cities.

The retail butcher shops sell most of the meat produced in the country to the consumers as fresh hot meat (unchilled).

This meat is then cooked in the households in many different ways depending on their taste and preferences.

The production of processed meat products in the organised sector got a fillip with the establishment of bacon factories in the Fourth Plan.

These bacon factories stimulated the establishment of many processing units in those areas.

Several traditional meat products like meat kabab, chicken biryani, tandoori chicken, meat curry, etc., are popular in the non-vegetarian population for a long time.

Some other foods products adopted in meat like meat samosa, meat tikka, meat kofta, meat balls, cutlets, meat pickles, etc., have been able to create an impact on the urban consumer.

Various region-specific meat products like Nihari (Delhi), Goa sausage (Goa), Pork pickle (Himachal Pradesh), Yakini and Gustaba (Kashmir), Rapka (Arunachal Pradesh), etc., have good acceptability in their traditional consumers. Western type meat products like cured ham, bacon, sausages, frankfurters, hot dogs, meat patties/burgers, luncheon meat and loaves, liver paste, etc., have good demand in cities. Eight bacon factories, five meat corporations and a fairly good number of MFPO licensees in private sector have taken up the production of a wide range of these products. They are catering to the requirements of defence, restaurants and household consumers. Canned meat products are relatively new entrants in the domestic market and are primarily being manufactured for defence supplies.

The prices of canned meats are comparatively high rendering them beyond the reach of common consumers, although their presence can be noticed in the departmental stores in the metropolitan cities.


DOMESTIC SCENE

- The meat industry in India is really concentrated in U. P and Western regions.
- There are about 12 large meat processing plants in India whose turnover ranges from Rs. 10 crores to Rs. 30 crores and about 50-60 small meat processing industries located in these regions.
- Most of these processors depend upon the slaughtering of the cattle at the local municipal slaughterhouses.
- The Asia’s largest slaughterhouse is at Deonar-Greater Mumbai.
- Since many of our slaughterhouses are not properly managed and organised on modern scientific lines, the slaughter of large number of livestock and proper utilisation of all the by-products profitably is very difficult to get the competitive price to fight the global competition.
- During the last decade, ten modern abattoir complexes have come up in public sector.
- An equal number have become functional in private sector also.
- Eight new projects on modern mechanized abattoirs were initiated in 1990-91.
- In the Eighth Plan, five private sector export abattoirs are nearing completion.
- These developmental activities are necessary to improve the image of the Indian meat sector.
- Among the large players in the field of meat industry in our country are Allanasons, Alkabeer and Hind Industries - all of them are major export houses.
- Meat industry in India belongs to a handful of business houses in small and medium sectors particularly dominated by one religious group.
- Large corporate houses did not venture in this business at all.
- The only major venture from corporate sector in meat processing was from Brooke Bond.
- In seventies, Brooke Bond had set up a large modern processing plant for export at Aurangabad in Maharashtra.
- The plant had a capacity of handling 500 buffaloes per day and was equipped with the processing facilities to produce blood meal, bone meal, etc.
- The project failed mainly for three reasons –
  - Non - availability of required number of buffaloes everyday.
  - Higher cost of production and therefore difficulty in marketing the same and
  - Marketing problems of by-products
- The plant was finally sold to Allanasons, who are organised well in selling chilled and frozen meat in the Middle East through their own retail outlets located there.

PROCESSED MEAT

- Out of the total meat produced in our country, less than 3% of the meat produced is sold as processed meat. In developed countries 65-80% of the meat produced is sold in the processed form.
- Under MFPO 1973, 220 licensed manufacturers produce 22,000 tonnes of processed meat comprising 50% of cured products, 20% sausages and 20% canned products.
- Lately, however, Indian dynamics is changing in favour of processed meat products especially in metropolis and big cities.
- The retail butcher shops sell most of the meat produced in the country to the consumers as fresh hot meat (unchilled).
- This meat is then cooked in the households in many different ways depending on their taste and preferences.
- The production of processed meat products in the organised sector got a fillip with the establishment of bacon factories in the Fourth Plan.
- These bacon factories stimulated the establishment of many processing units in those areas.
- Several traditional meat products like meat kabab, chicken biryani, tandoori chicken, meat curry, etc., are popular in the non-vegetarian population for a long time.
- Some other foods products adopted in meat like meat samosa, meat tikka, meat kofta, meat balls, cutlets, meat pickles, etc., have been able to create an impact on the urban consumer.
- Various region-specific meat products like Nihari (Delhi), Goa sausage (Goa), Pork pickle (Himachal Pradesh), Yakini and Gustaba (Kashmir), Rapka (Arunachal Pradesh), etc., have good acceptability in their traditional consumers. Western type meat products like cured ham, bacon, sausages, frankfurters, hot dogs, meat patties/burgers, luncheon meat and loaves, liver paste, etc., have good demand in cities. Eight bacon factories, five meat corporations and a fairly good number of MFPO licensees in private sector have taken up the production of a wide range of these products. They are catering to the requirements of defence, restaurants and household consumers. Canned meat products are relatively new entrants in the domestic market and are primarily being manufactured for defence supplies.
- The prices of canned meats are comparatively high rendering them beyond the reach of common consumers, although their presence can be noticed in the departmental stores in the metropolitan cities.

By- Manuprabh, Naveen, Pradeep
• Processed meat products are poised for continuous growth in the country. In big cities, there is an ever increasing demand for ‘heat and serve’ and ‘ready to eat’ convenience or fast foods. These are delicious, nutritious and if required, easy to carry home.
• The growth of fast food parlours and restaurants is attributed to the rapid urbanization, changing life styles and rapid increase in the number of working women.
• It may be pointed out that increase in consumption of value added processed meat products are closely linked with increase in disposable income and growth of urbanization.
• Thus, convenience type meat products are going to have spectacular growth in the coming years. Due to nutritional awareness and liberal food habits of the new generation, the adoption of western type products with indigenous flavour profiles is bound to take place at a rapid rate. We must strive to export processed meat products rather than live animals and fresh meat. There is a need to study the consumption pattern of meat products in importing countries, so that we can tailor our products according to their requirements.
• A shift from primary products to value added products besides fetching more profits would decrease the transportation cost and generates more employment. It will also encourage more efficient utilisation of meat by-products.

PROBLEMS ENCOUNTERED
• The odds are many, which are the major deterrent for many corporates to get into the sector.
• The main reason is the religious overtones in meat processing and animal slaughtering.
• The other reasons are availability of cattle or food animals. The organised cattle rearing are very labour intensive and there are too many pitfalls and uncertainties.
• Pollution control is also a major issue. The fodder and animal feed are also very scarce. To organise this is a mammoth task in India and if one wants to do it government policies, infrastructural framework and political will are almost non-existent.
• Besides, only productive, non-milking buffaloes are allowed to slaughter and thus meat yield and quality of that meat from aged cattle are not very remunerative in global market where tender meat fetches a better price and is in demand.
• Since the cattle graze in natural ground, Foot and Mouth Disease is an issue. For this reason, particularly in European and American markets Indian meat is not accepted.
• In India buffalo meat is traded whereas all over the world beef is actually from cow, which is banned here. This also has restricted to a limited geographical area.
• As per regulatory practices, in the slaughterhouses in India goat and lamb are certified as healthy ones whereas buffalo is certified as useless by Veterinary Surgeons before slaughtering.

PROMOTIONAL AGENCIES AND ASSISTANCE
• The Central and State Governments have several schemes for encouraging meat and poultry farming, processing industry through financial assistance/subsidy and marketing help, etc. It also provides assistance for development of hygienic retail outlets.
• Since, the issue of establishing and organizing abattoirs and meat processing plants is a complex one and there is no easy solution. A holistic approach is required to make this industry grow and prosper.

### Population of Food animals – World and India (2004)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Kind of animal</th>
<th>Number of heads</th>
<th>Number of heads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sheep</td>
<td>1,038,765,370</td>
<td>62,500,000</td>
</tr>
<tr>
<td>2.</td>
<td>Goats</td>
<td>780,099,948</td>
<td>120,000,000</td>
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<tr>
<td>3.</td>
<td>Cattle</td>
<td>1,334,501,290</td>
<td>185,500,000</td>
</tr>
<tr>
<td>4.</td>
<td>Buffaloes</td>
<td>172,719,487</td>
<td>97,700,000</td>
</tr>
<tr>
<td>5.</td>
<td>Pigs</td>
<td>951,771,892</td>
<td>14,300,000</td>
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<tr>
<td>6.</td>
<td>Chickens</td>
<td>16,194,925,000</td>
<td>425,000</td>
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### Number of animals slaughtered in World and India (2004)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Kind of animal</th>
<th>Number of heads</th>
<th>Number of heads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sheep</td>
<td>507,257,126</td>
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<td>2.</td>
<td>Goat</td>
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<td>3.</td>
<td>Cattle</td>
<td>293,442,922</td>
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<td>4.</td>
<td>Buffaloes</td>
<td>22,578,165</td>
<td>10,747,000</td>
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</table>

By- Manuprabh, Naveen, Pradeep
Quantum of Meat Production in World and India (In Mt) for the Year 2004

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species</th>
<th>Quantity (In Mt)</th>
<th>Quantity (In Mt)</th>
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<tbody>
<tr>
<td>1.</td>
<td>Mutton</td>
<td>7,892,259</td>
<td>238,800</td>
</tr>
<tr>
<td>2.</td>
<td>Chevon</td>
<td>4,210,132</td>
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</tr>
<tr>
<td>3.</td>
<td>Beef and Veal</td>
<td>58,702,028</td>
<td>1,483,200</td>
</tr>
<tr>
<td>4.</td>
<td>Buffalo</td>
<td>3,171,168</td>
<td>1,483,086</td>
</tr>
<tr>
<td>5.</td>
<td>Pork</td>
<td>100,392,230</td>
<td>497,000</td>
</tr>
<tr>
<td>6.</td>
<td>Chicken meat</td>
<td>67,718,544</td>
<td>1,650,000</td>
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</table>

Export of animal products

<table>
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<th>2001-02</th>
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<th>2003-04</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
<td>Value</td>
<td>Quantity</td>
</tr>
<tr>
<td>Buffalo Meat</td>
<td>243356</td>
<td>1144.4</td>
<td>297897</td>
</tr>
<tr>
<td>Sheep / Goat Meat</td>
<td>3915.1</td>
<td>33.07</td>
<td>4973.6</td>
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<tr>
<td>Poultry Products</td>
<td>19876</td>
<td>130.07</td>
<td>26450</td>
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<tr>
<td>Dairy Products</td>
<td>24774</td>
<td>182.45</td>
<td>21440</td>
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<tr>
<td>Animal Casings</td>
<td>464.28</td>
<td>9.63</td>
<td>8296.2</td>
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<tr>
<td>Processed Meat</td>
<td>267.13</td>
<td>1.29</td>
<td>669.48</td>
</tr>
<tr>
<td><strong>Total for Animal Products</strong></td>
<td><strong>292652</strong></td>
<td><strong>1500.9</strong></td>
<td><strong>359726</strong></td>
</tr>
</tbody>
</table>

MODULE-3: CONVERSION OF MUSCLE TO MEAT

Learning objectives
- This module will enable the learner to understand the various events in the sequential conversion of muscle to meat.
- This module will also facilitate the learner to comprehend the relationship between the sequential conversion of muscle to meat and meat quality.
- Further, the learner will also become conversant with ageing and the beneficial effects of ageing on meat quality.

INTRODUCTION
- *Meat is the post-rigor aspect of muscle* and the conversion of ‘Muscle’ to ‘Meat’ is the result of series of biochemical and biophysical changes initiated in muscle at the death of the animal due to stoppage of the blood circulation.
- There is immediate loss of oxygen supply to the muscle due to exsanguination (bleeding).
- As the Oxidation reduction potential is reduced, there is inhibition of aerobic pathway through TCA cycle as well as cytochrome system.
- The store of creatinine phosphate (CP) used for rephosphorylation of ADP to ATP (creatine phosphate + ADP = ATP + creatine) gets soon exhausted.
- Energy metabolism is then shifted to anaerobic pathway resulting in the breakdown of glycogen to lactic acid.
- This process continues till all the glycogen stored in the muscle is exhausted or the ultimate pH is reached.
- This resynthesis of ATP by anaerobic pathway is not enough to maintain the required ATP level and as it depletes, there is formation of actomyosin resulting in the onset of rigor mortis.
- The important changes that take place during postmortem period are follows:
  - Loss of Homeostasis
  - Postmortem glycolysis and pH decline
  - Rigor Mortis

By- Manuprabh, Naveen, Pradeep
Loss of Protection from Invading Microorganisms
- Degradation due to Proteolytic Enzymes
- Loss of Structural Integrity

- Thus the conversion of muscle to meat is a series of the above biochemical changes ultimately culminating in the resolution of rigor mortis.

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

**POSTMORTEM GLYCOLYSIS AND pH DECLINE**
- In the absence of oxygen, anaerobic glycolysis leads to the formation of lactic acid from the glycogen reserves:

  \[
  \text{Glycogen} \xrightarrow{\text{Aerobic Conditions}} \text{Lactic acid} + 2\text{ATP}
  \]

  - The accumulation of lactic acid lowers down the muscle pH, which is an important postmortem change during the conversion of muscle to meat.
  - The rate and extent of pH decline are variable, being influenced by the species of food animal, various preslaughter factors, environmental temperature, etc.
  - In most species, a gradual decline continues from approximately pH 7 in the living muscle during first few hours (5-6 hours) and then there is a little drop in the next 15-20 hours, giving an ultimate pH in the range of 5.5 – 5.7.
  - The rate of pH decline is enhanced at high environmental temperature. A low ultimate pH is desired to have a check on the proliferating microorganisms during storage.
  - A sharp decline in postmortem pH even before the dissipation of body heat through carcass chilling may cause denaturation of muscle proteins. So, the muscles depict pale, soft and exudative (PSE) condition.
  - Contrary to this, muscles which maintain a consistently high pH during postmortem conversion to meat due to depletion of glycogen prior to slaughter depicts a dark, firm and dry (DFD) condition. Both the conditions are undesirable.

**RIGOR MORTIS**
- It refers to stiffening of muscles after death and is another important postmortem change in the process of conversion of muscle to meat. It is now very well-known that a particular level or concentration of ATP complexed with Mg\(^{++}\) is required for breaking the actomyosin bond and bringing the muscle to a relaxed state and as it drops, permanent actomyosin crossbridges begin to form and muscle gradually becomes less and less extensible under an externally applied force.
- During the period immediately following exsanguination, the actomyosin formation proceeds very slowly at first and the muscle is relatively extensible and elastic. This period is called the delay phase of rigor mortis.
- Then actomyosin formation picks up and the muscle begins to lose extensibility. 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 is rapid. When postmortem pH decline is very slow or very fast, the onset and completion of rigor mortis is rapid. The onset of rigor mortis is enhanced at ambient temperature above 20°C.
- The phenomenon of rigor mortis resembles that of muscle contraction in a living animal muscle except that rigor mortis is irreversible under normal conditions.
The resolution of rigor mortis takes place mainly due to proteolytic activity of lysosomal enzymes or microbial degradation of muscle structure in due course of time.

Pre-rigor meat is quite tender but its toughness keeps on increasing until rigor mortis is completed. It continues to be tough for some more time. However, with the resolution of rigor due to denaturation or degradation or aging, meat becomes tender.

The onset of rigor mortis is also accompanied by a decrease in water holding capacity. This is true even when rigor mortis takes place at a high pH due to disappearance of ATP and consequent formation of actomyosin.

**LOSS OF PROTECTION FROM INVADING MICROORGANISMS**
- During postmortem period, body defense mechanism stops operating and membrane properties are altered.
- Except for low pH, most of the other postmortem changes favour bacterial growth.
- Hence, utmost handling precautions are necessary to prevent contamination of meat.

**DISINTEGRATION OF STRUCTURE 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.
- In fact, catheptic enzymes are capable of breaking down even collagenous connective tissue of the muscle and cause tenderisation of meat during aging.

**LOSS OF STRUCTURAL INTEGRITY**
- Postmortem alteration of membrane properties initiates the degradation of muscular proteins.
- There is a progressive disruption of myofibrillar structure.
- A rapid decline in muscle pH also causes denaturation of collagenous connective tissue.

**CONVERSION OF MUSCLE TO MEAT**
- Meat is the post-rigor aspect of muscle and the conversion of 'Muscle' to 'Meat' is the result of series of biochemical biophysical changes initiated in muscle at the death of the animal due to stoppage of the blood circulation.
- The most immediate change caused due to bleeding is the cessation of the oxygen supply to the muscle resulting in inhibition of the cytochrome system & therefore, oxidative phosphorylation.
- The sarcoplasmic ATPase depletes the ATP levels that increase the inorganic phosphate, which in turn stimulates the breakdown of glycogen to lactic acid.
- The ineffectual resynthesis of ATP by anaerobic glycolysis cannot maintain the ATP level and as it drops, actomyosin forms and the inextensibility of rigor mortis ensue.
- The loss of extensibility, which reflects actomyosin formation proceeds slowly at first (the delay period) then with great rapidity (the fast phase), extensibility then remains constant at low levels.
- The time to the onset of the fast phase of rigor at a given temperature depends most directly on the level of ATP.
- Synthesis of ATP from creatine phosphate and ADP or by glycolysis cannot maintain the ATP level for too long.
- Higher glycogen content of the muscle can prolong that time to some extent but not indefinitely.
- The onset of rigor is accompanied by a lowering in water holding capacity (WHC).
- This is not solely due to drop in pH and the consequent approach of the muscle proteins to their isoelectric point or due to denaturation of sarcoplasmic proteins.
- It has been shown that even when rigor mortis occurred at high pH, there was a loss of water holding due to the disappearance of ATP and to the consequent formation of actomyosin.
- The lowered ATP levels make it difficult to maintain the structural integrity of proteins.
- The lowering in pH, due to accumulation of lactic acid also makes liable to denature.
- Denaturation is accompanied by loss of power to bind water and the fall in pH causes the myofibrillar proteins approach their isoelectric point.
- Both events cause exudation.
- Denaturation of sarcoplasmic proteins also makes them liable to attack by cathepsin.
- The breakdown of proteins to peptide and amino acids and the accumulation of various metabolites from glycolytic and other processes afford a rich medium for bacteria.
- Resolution of rigor is a term used glibly to denote the decrease in tension generated in the muscle, during actinomyosin formation and muscle contraction.
- The resolution of rigor, is not on account breakdown of actinomyosin, but takes place due to decreasing tension, which is due to proteolytic degradation of specific myofibrillar proteins that lead to dissolution of Z discs, loss of ultrastructural integrity.
- Muscle, post the resolution of rigor is referred to as meat.
Meat Science (LPT-321)

- Ageing is the holding of carcasses just above its freezing point so as to obviate microbial spoilage, and this process is accompanied by an enhancement in tenderness and flavour of meat.
- The enhancement in flavour is mainly attributed to inosine (inosine monophosphate), a breakdown product of ATP (adenosine monophosphate).
- The breakdown of protein and fat during ageing resulting in formation of hydrogen sulphide, ammonia, acetone, and di-acetyl and an increase in free amino acids also adds to the development of characteristic meat flavour.
- The improvement in tenderness is on account of the subtle proteolysis that take place in the cytoskeletal proteins.
- Calpains are causally responsible for the proteolysis associated with ageing, which brings about the tenderness associated with ageing.
- Ageing period in different species of food animals:
  - Cattle: 14 days
  - Sheep and Goats: 7 days
  - Pigs: 5 days
  - Chicken: 2 days
- Techniques commonly adopted to decrease ageing periods include electrical stimulation of carcasses (should be within half an hour of slaughter, to be effective); Calcium chloride infusion into carcasses or injection into meat.

MODULE - 4: CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF SKELETAL MUSCLE

Learning objectives:
- At the end of this module the learner will become conversant with the chemical composition and nutritive value of meat.
- It will also enable the learner to understand significance of meat in the diet of human beings.

INTRODUCTION

- Since muscle is the principal component of meat, a brief discussion of its composition is necessary.
- Like the animal body, muscle contains water, protein, fat, carbohydrate and inorganic constituents.
- Muscle contains approximately 75% water (range: 65-80 %) by weight.
- Water is the principal constituent of the extracellular fluid and numerous chemical constituents are dissolved or suspended in it.
- Because of this it serves as the medium for the transport of substances between the vascular bed and muscle fibres.
- Proteins constitute 16-22 % of the muscle mass and are the principal component of the solid matter.
- Muscle proteins are generally categorized as sarcoplasmic, myofibrillar and stromal proteins based primarily upon their solubility.
- The sarcoplasmic proteins are readily extractable in water or low ionic strength buffers (0.15 or less).
- However, the more fibrous of the myofibrillar proteins require intermediate to high ionic strength buffers for their extraction.
- The stromal proteins are comparatively insoluble.
- The sarcoplasmic proteins include myoglobin, hemoglobin and the enzymes associated with glycolysis, the citric acid cycle and the electron transport chain.
- Although the enzymes of the TCA cycle and the electron transport chain are contained within the mitochondria, they are readily extractable, along with those found directly in sarcoplasm.
- The myofibrillar proteins constitute the proteins associated with the thick and thin filaments.
- They include actin, myosin, tropomyosin, troponin, alpha - and beta - actinin, C protein and M proteins.
- These salt solubl proteins are required for emulsion stabilization in the manufacture of emulsion type sausage products.
- In addition to proteins, other nitrogenous compounds are present in muscle.
- They are categorized as nonprotein nitrogen (NPN) and include a host of chemical compounds.
- Notable among these are amino acids, simple peptides, creatine, creatine phosphate, creatinine, some vitamins, nucleosides and nucleotides including adenosine triphosphate (ATP).
- The lipid content of muscle is extremely variable, ranging from approximately 1.5 to 13 %.
- It consists primarily of the neutral lipids (triglycerides) and phospholipids.
- While some lipid is found intracellularly in muscle fibres, the bulk of it is present in the adipose tissue depots associated with the loose connective tissue septa between the bundles, the latter type of fat deposit is called Marbling or intramuscular fat.
- The carbohydrate content of the muscle tissue is generally quite small.
- Glycogen, the most abundant carbohydrate in the muscle, has an abundance that varies from approximately 0.5-1.3 % of the muscle’s weight.
- The bulk of the remainder of the carbohydrate is comprised of the mucopolysaccharides associated with the connective tissues, glucose and other mono- or disaccharides and the intermediates of glycolytic metabolism.

By- Manuprabh, Naveen, Pradeep
Finally, muscle contains numerous inorganic constituents notable among which are cations and anions of physiological significance, calcium, magnesium, potassium, sodium, iron, phosphorous, sulphur and chlorine.

Many of other inorganic constituents found in the animal body are also present in muscle.

CARCASS COMPOSITION

Carcass composition is generally of greater concern for animal and meat scientist than is the animal’s total body composition.

Of the carcass compositional components, the proportions of muscle, fat and bone are of great interest with regard to the evaluation of livestock production practices.

When the percentage of fat increases, both the percentage of muscle and bone plus the tendon decrease.

These compositional characteristics affect carcass value and are influenced by genetic as well as environmental factors during the growth and development of the animal.

CHEMICAL COMPOSITION OF A TYPICAL ANIMAL MUSCLE

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>COMPONENT</th>
<th>PERCENT (WET BASIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Water (range 65 to 80)</td>
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<tr>
<td>2.</td>
<td>Protein (range 16 to 22)</td>
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<tr>
<td></td>
<td>Myofibrillar Proteins</td>
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<tr>
<td></td>
<td>Myosin</td>
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<td></td>
<td>Actin</td>
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</tr>
<tr>
<td></td>
<td>Elastin</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Other insoluble proteins</td>
<td>1.4</td>
</tr>
<tr>
<td>3.</td>
<td>Lipids (variable range 1.5 to 3.0)</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Neutral Lipids (range 0.5 to 1.5)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Phospholipids</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Cerebrosides</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Cholesterol</td>
<td>0.5</td>
</tr>
<tr>
<td>4.</td>
<td>Non-protein Nitrogenous Substances</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Creatine and Creatinine phosphate</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Nucleotides</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>(Adenosine triphosphate (ATP), Adenosine dephosphate (ADP), etc.)</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Free Amino acids</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Peptides (Anserine, carnosine, etc.)</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Other nonprotein substances [Creatinine, urea, inosine monophosphate (IMP), nicotinamide adenine dinucleotide (NAD), nicotinamide adenine dinucleotide phosphate (NADP)]</td>
<td>0.1</td>
</tr>
<tr>
<td>5.</td>
<td>Carbohydrates and Non Nitrogenous Substances (range 0.5 to 1.5)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Glycogen (variable range 0.5 to 1.3)</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Glucose</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Intermediates and products of cell metabolism (Hexose and triose phosphates, lactic acid, citric acid, fumaric acid, succinic acid, acetoacetic acid, etc)</td>
<td>0.1</td>
</tr>
</tbody>
</table>
6. **Inorganic constituents**

<table>
<thead>
<tr>
<th></th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.3</td>
</tr>
<tr>
<td>Total phosphorus (Phosphates &amp; inorganic phosphorus)</td>
<td>0.2</td>
</tr>
<tr>
<td>Sulphur (including sulphate)</td>
<td>0.2</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.1</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.1</td>
</tr>
<tr>
<td>Others (Including magnesium, calcium, iron, cobalt, copper, zinc, nickel, manganese, etc.)</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Nutritive Value of Meat**

**INTRODUCTION**

- Meat is very nutritious food.
- It is almost fully digestible.
- It is appealing to the eyes and pleasing to the sense of olfaction.
- The nutritive value of meat is attributed to its abundant high quality proteins, essential fatty acids, some important minerals and B-complex group of vitamins.

**MEAT PROTEINS**

- Meat is a concentrated source of proteins, which are far superior to the plant proteins due to very high biological value.
- Most lean meat cuts contain 16.5 to 20% proteins.
- These proteins are rich in essential amino acids since there is no provision in the body for the synthesis of these amino acids and a deficient diet will lead to protein malnutrition.
- In fact, among meat proteins, myofibrillar and sarcoplasmic proteins are of very high quality because they contain enough of essential amino acids.
- Connective tissue proteins have lower levels of tryptophan and sulphur containing amino acids.
- Collagen is essentially poor in lysine content.

**MEAT FATS**

- Meat fats contain ample amount of essential fatty acids (EFA) and the nutritional demand of EFA human beings is easily met by intramuscular fat itself.
- The calorific value of fat in meat is attributed to fatty acids in triglycerides.
- The number of calories from lean meat is frequently less than those derived from equal weights of many other foods.
- In fact, the calorific value of particular meat depends on the amount of fat in the meat cuts.
- The most important fatty acid in meat fat is oleic acid (mono unsaturated FA) followed by palmitic and stearic acids (saturated FA).
- The EFA in human diets are linoleic, linolenic, and arachidonic acids.
- Pork and organ meats are relatively good sources of linoleic and linolenic acids.
- It may be noted that excess dietary linoleic acid is converted to arachidonic acid in human body to meet its demand.
- The phospholipids are essential components of the cell wall as well as mitochondria and play a vital role in cellular metabolism.
- Meat fat always contains some quantity of cholesterol and blood cholesterol level increases after ingestion of cholesterol in food.
- However, dietary and serum cholesterol are not directly related.
- Organ meats have remarkable high cholesterol content as compared to skeletal meat.

**MINERALS**

- In general, meat is a good source of all minerals except calcium.
- The minerals are in close association with lean tissues in meat.
- Of these, quantitatively potassium is most abundant followed by phosphorus.
- Meat is a good source of iron, which is required for the synthesis of haemoglobin, myoglobin and certain enzymes and thus plays a vital role in maintaining good health.
- Since human body has a very limited capacity to store iron, mainly in liver, it has to be a part of regular dietary intake.
- Meat provides this important mineral in a form that is easily absorbed in the system.

**VITAMINS**

- Lean meat is an excellent source of B-complex group of vitamins.
- Fat-soluble vitamin found in meat is associated with body fat.
- Vitamin C is almost absent in lean meat, although certain organs contain it in minor quantities.
- Among the B-complex group of vitamins thiamine, riboflavin and niacin are present in high concentrations.
Meat Science (LPT-321)

- It may be noted that pork surpasses several meats with regard to B-complex vitamins are concerned.
- In fact, lean pork has 5-10 times more thiamine than other meats.
- It has been noted that in monogastric animals like pigs, intake of vitamins in feed is directly reflected in their tissues.
- Several organ meats have slightly less protein and fat than skeletal meats.
- However, these are quite often more economical sources of protein and vitamins than retail cuts of skeletal meats.
- Liver is a rich source of iron, riboflavin, niacin and vitamin.

**MODULE-5: FRAUDULENT SUBSTITUTION OF MEAT AND ITS RECOGNITION**

**Learning objectives**
- This module will enable the learner to understand anatomical, physical, chemical and biological methods (electrophoretic, immunological and DNA based methods) in vogue to detect adulteration of meat.

**FRAUDULENT SUBSTITUTION OF MEAT AND ITS RECOGNITION**
- In the handling of meats and preparation of meat food products attempts are sometimes made to substitute meat of lesser quality for that of higher quality with the object of deceiving public and gain more profit.
- The differentiation of the muscle and fat of animals is of importance in connection with the possible substitution of inferior and at times repugnant meat for that of good quality.
- The substitutions that may be practiced are, that of horseflesh for beef, chevon for mutton, mutton for venison, beef for mutton and occasionally the flesh of the cat for that of hare or rabbit.
- It is not difficult to differentiate the flesh and fat of these animals in the carcass form or in joints by means of anatomical confirmation.
- But, the recognition of horseflesh or other meats in minced or in sausage form depends on tests of chemical or biological nature.
- Horseflesh possesses high contents of glycogen than that of other food animals.
- Glycogen usually begins to disappear from the meat after slaughter.
- Hence, the interpretation of the result should be made with extreme caution.
- The level of the mixing may very from 1 to 99% - adulteration.
- However, the interpretation of the result should be made with extreme caution.
- We can differentiate or recognize the various types of meat being substituted as mentioned above, by three methods. They are
  - Physical or physiological methods.
  - Chemical tests and
  - Biological tests
- These methods are further classified as follows:
  - Physical methods
    - This is based on general appearance, colour, texture, odour and tenderness of different species of meat.
    - Besides the general characteristics of body fat, its colour, marbling, firmness of fat can be identified.
    - Dentition formula, vertebral formula and articulation pattern, rib number and degree of curvature, characteristics of long bones will also help to identify the species if the carcass is intact.
  - Chemical Methods
    - Linoleic acid content
    - Iodine value
    - Refractive index of fat
    - Melting point of fat
    - Myoglobin content
  - Biological Methods
    - Electrophoretic method
    - Immunological method
    - Latest techniques

**PHYSICAL METHODS**
- Physical methods like anatomical differences of each species of the carcass and appearance of muscle and fat colour, odour, texture and taste have provided a general difference between species in earlier days for food analysis.
- So, this can be attempted, provided the meats are in the form of joints and in carcass form.

**Carcasses of different species of food animals**
• **Horse**
  - Neck and the bones of limbs are longer than the ox.
  - Sternum of horse is canoe shaped.
  - No diarthrodial joint between the first and second sternal ribs.
  - There are 18 pairs of ribs and are narrower than those of ox.

• **Bull**
  - The outstanding characteristic in the bull carcass is the massive development of the muscles of the neck and shoulder and also in the hindquarters of the well-bred animals.
  - Neck is much thicker than that of the ox.
  - *Ligamentum nuchae* is thicker and stronger than in ox.
  - Anterior part of the ischio pubic symphysis is well developed and forms a distinct tubercle.
  - Inguinal canals are patent.

• **Ox**
  - Shows lesser muscular development than that of bull especially in the neck and shoulder region.
  - There is even covering of fat on the exterior.
  - The scrotal fat is prominent, nodular and more or less pointed. Pelvis is narrow and usually contains a relatively large quantity of fat.

• **Cow**
  - Thigh is less rounded than that of ox.
  - This is very noticeable in the hind quarters (sunken round).
  - The pelvis is broader. Anterior tubercular pelvis is broader.
  - Udder is present, if removed triangular area of attachment is noticeable on each side of midline of the abdominal wall.

• **Sheep**
  - The carcass of sheep (whether or ewe) is characterised by an abundant and even distribution of subcutaneous fat.
  - The carcass of ram is distinguished by great muscular development in the region of neck and shoulders; the *ligamentum nuchae* is large and strong.
  - The neck is thick and the inguinal canals are patent.

• **Goat**
  - Goats are long and lean.
  - There is very little subcutaneous fat, kidney fat abundant even in poor carcasses.
  - Subcutaneous connective tissue is sticky in nature and during skinning loose hairs from the skin become adherent to the subcutaneous tissue and cannot be removed completely.
  - Pelvis of goat is long and narrow.

• **Hog**
  - Carcass of pig cannot easily be mistaken for that of any other animal.
  - In most countries the skin is left on the carcass.
  - But even when the skin is removed there should be no difficulty in identification.

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**DIFFERENTIATION OF CARCASSES OF ANIMALS**

**Differentiation of carcasses of horse and ox**

- Carcass of the horse and ox may be differentiated by the following details
  - In the horse the unusual length of the sides is noticeable, together with the great muscular development of the hindquarters.
  - The thoracic cavity is longer in the horse; this animal possesses 18 pairs of ribs, whereas the ox has 13 pairs.
  - The ribs in the horse are narrower but more markedly curved.
  - The superior spinous processes of the first six dorsal vertebrae are more markedly developed in the horse and are less inclined posterior.
  - In the forequarter, the ulna of horse extends only half the length of the radius; in the ox it is extended and articulates with the carpus.
  - In the hindquarter, the femur of the ox possesses no third trochanter; the fibula is only a small pointed projection, but in the horse it extends two–third the length of the tibia.
  - In the horse the last three lumbar transverse processes articulate with each other, the sixth articulating in a similar manner with the sacrum.
  - They do not articulate in the ox.
  - The horse carcass shows considerable development of soft yellow fat beneath the peritoneum, especially in the gelding and mare, but in the stallion the fat is generally of a lighter colour and almost white. In the ox the kidney fat is always firmer, whiter and more abundant than in the horse.

By- Manuprabh, Naveen, Pradeep
Meat Science (LPT-321)

- Horseflesh is a dark red, initially brown or reddish brown on exposure to atmosphere the colour turns bluish.
- Marbling is absent in horsemeat; it is firm but sticky in nature due to high glycogen content.
- Horsemeat has a pronounced sweet taste, repulsive odour and well defined muscle fibre.
- Beef lack the bluish tinge.

**Differentiation of carcasses of sheep and goat**

<table>
<thead>
<tr>
<th>Features</th>
<th>Sheep</th>
<th>Goat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back and withers</td>
<td>Round and well fleshed</td>
<td>Sharp, little fleshed</td>
</tr>
<tr>
<td>Thorax</td>
<td>Barrel shaped</td>
<td>Flattened laterally</td>
</tr>
<tr>
<td>Tail</td>
<td>Fairly broad</td>
<td>Thin</td>
</tr>
<tr>
<td>Radius</td>
<td>1.25 times length of metacarpus</td>
<td>Twice as long as metacarpus</td>
</tr>
<tr>
<td>Scapula</td>
<td>Short and broad, superior spine, bent back and thickened</td>
<td>Possess distinct neck. Spine straight and narrow, lateral border thin and sharp</td>
</tr>
<tr>
<td>Sacrum</td>
<td>Lateral borders thickened in the form of rolls</td>
<td>Sharp</td>
</tr>
<tr>
<td>Flesh</td>
<td>Pale red and fine in texture</td>
<td>Dark red and coarse with goaty odour. Sticky subcutaneous tissue, which may have adherent goat hairs.</td>
</tr>
</tbody>
</table>

**Sheep, Goat and Deer**
- Among these carcasses, in deer, the scapula’s acromion is elongated into a sharp point, which is directed ventrally.
- The acromion is absent in the sheep and goat or is considerably smaller.
- The radio-ulna arch, which forms an oval opening in the sheep and goat, is very long in deer.
- In deer, the subcutaneous layer of fat is not as well developed as in sheep.
- The meat is poor in fat and possesses the odour of venison, which is easily distinguishable from the odour of sheep.

**Hog and Dog**
- The colour of dog meat is very darker than pork and is easily made out in cooked meat.
- The muscles of the dog are scarier and the fat is oilier than hog fat.
- The odour of the dog meat is repulsive.

**Cat and Rabbit**
- The meat of the cat is paler than rabbit meat.
- The fat of the cat appears whitish in contrast to rabbit fat, which is honey yellow.

**Meat and Fat of Sheep and Dog**
- The meat and fat of sheep and dog are indistinguishable by the naked eye and the carcasses of large dogs are sometimes substituted for mutton.
- The ribs and sternum of the sheep are broad and flat, while those of the dogs are round in section.
- In the hind leg, the sheep has only one bone, the tibia articulating with the tarsal joint, while the dog has both tibia and fibula.
- The sheep has triangular scapula with a broad, prolonging cartilage and the radius and ulna lies close together for their whole length, while the scapula of the dog has a semi-circular posterior upper edge with practically no prolonging cartilage and the radius and ulna are widely separated along the greater part of their shafts.
- The xiphoid cartilage in sheep is firm and grisly, while in the dog, it is softer and florous and shaped like a dagger.

**Cattle and Buffalo**
- Generally fresh buffalo meat is darker (more reddish brown) and the fibres are coarser and looser in structure than beef.
- The odour of the buffalo meat and fat are always strikingly musky and if boiled in strong acidified (H₂SO₄) water, it develops a disagreeable odour similar to that of cattle manure.
- The cutaneous shoulder muscle of buffalo is only 3 to 4 finger broad, while that of cattle it is considerably broader.
- The fat of buffalo is strikingly white and drier and less sticky than in cattle.
- The confirmation of the bones of the buffalo is generally thinner and the bones are very brittle.

By- Manuprabh, Naveen, Pradeep
The ischio pubic symphysis of the buffalo is strikingly plane.

**CHARACTERISTICS OF MEAT**

**Horse meat**
- The meat of horse is dark red in colour, on exposure to air acquires a bluish tinge or shield on the surface and later become very dark.
- Odour is peculiar – sweet and to most people more or less repulsive. Horseflesh contains large quantities of glycogen (2%).
- Fat is yellow or brownish yellow in colour and owing to its high olein content it is soft and greasy.

**Beef**
- The colour of beef varies from light red to dark red according to the age and the part of the carcass from which it was collected.
- The meat is moist, silky to the touch and is marbled with fat.
- Fat is fine usually creamy white or yellowish white in colour.
- In old cattle the fat tends to be more yellow and somewhat loosen in consistency.
- In Jersey and Guernsey fat is pronounced yellow colour.
- Meat of heifer closely resembles that of young ox.
- The meat of old cow is not marbled and tends to be lean, dry and somewhat coarse.
- However, the meat and fat of old dairy cows are often relatively moist.
- The veal is pale or grayish red in colour.
- Not very firm under pressure of fingers. Fibres are tough.

**Mutton**
- The meat of wether or ewe varies in colour from light red through brownish red to dark red.
- According to the age of the animal and to the part of the carcass – the fibres are fine, dense and firm. Marbling with fat is practically absent.
- The fat is white, very firm and odourless.

**Goat meat/Chevon**
- Chevon is not marbled and bears a fairly close resemblance to that of sheep.
- The meat of uncastrated adult goat has a goaty odour.

**Pig**
- The meat of pig varies in colour according to the age and nutritive condition of the animal and also according to the body region from which it is derived.
- It may be pale red, reddish gray; rose red, dark red or in certain parts may be almost colourless.
- It is less firm to the touch than other food animals.
- The fibres are fine, fat is white, soft and greasy.

**CHARACTERISTICS OF FAT**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Species</th>
<th>Colour</th>
<th>Consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cow</td>
<td>Yellow</td>
<td>Fairly firm</td>
</tr>
<tr>
<td>2.</td>
<td>Bull; heifer</td>
<td>Yellowish white</td>
<td>Firm</td>
</tr>
<tr>
<td>3.</td>
<td>Calf</td>
<td>White or grayish white</td>
<td>Soft and gelatinous</td>
</tr>
<tr>
<td>4.</td>
<td>Buffalo</td>
<td>Strikingly white</td>
<td>Fairly firm</td>
</tr>
<tr>
<td>5.</td>
<td>Sheep; Goat</td>
<td>Very white</td>
<td>Typically crispy in sheep. Very firm.</td>
</tr>
<tr>
<td>6.</td>
<td>Pig</td>
<td>Generously white</td>
<td>Fairly firm, greasy and not crispy</td>
</tr>
<tr>
<td>7.</td>
<td>Horse</td>
<td>Yellowish white</td>
<td>Soft and greasy</td>
</tr>
</tbody>
</table>

**CHEMICAL METHODS**

- The chemical tests consist of the determination of
  - the content of glycogen in flesh
  - the percentage of linoleic acid in fat
  - the melting point of fat
  - the amount of iodine absorbed by unsaturated fatty acids in fat and
  - the refractive index of fat.

**Test for Glycogen Content of Meat**

By- Manuprabh, Naveen, Pradeep
The horseflesh is richer than the flesh of other food animals in glycogen in horsemeat as compared with other kinds of meat, glycogen is found in large quantities irrespective of age.
- Horse – 0.5 to 1.0 %
- Beef - 0.0 to 0.5%
- Pork and mutton - nil

Disadvantages
- The flesh should be tested for the content of glycogen soon after the slaughter as it disappears from the flesh quickly.
- Liver of all food animals especially pig liver contains more glycogen when they are used in sausage making it gives a high percentage. So care must be taken in interpretation of results.

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
- Estimation of iodine value is a valuable test for the detection of horse fat.
- Iodine value is the amount of iodine absorbed by the unsaturated fatty acid present in the fat.
- Good lard has an iodine value of 66.
- The iodine value of the fat from various food animals is:
  - Horse - 71-86
  - Ox (cattle) - 38-46
  - Sheep - 35-46
  - Pig - 50-70

Refractive index
- Refractive index is another valuable test for the detection of fat of different animal species.
- Fat is liquefied by heat and converted into oil for estimation of refractive index.
- All liquids including oils possess a specific refractive index.
  - Horse - 53.5
  - Ox - less than 40
  - Pig - not above 51.9

Melting Point
- The melting point of fat varies with the species of food animals and the kind of feed fed to the animal.
- The range of melting points of fat is

Myoglobin content
- The myoglobin content of different species is:
  - Beef - 0.30 to 1%
  - Pork - 0.06 to 0.40%
  - Poultry - 0.02 to 0.18%

Other chemical tests for differentiation of different meat species are:
- Estimation of muscle nitrogen fraction
- Myoglobin content
- Muscle enzymes
- Composition of fat
- Carotene content
- Fatty acid composition

ELECTROPHORETIC METHODS
- The various electrophoretic methods include
  - Agar gel electrophoresis
  - Starch gel electrophoresis
  - Polyacrylamide gel electrophoresis
  - Sodium dodecyl sulfate polyacrylamide gel electrophoresis
  - Iso-electric focussing
- Agar gel electrophoresis
  - Electrophoretic separation of proteins on the basis of mobility of proteins in a supporting gel of agarose at a constant pH and electrical field is termed as Agar gel electrophoresis.
- Counter Immuno Electrophoresis (CIE)
  - The principle of this technique is very similar to agar gel immunodiffusion.
The diffusion of antigen and antibody is facilitated by the application of a low voltage current. Further, the endosmosis created by the agar gel changes the charge of g-globulins and moves them towards cathode.

- The meat proteins moving towards anode provide immunoprecipitate with homologous g-globulin at the point of equivalence.

- Polyacrylamide gel electrophoresis (PAGE)
  - Polyacrylamide gels are prepared using acrylamide and bis which provides cross linking between the polymerized long chains of acrylamide.
  - The separation of proteins on the basis of their mobility in a polyacrylamide gel is comparatively better since the resolution of different proteins are optimum. Polyacrylamide gel electrophoresis also requires a constant pH and electrical field to provide high resolution of protein.

- Iso-electric focussing (IEF)
  - It is an electrophoretic technique which utilizes the charge at the surface of the protein to drive it through a gradient gel.
  - The pH gradient is setup by polyacrylamide compounds, the ampholytes.
  - The proteins applied on to the gel reach a point where the surface charges becomes neutral at their iso electric point.

IMMUNOLOGICAL METHODS

- Immunological methods include
  - Tube precipitin test
  - Haemagglutination test (HAT)
  - Complement fixation test (CFT)
  - Agar gel immuno diffusion test (AGID)
  - Dry disc immuno diffusion test
  - Enzyme linked immuno sorbent assay (ELISA)

Agar Gel Immuno Diffusion Test (AGID)
- Based on a simple double diffusion method (Ouchterlony, 1948). Species specific antiserum (antibody) and unidentified meat extract (antigen) are allowed to diffuse towards one another in an agar gel slab. If the antigen and antibody are homologous a precipitin band is formed along the line where the two meet.

Enzyme Linked Immuno Sorbent Assay (ELISA)
- The technique involves the application of species specific antibodies to the proteins (antigen) coated on the plastic surface of micro-titre plate.
- The recognition of antigen results in the formation of antigen-antibody complex, which are detected by either enzyme linked immunoglobulin or protein A (antibody detector) producing visible colour reaction with added substrate.
- The colour intensity is measured objectively at a specific wave length in a micro ELISA reader as absorbance value.

Recent techniques in meat species identification include
- Production of monoclonal antibodies and application of ELISA.
- Use of DNA probes and application of DNA hybridization technique.
- Use of Polymerase Chain Reaction (PCR) in species identification.
MODULE-6: PRESERVATION OF MEAT

Learning objectives
- This module will enable the learner to understand the necessity of meat preservation, the principles of food and meat preservation, the various methods and techniques adopted in meat preservation, their advantages and limitations as well as adverse changes in meat due to improper preservation.

HISTORY OF PRESERVATION OF FOOD

Some of the important events in the history of food preservation are listed below chronologically:
- 1782 - A Swedish Chemist introduced canning of vinegar.
- 1810 - Preservation of food by canning was patented by Appert.
- 1813 - The use of Sulphur-di-oxide as a meat preservative is believed to have originated around the time.
- 1820 - W. Underwood and T. Kensett began the commercial production of canned foods in the United States.
- 1835 - A patent was granted to Newton in England for manufacturing condensed milk.
- 1837 - Winslow was the first to can corn on the cob.
- 1840 - Fish and fruits were canned.
- 1842 - A patent was issued to H. Benjamin in England for freezing foods by immersion in salt and ice.
- 1843 - I. Winslow was the first to attempt sterilisation by steam.
- 1854 - Pasteur began wide investigations.
- 1855 - Grimwade of England was the first to produce powdered milk.
- 1856 - A patent for the manufacture of unsweetened condensed milk was granted to Gail Borden in the U.S.
- 1865 - The artificial freezing of fish on a commercial scale began in the United States.
- 1874 - The first successful cargo of frozen meat went from Australia to England. The first from New Zealand to England was sent in 1882. The first extensive use of ice in transporting meat at sea began.
- 1882 - Krukowitsch was the first to note the destructive effects of ozone on spoilage bacteria.
- 1886 - American scientist A. P. Spawn carried out a mechanical process of drying fruit and vegetables.
- 1887 - Malted milk appeared first.
- 1888 - The pasteurisation of milk began in Germany.
- 1889 - The artificial freezing of eggs began in the U.S.
- 1890 - Commercial pasteurisation began around this time in the United States. Mechanical refrigeration for fruit storage began around this time in Chicago.
- 1893 - H. I. Court began a certified milk movement in New Jersey.
- 1895 - Russell carried out the first bacteriological study in canning of foods.
- 1908 - Sodium benzoate was given official sanction as preservative in certain U.S. foods.
- 1916 - R. Plank, P. Ehrnbaum and K. Reuter achieved the quick freezing of foods in Germany.
- 1917 - Charance Birdseye of The U. S began work on the freezing of foods for the retail trade.
- 1923 - Heat process calculations were introduced in the canning industry.
- 1928 - In France a patent was issued to the use of high-energy radiation for processing of foods.
- 1929 - Birdseye placed frozen foods in the retail markets.
- 1943 - B. E. Proctor of the U.S was the first to employ the use of ionizing radiation to preserve hamburger meat.
- 1954 - Nissin a bacteriocin was permitted in England for use in certain processed foods to control clostridium defects.
- 1955 - Sorbic acid was approved for use as a food preservative.
- Chlorotetracycline an antibiotic was approved for the use in fresh poultry – followed the next year – 1956.
- 1956 - Oxytetracycline another antibiotic was approved for the use in fresh poultry.
- 1967 - The first commercial facility designed to irradiate foods was planned and designed in the United States.

FACTORS INFLUENCING GROWTH OF MICRO ORGANISM
The growth of microorganisms in food is affected by a few inherent characteristics of the food, referred to as intrinsic parameters, and also by the conditions of environment in which the food is stored or held referred to as extrinsic parameters.

**Intrinsic parameters that affect microbial growth**

- **pH of the food** - Most microorganisms grow well at a pH of around 7 (6.6 – 7.5), while only few of them grow at pH below 4. Bacteria are more sensitive to pH requirements in comparison to yeast and moulds, which manage to grow across a pH range of 0 – 11.
- **Moisture content** - It is common knowledge that drying of food enhances its shelf life. The water requirement of microorganisms is generally described the water activity (aw) of the food. Water activity is the ratio of the vapour pressure of the food substance to the vapour pressure of pure water. Most spoilage and pathogenic bacteria in meat require a water activity in equal to more than 0.9, and the most tolerant bacteria is Staphylococcus aureus which continues to grow at a aw of 0.86. Most spoilage yeasts require a aw of 0.88, while spoilage moulds manage to grow at a aw of 0.80. If foods are dried to a final aw of 0.60 or lesser, the product becomes shelf stable.
- **Oxidation reduction potential (Eh)**, which is the ease at which a substrate gains or loses electrons, where gaining an electron is referred to as reduction, and losing an electron is known as oxidation. Aerobes require oxidized conditions for growth (a positive Eh value), while anaerobes require reduced condition for growth (a negative Eh value). Microaerophiles, require slightly reduced conditions whereas facultative anaerobes grow in both reduced and oxidized conditions.
- **Nutrient content** - Microbes require the following in adequate amounts for their normal growth:
  - A source of energy
  - A source of nitrogen
  - Vitamins and related growth factors and
  - Minerals.
- **Antimicrobial constituents** in foods are efficient protection against microbial growth. Examples of such substances include eugenol in cloves, allicin in garlic, allyl isothiocyanate in mustard, cinnamic aldehyde and eugenol in cinnamon and lactoferrin, conglutinin and Lactoperoxidase system in milk.
- **Biological structures** - Certain biological structures such as rind of fruits, shell of nuts and fascia in carcasses accords protection against microbial invasion to a certain degree.

**Extrinsic parameters that affect microbial growth**

- **Temperature of storage** - Most microorganisms in food are mesophiles, which grow well at temperatures between 30 - 40°C, while some of them optimally need a temperature range of 20 -30°C, but grow well at 7°C or below and are known as psychrotrophs. Some microorganisms optimally need a temperature range of 55 - 65°C, but grow well at 45°C or above and are referred to as thermophiles.
- **Gases in the environment** - It is common knowledge that oxygen is required for aerobes and anaerobes do well in the absence of oxygen.
- **Relative humidity** - Relative humidity has a role to play in both surface spoilage as well as deep seated spoilage.

**PRINCIPLES OF FOOD PRESERVATION**

- **Food may be preserved by adopting any of the following measures:**
- **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 food**
  - 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.
- **Prevention of damage because of insects, animals, mechanical causes, etc.**
  - The methods used to control the activities of the microorganisms usually are effective against enzymatic activity in the food or chemical reactions.
  - Methods like drying or use of low temperature, however, permit auto decomposition to continue unless special precautions are taken.
  - For example, most vegetables are blanched (heated) to inactivate their enzymes before being frozen.

**Delay of microbial decomposition**

- Most of the commonly employed methods of food preservation depend not on the destruction or removal of microorganisms, but rather on delay in the initiation of growth and hindrance to growth, once it has begun.
- The main factors of importance for bacterial growth in or on meat are the temperature, relative humidity, water activity, oxygen availability and the pH of the microbial environment.

By- Manuprabh, Naveen, Pradeep
Growth curve of microorganisms

- It is the time that elapses between the formation of a daughter cell and its division into two new cells.
- The generation time shorten as conditions become more favorable and lengthen, as they become less favorable.

**PRINCIPLES OF PRESERVATION OF MEAT**

- Preservation of food has been practised since time immemorial and was originally adopted by mankind to maintain a continuous supply of food throughout a year.
- Mankind began to preserve food in times of plenty, to tide over scarcity of food.
- The primary purpose of food preservation is to prevent food spoilage. The primary cause of spoilage is the action of micro-organisms such as bacteria, moulds or yeasts, aided by enzymes.
- Micro-organisms can survive and develop only under particular micro-environments; they die or fail to multiply under unfavourable conditions.
- The preservation of red meat, poultry and their products is accomplished by ensuring that their immediate micro-environment is unfavourable for the growth of spoilage organisms (bacteria, yeasts, moulds and parasites), and also by controlling the action of autolytic enzymes and preventing the chemical oxidation of lipids, which leads to rancidity.
- Preservation of meat was initiated by drying meat either in the sun or by fire.
- Most of the processed meats available today originated from techniques that were developed to extend the length of time between the slaughter of the animal and the consumption of the meat derived from the animals.

**CLASSIFICATION**

The methods of preservation of meat can also be classified as follows

- **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
  - Retort Processing

- **Preservation by Direct Microbial Inhibition**
  - Irradiation
  - Antibiotics
  - Chemicals

**POINTS FOR CONSIDERATION TO CHOOSE A METHOD OF PRESERVATION OF FOOD**

- Preservation of food most often involves application of measures to delay or prevent certain changes which make meat unusable as a food or which down grade some quality aspect of it.
- There are several processes by which such deterioration can occur and they include microbial, chemical and physical processes.
Most of the edible tissues of the healthy animal at the time of slaughter are either sterile or contain few microorganisms, owing to the several level of defence in place against microbial invasion.

Unfortunately, these efficient defence mechanisms are nullified at the time of animal’s death.

The momentary state of shock concomitant with exsanguination probably facilitates bacterial invasion from the intestinal tract.

The slaughtering operation contaminates the vascular system with numerous micro-organisms that may disseminate through the body before bleeding has been completed.

Bleeding largely depletes the body of the circulating antibodies and leucocytes. Therefore, a sudden cessation of the body’s defence against microbial invasion and as a consequence growth of foreign micro-organisms accompany the death of the meat animal.

There appear to be no residual bacteriostatic or bactericidal properties in the tissues of the freshly slaughtered animal.

Fresh meat is highly perishable because of almost neutral pH (low acid food), high moisture content and being rich in all the nutrients required for microbial growth.

Cured and processed meats are generally more stable than fresh meats with respect to microbial deterioration because of additives such as salt or moisture reduction (as in the case with dry sausages) or a combination of these agents.

The widespread availability of refrigeration has decreased the need to rely on curing and processing, for example, salt levels have been reduced to meet palatability and consumer health considerations.

Due to the greater microbial stability of such products, the other deteriorative processes can be of greater significance in them.

For example, the colour deterioration through chemical changes under some conditions might pose a serious problem.

Important advances in preservation have resulted through application of appropriate packaging materials and methods.

It is essential that in evaluating a method of preservation criteria other than that of merely preventing spoilage of meat must be considered.

Attention must be given to

- The effect of the method on product quality
- Any health hazards involved for either the food handler or the consumer
- Possible misuse of the method
- Distribution and marketing problems
- Engineering and evaluation of economics of the method’s commercial application.

The recognized methods by which meat foods may be preserved are

- Drying,
- Salting – curing,
- Application of low temperature – Chilling/cold and Freezing
- Application of high temperature - Thermal Processing
- By the usage of Chemicals, Antibiotics, etc.
- Radiation - Ionizing radiations.

Preservation by control of moisture

DRYING

At present drying plays only a minor role in preservation of meat on a commercial scale.

However, a few traditional dried meat products still enjoy a niche market in which they are considered delicacies, and the following products are still being produced commercially.

Jerked beef

In South America the dried meat is known as Jerked beef, which is prepared by cutting beef into strips and dried rapidly in the air.

Pemmican

In North America the dried product is known as Pemmican, which is made from venison, fish or beef.

In this method the meat is smoked before drying and then pulverized and equal amount of fat is added.

Biltong

In South Africa the common dried meat is popularly known as Biltong, which is prepared mainly from beef and also from flesh of game animals (antelope) and sometimes from Zebra and Ostrich.

Biltong is not heated during processing or before consumption. It is eaten raw and considered a delicacy.

The finest biltong with the best flavour is made from the sirloin strip and the most tender is derived from the fillet.

Charque

By- Manuprabh, Naveen, Pradeep
A number of Frigorificos in Uruguay and Brazil the dried meat product is called as Charque, which is prepared by salting and sun drying of the rib less forequarters of beef. Charque keeps well for months under ambient room conditions and is resistant to infestation by insects and growth of moulds.

**Uppukandam**
- In India especially in Tamil Nadu the dried meat is popularly known as Uppukandam, which is prepared form salted and sun dried mutton and/or goat meat (chevon).

**Odka**
- In Somalia and other East African countries a sun-dried meat product known as Odka is made of lean beef. Big meat strips are cut and dry salting is usually applied.
- Odka is stored by covering with oil and kept in an airtight container, which has a shelf life of more than 12 months.

**Qwanta**
- In Ethiopia and other East African countries dried meat manufactured from lean beef is known as Qwanta.

**Kilishi**
- In Nigeria and some of the West African countries the dried meat obtained from sliced lean beef, goat meat or lamb is called as Kilishi.

**Pastirma**
- In Turkey, Egypt and Armenia salted and dried beef from not too young animals is known as Pastirma.
- This has a better microbiological stability than biltong.

**FREEZE DRYING OR LYOPHILIZATION**
- This is the process of removing water from frozen foods.
- The removal of water is accomplished by sublimation, i.e the water in the frozen meat evaporates without melting of ice.
- Frozen meat is subjected to controlled vacuum and temperature conditions to accomplish the removal of water, by sublimation.
- The food product must be in comminuted form (sliced or diced) and packaging must be completely moisture proof since, the dried products are hygroscopic.
- This process can preserve beef, pork, chicken and shellfish.
- Whole steaks and chops can be freeze dried.
- Since, meat has high moisture content, it is expensive to preserve meat by lyophilization.
- The advantages of lyophilization are shrinkage and distortion of shape are very minimal, and retention of flavour and nutrition is excellent.

**INTERMEDIATE MOISTURE MEAT PRODUCTS**
- Sundrying of meat was one of the earliest preservative techniques used by man.
- Such meat had meager dehydration capacity resulting in poor juiciness and texture.
- Later studies revealed that meat products with 20-50% moisture had moderate juiciness and texture on rehydration.
- Such products were resistant to bacteriological spoilage and could be held without refrigeration.
- These products were referred as Intermediate Moisture Meats (IMM).
- The basic reason for the stability of these products lay in the reduced availability of water to the microorganisms.
- Since water activity generally remains in the range of 0.6 to 0.85.
- These semi-moist meats are of special significance to the developing countries where refrigeration facilities are not always available.
- Such products can be easily carried in defense expeditions and stress situations like floods, famines, for airdrop, etc.

**Humectants**
- Various additives employed for lowering the water activity of foods are known as humectants.
- Some of the most commonly used humectants are:
  - Glycerol
  - Propylene glycol
  - Sodium chloride
  - Polyhydric alcohols (e.g. sorbitol)
  - Sugars (e.g. sucrose, dextrose, corn syrup etc)
- The humectants are generally low molecular weight compounds, which are easily soluble in water.
- These are chemically inert and do not modify the normal sensory qualities of the product.
- Besides, these compounds are edible in large quantities without any adverse effect.
In addition to humectants, 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.

**Basic processing techniques**

Moist infusion or desorption
- Involves soaking and / or cooking of meat chunks or cubes to yield a final product having desired water activity level,
- E.g. sweet and sour pork, Hungarian goulash etc.

Dry infusion or adsorption
- Involves initial dehydration of meat chunks or cubes followed by soaking in an infusion solution containing desired osmotic agents.
- E.g. ready-to-eat cubes of roast pork, chicken a la king, etc.

Component blending
- In this process dry and wet ingredients or components are blended, cooked and extruded or otherwise mixed to give a final product of desired water activity.

Whatever process is adopted, the thumb rules for the preparation of IMM are:
- Reduction of water activity by addition of humectants,
- Retardation of microbial growth by addition of antimicrobial especially antimycotic agents and
- Improvement of sensory properties such as flavour and texture through physical and chemical treatments.

Composition of infusion solution developed by Brockmann (1970) for the preparation of sweet and sour pork ($a_w=0.85$) is given below to give an idea about the balancing of various additives:

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycerol</td>
<td>25.0</td>
</tr>
<tr>
<td>Catsup</td>
<td>23.55</td>
</tr>
<tr>
<td>Water</td>
<td>15.00</td>
</tr>
<tr>
<td>Vinegar</td>
<td>13.50</td>
</tr>
<tr>
<td>Sucrose</td>
<td>11.84</td>
</tr>
<tr>
<td>Starch hydrolysate</td>
<td>14.50</td>
</tr>
<tr>
<td>Salt</td>
<td>2.59</td>
</tr>
<tr>
<td>Corn starch</td>
<td>2.30</td>
</tr>
<tr>
<td>Monosodium glutamate</td>
<td>1.15</td>
</tr>
<tr>
<td>Potassium sorbate</td>
<td>0.30</td>
</tr>
<tr>
<td>Mustard powder</td>
<td>0.24</td>
</tr>
<tr>
<td>Onion powder</td>
<td>0.02</td>
</tr>
<tr>
<td>Garlic powder</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Stability of intermediate moisture meats
- IMF products are fairly stable at ambient temperature for several weeks or even months.
- However, prolonged storage may result in some quality deterioration due to the following reasons:
  - Limited breakdown of both myofibrillar and sarcoplasmic proteins.
  - Collagen being more susceptible to degeneration results in more hydroxyproline formation.
  - Degradation of haemoprotein (myoglobin and haemoglobin) causing loss of colour
  - Development of rancidity
  - Non-enzymatic browning resulting in loss of colour, consumer appeal, nutritive value and possibly off-flavour
  - Formation of lipid protein crosslinks causing decreased water binding capacity and net protein utilisation of meat products.

By- Manuprabh, Naveen, Pradeep
**SALTING**

- Salting, a very ancient method of preservation is the process of applying dry salt on the surface of meat and rubbing it to extend the shelf life of meat.
- In salted meat, dry salt is applied to the meat which dissolves in the meat fluid near the surface and further withdraws fluid from the meat forming a hypertonic solution.
- It then passes slowly inward, dissolves throughout the meat substance, until the concentration of salt is approximately the same throughout the meat substance.
- Thus salt has no harmful effects on the bacteria but act by extraction of water from the meat, by exerting a strong osmotic pressure, causing a drying effect and rendering water non-available to bacteria.
- Higher concentration of salt gives greater preservative action. The principle involved in applying salt is dehydration and germicidal.
- Most of non-marine bacteria can be inhibited by 20% or less sodium chloride, while some moulds generally tolerate higher levels.
- Organisms that can grow in the presence of and require high concentrations of salt be termed as halophiles, while, those that can withstand but not grow in higher concentration are termed as halodurics.
- In curing halophiles are allowed to grow and halodurics are kept at low levels.
- The difference in the growth rate of these two kinds of bacteria is taken advantage of in the curing of meats.
- Salted meat is different from cured meat (Example - Ham, Bacon, Corned beef, etc.). In curing, sugar and other salts such as sodium nitrate/nitrite are added either as a dry cure or as brine solution.
- Parasitic cysts, cysticerci, in meat are fairly rapidly destroyed, when the ratio of the salt to moisture in the meat is not more than 1:4. At that concentration the cysticerci are viable after 16 hours but 50% are destroyed after 90 hours and all are rendered non-viable after 136 hours.
- The destruction of parasitic cysts in biltong may therefore be ensured by submitting the biltong to an adequate salt concentration followed by a holding period of not less than 6 days.

**CURING**

- Curing may be defined as the addition of salt (Sodium chloride), sugar and nitrate or nitrite to the meat, which results in conversion of the meat pigments into the characteristic cured meat pigments imparting the characteristic cured meat colour and production of characteristic meat flavour.
- The process of meat curing is currently valued as a means of imparting organoleptic qualities to the cured products, though it originally was introduced as a means of preserving meat.
- Due to the advent of efficient and widespread refrigeration the need for preserving meat by curing alone has reduced.
- Apart from characteristic colour and flavour, the meat packing industry is concerned with the following attributes also:
  - Preservation,
  - Tenderness and
  - Yield.

**Curing Ingredients**

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

**Action of Curing Ingredients**

- **Salt**
  - Salt acts by dehydration and alteration of osmotic pressure so that it inhibits bacterial growth and subsequent spoilage.
  - It ionizes to yield the chlorine, which is harmful to the organisms.
  - It sensitizes the cells against CO₂.
  - It interferes with the proteolytic enzyme action.
  - The effectiveness of sodium chloride varies directly with its concentration and storage temperature.
  - An acceptable level of salts in hams has been reported to be about 3% and about 2% for bacon.

- **Sugar**
  - Sugar softens the products by counteracting the harsh and hardening effects of salt.
  - It interacts with amino groups of the proteins and upon cooking, forms browning of the products, which enhances the flavour of the cured meats.
  - Sugar substitutes have been used in bacon cures to prevent excessive browning during cooking.
  - It acts as a preservative by dehydration.
• **Nitrates and Nitrites**
  - Nitrates and nitrites bring about the desired pink color development—nitrosyl hemochromes.
  - Both nitrates and nitrites are used where nitrates act as a reservoir for nitrites.
  - Nitrate raises the oxidation-reduction potential and therefore are more favorable to aerobic than anaerobic organisms.
  - They inhibit the growth of food poisoning and spoilage organisms. It has been clearly demonstrated that nitrite is effective in preventing the growth of the *Clostridium botulinum* organism.
  - They retard the development of rancidity.
  - Nitrate or nitrite alone or in combination of both shall not be more than 200 ppm in finished products as it is toxic.
  - The European Directive 95/2/CE (1995) allows 150 ppm of nitrite (if alone) or 300 ppm when combined (nitrite plus Nitrate), and the residual values should be less than 50 ppm (if alone) or 250 ppm (if combined).
  - There are more stringent limits for curing agents in bacon to reduce the formation of nitrosamines. For this reason, Nitrate is no longer permitted in any bacon (pumped and/or massaged, dry cured, or immersion cured).

**Levels in finished products according to U.K. Regulations**
  - Nitrite as sodium nitrite (NO\textsubscript{2} as Na\textsubscript{2} NO\textsubscript{2}) : Not to exceed 150 PPM in non heat treated products, while if sterilised only 100 PPM is allowed. The only exceptions are in traditional products.
  - **Nitrosamine**
    - The reaction of nitrous acid (which is formed by the breakdown of nitrite) with secondary amides produces nitrosamine.
    - The reaction of nitrous acid with dimethyl amine is shown below:
    - It is demonstrated that nitrosamine are carcinogenic compounds.
    - They have been isolated from cured meats in a few instances.
    - Work is now underway to determine the factor that controls their formation, but the final answer is not available.
  - **Phosphates**
    - Alkaline phosphates are used to increase the water binding capacity and thereby the yield of the finished product.
    - Decrease the amount of shrinkage in smoked products when cooked.
    - To reduce the degree of purge or cook-pout in canned product so that the consumer receives a higher percentage of usable products.
    - Approved phosphates are
      - Sodium tripolyphosphate
      - Sodium hexa metaphosphate
      - Sodium acid pyrophosphate
      - Disodium phosphate
    - Only sodium acid pyrophosphate is permitted in sausages.
    - Legal limits for added residual phosphates are set at 0.5% in the finished products.
  - **Ascorbic Acid/ Ascorbates**
    - Ascorbates take part in the reduction of metmyoglobin to myoglobin, thereby accelerating the rate of curing.
    - Ascorbates react with nitrates to increase the yield of nitric oxide from nitrous acid.
    - Excess ascorbate acts as antioxidant, thereby stabilising both colour and flavour.
    - The antioxidant properties of ascorbate not only prevent development of rancidity but also prevent fading of colour of sliced meats upon exposure to light.

**Federation Regulations permits**
  - 0.75 oz ascorbic acid or 0.875 oz sodium bicarbonate per 100 pounds of sausage emulsion and
  - 75 oz ascorbic acid or 87.5 oz sodium bicarbonate per 100-gallons pickle for curing primal cuts.
  - Monosodium glutamate (MSG)
    - It has been used in a number of products to enhance the flavour.
    - There is little advantage of its use in cured meat products. It is added at 0.1% level.

### Abstract of ingredients used, their level of addition and function

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Ingredient</th>
<th>Level in brine solution</th>
<th>Function (Action)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sodium chloride</td>
<td>15 to 30%</td>
<td>Preservative, improves texture</td>
</tr>
<tr>
<td>2.</td>
<td>Sodium nitrate</td>
<td>0.15 to 1.5%</td>
<td>A source of nitrate</td>
</tr>
</tbody>
</table>

By- Manuprabh, Naveen, Pradeep
### Muscle pigments
- There are a number of muscle pigments in meat including myoglobin, haemoglobin, the cytochromes, catalases, the flavins and other coloured substances.
- Quantitatively the first two listed myoglobin and haemoglobin are abundant.
- The lesser pigments also play role in colour development and stabilization.
- Myoglobin and haemoglobin are complex proteins and undergo similar reaction in meat.
- However, their roles in living tissues are quite different.
- Haemoglobin is the red pigment found in blood and acts as the carrier for oxygen to the tissues.
- Myoglobin is the predominant pigment in muscle and serves as the storage mechanism for oxygen at the

### CHEMISTRY OF CURING REACTION

- Colour develops as a result of interaction of nitrite with the muscle pigments.
- The nitrate and nitrite reactions in meat curing are as shown below
- Nitrate reducing organisms

![Chemical changes of myoglobin that may occur during the curing reaction are as follows](image)

### Chemical changes

Chemical changes of myoglobin that may occur during the curing reaction are as follows:

By- Manuprabh, Naveen, Pradeep
The ultimate pigment desired in most heat processed cured meats is the conversion of muscle pigment myoglobin into nitrosyl haemochrome (pink).

Undesirable Changes
- Under some conditions the nitrosyl haemochrome pigment in meat may be oxidized to green, yellow or colourless porphyrin substances.
- Such undesirable changes of the cured meat pigment may result from bacterial action or from chemical oxidation by peroxides, hypochlorites or other agents.
- Light catalyzes these oxidative changes, as demonstrated by the tendency of cured meat surfaces to fade rapidly under strong light.

Curing Temperature
- The curing room temperature is maintained at 3°C in most curing commercial operations.
- Bacon factories maintain their pickling cellars between 3.3 and 5.6°C, for at this temperature the growth of microorganisms is very slow, especially in the presence of salt.

CURING METHODS
- There are two general methods of curing with a number of modifications of each method.
  - The first method of curing is by applying salt to the surface, which is referred to as DRY CURING.
  - The second method is by using a brine solution, in which the product is immersed or the brine solution is injected into the products with a needle. This is called as PICKLING. Pickling is achieved either by arterial brining, stitch curing, or by multiple needle injection.
- In ARTERY PUMPING, the brine is injected into one of the main arteries. Ham is the only product cured in this manner and even this entails the careful fabrication of ham so as to maintain the femoral artery intact. This technique, being essentially a slow process is not very suitable for high speed high volume production requirements of industries and hence is seldom employed.
- In STITCH CURING, an injection with a single needle, provided with many openings is used to deliver the brine into the meat. The operator inserts the injection in many places in the meat to ensure uniform distribution, and hence an experienced operator becomes necessary. Further an equilibration time after injection is also required to facilitate uniform distribution of the brine.
- In MULTIPLE NEEDLE INJECTION a syringe with multiple needles is employed to pump the cure into meat. These machines can be so configured to pump cure into bone-in as well as boneless meat. It is very effective in terms of both excellent distribution as well as high speed and hence has become very common.

Precautions
- The cure room should be maintained at 30 to 40°F.
- At a temperature in excess of 50°F the brine will sour and the product will develop off flavour and sour around the bones.

Types of meat cured
- Curing may be applied to all kinds of meats.
- It is best applied to those meats with high fat content.

By- Manuprabh, Naveen, Pradeep
Curing therefore yields excellent results when applied to pork or fine fibred beef intermixed with fat and it is for this reason brisket and flank of beef make excellent pickled meat.

On the other hand lean beef, veal or mutton become dry and unpalatable as a result of pickling process. For durability, dry salting is the best and for palatability pickled meat is advisable (good).

**CURING TIME**

The time of curing is also known as the rate of curing, which may be stated as, the rate of diffusion of the curing brine.

- The curing time for ham is 3 days per kg and that for bacon is 7 days per inch thickness of subcutaneous fat.
- The following factors influence the total curing time/rate of curing:
  - Type of curing technique
  - Thickness and weight of ham/bacon
  - Strength of curing pickle (degree of salinometer reading)
  - Temperature of the curing room and
  - Temperature of the ham/bacon when cured.

**SMOKING**

After curing, the meat is soaked in water at the temperature of 20°C for about an hour (desalination) and then dried and placed in smoke house.

Smoking is done in addition to curing.

- Smoking and cooking, which are generally carried out together, are also involved in the development of the colour, e.g. cure meat colour, which is stabilized by heating.
- The chief bacteriostatic and bactericidal substance in wood smoke is formaldehyde.
- Varying amounts of heats are applied in the smoke room and the combination of heat and smoke usually causes a significant reduction in the surface bacterial population.
- In addition, a physical barrier is provided by superficial dehydration, coagulation of protein and the absorption of resinous substances.
- The browning or maillard reaction is responsible for the development of characteristic brown colour on the surface of smoked products.
- It involves the reaction of the free amino groups from proteins or other nitrogenous compounds of meat with the carbonyl of smoke.
- Since carbonyls are major components of wood smoke, they play a major role in browning during smoking of meat.
- Smoking also is known to have a definite influence on the development of rancidity by virtue of its antioxidant activity.
- This extends the shelf life of smoked meat products and helps to account for their desirability.

**PURPOSE OF SMOKING**

- Improved shelf life
- Development of desirable organoleptic characteristics such as flavour and colour.
- Protection of fat from oxidation.
- Creation of newer product.

**COMPONENTS OF SMOKE**

The most important components of wood smoke are:

**Phenols**

- About 20 different phenols have been isolated and identified from wood smoke, e.g. P-cresol, guaiacol, methyl guaiacol.
- They act as antioxidant, contribute to the characteristic flavour of the smoked products and have a bacteriostatic effect that contributes to preservation.

**Alcohols and Aldehydes**

- Primary, secondary alcohols mainly methanol or wood alcohol may exert a minor bacteriostatic effect.
- Formaldehyde acts as a bacteriostatic agent.
Organic acids
- Formic acid, acetic acid, propionic acid, butyric and iso-butyric acids, etc., are some of the important organic acids commonly used.
- They also appear to have only a minor preservative action.
- In artificial smoked preparations they play an important part in coagulation of surface proteins of smoked meat products of skinless frankfurters.

Carbonyls
- A large number of carbonyl compounds contribute to smoke e.g. diacetyl, acetone, propanol, etc.
- Certain carbonyl compounds contribute to smoke flavour and aroma and browning of the product.

Hydrocarbons
- A number of polycyclic hydrocarbons have been isolated from smoked foods, e.g. 4-benzapyrene and diphenanthraene.
- They do not appear to impart preservative or organoleptic properties.

**PRODUCTION OF SMOKE**
- To minimize the production of carcinogenic substances, combustion temperature of 340°C appears to be reasonable.
- Although combustion temperature of 400°C is desirable for maximum production of phenols, this high temperature also favours the formation of benzapyrene and other polycyclic hydrocarbons.
- As soon as the smoke is generated numerous reactions and condensations occur.
- Aldehydes and phenols condense to form resins, which represents about 50 per cent of the smoke components and are believed to provide most of the colour in smoked meats.
- Formaldehyde appears to be the chief bactericidal substance.
- After completion of smoking the meat product (Usually bacon) is chilled and the product can be labeled ready to eat under USDA inspection.
- It must be maintained at an internal temperature of not less than 140°F for a period of 30 minutes.

**Deposition of smoke on meat**
- The smoke density, velocity and relative humidity of smoke air and the surface of the product being smoked influence the amount and rate of deposition of smoke.

**METHODS OF SMOKING**

Natural air circulation
- In this method fire pit designed to use logs, sawdust or combination of both is utilized.
- Opening and closing of dampers help to control volume of air.

Air-conditioned smoke house
- This has largely replaced natural air type smokehouses.
- This method permits much more control of smoking, control temperature for cooking and resultant control of shrinkage.
- The air circulation is controlled by fan.
- This house usually control smoke velocity and regulates humidity.

Continuous smoke house
- This comprises a part of the continuous process system and was developed specially for frankfurters production.

**TYPES OF FUEL USED**
- Most commercial smoking operations have been using sawdust, which is easier to utilize and gives a greater volume of smoke.
- Hard woods have been reported to be the best for smoking e.g. sawdust of hickory, maple, oak, cherry and pecan
- However, liquid smoke has been produced satisfactorily from both hard and softwood with excellent results.

Liquid smoke
- Several liquid smoke preparations are available in developed countries.
- The liquid smoke is prepared from hard wood.
- The tarry droplets/polycyclic hydrocarbons are removed by filtration.
- Final product is composed of primarily of the vapour phase containing mainly phenols, organic acids, alcohols and carbonyl compounds.
- They do not contain polycyclic hydrocarbons especially benzapyrene a carcinogenic substance, which is removed during production of liquid smoke.
- Liquid smoke has several advantages.

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• It has a little or no preservation effect although it contributes to the flavour.

**Application of liquid smoke**
• It is generally spread on the product just before cooking.
• Smoke solutions are diluted with water or frequently with vinegar or citric acid.

**Composition of liquid smoke**
• 20 – 30 parts of liquid smoke
• 5 parts citric acid or vinegar
• 65 - 70 parts of water
• Citric acid or vinegar is used to enhance the skin formation on skinless frankfurters.
• Acid is commonly added to reduce the cost.
• Liquid smoke makes it easier to keep the equipment clean.
• Cooking after spraying with liquid smoke preparation is essential to give good smoke colour formation.

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**EFFECT OF SMOKING ON NUTRITIVE VALUE**

• Federal Regulations specify a final internal temperature of at least 58°C for smoked ham.
• Many processors maintain single temperature schedule of 38 –82°C from the beginning to the end of the cooking schedule.
• Frankfurters, bologna and loaf items are cooked to an internal temperature of about 68°C and fully cooked hams at 66 – 68°C.

**Action of smoke on nutritive value**
• The phenols and polyphenols tend to react with the sulphhydril groups of the proteins, whereas the carbonyl group from the smoke reacts with the amino groups.
• Both of these reactions can decrease the nutritive value of the proteins by causing a loss in the available amino acids, especially of lysine.
• Smoking can also cause some destruction of thiamine.
• The antioxidant properties of wood smoke should help to stabilize the fat-soluble vitamins and would also be expected to prevent surface oxidation of smoked meat products.
• Thus, smoking has some advantages.

**Nature of smoke**
• Smoke has a vapour and particulate phase.
• The vapour phase contains the more volatile components and is largely responsible for the characteristic flavour and aroma of smoke.
• Furthermore, removal of the particulate phase by precipitation also greatly reduces the components of tars and polycyclic hydrocarbons, all of which are undesirable in smoke.

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**Preservation of Meat By Low Temperature**

**PRESERVATION BY LOW TEMPERATURE (COLD)**

• It is common knowledge that meat will not keep for a long time unless properly preserved.
• Preservation by cold method is the simplest form of preservation, and the advent of refrigeration only accelerated the growth of the meat industry and the modern meat industry is based on efficient refrigeration.
• Low temperature preservation is referred to as refrigeration.
• Refrigeration process means extraction of heat from a body and thus cooling it to a temperature below the surrounding atmosphere.
• Refrigeration may be classified depending on the extent of the extraction of heat from the product, as chilling (refrigeration above the product's freezing point) or freezing (refrigeration below the product’s freezing point).
• By efficient refrigeration, meat can be preserved in a condition approaching its natural state for periods adequate for commercial requirement.
• The method alters the appearance, weight and flavour of the meat to a little extent and no substance is added or extracted from it.
• The use of low temperature preserved foods is based upon the fact that, the activities of food borne microorganism can be slowed down and or stopped at the temperature just above freezing and generally stopped at sub-freezing temperature.
• At a temperature of –8°C the multiplication of all microorganisms stops and only resumes when temperature is raised later to a suitable level.
• The failure of bacteria to grow at or below freezing depends mainly on the removal of the available water as ice; about 70% is removed at 3.5°C and 94% at –10°C.
• Another factor is the inhibition of the life processes of spoilage organisms at low temperatures.
• In the case of flesh foods low temperature inhibits the action of natural autolytic enzymes.

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The reason for these is that all metabolic reactions of microorganisms are enzyme catalyzed and the rate of
enzyme-catalyzed reactions is dependent on temperature. With decrease in temperature, there is an decrease in
reaction rate.

The surface growth of mould on meat is controlled not only by the temperature but also by the relative
humidity of the atmosphere.

The organisms that grow well at low temperature are referred to as psychrophiles.

Most psychrophilic bacteria belong to the genus Pseudomonas and to a much lesser extent to the
genera Achromobacter, Flavobacterium, Alcaligenes, Micrococcus and others.

Among the moulds and yeasts, species and strains from a large number of genera are capable of growth at
refrigerator temperature.

Moulds belonging to the genera Penicillium, Mucor, Cladosporium, Torulopsis, Candida, Rhodotorula and
others are known to be mesophilic.

Moulds require high relative humidity for them to multiply, and in the absence of suitable relative humidity, they will wither away.

For the prevention of mould the temperature and relative humidity must therefore be kept as low as possible.

**PRINCIPLES OF A REFRIGERATOR**

1. Three basic laws of physics are involved in working of refrigerators
   - A cold object placed next to a hot object, the cold object will become warmer and the hot object will
     become cooler.
   - The boiling point of a liquid is directly proportional to the pressure it is subjected to. (Water boils at
     100°C at 1 atmospheric pressure, but it boils at 46°C itself at 0.1 atmospheric pressure and conversely water
     vapour at 50°C and 0.1 atmospheric pressure can be condensed back into liquid by increasing the pressure to 1
     atmospheric pressure)
   - Evaporation produces cooling, as the vapour absorbs heat and heat is given off or lost by a liquid as it
     condenses.

2. All refrigerators make use of refrigerants to bring about their action.

3. Refrigerants are liquids or liquefied gases with very low boiling points. For example, ammonia, a common
   refrigerant used boils at -33.34 °C. These basic components are the evaporator, compressor, condenser, and metering
device.

   - The evaporator is where liquid refrigerant evaporates. As stated already, the evaporation of this refrigerant
     requires heat. Because the temperature of the food is higher than the evaporator, heat leaves the food and enters the
     evaporator, increasing the temperature of the liquid refrigerant.
   - Since when a liquid reaches its boiling point, the temperature stops rising and begins to boil when more heat
     is added, refrigerant with very low boiling points begins to boil and evaporate in the evaporator.
   - The evaporator stays at the same temperature (cold) until all the refrigerant boils away (evaporates).
   - This means that the evaporator would continue to absorb heat from food inside the refrigerator. The effect is
     refrigeration; warm air from inside the food of the refrigerator is absorbed as the refrigerant evaporates.
   - Eventually all the refrigerant will have evaporated and we won’t be able to cool food any more, if it is allowed
     to progress without the heat in the refrigerant being absorbed. This is where the compressor comes into play.
   - The compressor is like a pump for refrigerant. It creates a suction that draws the refrigerant out of the
     evaporator, keeping the low pressure in the evaporator needed to boil more refrigerant.
   - As the refrigerant is compressed, two things happen. Its pressure goes up, because it’s being squeezed into a
     smaller space, and as a consequence its temperature also increases. So while the compressor sucks in cold, low
     pressure refrigerant vapour, it pumps out hot, high pressure refrigerant vapour. This high pressure refrigerant vapour
     is pumped into a condenser, where it (logically) condenses.
   - The boiling point of the refrigerant vapour has increased because it is at a high pressure. The condenser looks
     very similar to the evaporator, and with good reason, they perform the same function.
   - Both are designed to move heat; the evaporator moves heat from the food to the refrigerant and the condenser
     moves heat from the refrigerant to the air blowing past its coils.
   - After the refrigerant turns back into a liquid, we’re ready to send it back to the evaporator and use it for more
     cooling. It is still at a high pressure. This is the big difference between the evaporator and condenser, the difference in
     pressure. Just connecting the condenser and evaporator together won’t work because the high pressure liquid won’t
     boil in the evaporator. This is where the metering device comes into play.
   - There are various kinds of metering devices. The simplest is just an extremely thin piece of tubing. The idea
     is to just let a tiny trickle of refrigerant into the evaporator; just enough to replace what the compressor is sucking out
     without raising the pressure.

**FACTORS CONTROLLING EFFICIENCY OF CHILLING**

- The temperature of storage is probably the most important factor determining the efficiency of chilling.
- Higher temperatures are less effective in preservation and shrinkage is also high.
- The rate of chilling is another factor that affects the efficiency of chilling, with quick chilling being markedly
  superior with respect to both keeping quality (retardation of surface bacterial growth) and sensory qualities (superior
  bloom) and shrinkage is also lesser as well.

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The air velocity is directly proportional to rate of chilling and hence thus higher velocities enhance bloom and impart greater preservative effect, but cause increased shrinkage. Hence, initial chilling of warm carcasses, sides, or quarters is carried at 7°C and the mean air speed of 0.75m/s, while in the terminal stages of chilling temperature must be maintained between -1°C and 2°C, with mean air speed of 0.5m/s.

Meat packed on trays or in cartons the temperature must be below 3°C and mean air speed of 0.75m/s.

Higher air circulation rates are not associated with shrinkage, especially when the carcass is fresh and still wet, wherein higher circulation rates result in rapid decrease of the carcass surface water vapour pressure, thus reducing shrinkage.

Air circulation rates of up to 70-110 volumes of the room per hour are maintained in quick chilling to rapidly lower the temperature.

Slower air circulation rates are beneficial once the temperature of the carcass is sufficiently lowered.

Relative humidity of the chilling room also has an important role to play in the efficiency of chilling. High relative humidity’s will reduce shrinkage but will favour mould growth.

A relative humidity of 95% may be maintained to chill the carcass and store chilled carcass, if storage is to be for less than 72 hours, if extended beyond 72 hrs, it has to be reduced to 90%.

Uniformity of air flow throughout the chill room is yet another factor that has a role in determining efficiency of chilling, but this itself is determined by the evenness of hanging the carcass in the chiller room.

The recommended rail spacing in a chiller or freezer room should be 0.9m for beef, 0.7 m for pork and 0.5 m for lambs and the minimum space between carcasses on these rails should be 0.3 to 0.4m. Further, the rails should be placed 0.6 m (0.9 m, in case of header and traffic rails) clear off refrigerating equipment, walls and other fixed parts of the building to ensure hygiene and protection to walls.

The top of the chill rail from the floor level should be atleast 3.3 m for beef sides, 2.7m for headless pigs and calves, 2.2 m for beef quarters, and 2m for sheep and goat.

**PHYSICAL CHANGES IN CHILLED MEAT**

- Meat undergoes certain superficial changes as a result of storage, chief of which are shrinkage, sweating and loss of bloom.

**Shrinkage**

Shrinkage or loss of weight occurs as a result of evaporation of water from meat surface; carcass cut into quarters dissipate water vapour rapidly and continuously and retail joints even more so.

On the other hand the evaporation inhibited by membranes such as the pleura and peritoneum and in well nourished carcass, by the solidification of the superficial fat and drying of the connective tissue.

A freshly killed carcass dissipates body heat slowly, usually 1.5 to 2.0% of weight by evaporation during the first 24 hours of hanging.

Further loss of weight during storage depends on the humidity of the storage room, the drier the air the greater being the evaporation.

Avoidance of all evaporative weight losses by high humidity facilitates the formation of moulds, so an accurate balance between temperature and humidity must be maintained: the dry impervious film on the carcass surface is perhaps the best protective against the growth of spoilage organisms.

**Sweating**

Denotes condensation of water vapour on meat brought from a cold store into ordinary room temperature.

The condensation occurs because of the cold refrigerated carcass lowers the temperature of the air to below the dew point.

In winter months in Britain the dew point is generally below 4.5°C and sweating is unlikely to occur, but in summer the dew points is always over 7°C and moisture will be deposited on the carcass.

If the quarter or side is cut up immediately after removal from the chilling room the sweating will be extended to the individual joints.

**Loss of bloom**

Bloom is defined as the colour and general appearance of the carcass surface when viewed through the semitransparent layer of connective tissue, muscle and fat, which form the carcass surface.

If these tissues become moist, the collagen fibers in the connective tissue swell and become opaque and the meat surface assume a dull, lifeless appearance.

Loss of surface bloom in beef carcasses may also be caused by dehydration or undue oxidation, but it may be prevented by avoiding temperature fluctuation that permit alternate drying and dampening of the carcass surface.

It is also important to keep the relative humidity of cooling chamber high and ensure that there is circulation of air.

Muscular tissue also tends to become brownish on exposure to air as myoglobin changes to the brown pigment metmyoglobin, but the actual amount of exposed muscle in a side of beef is so small that is of little or no consequence.

Refrigeration has little effect on the carcass fat except in the case of frozen meat, which has undergone a prolonged period of storage.

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### CHEMICAL CHANGES IN CHILLED MEAT

- There is a slight degree of breakdown of muscle protein by endogenous enzymes or by those of the microorganisms, which is due to the chemical changes that take place after slaughter.
- The meat odour becomes progressively more marked but never disagreeable, the flavour may be described as stale, rendering the meat unpalatable but not repulsive.
- The storage life of meat is more dependent on the chemical changes that take place in fat rather than in muscle, for fat rancidity even in slight degree is objectionable.
- The condition of the fat therefore determines the length of storage.
- While the lean muscle of a carcass may be still improving in flavour; the changes in fat may render the meat repugnant and unmarketable.
- Rancidity is most likely in the kidney fat and in hot weather; the retail butcher removes the kidneys and fat of home killed beef soon after slaughter.
- In EEC approved plants these are always removed prior to weighing.

### CHILLING OF CARCASSES

- The carcasses of meat animals normally are refrigerated immediately after slaughter, unless they are hot boned.
- Rapid cooling is necessary to prevent spoilage around the lymph nodes deep in the carcass (referred to as bone souring).

#### Chilling of carcass in a modular chiller

- Beef carcasses are skinned and wrapped in shroud cloth before chilling; veal may be skinned either immediately after slaughter or after chilling, or in some cases it may be shipped skin-on.
- Pork carcasses and poultry ordinarily are not skinned.
- The regulations concerning the temperatures at which meat, offals and meat products are to be held vary in different countries.

EEC regulations recommend the following standards:

- Meat must be chilled after post-mortem inspection and must be held at a temperature of not more than +7 °C for carcasses and cuts in case of red meats, +4 °C for poultry and +3 °C for offals.
- Cutting plants must have cooling equipment to keep meat at constant internal temperature of not more than +7 °C.
- The temperature of the cutting rooms should never exceed +10 °C during cutting.
- Cutting plants must be provided with a thermometer and a telethermometer.
- South African regulations recommend the following standards
- Initial chilling of warm carcasses, sides, or quarters should be carried at 7°C and the mean air speed of above 0.75m/s, while in the terminal stages of chilling temperature must be maintained between -1°C and 2°C.
- Meat packed on trays or in cartons the temperature must be below 3°C and mean air speed of above 0.75m/s.
- For storage of chilled carcasses, sides or portions the temperature must be within the range of-1°C and 5°C and mean air speed of above 0.5m/s over the product. The relative humidity must be maintained below 95% or, if the product is stored for more than 72 hours, below 90%.
- Since warm carcasses will raise the cooler temperature, these rooms must not be overloaded.
- The amount of refrigeration energy required depends on the weight of the carcasses to be chilled, their temperature and their heat capacity.
- The heat capacity or specific heat of the meat depends to a large extent on the ratio of fat: lean 0.51 to 0.57 in pork to 0.70 to 0.77 in veal.
- The rate of cooling depends on the size and heat capacity of the carcass, the amount of fat covering, and the temperature in the cooler.
• Heavy carcasses may require as long as 72 hours to chill; light beef carcasses, pork, lamb and veal require up to 24-36 hours.
• Efficient chilling and further maintaining a temperature range of -1°C and +0.5°C during storage, transport and display, in conjunction with strict hygiene and excellent packaging may extend shelf life to about 12 weeks, though in commercial practice beef carcasses itself may be held without deterioration for about 35 days only.

REFRIGERATION INSTRUMENTATION

• Good monitoring of refrigeration performance should always be insisted upon.
• There are a variety of portable instruments available for measuring temperature, air velocity and relative humidity.
• A thermograph is a clockwork-driven chart recorder, which can record for temperatures a period up to 7 days over a range of –15°C to 40°C.
• A thermohygrograph that can measure temperature (range of –15°C to 40°C) and RH (range of 10 – 100% HR ± 3% RH) is also available.
• ‘Spear’ thermometers may be inserted into carcasses and cuts.
• These consist of either an ordinary mercury thermometer encased in a stainless steel sheath or a bimetallic strip connected to a recording dial.
• Both types have pointed ends for ease of insertion but are slow in operation and easily damaged.
• More elaborate electronic and thermistor probe thermometers give more accurate results and are more durable.
• Instruments, which can record temperature on charts, may be obtained and a thermodenemometer (records temperature and air velocity) is available.
• Various types of hygrometers and wet-and-dry bulb indicators are manufactured to measure RH, but are slow and liable to damage and contamination of the hygrometric material.
• A thermohygrograph or a Wet-and-dry indicating psychrometer (range 0-90°C or –10-80°C) gives more accurate measurements.
• Different types of velometers (anemometers) are available to measure air velocity.
• The more elaborate are combined with thermometers and are usually more accurate and reliable.

COLD SHORTENING

• Cold shortening is an undesirable change associated with quick chilling
• Cold shortening is noticed when pre-rigor muscles, (i.e. while the pH of muscle was still above 6.2 and Adenosine Tri-Phosphate (ATP) was still present) were subjected to a temperature of below 10°C, in which the meat is very tough of meat occurred due to extreme contraction.
• Thus a pH of above 6.2 and presence of ATP is a pre-requisite for cold shortening to occur.
• The phenomenon of cold shortening was first encountered in New Zealand when rapid cooling schedules for lamb freezing were first introduced.
• Cold shortening can also occur with beef carcass and even in parts of the carcass, e.g. the loin, with fairly slow chilling.
• Cold shortening is not an important concern in the pork or poultry industry as white muscles are less prone to cold shortening.
• Cold shortening occurs due to the inability of the sarcoplasmic reticulum to sequester Ca ++ at low temperatures (0°C - 5°C) and a decreased binding ability of mitochondria to bind Ca ++.
• The inability of sarcoplasmic reticulum and mitochondria to bind Ca ++ results in its spillage into the sarcoplasm and cold shortening ensues much in the same fashion as Ca ++ triggering muscle contraction.
• This is not a serious problem in white muscles as they possess a rather better developed sarcoplasmic reticulum, in comparison to red muscles and possess fewer mitochondria than red muscles.
• The fact that white muscles also possess greater amounts of ATP, which provides energy for re-accumulation of Ca ++ by sarcoplasmic reticulum and lesser extent mitochondria, also ensures cold shortening does not occur in white muscles.
• It can be avoided by delaying the start of chilling, e.g. for 10-12 h when the pH will be below 6.2 and the rigor will have taken place with the complete disappearance of ATP from the muscle or not chilling below 10°C in less than 10 h.
• Cold shortening can also be prevented by the use of electrical stimulation, which advances the onset of rigor, tender-stretch method of suspending carcasses and by ageing.

ELECTRICAL STIMULATION

• Electrical stimulation refers to the passing of high voltage electricity through the carcass immediately after slaughter, the current causing the muscles to contract and thereby use up glycogen, ATP and creatine phosphate.
• A number of muscle contractions are made to occur in a short time, thereby accelerating the onset of rigor.
• The process of rigor mortis is advanced and the pH is brought down to less than 6.0 within 2-3 hours of slaughter.
Mechanism of action of electrical stimulation

- Two theories have been proposed as putative mechanisms for the effectiveness of electrical stimulation to hasten the onset of rigor and thus prevent cold shortening.
- The first theory suggests that electrical stimulation results in the conversion of the inactive form of the enzyme phosphorylase (phosphorylase a) to the active form of the enzyme phosphorylase (phosphorylase b), which stimulates the breakdown of glycogen (glycolysis), which results in the drop in pH.
- It was further suggested that the enzyme involved in the conversion of phosphorylase, phosphorylase kinase is stimulated by an increase in myofibrillar ATPase activity, which takes place as a consequence of electrical stimulation.
- Subsequent studies clearly determined that the increase in the active form of the enzyme phosphorylase (phosphorylase b) was transient and lasted for just 35 minutes.
- The other theory suggested that the increase in Ca**+ caused a stimulation of glycolysis), which results in the drop in pH.

REFRIGERATED MEAT TRANSPORT

- Meat may be transported by road in properly insulated and refrigerated vehicles or in insulated or non-insulated non-refrigerated vehicles.
- Only refrigerated transport can be considered adequate.
- The latter vehicles are totally ineffective, especially the non-insulated type, particularly for chilled meat.

- A well-designed refrigerated road vehicle should have the following qualities –
  - High standard of insulation
  - Internal lining, which is impermeable, easily cleaned, without seams and durable
  - Airtight door seals
  - Watertight flooring
  - Rigidity of construction
  - Efficient refrigeration unit, noiseless, economical and lightweight
  - Provision of indicators in driving cab
  - Properly spaced overhead rails.
- Solid carbon dioxide is sometimes used, either as solid blocks or crushed, and provides a temperature of 0-10ºC.
- The van cooler is provided with a fan, which blows the cool air over the CO₂ and load.
- A thermostat switches off the fan when the desired temperature is reached and a microswitch ensures that the unit does not operate when the vehicle doors are open.
- The maintenance of the internal temperature is influenced by the difference between the inside and outside temperatures, the number of times the doors are opened and closed, loading temperature of the cargo, capacity rating of the refrigerating system, respiration rate of the product, etc.
- Vehicles, which are left standing with doors wide open in high summer temperatures attract not only heat but also undesirable arthropods.
- Urethane foam sprayed between inner and outer linings forms an efficient insulating medium.
- This material expands to fill all the crevices and has low heat loss factor, a low water absorption rating and a density of 124 g/cm³.
- Lining materials must be smooth, impermeable, durable, easily cleaned and able to withstand detergents and hot water.
- They must also be non-toxic and as far as possible free from seams.
- Typical lining materials are glass-fibre reinforced panels, special non-marking aluminium (bare aluminium can mark fresh unwrapped hanging meat), plastic-covered plywood and galvanized sheeting.
- Floors should be very durable, watertight and easily cleaned.
- There should be no crevices or sharp corners throughout the inside of the vehicle, which would hinder cleaning.
- While construction of transport vehicles is normally suitable for hanging quarters of beef, lamb carcasses, packaged meat, etc., the same does not hold for offal, which is not in cartons.
- It is important that for the retail delivery of meat and offal there should be good handling facilities and offals should not be placed in an unwrapped state on dirty floor.

FREEZING

- Freezing of meat involves the reduction of the internal temperature of meat below its freezing point of, -1.5 °C and further storing it at temperatures of less than its freezing point.
- Freezing of meat only has made the trans-continental trade in meat a reality and it is probably the most important contributor for the pre-eminent place that meat occupies in world trade.
However, there exist wide differences in opinion as to the proper freezing temperature.

In Germany the temperature is maintained at -6 °C, while in Australia it is maintained at -11 °C.

In South America much lower temperatures are maintained and pork may be stored at -18 °C.

During sea transport, a temperature of -9 °C to -8 °C is maintained at the holds, while the air is kept dry and in circulation.

In the United Kingdom, it has been customary to hold meat in cold stores at temperatures of -20 °C.

But currently, it is generally recognised that lower temperatures are more satisfactory since they reduce the deterioration of carcass meat, and temperatures no higher than -18 °C and even -30 °C are recommended.

The reason behind the change in the recommendation is due to the realisation that the belief that very low temperatures caused excessive dehydration is actually wrong.

The EEC regulations stipulate that:

- Beef quarters will be accepted for freezing at a temperature not above +7 °C and frozen within 36 hours to an internal temperature of -7 °C or below.
- The acceptance temperature for pig sides is +4 °C; they must be frozen at -30 °C and held in the freezer until all the meat is at -15 °C or below.
- Frozen storage for beef must be at a temperature of -17 °C and at -20 °C for pork.
- The meat must be wrapped in a polythene pack of at least 0.05 mm thickness and in stockinette.
- Such low temperatures can be attained by special blast freezers with temperatures around -34 °C, air speeds of about 3.5m/s and holding times of up to 25 hours.

The form of wrapping greatly affects the freezing time; if it is loose, the pockets of air or cartons act as insulation and thereby increase freezing times.

- Wrapping in moisture proof packaging can offset water losses.
- If thoroughly chilled meat is frozen, the rate of freezing probably does not have any effect on the microbiological quality of the product.

However, if warm meat (e.g. 21°C or higher) is frozen slowly, considerable microbial growth may develop before the temperature of the meat is brought down to the freezing point.

Therefore, a freezer unit should never be over loaded with warm meat, particularly if the meat has been ground or comminuted which results in distribution of the microbial load throughout the product.

The commonly held belief that frozen meat can be held indefinitely is not right.

Freezing of any type or by any method does not destroy bacteria completely.

The practical storage life of frozen carcass meat is furnished in the table below.

<table>
<thead>
<tr>
<th>Name of carcass</th>
<th>-12°C</th>
<th>-18°C</th>
<th>-24°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>8</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Lamb</td>
<td>18</td>
<td>24</td>
<td>&gt;24</td>
</tr>
<tr>
<td>Pork</td>
<td>6</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Edible offals</td>
<td>4</td>
<td>1-2</td>
<td>18</td>
</tr>
</tbody>
</table>

**METHODS OF FREEZING**

Freezing undertaken in a cabinet freezer is essentially a slow process and is referred to as slow freezing, or in blast freezers in which case, it is quicker and the method is often referred to as quick-freezing.

Quick freezing can also be achieved by Freezing by Liquid Immersion and Liquid Sprays and also by Cryogenic Freezing.

Slow freezing generally takes about 72 hours while quick freezing is completed in 30 minutes.

- The delay involved in slow freezing usually results in greater drip loss, during thawing than that associated with quick-freezing.
- The reasons for this difference is summarised below:

  - Slow freezing
    - The temperature of the product being frozen remains near the initial freezing point for an extended time in case of slow freezing. This results in the formation of a continuous freezing boundary and freezing proceeds slowly from the exterior to the interior.
    - Extracellular water freezes more rapidly than intracellular water due to its lesser solute concentration.
    - Slow freezing favours the formation of pure ice crystals and concentration of solutes in unfrozen condition.

Moreover, intracellular solutions may be deficient in nucleation sites (suspended microscopic particles) necessary for small ice crystals. These conditions favour gradual migration of water out of muscle fibres, resulting in collection of large extracellular pools at sites of ice crystal formation, and intracellular concentration of solutes.

- Consequently, there is even further reduction in the freezing point of intracellular water. This process of depressing the freezing point by increasing concentration of solutes is called eutectic formation.
The total contribution of this process to freezing damage is not fully understood, but it apparently causes chemical alterations, including losses in protein solubility and elasticity of thawed muscle tissue.

Long periods of crystallisation exist in slow freezing, producing numerous large extracellular masses of ice crystals that are easily lost as drip during thawing. Slow freezing also might result in mechanical damage to muscles, due to volume changes, associated with formation of large ice crystals and concomitant shrinkage of muscle fibres that have lost water to extracellular pools. Such muscle tissue has a distorted structure in frozen form that completely obliterates normal striations.

Quick freezing
- The temperature of the product being frozen falls below the initial freezing point rapidly in case of quick freezing.
- Numerous small ice crystals with filament like appearance are formed both intra- and extracellularly at approximately the same speed.
- Small ice crystals formed, have very little opportunity to grow in size. Hence, quick freezing causes spontaneous formation of numerous small ice crystals, resulting in a discontinuous freezing boundary and very little translocation of water.
- Most of the water inside the muscle fibre freezes intracellularly, so drip losses during thawing are considerably lower than in slow frozen meat.
- Muscle fibre shrinkage and distortion are minimised than in slow frozen meat.
- Volume changes are less and periods of crystallisation are shorter than in slow frozen meat and consequently, mechanical damage is correspondingly less.
- Filament like ice crystals entrap solutes and thus minimise the ion concentration effect.
- 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

Freezing can be undertaken by the following methods - Still Air Freezing, Plate Freezing, Blast Freezing, Freezing by Liquid Immersion and Liquid Sprays and Cryogenic Freezing. Quick freezing is achieved by, Blast Freezing, Freezing by Liquid Immersion and Liquid Sprays and also by Cryogenic Freezing while freezing in a Still Air Freezer results in Slow Freezing.

Still Air Freezer
- The medium of heat transfer is air in a still air freezer. In this method heat transfer is entirely based on convection, as air is a poor conductor of heat. Hence freezing is very slow.
- Cabinet or desk freezers or freezers of home refrigerators are good examples of still air freezers.
- The temperature range of commercial still air freezers fall between -10°C and -30°C.
- Their capacity to freeze unfrozen meat, particularly when overloaded is rather poor and are best suited to store frozen meat at freezer temperatures.

Plate freezers
- The medium of heat transfer is metal in a plate freezer. In this method heat transfer is entirely based on conduction and hence freezing rates are slightly faster than still air freezers.
- Meat as such or packed in trays is directly placed in contact with freezer plates or shelves.
- The temperature range of commercial still plate freezers fall between -10°C and -30°C. This method is commercially restricted to freezing thin pieces of meats such as steaks, chops, fillets and meat products such as patties.
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 18 m/sec. High air velocities increase the cost of freezing and also the risk of freezer burn.
- Hence, a temperature of -30°C, and air velocities of about 12.5 m/sec are probably the most economical and practical conditions employed in the industry.

Proper stacking and spacing of meat and meat products on shelved racks and pallets are important criteria in determining efficiency of freezing in freezer rooms.
Conveyor speeds, which are set based on the time required to freeze the product in question, is an important criterion in determining efficiency of freezing in blast tunnels. Sometimes, blast freezers are used to partially freeze meat, to complete surface hardening and further freezing is undertaken in a still air freezer.

Freezing by Liquid Immersion and Liquid Sprays
- This is the most commonly used commercial method for freezing poultry, though some fish and meat products are frozen by this method. The medium of heat transfer is the freezing liquid used, in this method.
- In this method heat transfer is entirely based on conduction and hence heat transfer rates are rapid than blast freezers, and hence higher temperatures can be used. However the freezing rates achieved in a blast freezer are comparable with freezing by liquid immersion and liquid sprays.
- Meat packed in plastic bags, stacked on shelved racks or pallets are either immersed in freezing liquid by forklifts, passed through the freezing liquid by conveyors. Products may otherwise be conveyed through enclosed freezing cabinets in which freezing liquids are directly sprayed over the products.
- The products after being removed from the immersing tank or freezing cabinets must be rinsed with water to remove the freezing liquid. The extent of freezing is determined by length of immersing or spraying. Sometimes freezing by liquid immersion and liquid sprays is carried out for partial freezing, to complete surface hardening and further completion of freezing and storage is undertaken in a blast freezer.
- Liquids used for freezing either for immersion or for spray must possess low viscosity, freezing points, high heat conductivity and must also be non-corrosive, relatively inexpensive and non-toxic. Sodium chloride brine (Corrosive in nature), glycerol and glycols such as propylene glycol are commonly used for freezing. A problem associated with this method is the possible seepage of freezing liquid on to product surface through holes in protective package.

Cryogenic freezing
Cryogenic freezing is very low temperature freezing accomplished with condensed or liquefied gases by direct immersion of the product to be frozen in the liquid, or spraying the liquid over the product to be frozen, or by circulating the vapour of the cryogenic liquid over the product to be frozen. The agents usually used are either liquid nitrogen or carbon – di – oxide, and rarely liquid nitrous oxide is also used.

Direct immersion of large pieces of meat is rarely used due to extensive shattering or cracking of products. So, generally liquid nitrogen is usually evaporated in a freezing chamber and the great cooling capacity, as it changes to nitrogen gas is used to freeze meat products.

Liquid nitrogen or carbon – di – oxide released as snow, combined with conveyor systems, are used to rapidly freeze meat products of small size such as patties, diced meat, fish and shell- fish. Meat products frozen by this method have excellent sensory qualities.

### PHYSICO-CHEMICAL CHANGES DURING FROZEN STORAGE OF MEAT

- Freezer/frozen storage is a highly effective means of preservation.
- It is a form of low temperature dehydration.
- However, it has been shown that even under ideal frozen stored condition a certain amount of deterioration in quality of meat so not uncommon.

### Alteration of the state of proteins

- The physical state of the muscle plasma (globulin and albumen proteins) is considerably altered.
- When meat is frozen below −2°C the formation of ice crystals so raises the concentration of these proteins that they become insoluble and do not regain their solubility when the meat is thawed.

### Weep or drip

- Weeping denotes the presence of a watery, bloodstained fluid, which escapes from frozen meat when thawed and consists mainly of water, together with salts, extractives, proteins, peptides, amino acids, lactic acids, purines, vitamins of B-complex and damaged blood corpuscles.
- The latter are responsible for the pink coloration of the fluid and are readily recognizable on microscopic examination.
- Weeping is an undesirable feature and most insurmountable disadvantage of freezer stored meat.
- This 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.
- The size of the ice crystals in frozen meat bears a direct relationship to the damage done to the cells and therefore to the amount of weeping or drip.
- Slow freezing produce large ice crystals, which mechanically rupture the thin sheath of the muscle fibres; rapid freezing incurs less time in the zone of maximum ice formation and the smaller crystals will cause little or no damage.
- The amount of drip is greater in beef than in mutton, lamb or pork, but the better the original quality of a beef carcass the less on the average will be the drip from the meat after thawing.
- Quarters of frozen beef defrosted at 10°C for 3 days and cut into large wholesale joints lose about 1-2% of their weight during the following day while smaller joints of the retail trade lose 1.5 to 2.5%.
- The rate of thawing in both meat and fish is of less importance than the rate of freezing, for if large crystals of ice have already formed the damage done to the muscle is irremediable.
- The drip is minimized if thawing is very slow.
- One method employed for beef is to subject the meat to a temperature of 0°C with 70% RH, gradually increasing the temperature to 10°C and RH to 90%; the fore quarter requires 65 h for complete thawing and the hind quarter 80 h.
- The faster the rate of breakdown of ATP in muscle the more rapid is the onset of rigor mortis and the greater the release of fluid from the muscles.
- If the rate of breakdown of ATP could be slowed, i.e. rigor mortis is delayed; less free fluid would be available for drip formation on subsequent freezing and thawing.
- Again, meat which has a high pH prior freezing has a low drip when thawed, and a useful diminution of drip from butcher’s cuts can be brought about when pH of meat before freezing is 6.1 – 6.3.

### 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.
- The storage temperature and exposure to light are critical factors governing the pace of the onset of rancidity.

An enhancement in tenderness of meat and a depression in juiciness is the main changes on sensory attributes caused by freezing of meat

### UNDESIRABLE CHANGES IN FREEZER STORAGE OF MEAT

### Freezer burn

By- Manuprabh, Naveen, Pradeep
Freezer burn is an extension of surface desiccation associated with freezing. It occurs on the outer surface of imported frozen offals, like kidneys livers. 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. The meat or offals have a brown withered discolouration. Storage temperature influences both the rate of desiccation and the development of freezer burn. This can be prevented by using suitable packaging.

Bone darkening
Bone darkening is a condition, which develops when young poultry is frozen and thawed. Organoleptic properties of the muscle are not affected, but the brown to black appearance of the long bones and the surrounding muscles results from leaching of haemoglobin out of the bone marrow. Subsequent oxidation of the red haemoglobin to methaemoglobin produces the dark colour. Bone darkening is a problem only in young birds for two reasons:
- First, more haemoglobin is present in the bone marrow of young, rapidly growing birds.
- Secondly, incomplete calcification of the bones allows the haemoglobin to escape from the marrow cavity.

Recrystallization
Recrystallization is an important physical change which may take place during frozen storage, resulting in translocation of water and consolidation of the unfrozen soluble water molecule tend to migrate from small to large crystals. This migration is promoted by fluctuating storage temperatures. Many workers have found that fluctuating temperatures result in moisture loss and quality deterioration.

Thaw rigor
When prerigor 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. Although shortening is less in a muscle attached to skeleton, the condition results in tough meat and heavy drip losses.

THAWING OF FROZEN MEATS
Thawing or defrosting of frozen meat is usually done before cooking. This is done in order to bring the meat to the room temperature. Defrosting may be achieved in many ways, viz.,
- Slow defrosting in a refrigerator or in cold air
- At room temperature in a rack or warm air
- In circulating cold water and
- Quick de-frosting in warm water or cooked without prior thawing.
Defrosted meat is cooked in the same way as fresh meat. Meat, when thawed, sometimes produces a water fluid called “Weep or Drip”. This fluid mainly consists of water, salts. Due to the presence of large ice crystals in muscle, protein is also to some extent unable to reabsorb the entire water when the meat is thawed.
In the present context of preservation of meat, the drip fluid offers a good medium for growth and multiplication of bacteria, which is present in the frozen meat. Therefore, thawed meat is liable to spoil quickly than fresh meat. As the shelf life of the thawed meat is low, re-freezing of such thawed meat will materially yield meat of poor stability.
Palatability differences among thawing methods are negligible. The method of thawing affects the amount of moisture or drip loss from the meat. The extent of this loss from a given product depends also upon the temperature at which the meat was held during frozen storage.
Fluctuating temperatures tend to increase the drip loss on thawing. As a practical matter, frozen meats that have more drip loss during thawing loose less moisture during cooking; the over all drip loss from the frozen to the cooked state is almost the same for all the methods of thawing. The time required for thawing frozen meats depends upon the temperature of the meat and its thermal capacity, the thawing medium (air or water) and its temperature and circulation, the size of the unit being thawed, etc. In situations where the thawing will take a long time, care should be taken to avoid surface temperature that will permit rapid microbial growth.
Although the microorganisms do not grow faster on thawed meat than on fresh meat, the product is very perishable as soon as the surface temperature goes 0°C (32°F). Therefore, frozen meat should not be thawed too long before cooking.
In refrozen thawed meat, there will be increased damage to the tissues, which will cause an increased drip loss, thus a loss of more water-soluble nutrients, and there will be some decrease in palatability.
Meat, which has a high pH prior to freezing, has a low drip when thawed.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Factors</th>
<th>Chilling</th>
<th>Freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Temperature</td>
<td>-1.1°C (30°F)</td>
<td>Much below -1.4°C (29.4°F)</td>
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<tr>
<td>2.</td>
<td>Durability</td>
<td>Less (35 days)</td>
<td>Beef-1 year, Mutton-9 months, Pork-6 months</td>
</tr>
<tr>
<td>3.</td>
<td>Bloom</td>
<td>Excellent</td>
<td>Lost</td>
</tr>
<tr>
<td>4.</td>
<td>Colour</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>5.</td>
<td>Kind</td>
<td>Only high grade meat alone can be used</td>
<td>Any kind of meat can be used.</td>
</tr>
</tbody>
</table>

**EFFECTS OF FREEZING ON MICRO-ORGANISMS AND PARASITES**

- Effect of freezing on the pathogenic microorganisms and parasites
- Freezing destroys some bacteria but in other, the temperature is merely inhibiting their growth and multiplication until conditions favorable to their growth appear.
- Freezing, is therefore of, no great value as a method of reducing carcasses affected with pathogenic bacteria safe for human consumption or bacteria commonly found on the beef carcasses destroyed by slow or short freezing.
- Anthrax bacilli can withstand at -130°C while organism of salmonella group can withstand at -175°C for 3 days.
- A tubercle bacillus is found viable for over 2 years in carcasses frozen at -10°C.
- The foot and mouth virus can remain viable for 76 days, if the carcasses of animals slaughtered during incubation period of the disease and chilled or frozen immediately afterwards.
- Under similar conditions swine fever virus remain infective in the bone marrow for at least 73 days and the virus has been shown to be viable in frozen pork for 1500 days.
- Freezing, however, is a 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.

**PRECAUTIONS FOR EFFICIENT CHILLING AND FREEZING OF MEAT**

- The following precautions must be adopted to ensure chilling and freezing is efficient and delivers a consistently excellent product:
  - Initial design of refrigeration space should take into consideration – product tenderness, weight loss, possibility of spoilage, size of individual units, space required, rail height, wall and floor surfaces.
  - Temperature and relative humidity must be maintained at recommended levels constantly, and must be monitored regularly.
  - Overloading must be avoided and carcasses must not touch each other.
  - Door opening and closing must be kept to a minimum and access must be restricted to authorised personnel only.
  - Adequate air flow around carcasses is essential.
  - Carcasses of different species must not occupy the same area.
  - Drip pans must be placed under carcasses and meat.
  - Cold shortening must be avoided by delaying chilling to less than 10°C, 10 hours after slaughter.

**Preservation of Meat by High Temperature - Canning**

**CANNING (THERMAL PROCESSING OR THERMAL PRESERVATION)**

- Commercial canning is a method of food preservation in which, carefully selected and prepared foods contained in a permanently sealed containers are subjected to heat for a definite period of time and then cooled.
- 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.
- Canning has been in vogue for about 200 years now, since the French Biochemist, Nicholas Appert, in 1809 discovered the method of hermetically (without any hole) sealing glass jars filled with various foods, after heating it in a water bath, to overcome the problem of preservation of meat in the armed forces.
- In 1810, an English man, Peter Durrand, conceived and patented the idea of using tin cans instead of glass containers.
- William Underwood followed it in 1817.
- Boston and Thomas Kensette began using tins as cans in 1819 in New York.
- Further, many more advances have been made in canning.
Canned meat products

Recent developments in canning include:

- **Aseptic Canning**
  - Recently a new method of canning, known as aseptic canning, has been developed, which involves the use of high temperature for shorter duration.
  - The food is sterilized at 120°C for 6 sec to 6 min, depending on the food, before it enters a sterilized can, which is then closed with a sterilized lid.
  - This method is said to improve the flavour and the vitamin content.

- **Aluminium Cans**
  - More recently aluminium or coated aluminium has been used in the fabrication of cans.
  - While it has the advantage of lightness and freedom from sulphiding and rust, it buckles fairly easily.

**Efforts are being made to produce an alloy strong enough to withstand the stresses of processing, packaging and transport.**

**Retort Processing**

- Flexible pouches made from laminates of thermoplastic and aluminium foil are widely used in Japan and are now being adopted in Europe and the United States.
- They will not, however, withstand the high internal pressure developed during processing and must therefore be sterilized in media (water or steam and air) capable of providing an external pressure sufficient to balance the internal one.

**Developments in modes of sterilisation**

- For the thermal processing of the open or sanitary can, flame sterilization, e.g. the Tarax flame sterilizer developed in Australia, combined with rotation of the can, is now used for certain products. This system has the advantage of being relatively cheap and is capable of providing very efficient heat transfer in those products with some liquid.
- Future forms of thermal processing may involve the use of microwave energy, hydrostatic sterilizers using high-efficiency steam and fluidized-bed systems.

**Thermal Destruction of Micro-organisms**

- The effect of canning is destruction of spoilage organisms and both temperature employed and length of heating time determine the efficacy of the thermal process employed in killing spoilage organisms.
- When bacteria in a suspension are exposed to heat, the number of remaining alive follows a logarithmic course (survivor or thermal death rate curve) against the length of heating time at a constant temperature. Some of the important concepts in thermal destruction of micro-organisms is listed below.
- The decimal reduction time (D value) is the time taken at a constant temperature to reduce the surviving bacteria in a suspension to 10% of their original number (or) in other words to destroy 90% of the surviving organisms.
- Total sterility is never achieved and the effect of any thermal processing is measured against the activity of the spores of *Cl. botulinum*, the most heat resistant pathogenic form known.
- In modern canning operation there must be sufficient heat process equal to 12 times the D (decimal reduction time) of *Cl. botulinum* spores.
- By a factor of $10^{12}$ i.e. a heat process equal to 12 times the D (decimal reduction time) of *Cl. botulinum* spores.
- Foods with a pH of less than 4.5, in which *Cl. botulinum* spores do not germinate, may be subjected to milder heat treatments.
- $Z$ value refers to the degrees Fahrenheit required for the thermal destruction curve to traverse one log cycle. This may be used to determine equivalent thermal processes at different temperatures.
- If, for example, 3.5 minutes at 140°F is considered an adequate process and $z = 8$, either 0.35 minutes at 148°F or 35 minutes or 35 minutes at 132°F would be considered as an equivalent process.
• **F value** refers to the equivalent time, in minutes, at 250°F of all heat considered with respect to its capacity to destroy spores or vegetative cells of a particular organism.

### CANS - TYPES OF CANS

- **As a food containers, the metal can possesses certain virtues possessed by no other type of containers for heat processed foods, viz.,**
  - It has a high conductivity, which is of importance during processing.
  - It cannot be easily broken.
  - Being opaque, any possible deleterious effects of light on the foodstuffs are avoided.
- Although, the term ‘can’ is applied to modern containers, this is somewhat of a misnomer, as they are constructed of mild steel with a thin coating of pure tin.
- The actual amount of tin being only about 1.5 % of can’s weight. It is important that the tin used should not contain more than 1% of lead.
- Coating of steel plate is necessary to prevent corrosion for steel is an unstable compound and in some foodstuffs, such as fish or fruit. The tin plate is protected by a fish or fruit lacquers.
- Unsightly staining of surface of certain foodstuffs known as sulphiding may also occur and is avoided by use of a phenolic meat lacquer or a sulphur resistant lacquer.
- An alternative method of avoiding sulphiding is now being extensively employed for meat pack and consist of chemical treatment of the inside of the can to form an invisible protecting film a solution used being a strong alkali bath containing phosphate and chromates.
- The design of cans and the techniques of can manufacture are being constantly researched on and developments are constant in this industry.
- Two of the most important advances achieved by these research activities is the great reduction of metal in the cans and the replacement of soldering, which involved use of lead by electrical welding.

#### Types of Can

- Three types of cans are mainly in vogue currently and they are the three piece food can, two piece drawn and wall ironed can and drawn and redrawn can.

##### Three Piece Food Can

- Tinplated steel, coated with lacquer, so as to prevent contact between the tinplate and the food to be canned, and dried in ovens for 15-20 minutes is cut into strips of specific lengths and widths as per the size of the cans desired.
- Such individual strips are then rolled into cylinders and the two edges of the cylinder drawn with an overlap, which is electrically welded.
- At this stage the cylinders are further given a coating of lacquer on the seams and dried in ovens.
- A lip is next formed on each end of the of the cylinder.
- Separate ends (lids and bases) are made in a different area and the rims of these ends are curled and a sealing compound is injected into the curl.
- The base is next joined to the cylinder body, the sealing compound forming an airtight seal.
- The cans, with the separate lids are ready for use.

##### Two Piece Drawn and Wall Ironed Can

- These cans consists of two pieces of tinplate, the body and base being formed from one piece of metal and the lid from another.
- The body and base are shaped from a thick piece of tinplate which is drawn up, ironed and ridged for strength and then given a coat of lacquer.

##### Drawn and Redrawn Can

- Drawn and redrawn cans are manufactured from two pieces of tinplate, the body being made from a disc shaped piece lacquered on both sides and drawn up to form a shallow cup and then drawn and redrawn to form a deep cup.

### OUTLINE OF CANNING OPERATION

#### Preparation of the raw material (meat)

- The handling of meat prior to heat treatment is very important.
- Meat should be handled hygienically and under strict temperature control so that contamination is avoided and the multiplication of microbes is prevented.
- The long-term storage of meat intended for canning should be preserved under a temperature of −12°C to −18°C.
- A variety of processes like grinding, trimming, cutting, washing, canning, mincing, dicing, addition of emulsifiers, binders and other supplements should be carried effectively and rapidly.
- Meat should be thawed in special thawing rooms or in chillers.
- The meat and its offal intended for pet food manufacture are not thawed but minced and diced in frozen state.

By- Manuprabh, Naveen, Pradeep
Most canned meat products are salted because it does reduces the heat resistance of bacterial spores and thereby reduces the cooking time also.

**Precooking / Blanching**
- Products like meat is precooked whereas, vegetables and fruits are scalded or blanched in hot water at a temperature of 87°C to 95°C or exposed to steam.
- Blanching is done to
  - Remove the respiratory gases, which would reduce vacuum in the can.
  - Inhibit the enzymatic action, which can reduce quality and nutritive value of meat.
  - Cause shrinkage of the product.
  - To clean the product.

**Filling of cans**
- Filling of cans is the critical part of the canning operation, which can be done mechanically or by hand, which should be done carefully.
- There are two types of can filling.
  - Hand filling
  - Mechanical filling (Machines)
- Hand filling is generally employed depending on the size or configuration of the product.
- Products, which are susceptible for damage during mechanical filling, are subjected for hand filling.
- Mechanical filling can be done by a wide variety of semi or fully automatic mechanical fillers.
- In mechanical filling mostly comminuted products and products which have fine particle size are filled in.
- The steps in canning operations are as following

**Exhausting**
- The exhaustion is done by removal of air from the can before it is sealed.
- Exhaustion is necessary because
  - Can sealed without previous exhausting may show such expansion of the contents during possessing as to force the seams and produce a ‘Leaker’
  - It produces a concavity of the ends of the tins. So that, any internal pressure may be readily detected and the can rejected.
  - It lowers the amount of oxygen in the can and prevents discoloration of the surface of the food and corrosion of the can.
  - In fruits packs, it reduces the chemical action between the food products and the container thus, largely eliminate “Hydrogen Swell”.
  - Although the production of a vacuum, probably has very little effect on microorganism. Experience has showed that, tin containing a vacuum keep better than those from which the air has not been exhausted.
- Exhaustion of a can may be carried out in three ways, such as
  - Heat exhausting
    - The contents of the can are filled cold, which is then passed through steam produce in a exhaust chamber and heated immediately before sealing.
    - The effect is to release air or gas trapped in the product.
  - Vacuumizing or Mechanical Exhaust
    - The cold material is filled in to the can, and then closed in a vacuum-closing machine, the can being subjected to a high vacuum during the seaming operation.
  - Steam Injection
    - This method involves injecting a blast of steam into the headspace as lid of the can is being positioned.

**Sealing or seaming of the container (closure)**
- The sealing of can after evacuation is achieved by curling the edge of the lid over the can.
- The sealing material often a synthetic rubber compound must retain its resilience over a temperature range from below room temperature to above 130°C.
- Sealing is done by a double seamer and the sealing operation takes about one second.
- There are two seaming operations.
- First is seam operation and the other is the hermetic seal operation.

**Thermal Processing / Sterilization**
- After exhausting and closing the cans must be heated for an accurately predetermined time and temperature in an atmosphere of saturated steam in heated water or occasionally in an air steam mixture.
- Food to be canned is threatened on one hand by spoilage due to bacteria and on the other by damage of overheating.
The canner, therefore, choose a middle course, the minimum heat employed in processing being controlled by the nature of food in the can and types and number of bacteria likely to be present. During processing, heat penetrates to the center of the can by conduction and by convection currents. In the solid meat pack the diffusion of heat is brought about by conduction and the process is therefore slow. Solid loosely packed in a liquid will, therefore, heat more rapidly due to convection current than those, which are tightly packed. pH or the acidity of the food contents also has an important bearing on the temperature required for processing. Acid foods, which include the common fruits, are easily processed. The temperature must be sufficient to kill yeast, moulds and certain bacteria capable of growing in the acid medium. In non-acid foods, such as meat, the destruction of the bacterial spores is slow and these foods require temperature of 115°C with sufficient time (45 minutes). A serious problem associated with conduction heating is time. When small volume of product at the can center is sterilized, the peripheral portions are severely over cooked. To avoid this agitation during cooking and the presence of headspace not only minimizes the uneven treatment but effectively the temperature and time required for safe processing. Rotational end-over-end or axial movement of the retorts (cookers) achieves the agitation. Canning in smaller retorts is called batch method. The sealed cans usually not more than a few thousand per batch are manually loaded into the retort on trays or in metal baskets. The cooking takes place under steam pressure.

Cooling
Prompt cooling after processing is important and it checks the action of heat on the food and prevents any change in texture and colour. In addition, a marked internal pressure exists in the can when it is removed from steam pressure retort and rapid reduction of this internal pressure is ensued by prompt cooling of the cans. Cooling is done either by placing the can under showers (Spray) of cold water or by immersing then in a cold-water tank. Cooling can also be done by pressure cooling in the retort when the processing is completed. The cans should be cooled to an average temperature of 37°C. At all times cooling water should be potable and bacteriologically clean.

Can washing
Can which has been just cooled are dirty and greasy on the outside and are therefore passed through a detergent bath to facilitate subsequent handling, lacquering and labeling. This bath is usually composed of soap or sulphonated fatty alcohol.

Outside lacquering, labelling and storage
Commercial lacquer or enamel is a coloured varnish containing vegetable resins or synthetic resins. Tins after removal from the detergent bath are washed and lacquer may be applied to the outside of the tin to prevent external corrosion, particularly when the cans are estimated for moisture.

Spoilages of canned foods - Distortion of cans
Canned goods are classified as spoiled when the food has undergone a deleterious change or when the condition of the container renders such change possible. Spoilage may be due to variety of causes, and spoiled cans may usually show obvious of abnormalities such as distortion, blowing, concave ends or slightly constricted sides; or they may present a perfectly normal external appearance. The various distortions commonly encountered are:

Swell or blower
A can with it ends bulged by positive internal pressure due to gas generated by microbial or chemical activity is termed as swell or blower.

Flipper
A flipper is a can of normal appearance in which one end flips out when the can is struck against a solid object but the end snaps back to the normal when very slight pressure is applied.

Springer
A springer is the term used to describe a can in which one end is bulged but can be forced back into normal position, where upon the opposite end bulges.

Leaker

By- Manuprabh, Naveen, Pradeep
• A leaker is a can containing a perforation from any cause whereby atmospheric air may enter the can or its contents escape.
• May be detected by disappearance of vacuum from the sides and ends of the cans and the bubbles that appear from the can when held under water and squeezed.
• Another test for leakage is to heat the can until the temperature is $38^\circ C$ in the interior and allowing it to cool slowly. When if a leak is present, there will be no concavity of the sides or ends.
• The commonest leaking is at the seams, and may sometimes be detected by the appearance of liquid or stain on the can surface.
• Mould formation on the surface of canned meat is also indicative of leakage through the seams but cannot be detected until the can is opened.
• The detection of leakers by striking the suspect tin with a mallet has little value in industrial practice.

**Over filled can**

• An overfilled can is one in which the ends are convex due to overfilling.
• Though an overfilled can, cannot properly be regarded as a spoiled can, it must be differentiated from a blower, and it emits a dull sound when struck, where as a blown tin emits a resonant sound.

**Slack caps**

• The term slack cap is used in the trade to denote a can, which has a movement of one of the ends similar to a can in the early stages of blowing, and the great majority of can classed as slack caps are blown and should be treated as such.
• Blower and slack caps should be condemned.

### BACTERIA IN CANNED FOODS

- It was at one time thought that, the keeping quality of canned foods depend upon the complete exhaustion of air.
- Later, it was suggested that, heating destroy all microorganisms, while the sealing of the can prevented entry of others and the decomposition when it occurred was due to faulty sterilization or to entry of bacteria to the fault in the cans.
- Neither of these views expresses the whole truth because, living bacteria can after found in the sound and wholesome food.
- Bacteriological methods show that many canned meat or meat products contain living organisms even after modern processing methods.
- The mere presence of living organisms is of little or no significance in assessing the soundness of canned goods.
- The organism responsible for spoilage in canned foods may be spore-forming organisms and therefore, resistant to commercial processing, or they may be a non-sporing organism, which gains access to the cans by leakages after processing.
- Presence of yeasts, moulds or non-sporing bacteria in canned meat foods is evidence of the leakage after after csealing lean and can make the food unsound.
- Canned goods which, on opening show such evidence should be condemned.

### FACTORS AFFECTING MICROBIAL SPOILAGE

**Microbial spoilage**

- Type of microorganisms
  - Bacteria of decomposing of fermenting type are the most important, while the store forming bacteria are the most resistant.
  - These are three main types of spore forming organism, which can resist normal processing and may cause spoilage in canned foods, viz.,
    - *Gas producing anaerobic organisms* growing at an optimum temperature of $55^\circ C$.
    - *Gas producing anaerobic and aerobic organisms* with an optimum temperature growth of $37^\circ C$.
    - Both of the above types are associated with the form of spoilage recognized by blowing or swell.
    - *Non-gas producing aerobic or facultative anaerobic spore-forming organisms* with an optimum growth temperature of about $55^\circ C$, which produce 'flat sours'.

The factors determining microbial, unsoundness in canned goods are

- The number of microorganisms present
  - Processing is not a substitute for cleanliness and it is recognized by canners that, a small number of bacteria are likely to be destroyed more easily by processing than, are a large numbers.

By- Manuprabh, Naveen, Pradeep
• Efficiency of processing
  o Insufficient processing must be regarded as a cause of unsoundness of canned foods, though not the all-important factor as generally assumed.
• Access of the air to the can
  o The bacteria found in the canned meat are nearly always secondary invaders gaining access to the food through a leaking tin.
  o Microbial spoilage may thus result from under-processing or leakage through the tin.

**FLAT SOURING**

• The flat souring in canned goods is manifested by the presence of a sour odour of foodstuffs, but without the can becoming blown.
• Canned foods susceptible to this deleterious change are those containing sugar or starches, and meat products such as sausages or paste containing cereals.
  o True flat sours are commonly caused by the growth of thermophilic organisms (B.coagulans, B.stearothermophilus, B.circulans), which attack carbohydrates with production of acid but not gas.
  o The exceptional heat resistance of such organisms makes them to survive the normal processing given to the canned foods.
  o Sourness in canned foods may also arise due to leaking cans or it may have developed in the food before processing.
  o The latter forms of spoilage is the most liable to occur in cold-filled pack in warm weather, and its incidence is greatly increased by allowing the product to be stored in open for even short period prior to processing.
  o In corned beef, the presence of souring without gas production may be due to under-processing or leaking seams, but the development of pre-processing storage is also likely to be the cause.
• Flat sours of canned foods due to thermophilic spore forming organisms can not be detected until the can is opened and its content examined, but is unlikely to occur in temperate climates but its occurrence is common in tropical and sub-tropical countries or when cans imported to temperate climate from hot climates.

**CHEMICAL SPOILAGE - HYDROGEN SWELL**

• The most important problems encountered in the canning industry owing to spoilage on account of chemical changes are Hydrogen Swelling, Purple Staining and Rust or Damage.

**Hydrogen Swell**

• Hydrogen swell happens independent of microbial spoilage, and is associated with the formation of hydrogen gas in the can following internal corrosion.
• Imperfection or scratches on the inner coating may expose small areas of steel and when the contents are acid, an electric couple may result, the reaction producing hydrogen gas.
• Electrolytic action is accelerated by the presence of atmospheric oxygen and by the colouring matter – anthocyanine of the red fruits.
• Lacquering of can also increases the rate at which hydrogen swells are formed.
• For cracks inner lining of the lacquer serves to concentrate electrolytic action on the areas of iron exposed by the cracks.
• Can affected with hydrogen swell may show varying degrees of bulging from flipping to blowing and if the tin being punctured, there is emission of hydrogen gas, which is odorless and burns on the application of a flame
• This condition is chiefly associated with food containing organic acids particularly fruits such as plums, cherries, raspberries, etc.
• The range of acidity most favorable to the production of hydrogen swells lies between pH 3.5 and 4.5.
• This condition is unknown in canned meat foods, but it is sometimes seen in sardines.
• Judgement
  o Though the content of the can in hydrogen swell may be quite harmless, the routine methods employed in the examination of canned goods render it impossible to distinguish between the tins which are blown due to hydrogen swell and those which are blown as a result of deleterious changes due to bacteria or yeasts.
  o So, all blown tins, leakers, springers and flat-sours together with tins whose contents show evidence of mould must be regarded as unfit for food, hence, should be condemned.

**SULPHIDING**

• Purple staining on the inner surface of the cans in which sulphur-containing foods are packed may occur with all fish and meat products, especially, liver, kidneys and tongue.
• It is due to the breaking down of sulphur containing proteins at a high processing temperature with a result that, hydrogen sulphide is liberated and a thin layer of tin sulphide is formed on the inside of the can.
• This discoloration, which does not involve foodstuffs itself and varies from a light pink to a dark purple but a blackening of both inside of the can and the surface of the foodstuffs may accompany it.
• These latter changes are due to attack of hydrogen sulphide on the steel base with a formation of iron sulphide.
• It is of more serious impart than the deposition of tin sulphide as it may lead to pitting of the steel and disfigurement of the surface of the meat pack.

By- Manuprabh, Naveen, Pradeep
Prevention or Treatment of the Can
- The basis of which is, copal gum, dissolved in a suitable solvent to which an added substance capable of uniting with volatile “sulphur” gases released while the food is being processed.

Judgement
- Purple staining of the inside of the can is of no significance, while blackening of surface of the foodstuffs may be removed by trimming.

<table>
<thead>
<tr>
<th>RUST OR DAMAGE</th>
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</thead>
<tbody>
<tr>
<td>Rust</td>
</tr>
<tr>
<td>Can showing external rust require careful consideration and it is conditions particularly liable to occur beneath can labels, when the adhesive contains hygroscopic substances.</td>
</tr>
<tr>
<td>Judgement</td>
</tr>
<tr>
<td>Can in which the external surface rusted without noticeable pitting of iron may be released for immediate sale and consumption.</td>
</tr>
<tr>
<td>But if the rust is removed with a knife and inspection with a hand lens reveals the iron plate to be definitely pitted, there is dangerous of early perforation and the can should be condemned.</td>
</tr>
<tr>
<td>Minute perforations of the plate to spoilage of the can content.</td>
</tr>
<tr>
<td>Pin holing may originate from the outside but also from the inside of the can where the tin plating is imperfect or has been fractured during seaming, and in this case lacquers lining aggravates the trouble, as the cracks which occur in the lacquer aids in concentrating the chemical action on a small area.</td>
</tr>
<tr>
<td>A can, which is a leaker or pin holed, may occasionally seal itself by blocking of holes with the contained foodstuffs, and may then proceed to blow up.</td>
</tr>
<tr>
<td>Such self-sealing can may blow early in its life, generally within the first few months.</td>
</tr>
<tr>
<td>Unfilled cans</td>
</tr>
<tr>
<td>Where unfilled cans are stored and allowed to rust internally before being filled, the can edges may become rusted, with the result that during processing a chemical action may take place between the rust and meat juices and give rise to an unsightly grey precipitate of iron phosphate in the meat jelly.</td>
</tr>
<tr>
<td>Damage</td>
</tr>
<tr>
<td>Considerable significance should be attached to cans damaged by rough handling, the important factor in their judgement being, the extent and location of the damage.</td>
</tr>
<tr>
<td>Judgement</td>
</tr>
<tr>
<td>Can showing seam damage should be condemned.</td>
</tr>
<tr>
<td>Slight indentations on the can body are permissible, but severe dents on the body may cause seam distention with danger of leakage and such can should be rejected.</td>
</tr>
<tr>
<td>Any can having a dent at one end should also be rejected for it is possible to reduce a springer to normal, at any rate temporarily, by hitting it upon the corner of a box.</td>
</tr>
<tr>
<td>Nail holes in cans cause during closing of packaging cases may also be encountered, and such cans should be rejected even if the contained foodstuffs appear perfectly normal.</td>
</tr>
<tr>
<td>It is a wise action to reject any can which is in the least suspicious or which shows lack of concavity of the end.</td>
</tr>
</tbody>
</table>

THE PUBLIC HEALTH ASPECT OF CANNED FOODS
- Improvements in canning industry during recent years, together with greater appreciation of its hygienic requirements, have done much to remove the prejudice in the minds of lay public against canned foods based on the opposition that canned foods might cause Food poisoning.
- Food poisoning is usually the result of improper handling of food during preparation or storage, and, with the exception of botulism, food poisoning outbreaks are always caused by bacteria which would be destroyed during processing.
- Botulism is caused by the botulinal toxin produced by Clostridium botulinum (or Cl. botulinum) an obligate anaerobe which is ubiquitous, being found in the air, soil, waters, intestinal tracts of fish and mammals, and gills and viscera of crabs and other shellfish.
- Clostridium botulinum grows well in low-acid foods such as canned vegetables, processed meats, sausages, smoked fish, and other seafood products.
- There are seven known types of Clostridium botulinum bacteria. These differ in such characteristics as proteolytic activity, tolerance to salt and reduced water activity, minimum growth temperature and resistance to destruction by heat.
- The nonproteolytic type B, E and F strains can grow at refrigerated temperatures, but produce spores of very low heat resistance. These types cause problems primarily in pasteurized or unheated foods. Because they are nonproteolytic, no off-odor or evidence of spoilage may be produced with toxin development
- Type C strains cause botulism in birds, turtles, cattle, sheep and horses.
- Type D is associated with forage poisoning of cattle and sheep in Australia and South Africa.
- No outbreaks of type G have been reported; however, type G has been isolated in cases of sudden and unexpected death in humans.

By- Manuprabh, Naveen, Pradeep
Inactive Clostridium botulinum spores are found in soil and water throughout the world. It is comparatively harmless in the spore form.

A lower processing temperature is however permissible in the case of a few special packs such as cured meats, in which the curing salts have an inhibitory effect on the growth of organisms and the production of its toxins.

In Britain, there is no record that canned foods have been incriminated in outbreaks of botulism.

Staphylococci and more rarely streptococci are now recognized as a cause of food poisoning and the majority of foods in which pathogenic staphylococci have been concerned were prepared or unheated foods such as cheese, salad, milk or ice cream.

These organisms are ubiquitous in nature being found in air, water, milk and sausage but the main source is the human or animal body where they are normally present on the skin, in the intestines and in the respiratory tract.

Staphylococci, however, are relatively susceptible to heat and even the more resistant staphylococcal enterotoxin, which may withstand a temperature of 100°C for 30 minutes, would be destroyed during commercial processing.

Cans may occasionally become infected if these organisms gain entrance through a leaking can and in absence of accompanying gas-forming bacteria, the can will not blow. While its contents, though, they appear normal may contain large amount of the organisms and its toxins.

Most cases of food poisoning now associated with canned foods are the result of contamination of food stuffs after the can is opened, but a number of cases of typhoid fever associated with canned foods have occurred in Britain in recent years.

The outbreak in Aberdeen in 1964 in which there were over 400 confirmed cases attributed to the entry during the whole processing period of contaminated cooling water into a 6 lbs of tin of corned beef of South American origin.

Viewing the question as a whole, it may be stated definitely that canned foods are considerably less likely to be a source of food poisoning than are ordinary fresh foods.

The possibility of canned foods being rendered dangerous by secondary contaminated with pathogenic bacteria also raises the question of the wisdom or otherwise of leaving food in a can after it has been opened.

So, from the public health point, there is no reason, why an open can properly stored, should not be used as a food container, the only requirement being that it should be kept covered to prevent contamination and that can and its content should be kept cool. But it is the sporulated Cl. botulinum that is able to resist high temperatures and survive a wide range of unfavorable living conditions, such as extreme cold, 5–10 hours in boiling water, and the presence of chemicals. Cl. botulinum reverts to its vegetative form once conditions become favorable and reproduces like other bacteria. Fortunately, botulinic toxin is not heat resistant like the spore form. It can be inactivated by boiling temperatures of 212 ° F (100 ° C) for at least 10 minutes. The salmonella groups of organism are destroyed with certainty by the temperature attained in commercial processing. The minimum standard of processing now universally recognized by reputable canners ensures the destruction of Cl.botulinum spores in low acid and medium acid foods.

**MICROBIAL EXAMINATION OF CANNED MEATS**

In case of suspected outbreaks of food poisoning of canned foods the normal laboratory procedures for isolation of the responsible organism (Salmonella, Staphylococcus, Clostridium, etc) are to be adopted and care to be taken in sampling, transport, etc., of the suspected food.

Where it is desired to control the safety and stability of large consignments of hermetically sealed containers of meat products, attention is directed to the standards of methods used at the point of production, viz., hygiene levels, temperature for heat treatment, water supply, etc., information on microbiological tests to detect botulism.

Examination of the quality of containers is important to ensure that there are no damaged, rusty, blown, etc., cans.

If the meat products in hermetically sealed containers is unsatisfactory and hence a reason for suspicion on the consignment sampling and inspection procedures should be adopted along the lines recommended by the Codex Alimentarius Commission (1983).

The number of samples to be taken is assessed according to the expected hazard and the laboratory facilities available in the case of shelf-stable canned products.

For non-shelf-stable products five containers are examined visually and their contents examined microbiologically.

Both aerobic and anaerobic techniques are undertaken, decisions as to rejection or approval being based on bacterial plate counts (Sampling and Inspection Procedures for Microbiological Examination of Meat Products in Hermetically Sealed Containers, Codex Alimentarius Commission of FAO/WHO 1983).

**Preservation of Meat by Direct Microbial Inhibition**

**PRESERVATION BY USE OF ANTIBIOTICS**

The antibiotics when used in the required concentration impart no flavour or odour to the meat and do not discolor the product, while most of them are considered relatively harmless to humans.

Broad-spectrum antibiotics such as Chlorotetracycline, Oxytetracycline and Chloramphenicol are commonly used.
Infusion of beef carcasses with tetracycline antibiotics seems to have improved their keeping quality and retarded internal spoilage.

Antibiotics can also be injected into the living animal just prior to slaughter.

Administration may either intravenously or intraperitoneally of the animal.

But, the intraperitoneal is commercially impossible (impracticable) because of the time factor, which cannot be easily offered in commercial slaughter practice.

It is, however, a procedure, which could be adopted in countries lacking refrigeration and thus making possible for the meat to be distributed to a much wider area than at present.

These antibiotics are also used in the preservation of foods such as poultry and fish also.

The antibiotics are added to water in a proportion of 5 to 40 ppm and poultry dipped into treated water for chilling.

Alternatively, the antibiotics are added to ice in amounts of 2 to 5 ppm.

Chicken is soaked in this ice and water. Such methods have been seen to increase the shelf life of the foods considerably.

An important objection to inclusion of antibiotics in meat is that, it will create antibiotic resistant strains of pathogenic bacteria.

Yet, another objection is that, the antibiotics are ineffective against yeast and moulds.

There is also the danger that, producer, may be tempted to supplement good ideal practice under antibiotic cover.

Chloramphenicol and Streptomycin are somewhat toxic.

Penicillin produces hypersensitivity.

Streptomycin, polymixin and subtilin have limited anti-bacterial spectra.

Antibiotics should not be used to replace good hygiene, but when employed such that all the above dangers are avoided, and in conjunction with mild refrigeration or pasteurising doses of irradiation they afford a means of preservation without materially altering the product.

However, preservation of foods using antibiotics has been banned in many countries due to public health concern.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Name of antibiotic</th>
<th>Active against</th>
<th>Effective pH range</th>
<th>Stability</th>
</tr>
</thead>
</table>
| 1     | Chlortetracycline -                | Gram + ve and – ve   | 4 to 7             | • 2 Weeks at pH at 4°C.  
• Rapid deterioration over pH 7 |
| 2     | Oxytetracycline -                 | -do-                | -do-               | • One month at pH 3.9 at 5°C.  
• Rapid deterioration above pH 7.0 unless refrigerated. |
| 3     | Penicilllin                        | Gram + ve only.     | 5 to 7             | • 2 days at pH 6.0 at 10°C.  
• Rapid deterioration below pH 5.0 or above 7.0. |
| 4     | Streptomyacin and dihydrostreptomy | Gram – ve only.     | 7 to 9             | • 2 to 3 months at pH 4 to 7 at below 7°C. |
| 5     | Polymixin                          | Gram –ve only       | 4 to 8             | • 2 months at pH 6.0. |

**RADIATION PRESERVATION OF MEAT**

Food and meat may be preserved by the application of radiation, either ionising or non-ionising, and such food is referred to as irradiated food.

Ionising radiation is defined as radiation having energy sufficient to cause loss of electrons from atoms to produce ions.

Non-ionising radiation is defined as radiation not having sufficient energy to cause loss of electrons from atoms to produce ions.

**Ionising radiations**

Ionising radiations include high speed electrons produced from a variety of electron generators such as cathode ray tubes, X-rays generated by electrons when they strike heavy metal, and electrons and gamma particles emitted from radio-isotopes such as cobalt 60, cesium 137.

Ionising radiation is capable of killing microorganism on meat without significantly raising the temperature, hence referred to as cold sterilisation.

The amount of radiation energy absorbed by meat is expressed in rads (or) gray which is equal to 100 rads.
• A mega rad is a million rads or 10,000 Gray or 10 kGy.
• A dosage of about 4.5 megarads or 45 kGy is considered to be capable of sterilising products to a state where they can be stored without refrigerated storage.
• Radiation preservation may be classified as Radappertisation, Radurization and Radicidation in the decreasing order of dosage.
• Radappertisation, which brings about sterility in meat, involves the application of radiation in the range of 20 to 30 kGy.
• Hence it is also referred to as radiation sterilisation.
• It is often associated with development of unpleasant odours, flavors and off colours.
• The odour that emanates has been likened to Wet Dog Hair odour.
• Beef is particularly liable to such changes while pork and poultry less so.
• Radurization is otherwise referred to as radiation pasteurisation, and this uses doses less than that required for sterilisation, typically in the range 1 to 10 kGy, as this dosage is sufficient to kill many spoilage organisms and thus can extend shelf life of meat under refrigeration significantly.
• Radicidation is a process in which doses less than 1kGy are employed to increase shelf life, prevent sprouting in vegetables and for rendering pork free of Trichinella spiralis.

Non-ionizing radiation
• Microwave and infrared rays have wavelength greater than visible lights are capable of generation of heat in the irradiated object and thus impart preservative effect, if any.
• Ultra violet rays when absorbed by microorganisms is lethal to them and thus germicidal.
  o It is used mainly in aging of meat.
  o Limitation of using ultra-violet rays are
    • Poor penetration, so can be used only for sterilising surfaces of carcasses and meat products.
    • Catalyzes many oxidative changes in the irradiated products. So, cause rancidity, discoloration and other type of oxidative deterioration and
    • Infra-red rays have been used to dry fruits and vegetables and for heat blanching in the same way as high frequency radiation.

CHEMICAL PRESERVATION
• When hygienic principles were little practical, and less understood, chemical preservatives were not infrequently used in food to offset what is now recognized as micro biologically dangerous action.
• Nevertheless, this remedy has drawbacks because chemical preservative may be non-specific protoplasmic poison and as undesirable for the consumer as for the microorganism against which they are directed; moreover their effect may be cumulative rather than immediate.
• Preservative means any substance, which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other deterioration of food or of masking any of the evidence putrefaction but does not include common salt, lecithins, sugars or tocopherols; nicotinic acid or its amide, vinegar or acetic acid, lactic acid, ascorbic acid, citric acid, malic acid, phosphoric acid, pyrophosphoric acid or tartaric acid or the calcium, sodium or potassium salts of them, glycerol, alcohol, or portable spirits, isopropyl alcohol, propylene glycol, monoacetin, diacetin, or triacetin, herbs, spices or their extracts, or essential oils when used for the purposes of flavouring.
• There are many chemicals, which prevent microbial growth in foods and act as preservatives. Several organic acids have been Generally Recognized As Safe (GRAS) for use as chemical preservatives.
• More recently, however, the addition of nicotinamide and ascorbic acid to meat, as colour preservative, was prohibited.
• Formaldehyde, as such, is also prohibited, since it is demonstrably toxic, but is permitted up to 5ppm.
• Fresh meat, when in the intact carcass, is not usually severely contaminated.
• On the other, in preparing products containing comminuted or minced meats, there is every possibility for massive bacterial contamination from the hands of operatives or from equipment.
• Hence, chemical preservatives were particularly employed in relation to meat.
• Very few chemicals are now permitted as preservatives and these only in minute quantities.
• Apart from nitrate, nitrite, sorbic, acid and tetracyclines, the U.K. preservatives in food regulations act, 1962 lists only seven, namely sulphur-di-oxide, propionic acid, benzoic acid, methyl-p-hydroxy-benzoate, ethyl-p-hydroxy-benzoate, diphenyl, O-phenylphenol and copper carbonate, of these seven, only sulphur di-oxide is permitted in meat preservation up to 450 ppm being in sausage and sausage meat.
• Its effect is antimicrobial, and at that permitted level it has no beneficial effect on meat colour, so that deception of the public on this basis not possible.
• Boric acid was also employed until relatively recently both in sausage meat and in curing; but its use in the U.K. was discontinued in the afore mentioned Act of 1928.
• Spices and essential oils are excluded from the U.K. preservatives in food regulations act, when used for flavoring purpose as per regulations.
• Various essential oils have preservation properties and have been used to extend the storage life of meat products.

By- Manuprabh, Naveen, Pradeep
These include eugenol in cloves and alkyl isothiocyanate in mustard seed and 0.3 percent of sage or rosemary was inhibitory and 0.5 percent bactericidal.

Carbon-di-oxide and ozone have been used to discourage the growth of surface microorganisms on beef carcasses during prolonged storage at chill temperatures.

Since, ozone leaves toxic residues in the meat, its use in the store can be dangerous for personnel and it accelerates the oxidation of fat and is more effective against air-borne microorganisms than against those on the meat.

Citrone, propionic acid, benzoic acid and their salts are effective mould inhibitors.

Acetic acid and lactic acid prevent bacterial growth.

Sorbate and benzoate are capable of arresting the growth of yeast in foods.

TYPES OF MEAT PRODUCTS

- Meat products may be classified based on the treatment applied to meat as
  - Comminuted Meat Products (Comminution)
  - Cured Meat Products (Curing)
  - Fermented Meat Products (Fermentation)
  - Dried Meat Products (Drying)
  - Smoked Meat Products (Smoking)
  - Enrobed Meat Products (Enrobing of the product with batter)
  - Barbecued/Grilled or Tandoor Products (Type of cooking)
- A meat product must have at least 50% of lean meat in it.

PRINCIPLES OF PROCESSING MEAT

- Four primary factors to be attended to in processing of meat
  - Moisture. The natural moisture content of the lean meat, and any liquids added in the recipe, should be retained to a consistent optimum extent during the manufacturing process - bearing in mind the interests of both yield and product quality, through the stages of distribution, storage and eventual cooking by the consumer.
  - Fat. The natural fat content of the meat and any extra fat which the product is designed to incorporate should similarly be retained to a maximum or optimum extent throughout.
  - Connective Tissue. Where the product contains any of the tougher connective tissues, there should be presented in some more acceptable form Cohesion.
  - The product should retain its physical integrity.

MODERN PROCESSING TECHNOLOGIES IN COMMINUTION OF MEAT

- Comminution of meat (less noble cuts), trimmings from noble cuts of meat, offals and fat result in the following useful effects:
  - Uniformity in size and shape, rendering them more attractive.
  - Breaking up of connective tissue making it less obtrusive
  - Mincing fat and meat together, so as to make large to moderate to large proportions of fat less obtrusive
  - Comminuted lean meat binds the whole mixture together especially in the presence of salt.
  - The texture and eating quality of the products are therefore superior to the raw materials used and are hence more desirable to consumers.
  - Comminuted meat products may be further classified as coarsely ground or finely ground meat products (emulsion based meat products).
  - The different technologies utilised in comminution of meat include Mincing, Milling Chopping, and Flaking.

Mincing

By- Manuprabh, Naveen, Pradeep
Mincing or grinding, the first step in development of comminuted meat products usually, is undertaken in a mincer, which consist of screw conveyor housed in a chamber, and a rotating inner plate of knives at one end of the conveyor.

Considerable pressure is put on the meat in the screw feed chamber. Tearing occurs between the screw flights and the chamber. Final comminution occurs when portions of the meat extruded through the rotating inner plate of knives are either passed on through holes in the fixed outer plate or sheared off as the holes pass out of register. Thus, there is great tearing, pressure and great shearing and the meat is not cut cleanly or finely. Connective tissue is fairly well divided in a sharp mincer, but may be troublesome in a blunt one. Minced meat can be used for development of coarse ground meat products, or may be further chopped in a bowl chopper to produce emulsion based meat products.

Milling
- A miller is used for milling of meat and a miller is very similar to meat mincer, except that:
- There is no feed screw; the plates are mounted horizontally and fed by the weight of material above.
- A rotating knife which moves at much higher speed;
- Some cutting or tearing action in the space between the plates as well as at the edges of the holes in them.
- There is finer comminution than in a mincer and the operation is much faster.
- The fineness of comminution and intimate mixing, when used with fatty materials, these machines may be referred to as emulsifiers.
- These are extremely suitable to manufacture patties.

Chopping
- Chopping is undertaken in chopper, which are of two types – Rotary Bowl Chopper and Stationary Chopper
- A rotary bowl chopper consists of three or more curved knives rotating at high speed in vertical plane close to the surface of a curved bowl which itself rotates slowly in a horizontal plane.
- In addition to the vigorous cutting action of the knives, the massaging effect of the side of the knives on the mass of chopped meat may be important.
- Satisfactory chopping temperatures range from -1 °C to +22 °C.
- Colder temperatures lead to damage to knives; while warmer temperatures lead to over chopping of fatty tissue and release of free fat.
- Advanced designs possess the property of chopping under vacuum.
- Chopping is finally undertaken to produce the emulsion to manufacture emulsion based meat products.
**Flaking**
- Flaking is undertaken either in an impeller flaker or a block flaker, and flaking is carried out cut slivers of meat of constant thickness and parallel sides.
- An impeller flaker consists of an impeller which propels the motion of the meat fed into the machine, to the sharp edges of knives arranged in a static ring.
- The thickness of the slivers can be adjusted by adjusting the ring of knives.
- Connective tissue is also cut clean.
- A block flaker is used to cut slivers of meat from frozen blocks.
- The flakes produced are coarse than that of an impeller flaker.
- A guillotine cuts flakes from the end of a frozen block.

**MODERN PROCESSING TECHNOLOGIES IN CURING OF MEAT**
- The various technologies involved in hastening the curing of meat by brine cure application is massaging, tumbling and mixing.

**Massaging**
- Massaging involves frictional energy resulting from meat pieces rubbing together.
- Meat massagers are vats that contain a mechanism for the slow stirring of meat pieces.
- The stirring arms or paddles are made to set at various configurations.
- This process is a gentler form of mechanical energy output and is very suitable for the production of whole muscled cured products.

**Tumbling**
- Tumbling is a more severe type of physical treatment.
- Tumbling involves the use of impact energy resulting from meat pieces falling and striking baffles or paddles contained in a rotating drum.
- Tumbling aids the extraction of proteins as in massaging, and thus enhances tenderness and juiciness.

**Mixing**
- Mixing imparts a rather vigorous mechanical energy to the product.
- Mixers possess some type of paddles or ribbons that rotate around a metal shaft.
- Short mixing times are usually the rule as they tend to tear up whole muscle products.
- It is most suitable to manufacture sausage type products.

**MODULE-8: FORMULATION AND DEVELOPMENT OF MEAT AND SEA FOOD PRODUCT**

**Learning objectives**
- This module will facilitate the learner to become conversant with development and formulation of meat products such as sausages, meat patties, meat balls, meat soup, meat kababs, meat pickles, tandoori chicken, and sea food products such as surumi and smoked fish.

**SAUSAGES**
- Sausage may be defined as a food consisting of a mixture of minced or chopped meat and cereal for binding purposes, seasoned and spiced with sage, pepper and other substances, and stuffed into casings.
- The origin of this popular form of meat food is difficult to trace but certainly it is over two thousand years.
- Sausage can trace its ancestry to the Latin word salsus, which means salted or literally, meat preserved by salting.
- Though sausages originated in the western world, these products acquired universal popularity due to variety and convenience to the consumers.
- Sausages are economical since; these are generally prepared from cheaper cuts of meat and by-products of meat industry.
### Classification of Sausage

<table>
<thead>
<tr>
<th>Classification</th>
<th>Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh sausages</td>
<td>• Fresh meats (chiefly pork); uncured, comminuted, seasoned and usually stuffed into casings; must be cooked fully before serving</td>
<td>• Fresh pork sausage, Bratwurst</td>
</tr>
<tr>
<td>Dry and semidry sausages</td>
<td>• Cured meats; fermented air-dried, may be smoked before drying; served cold.</td>
<td>• Genoa salami, Pepperoni, Lebanon bologna.</td>
</tr>
<tr>
<td>Cooked sausages</td>
<td>• Cured or uncured meats; comminuted, seasoned, stuffed into casings, cooked and sometimes smoked; usually served cold.</td>
<td>• Liver sausage, Summer sausage, Braunschweiger, Liver cheese.</td>
</tr>
<tr>
<td>Cooked, smoked sausages</td>
<td>• Cured meats; comminuted, seasoned, stuffed into casings, smoked and fully cooked; do not require further cooking, but some are heated for serving.</td>
<td>• Frankfurters, Bologna, Cotto salami.</td>
</tr>
<tr>
<td>Uncooked, smoked sausages</td>
<td>• Fresh meats; cured or uncured, stuffed, smoked, but not cooked; must be fully cooked before serving.</td>
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<tr>
<td>Cooked meat specialties</td>
<td>• Specially prepared meat products; cured or uncured meats, cooked but rarely smoked, often made in loaves, but generally sold in sliced, packaged form; usually served cold.</td>
<td>• Loaves, Head cheese, Scrapple</td>
</tr>
</tbody>
</table>

### Containers
- Casings serve the purpose of providing a container or the sausage material during the subsequent cooking and smoking procedures.
- Casings can be classified as one of the general types:
  - Natural
  - Artificial, and
  - Reconstituted collagen

### Sausage Ingredients

#### Raw Materials
- Excellent sausages can be made from various fresh trimmings and cuts that might ordinarily be underutilised.
- Materials such as cheek, jowl, head meat, pork fat and trimmings, which are seldom used freshly, make palatable sausages and are as good for this purpose as are any other cuts of meat.
- Other cuts from low quality carcasses may also be used.
- Only clean fresh or cured meats free from bones, tendons, and joints should be used.
- The skin should be removed from the pork.
- Meat by-products such as heart, liver, kidney, tongue and tripe obtained from beef, calves, sheep and hogs are used in many sausages.

#### Water
- Water is the most important non-meat ingredient and it should be permitted up to 3% for fresh sausages, luncheon meats and meat loaves.
- The final cooked sausage product should not exceed four times the protein content plus 10%.

#### Protein
- During preparation of sausage batters or emulsion, meat proteins serve two functions:
  - To encapsulate or emulsify fat, and
  - To bind water.
- If either of these is not accomplished properly, the sausage will be unstable and subject to breakdown during cooking.
- The fraction of muscle that contains salt-soluble myofibrillar (contractile) proteins is more important than the sarcoplasmic fraction, which contains water-soluble proteins.
- Approximately 55% of total muscle protein is myofibrillar, composed largely of myosin and actin.
- During the onset of rigor, myosin and actin are complexed to form actomyosin.
- The dissociated proteins are more extractable and have a greater ability to swell and bind water.
After the onset of rigor the swelling and extractability are influenced mainly by temperature and ultimate pH. The presence of excessive collagen in most sausage is undesirable and it is usually desirable for finished sausages to have no more than 25% of the total protein as collagen.

**Fat**
- Fat contributes greatly to palatability of sausages, but it is also the source of many processing problems.
- Tenderness and juiciness of cooked sausages are affected by their fat content.
- Fat is added to emulsions or batters primarily through inclusion of beef and pork trimmings in formulations.
- Since the pork fats are softer and melt at lower temperatures, they are easier to comminute than beef fats.
- During comminution, beef fats require higher temperatures than pork fats.
- Cooked sausages such as frankfurters, bologna and similar comminuted sausage products are limited by U.S. government regulation to a maximum of 30% fat.

**Non-meat ingredients**

**Salt**
- Salt is the most critical ingredient in sausage manufacturing.
- Without salt sausages cannot be made.
- Salt has 3 primary functions - preservation, flavour enhancement and protein extraction to create the product to bind.
- Most sausages have 2-3 % of added salt.

**Sugar**
- A variety of sugars are commonly used ranging from sucrose (cane or beet sugar C₁₂H₂₂O₁₁) to dextrose (corn sugar C₆H₁₂O₆), corn syrup, corn syrup solids, sorbitol are also used in later group.
- Sugars are used mostly as flavouring agents to counteract the salt flavour intensity and to provide food for microbial fermentation in fermented sausages.
- Most sugars, except sorbitol increase the browning of meat during cooking.
- Dextrose is usually added at the 0.5 to 1 per cent level (of the meat weight) for fermented sausages.

**Spices and flavourings**
- Spices are dried aromatic vegetable substances.
- The term may be applied to all dried plant products, which include herbs, aromatic seeds and dehydrated vegetables.
- Spices are liable to certain variations in flavour, strength and quality.
- Allspice, ginger, nutmeg and pepper are products of tropical plants.
- They may represent the root, bark, bud, flower or fruit.
- Spices are used either whole or in one of the following processed forms: (1) ground, (2) essential oils, or (3) oleoresins.
- The latter two must be classified as flavourings.
- Most spices are used in processed form.
- Whole peppercorns used in certain dry sausages are an example of a whole spice.
- Flavourings are spice extractives: essential oils or oleoresins.
- Extractives have the advantages of elimination of colour specks, freedom from bacteria, reduced shipping costs and less storage area.
- Herbs are leaves of plants grown in both temperate and tropical zones and are relatively low in total oil content while true spices are relatively high.
  - Marjoram, sage and thyme are examples of herbs.
  - Aromatic seeds are derived from plants cultivated in both temperate and tropical areas.
  - Anise, coriander, dill and mustard are examples of aromatic seeds.
  - Vegetables are used in the dehydrated form. Examples are garlic and onions.
  - Seasonings and flavourings are included in sausage emulsions or batters to add flavour to the product.
  - Examples of seasonings and flavourings are
  - Hydrolyzed plant proteins contribute a characteristic meaty flavour.
  - Black pepper, cloves, ginger, mace, rosemary, sage and thyme possess antioxidant properties.
  - Other flavour additives include smoke flavouring which is usually added as an oil or water solution of natural smoke and vinegar used in products like sulze or some pickled sausages. Both of these have definite bacteriostatic properties.

**Extenders and binders**
- These are called as nonmeat materials and also are less frequently referred to as fillers, emulsifiers or stabilizers.
- They are added to basic meat formulations for one or more of the following reasons:
To improve emulsion stability
- To improve cooking yields
- To improve slicing characteristics
- To improve flavour, and
- To reduce formulation costs.

- The use level is generally restricted to 3.5% with exception of soy protein isolate, which carries a 2% limit.
- Many extenders have an effect on colour, flavour and texture.
- Milk products are well accepted due to their positive flavour contribution.
- Nonfat dried milk, dried wheys, modified wheys and partially delactosed wheys are also available.
- Cereal extenders are mainly starch, bind water and impart a bland flavour.
- Soy proteins include grits or flour (50% protein), concentrate (79% protein) and isolate (90% protein).
- They may be available in a textured as well as a powder or ground form.
- Soy isolate is a good binder, functioning much like meat protein in an emulsion or batter.
- Among other extenders are mustard flour and deheated ground mustard, which may be used at levels up to 1%.
- Yeast proteins represent another group of extenders as do milk protein hydrolysates.
- Many of these can be classified as flavourings.
- Gelatin, while not specifically an extender, is used as a binder for some loaf type products.
- Gelatin varies in gel strength and clarity according to Bloom number.
- Fillers such as starch, cereals and wheat flour and corn meal are used occasionally to lower the cost and the shrinkage and to bind to the product.

Nitrite and Nitrate
- Sodium nitrite (NaNO₂) or potassium nitrite (KNO₂) is added directly to sausage batter.
- Nitrite has four functions in cured meat and sausage products:
  - To develop the characteristic pink colour
  - To provide bacteriostatic properties
  - To improve the flavour
  - To serve as a powerful antioxidant
- The bacteriostatic properties of nitrite are extremely important in the thermally processed, vacuum packaged products.
- Without nitrite the organism *Clostridium botulinum* will jeopardize the safety of these products, the bacteria that causes botulism.
- Nitrite prevents the outgrowth of *Clostridium botulinum* spores and subsequently the production of toxins.
- About 400 ppm of nitrite in the finished product is considered necessary for the formation of the cured colour.

Ascorbates and Erythrobates
- Ascorbates and Erythrobates are strong reducing agents that accelerate the conversion of metmyoglobin to myoglobin and nitric oxide.
- The vitamin ascorbic acid (C₆H₈O₆) derivatives are also known as cure accelerators, since they hasten the curing reaction.
- The use level is 7/8 oz per 100 lb of meat (approximately 550 ppm).

Antioxidants
- Antioxidants are added to the fresh and dry sausages to retard the development of oxidative rancidity.
- Oxidative rancidity develops in the unsaturated (double) carbon-carbon bonds in fatty acids present in meats.
- Salt, light, heating and freezing and traces of certain metals also increase oxidative rancidity.
- Grinding and chopping of meat for sausage production exposes more of the membrane fatty acids to oxidation.
- The most common antioxidant compounds used are BHA (Butylated hydroxy anisole), BHT (Butylated hydroxy toluene) and propyl gallate. They are added at 0.01 to 0.02% of fat content.

Phosphates
- Phosphates are added to improve the water binding capacity of meat and solubilize proteins and act as antioxidants and help protect and stabilize the flavour and colour of finished product.
- Through the use of phosphates, processors can attain a longer product shelf life and improve smokehouse yield.
- Phosphates are approved at a level not to exceed 0.5% in the finished product.
- The following phosphates are approved – Di-sodium phosphate, Sodium metaphosphate, Monosodium phosphate, Sodium poly phosphate, Sodium tricophosphate, Sodium pyrophosphate, Dipotassium phosphate and Potassium pyrophosphate.

Anti-microbial agents

By- Manuprabh, Naveen, Pradeep
In general these are not permitted in sausage products. But they are allowed as a surface application on dry sausage to retard mold growth. A 3.5% solution of propyl paraben or a 2.5% solution of potassium sorbate may be used for this purpose. Usually these are applied as a drip.

Monosodium glutamate (MSG)
- Monosodium glutamate is the sodium salt of glutamic acid, which is one of the common, naturally occurring, non essential amino acids found in protein.
- MSG brings out food tastes without contributing any noticeable odour or taste.

Sodium lactate
- Sodium lactate is the sodium salt of lactic acid.
- It naturally occurs in animals and humans.
- Sodium lactate improves product stability and improves shelf life because of its bacteriostatic effect.
- It is a colourless syrupy liquid.

### FORMULATION AND DEVELOPMENT OF SAUSAGE

Sausages are cured ground meat products (coarse of fine ground) and encased in a casing, traditionally made from the submucosal layer of sheep intestines, but currently in synthetic collagen casings.

#### The formula for a sausage
- Ratio of Lean meat to Offal Meat 7: 3
- The other ingredients are to be added in terms of % wt of meat (i.e 2% means - 2% of the weight of meat added)
  - Fat-10%
  - Salt-2.5%
  - Sodium or Potassium nitrite- 200 ppm
  - Pyrophosphates -0.3%
  - Spice mix -2%
  - Condiments - 4% (3% onions and 1% garlic)
  - Binder or extender - 10%
  - Added water, preferably as crushed ice. - 10%

#### Development of Sausage
- In case of coarse ground products mincing alone will do, but for emulsion based products, chopping has to be undertaken.
- The steps on development of an emulsion based product is discussed in this section. The same will not be repeated in the section on patties and meat balls, both of which are coarse ground products and hence can be formed into their respective shapes after grinding, prior to cooking.
  - Steps in processing
  - Steps in production of the emulsion

#### DEVELOPMENT OF SAUSAGE - STEPS IN PROCESSING
- Processing of sausages is a continuous sequence of events in which each step is an integral part of the whole.
- Thus it is not proper to consider any one step separately or to assign more importance to one step than to another.
- Mincing
  - It is advisable to cut the meat in small pieces, prior to mincing it.
  - Fat is also minced in this
  - Meat grinder with 1/8” plate and 5/8” plate are used for grinding the meat.
- Mixing

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This step may or may not be followed, but this increases uniformity.

The cylinders of fat and lean obtained by grinding are tumbled in a mixer to give a uniform distribution of fat and lean particles.

Mixing also aids in extracting and coating the fat and lean particles with salt soluble proteins.

**Chopping**

- A chopper is composed of a revolving metal bowl that contains the meat while the knife blades rotating on an axle cut through the revolving meat mass.
- The meat is first added followed by the salt, curing salts, phosphate and then the fat spice mix condiments and finally binder or filler is added and chopped together to produce a fine ground emulsion.
- The emulsion formed is not a true emulsion and is only a pseudo emulsion as fat and water are not in direct contact at all.
- Chopping results in extraction of muscle protein, especially myosin which serves as the dispersion matrix in which both fat and water of meat are dispersed on either side of the matrix.

The next two steps i.e stuffing in a casing and kinking and tying are unique to sausages alone.

**Stuffing**

- The sausage emulsion is also known as mix.
- Sausage dough or batter is transferred to stuffers for extruding into casings.
- At this point the size and shape of the product is determined.
- Natural casings (hog stomachs, beef bladders, or sheep intestines) or artificial casings (cellulose) may be used to package the meats.
- While making sausage one should be careful not to stuff the casings too tightly.
- Space is allowed for swelling during cooking otherwise, the casings may burst.
- There are three types of stuffing pumps.
  - Piston type recommended for coarse-ground sausages and those having fat chunks.
  - Screw type and
  - Rotary type used for small sausages.

**Linking and tying**

- After the emulsion is stuffed into casings, the encased mass is tied with thread or fastened with metal clips.
In case of small sausages such as frankfurters, stuffed casings are hoisted or drawn together to produce links either by hand or by mechanical devices.

In linking sausage, the casings are pressed together at appropriate intervals and twisted around once.

The direction of the twist is alternated, to allow the sausage to remain linked.

One should be careful not to break artificial casings while linking, tying and knotting the links with string.

- **Smoking and cooking**
  - The sausages are placed on smoke trees or trolleys with 12 to 18 sticks per tree.
  - The trees are transferred to the smoke house usually having an internal temperature of 15 to 20°C.
  - During cooking the temperature rises to 68 to 72°C.
  - The air velocity (4000 ft/min) in the smoke house influences the rate at which the sausages are cooked.
  - Humidity of 35-45% is required to transfer smoke through cellulose casings into the product.

- **Chilling**
  - After smoking and cooking, the product is showered with cold water and then chilled by refrigeration.
  - On large volume continuous operations, chilling is frequently done with a 6% brine solution by dipping or spraying.
  - The brine permits lower chill temperatures and rapid cooling of the product.

- **Peeling and packaging**
  - After properly chilling the product to an internal temperature of 1.5 to 4.5°C, the cellulose casings on frankfurters are removed.
  - This is known as peeling.
  - Peeling can be done by hand/machines.
  - Peeled frankfurters can be packed with general information for sale to the consumers.
  - Cleanliness cannot be overstressed in the making of sausage.
  - Sanitation of ingredients as well as utensils is essential for best results.
  - Sausage may be successfully stored in the freezer.
  - These products tend to lose flavour during freezer storage.
  - Therefore they should be used without long storage.

### STEPS IN PRODUCTION OF THE EMULSION

- Lean meat highest in myofibrillar proteins is used for the formation of emulsion by mincing in a bowl chopper.
- Salt is added to about 4 to 4.5% of the lean meat and chopping is initiated by keeping the temperatures below 3°C (37°F).
- Commercially cold water or chopped ice is often added during processing to keep the meat from heating while being chopped.
- Chopping continues to a final temperature of 13°C (55°F) to 18°C (64°F).
- If the chopping is done in high temperature, the emulsion may ‘break’ causing fat separation during the subsequent cooking step.
- In over chopping, fat particles are coated and the protein interface broken by further comminution.
- Once the emulsion is formed, the batter is at critical stage.
- Excessive physical handling, long holding times, etc., can reduce stability.
- The product should be stuffed into appropriate casing and moved to heat processing as soon as possible.
- Frankfurters
  - These are the most popular of all cooked and smoked sausages, representing 25% of all sausages sold.
  - The meat formulation for frankfurters usually is 40-60% beef and 40-60% pork.
  - Deviations from these limits are not uncommon where all meat by-products are used extensively or where all beef products are manufactured.
  - Bull meat, boneless chucks plates, hearts and trimmings are the most commonly used beef ingredients.
  - Pork trimmings containing various amounts of trimmable fat, and back fat and hearts compose the major pork ingredients.
  - Filler meats such as tongues, snouts, lips and other by-products may be used, but it is generally agreed that they should not exceed 20% of the meat formulation.
Frankfurters

- Salami
  - These are fresh emulsion type of pork sausages.
  - The batter is stuffed in broader casings, usually dried cattle oesophagus and hanged for 2 days at 4°C.
  - It is smoked and cooked simultaneously in India.
- Thuringer
  - This is a coarse ground, fermented, semi dry type sausage – also known as Thuringer Summer Sausages.
  - The pH of the sausage mix comes down to about 5.0 due to bacterial fermentation.
  - Dextrose serves as a substrate for fermentation.
  - Sausage mix prepared at 0°C is stuffed into casings and held in green or ripening room maintained at 25°C and 85-90% relative humidity until fermentation is complete (2-3 days).
  - These are smoked and cooked at 60-65°C.
  - The moisture content of finished product is nearly 50%.
- Dry sausages
  - These are coarse ground, fermented sausages, e.g. Pepperoni.
  - Sausage mix is stuffed into 40-44 mm animal casings and held for 9-11 days at 4°C.
  - It is transferred to green room for 2 days to be maintained at 20°C and 70% relative humidity and then smoked for 3 days at 35°C and 80% relative humidity.
  - The product is not cooked but held for 21 days in the drying room at 35°C and 70% relative humidity during which it will have shrinkage.
  - The final product will have only 30-35% moisture content.
- Bologna
- Hotdog
- Mortadella

FORMULATION AND DEVELOPMENT OF MEAT BALLS/ PATTIES

- Meat patty is one of the most popular products among the ground meat items and is generally used as filling for burger roll or sandwich. Some people prefer to consume it separately with tomato sauce or chutney.
- Meat balls is a traditional Indian product made from ground meat
- Meat patties have a very good demand in big towns and cities in India.
- Meat balls are a traditional Indian product made from ground meat
- Patties are coarse ground products, contain less than 30% fat and are made into balls manually.
- Patties are coarse ground products, contain less than 30% fat and are moulded manually or mechanically.

By- Manuprabh, Naveen, Pradeep
• An optimum formulation is presented below
  ○ Ratio of Lean meat to Offal Meat 7: 3
  ○ The other ingredients are to be added in terms of % wt of meat (i.e 2% means - 2% of the weight of meat added)
  ○ Fat-10%
  ○ Salt-2.5%
  ○ Sodium or Potassium nitrite- 200 ppm
  ○ Pyrophosphates -0.3%
  ○ Spice mix -2%
  ○ Condiments - 4% (3% onions and 1% garlic)
  ○ Binder or extender - 10%
  ○ Added water, preferably as crushed ice. - 10%
• Lean meat is minced twice through 6mm plate and fat through 4 mm plate of a meat grinder.
• These are mixed thoroughly with all other ingredients manually
• The batter may be made into balls manually to prepare meat balls
• The batter weighing 80-100 g is moulded into 70-80 mm diameter and 15-20 mm thick patties.
• Meat Balls or raw patties may be frozen for future use or broiled in a preheated oven at 190°C for 20 minutes.
• The internal temperature must reach 72°C. These are deep fat fried in many commercial establishments.
• The meat balls /patties are cooled and consumer packed.

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**FORMULATION AND DEVELOPMENT OF MEAT PICKLE**

• Pickles are a preserved product usually based on vinegar or oil preservation.

**Formulation**
1. 1 kg Meat pieces
2. 150g Ginger paste
3. 150g Garlic paste
4. 80g Green chilli powder
5. 25g Cumin
6. 25g Mustard
7. 10g Asafoetida
8. 5g Fenugreek seed
9. 100g Red chilli powder
10. 15g Turmeric powder
11. 70g Salt
12. 300ml Vinegar
13. 400 ml Sesame oil
14. 10g Spice mix
15. 10g Curry leaves
16. 10g Citric acid
17. 5g Sodium Benzoate

**Method**
- Dice the meat into medium sized pieces (about 1” cubes) and add to it 25g of red chilli powder, 20 g of salt and the entire turmeric powder and marinade for an hour.
- Heat oil in a pan and fry meat pieces till golden brown.
- Drain the meat and keep aside.
- Put in the same oil all the green condiments (items 2-4) and cook well.
- Add the cumin, mustard, asafoetida and fenugreek and stir it well.
- Add the vinegar and continue to stir cook it.
- Then add the remaining salt, chilli powder and the spice mix one after the other and simmer it.
- Finally add citric acid and sodium benzoate and continue to cook.
Add the meat pieces again and simmer for 10 minutes.
Remove the pan from the fire.
Let it cool.
Put the pickle in the sterilised jar.
Top it with vinegar and mix it lightly.
Cover the lid and store in a cool place.
Consume meat pickle after a day of preparing.

FORMULATION AND DEVELOPMENT OF MEAT SOUP
- Soup is a food that is made by combining ingredients such as meat and vegetables with stock. (Stock is made by simmering various ingredients such as leftover meat or bones) water or another liquid.
- Hot soups are additionally characterized by boiling solid ingredients in liquids in a pot until the flavors are extracted, forming a broth.

**Formulation**
1. 1 kg Bones
2. 800G Onions
3. 200g Tomatoes
4. 200g Finely ground pepper
5. 100g Ginger
6. 100g Garlic
7. 100g Coriander leaves
8. 60g Red chilli powder
9. 40g Cumin seeds
10. 15g Turmeric Powder
11. Salt to taste.

**Method**
- Saute onions, tomatoes, ginger, garlic and cumin seeds in a frying pan.
- Transfer this to a tall vessel and add the bones in this.
- Add four litres of water, salt, pepper and chilli powders and allow it to cook for an hour.
- Garnish with coriander leaves before serving.

FORMULATION AND DEVELOPMENT OF MEAT KABAB
- Kabab includes grilled, roasted, and stewed dishes of large or small cuts of meat, or even ground meat; it may be served on plates, in sandwiches, or in bowls.

**Ingredients**
- 450 g (1 lb) Finely minced meat
- 1 Egg lightly beaten
- 5 g Coriander seeds, ground
- 2.5 g Chilli powder
- 2.5 g Cumin
- 2.5 g Garam masala
- 2 Cloves garlic, crushed
- Salt to taste
- 1 Onion, grated or liquidized
- Breadcrumbs (optional)
- 30 ml Oil
- **As accompaniment**
  - 1 Lemon, sliced, pips removed
  - 1 Onion, sliced into rings
  - 1 tomato, skinned and sliced

**Method**
- Mix the lightly beaten egg and beef in a bowl.
- Add the spices, salt and grated onion to the beef and use breadcrumbs to stiffen and bind the mixture if necessary.
- Oil your fingers and the skewers.
- Wrap the meat around the skewers in cigar shapes.
- Brush the meat with oil and cook under a moderate grill until evenly browned.
- Serve garnished with lemon, onion and tomato slices.

SURIMI

By- Manuprabh, Naveen, Pradeep
Surimi, an intermediate product obtained from fish mince which, because of its characteristic ability to form gels, can be used to develop a variety of products conforming to consumer fancies.

- Surimi is the myofibrillar protein concentrate produced by repeated washing of fish mince in order to remove water-soluble nitrogenous matter and flavour compounds.
- Washing enhances the gel forming capacity of the structural proteins.
- Surimi is used as a raw material for the preparation of seafood analogues, but in Japan, where the technology originated, surimi is mainly used to prepare the traditional kamaboko products.

**FORMULATION AND DEVELOPMENT OF SURIMI**

**Raw material**
- Fish having white meat and low fat content is generally used.
- Alaska Pollock (*Theragra chalcogramma*) has been the traditional material.
- Decline in the Alaska Pollock fishery has resulted in the producer countries increasingly using other species like Pacific Whiting, Hoki, Croaker, Lizard Fish, Barracuda, Ribbon Fish, Threadfin Bream etc.
- Even fatty fish has recently been employed after removing the fat with alkali washing.

**Processing of surimi**
- The basic steps of production of surimi are as follows:
  - Heading and gutting
    - The head, viscera and most of the backbone of the fish are removed.
    - The kidney, intestines, parts of stomach and liver, if allowed to remain, may severely damage the quality of protein during processing.
    - Filleting before mincing reduces yield, but it increases the quality of surimi produced.
    - It has become a common practice now to install a filleting machine at the beginning of the surimi line.
  - Mincing
    - Meat is separated from the skin and bones of the dressed fish by a mechanical deboner.
    - This is done by extruding the muscle through small perforations (3-5 mm dia) in a rotating stainless steel drum.
  - Washing
    - The deboned mince is mixed with fresh water in a series of leaching tanks.
    - It is important to maintain the water/mince ratio at such a level that proper washing is performed without leading to overhydration.
  - Refining
    - The refiner is a high speed rotating spiral surrounded by a screen having perforations of 1.2 mm to 3 mm.
    - The washed meat is forced through the perforations, leaving behind any impurities.
  - Dehydrating
    - The water content of the washed and refined mince is further reduced in a screw press.
    - The screw press is a perforated drum of about 10 feet long, inside which rotates a spiral screw.
    - As the screw rotates, it pushes the meat down the length of the drum.
    - The dewatered material comes out through a chute at the end of the drum.
  - Mixing with cryoprotectants
    - The dewatered mince is mixed with cryoprotectants like sugar, sorbitol and polyphosphates which prevent protein denaturation during frozen storage.
  - Freezing
    - The prepared surimi is immediately frozen at -40°C in a contact plate freezer and stored at -20°C.

**Processing yields at different stages**

<table>
<thead>
<tr>
<th>Stage of Operation</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material</td>
<td>100</td>
</tr>
<tr>
<td>Heading &amp; gutting</td>
<td>60</td>
</tr>
<tr>
<td>Mincing</td>
<td>45</td>
</tr>
<tr>
<td>Washing</td>
<td>42</td>
</tr>
<tr>
<td>Refining</td>
<td>30</td>
</tr>
<tr>
<td>Dewatering</td>
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</table>

**USES OF SURIMI**

**Traditional surimi products of Japan**
- The major traditional products of Japan are

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- **Chikuwa** - tube shaped fish paste
- **Kamaboko** – boiled fish paste
- **Satsumaage** - fried fish paste product
- **Hampen** - floating type boiled fish paste.
- Diversified traditional products like *kanikama* (artificial crab leg), cheese sandwiched *hampen*, easy-to-eat *kamaboko*, *Satsuma age* with hampen taste, squid-surimi *kamaboko* are also being marketed in Japan.

**Other uses**
- Surimi is used in meat products as meat binders.
- Surimi is used as a protein supplement or binder in various food products such as pasta, sausages, bakery products, restructured products health foods and pet foods.

**SMOKED FISH**

- Smoked fish is fish subjected to smoking
- Quality of the raw fish has significant influence on the quality of the smoked product.
- Pelagic fishes (Fishes found on the surface of water) are considered best for smoking when their fat content is the highest.
- However, depending on the end product desired, fish of different fat contents are preferred.
- Generally fish for smoking should be kept chilled.
- In certain cases, non-fatty fishes are also used.
- Fish may be smoked whole or after splitting, gutting etc.
- It is considered desirable to keep the fish iced for two days before smoking.

**FORMULATION AND DEVELOPMENT OF SMOKED FISH**

**Salting**
- Fish is salted either by mixing with solid salt or by immersing in strong brine.
- Size of the fish, fat content, whether the fish is whole, gutted, split or cut, presence or absence of skin and other requirements in the end product etc. are the factors considered in determining the duration and type of salting.
- Depending upon the concentration of brine there may be an uptake or loss of water in the fish.
- Most common concentration of brine employed is 70-80 per cent.
- Fish salted in 100 per cent saturated brine is not preferred as it is likely to make the product unattractive because of the powdery, unattractive, crystals of salt that may be left on the surface.
- In weaker brines longer periods of immersion are needed and there will be an uptake of water, which will have to be evaporated during drying.
- Salting is adjusted that the fish takes up 2-3 per cent salt which is the optimum requirement in many smoked fish.
- However, when the fish is dry - salted the uptake of salt will be very high.
- Such fish are soaked for several hours in water before smoking to bring down the salt content to the desired level.

**Hanging**
- After salting the flesh of the fish will be moist.
- Surface proteins will dissolve in the brine yielding a sticky solution.
- For efficient smoking fish must be dry enough with no free water on the surface.
- Free water can cause condensation of the distillation products, particularly tar, which leave dark brown colour in the product.
- During hanging the sticky solutions dries on the surface and makes the skin glossy.
- However excessive drying will prevent the fish from acquiring a proper smoky flavour.
- Drying can be done in open air or a hot air drier or even directly in the smoke chamber by burning wood without producing smoke.
- Split and salted fish should remain in stretched out position for uniform exposure of all parts to smoke.
- Hanging is done in several styles depending on the fish handled and the end product desired.
- Fish like sardine meant for canning after smoking are threaded through the eyes.
- Large split whole fish like salmon are suspended by the tail and kept flat open by means of sticks or skewers threaded through the flesh.
- Fish can be hung or even spread on wire mesh trays, however, care has to be taken to ensure that the mesh does not leave excessive mark on the skin or flesh.

**Smoking process and types**
- Two types of smoking are popular, cold smoking and hot smoking.
- The essential difference between the two processes is the amount of heat the fish receives during the process.
Cold smoking is a mild process where temperature is not raised enough for the fish to undergo even a partial cooking.

In hot smoking the temperature of the smoke is high and the fish flesh is cooked even to the extent of partial sterilization.

However, this partial sterilization does not result in any increased shelf life as the fish may get re-infected with microorganisms during subsequent handling and packaging.

**Cold smoking**

- Cold smoking is still carried out in more or less the conventional style, mostly using traditional chimney kilns.
- Fish is kept hung or spread in mesh trays in an upward draft of smoke produced in the floor by the burning fire.
- In the initial stages the fish is moist and the smoke is highly humid.
- Under these conditions use of high temperature will invariably result in cooking of the fish flesh.
- To avoid this, the temperature inside the chamber should not be raised to the maximum employed in the process.
- In the second stage, when the surface of the fish is considerably dry, the temperature inside the chamber could be raised to a level that the fish species concerned will tolerate.
- However, it is desirable to complete the process at the same temperature throughout.
- The highest output of good quality products is achieved when the temperature, relative humidity and the quantity of ventilated smoke are maintained in the correct proportion.
- During smoking the fish dries as also absorbs the aromatic substances from the smoke.
- The relative humidity inside the chamber also is a decisive factor in determining the quality and output of the products.
- RH above 70-80 per cent will considerably slow down the drying and smoking process.
- To control the RH of the smoke, the flame dampers may be kept open thus providing a good draught whenever the per cent RH goes beyond the required level.
- Cold smoking is generally carried out at temperature not exceeding 40°C.
- Duration of smoking extends to several hours, say 36-72 hr.

**Hot smoking**

- Several designs of kilns tunnels are available for hot smoking fish.
- The fuel is burnt either directly inside the kiln on movable trolleys or in external hearths located near the tunnel.
- The fish is charged into the tunnel in cages.
- The chamber will be having a metal frame structure and brick walls and can hold a number of fish cages.
- In contrast to cold smoking where cooking of the flesh is neither the aim nor is attained in any case, in hot smoking fish is dried and cooked in the kiln before it is smoked.
- Drying is done in an intense draught of hot air at 75 to 80°C produced by burning fire.
- The skin of the fish becomes dry while flesh becomes cooked as well.
- At this stage the fish is considered ready for smoking.
- Smoke is produced by covering the burning logs with saw dust and the temperature in the chamber is maintained at or above 100°C.
- A schedule of operation in hot smoking can be considered as drying at 75 to 80°C for an hour followed by smoking at 95 to 100°C for another one hour.
- The requirements will vary with the size and species of fish.

**Other methods**

- In addition to cold smoking and hot smoking, there are other methods. They are
  - Dark smoking
  - Moist smoking
  - Electrostatic smoking
  - Liquid smoke
  - Gas-Phase smoke
  - Closed smoking
  - Indirect smoking

**Use of artificial colouring**

- It is often difficult to achieve uniformity in the product, particularly colour, in smoked fish.
- Even if near uniformity in colour can be achieved, batch to batch variation occurs.
- One way of overcoming this inherent deficiency of smoking process is to artificially colour the fish with permitted dyestuffs in the brine used for salting.
- Vegetable dyes, coal tar dyes etc are so used, the selection being dependent on the type of the product.
**Post process handling**
- On removing from the kiln the smoked fish is warm and is generally allowed to cool before grading and packing.
- Cold smoked fish may lose up to 5 per cent of its weight by further evaporation.
- If the smoked fish is packed while warm, moisture will condense and deposit inside the containers.
- This will create a situation conducive to premature mould growth.
- Smoked fish can also be frozen and cold store which will minimize the chances of spoilage before consumption.

**TANDOORI CHICKEN**
- Tandoori chicken is a dry type cooking preparation without oil and with minimum spices, cooked in conserved heat using a conventional type mud tandoori pot.
- Young cockerels (white leghorn) of the age group of 8 to 12 weeks and 5-6 weeks old broilers are ideal for this preparation.

**Formulation**
1. 5 litres Curd
2. 150 g Chilli powder
3. 500 g Garlic paste
4. 350 g Ginger paste
5. 20 g Turmeric powder
6. Lime juice from 10 lemons
7. 250 g Salt

**Cooking**
- Skin less dressed chicken is used.
- Leg and breast muscles are incised with a sharp knife to facilitate better penetration of spice mix during marination.
- A minimum of 2 hours marination time is required.
- Then excess spice mix can be drained off and long iron rods are inserted into the marinated chicken along the long axis to facilitate better cooking and for easy handling in the hot tandoori pot.
- Initially cook for 10 minutes and then apply butter and cook for 10 more minutes. Now the product is ready for serving.

**MODULE-9: PACKAGING OF MEAT AND MEAT PRODUCTS**

**Learning objectives**
- This module will introduce the learner to the important role of packaging in the logistics of distribution of meat, the ideal characteristics of packaging materials meant for meat, packaging materials ans forms and various methods involved in packaging of meat, their utility and disadvantages.

**PACKAGING**
- Packaging is the technique of using the most appropriate containers and components to protect, carry, identify and merchandise any product.
- It constitutes a vital link between the processor and consumer for the safe delivery of the product through the various stages of processing, storage, transport, distribution and marketing.
- The primary function of a meat package is to present the product to the consumer in the most attractive manner possible and at the same time protect the product from physical damage, microbial deterioration and chemical changes.

**Functional requirements of packaging**

Packaging, in the meat industry serves the following functions,
- Containment
- Protection
- Preservation
- Apportionment—the function of reducing industrial output (i.e., Dressed Carcass) to an appropriate size for further processing or consumer use
- Unitization—the function in which primary packages are consolidated for shipment. Primary packages are unitized into secondary packages, for example placement inside a cardboard carton. The secondary packages in turn are unitized into a tertiary package; for example a stretch wrapped pallet that may, in turn form a quaternary package – a shipping container or truckload. Unitization allows optimization of materials handling by minimizing the number of discrete packages that need to be handled. On delivery the process is reversed from distributor to consumer so the latter is presented with a primary package (fortunately) and not a truck load.
- Convenience–Microwaveable packs and meat based whole meals.

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Packaging films utilised in packaging of meat must possess the following characteristics:

- flexibility
- mechanical strength
- light weight
- odourless
- hygienic (clean and toxicologically harmless)
- easy recycling
- resistance to hot and cold temperatures
- resistance to oil and fats
- good barrier properties against gases
- sealing capability
- low-cost

**Barrier against gases**

- Good barrier properties against oxygen and evaporation are the critical to ensure the maintenance of colour of meat, prevent development of oxidative rancidity; and shrinkage losses and drying, respectively especially in case of processed meats.
- However, oxygen permeability is acceptable and rather a necessity in the case fresh ready-to-sell meat portions in self-service outlets where the oxygen permeability is required to maintain bloom.

**Barrier against light**

- Prolonged exposure of meat and meat products to natural and artificial light hastens undesirable colour changes, oxidation and rancidity as light provides the energy for these processes.
- But, transparent packaging films aid the presentation of the product in an attractive manner as the packaged product is visible.
- But they do not provide protection against light impact.
- Such films are laminated with aluminium to counter the adverse effects of light, while maintaining the attractiveness of the product.

**Sealing capability**

- Some packaging materials are required to have good thermoplastic properties.
- They are heat sealable, which means that two of these films, put closely in contact to each other under slight pressure and with simultaneous high temperature application, will melt or seal together along the heated area, resulting in hermetically closed plastic pouches or bags.

**MODERN PACKAGING MATERIALS AND PACKAGE FORMS**

- Packaging materials and forms may be classified as Rigid packaging materials and forms, Semi-rigid packaging materials and forms, Flexible Packaging materials and Flexible Packaging forms as detailed below.

**Rigid packaging materials and package forms**

- Glass containers
- Metal cans
- Composite containers
- Aerosol containers
- Rigid plastic packages

**Semi-rigid packaging materials and package forms**

- Aluminium containers
- Set-up paper board boxes
- Folding paper board cartons

**Flexible packaging materials**

- Paper-the basic papers used consists of bonds, tissue, litho, krafts, glassines, parchment and grease proof.
- Films-cellophane, cellulose acetate, polyethylene (HDPE & LDPE), Polypropylene, polyamide, polyester, polyvinyl chloride, polyvinylidene chloride, polyvinyl acetate and polyvinyl alcohols
- New films-amylase films (edible), Ionomers like surlyn A, Ethylene vinyl acetate copolymers, polypropylene copolymers, co extruded structured films, aluminium foils and steel foil.

**Flexible package forms**

- Wrappers
- Preformed bags or envelopes
- Pouches
- Collapsible tubes

**TYPES OF PACKAGING**

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• Practically all films used for meat packaging derive from synthetic “plastic” materials.
• Even cellulose, formerly widely used in the form of transparent films is no longer put into much use to pack meat.
• The most common synthetic materials used for meat packaging are:
  - Polyethylene (PE) (oxygen +, water vapour -)
  - Polypropylene (PP) (oxygen +, water vapour -)
  - Polyvinylchloride (PVC) (soft) (oxygen +, water vapour -)
  - Polyester (PET) (oxygen ±, water vapour -)
  - Polyamide (PA) (oxygen -, water vapour+)

  + : relatively permeable
  - : relatively impermeable

• Both Polyvinylidene chloride (PVDC) and Ethylene vinyl alcohol (EVOH)

• Foils made from the above synthetic materials are selected based on their different properties related to oxygen and water vapour.
• Packaging films may be conveniently classified into
  o Single-layer films or
  o Multi-layer films

**Single-layer films**
• Single-layer films are commonly used in the wrapping of meat pieces, processed meat products, bone-in or boneless meat cuts or even entire carcasses.
• These films are usually self-adhesive, i.e. they cling together -“cling film”- in the overlapping areas.
• Hence they offer good protection from external contamination and to some extent from evaporation, but do not protect from oxygen ingress, as they are not hermetically closed or sealed packages.
• Foils with good self-adhesive properties are polyethylene, polyamide, polyvinylidene chloride and polypropylene.
• Single-layer films are used for freezer storage.
• Single-layer films are stretched tightly around the meat surface prior to freezing or frozen storage of meat blocks, meat cuts or smaller portions of meat or meat products.
• Since the film is in tight contact with the product’s surface it prevents evaporative losses, commonly encountered freezer storage of unpacked products.
• The tight contact between the product’s surface and the film also prevents ice formation and freezer burn is liable to develop at non contact spots
• Suitable cold resistant films for freezer storage are polyamide and polyethylene.
• Yet another specific utility for single-layer films is the wrapping of chilled meat portions for self-service outlets (supermarkets, etc.).
• The product to be packed is placed in a hygienic cellulose or plastic tray and tightly wrapped with single-layer plastic film. The ends of the foil are overwrapped at the bottom side of the tray, where they firmly cling together.
• Films to be used should have low water vapour permeability to avoid the drying out of the meat during storage, but must possess high oxygen permeability so as to ensure the meat retains its bloom owing to the formation of oxymyoglobin.
• Suitable single-layer films for fresh meat packaging are polyethylene or soft polyvinylidene chloride.

**Multi-layer films**
• The plastic films used in meat packaging are permeable either to moisture or oxygen.
• Ideally for packaging of meat a combination of oxygen and moisture impermeability is required.
• Hence multi-layer films have been developed in which the film on the outer layer has good mechanical strength and is impermeable to oxygen and the inner most layer is impermeable to water vapour and must possess good sealant properties too.
• The multiple layers may just have two layers or more layers too.
• A very efficient combination is polyamide and poly ethylene.
• The outer layer, polyamide is relatively oxygen proof but permeable to some extent to water vapour.
• Poly ethylene has exactly the opposite properties, it is water vapour proof but permeable to oxygen.
• The combination of both renders such a multi-layer film impermeable to both oxygen and water vapour evaporation.
• Moreover, the poly ethylene used as the inside layer has good thermoplastic properties and is therefore well suited for heat sealing.
• Sealant layers consist mostly of polyethylene or ionomer. Outside layers may be polyamide, polyester or polypropylene (PP).
• Barrier layers for oxygen are made of Polyvinylidenchloride or materials with similar properties.
PACKAGING OF MEAT AND MEAT PRODUCTS

Packaging materials used for fresh meat
- Trays—made of polystyrene
- Transparent films—cellophane, LDPE (most commonly used for fresh meat), PVC
- Shrink films—PVC, cellophane, rubber hydrochloride, polypropylene, irradiated PE and PVDC are used in shrink wrapping of meat.

Advanced and emerging systems of packaging of meat and meat products

Vacuum packaging
- It is the placing of primal or sub primal cuts of meat into plastic bags or pouches and extracting air from them by means of a nozzle type vacuumizing machine or a vacuumizing chamber.
- The bags are then sealed to effect closure with either metal clips or heat-impulse sealing of the sides of the bags.
- The most commonly used film for fresh meat vacuum packages is PVDC.

Modified atmosphere packaging
- It is a technology where in foods are packaged in high barrier packages in which air has been replaced with an artificial (modified) atmosphere.
- Commonly used gases are oxygen, carbon dioxide and nitrogen.
- For red meats, high-oxygen MAP systems utilize atmospheres containing approximately 20% to 30% carbon dioxide, 60% to 80% oxygen, and up to 20% nitrogen. The elevated oxygen concentration enhances the bright red meat color and the elevated carbon dioxide concentration inhibits the growth of aerobic spoilage microorganisms. High oxygen concentrations in display packs enhance meat color by increasing the thickness of the oxymyoglobin surface layer. At the same time the metmyoglobin layer lies deeper in the meat.
- The time taken for that layer to reach the surface is increased, so display life is extended. Unlike overwrapped trays, high oxygen display packs use a film with high gas barrier properties, to prevent the gases equilibrating with the ambient atmosphere. The modified atmosphere display packs consist of deep high barrier trays that are gas flushed before an upper high barrier film or lid is sealed in place. However, the pack atmosphere tends to change during display because the oxygen is lost to respiration and carbon dioxide is highly soluble in meat.
- The absorption of carbon dioxide can lead to pack collapse. The pack atmosphere remains reasonably stable and the pack shape is maintained when the ratio of pack volume to meat volume exceeds approximately 3 to 1. The use of high oxygen with high carbon dioxide effectively doubles the color stability and time to spoilage over that achieved using ambient atmosphere overwrapped packs.
- High-oxygen MAP, which provides a chilled product life of only 5 to 10 days, is not suitable for prolonged storage of meat. Its suitability for display packaging is determined as much by commercial merchandising strategies as by the preservative capability of the packaging.
- The excessive space occupied by deep tray packs, compared to net weight of meat sold, tends to restrict MAP packaging to high value products catering to the upper end of the market. As discussed previously, the rate of discoloration is inversely related to temperature, so the importance of display cabinet temperature management cannot be overemphasised.

Mother bag concept in MAP
- These are the simplest two-phase packaging systems, consisting of retail-ready packs inside an outer preservative pack. The retail-ready packs may be overwrapped trays or lidded packs. In both cases, retail films must be highly gas permeable, first, to allow the meat contact with the carbon dioxide preservative atmosphere and later, on removal from the mother pack, to allow atmospheric oxygen to bloom the meat.
- While a simple outer bag could be used to contain the carbon dioxide atmosphere, the inner packs would be free to move within the pack. Such movement could damage both inner and outer packs. Consequently, most proprietary mother pack systems employ a semi-rigid outer container to protect and restrain the inner packs.

MODULE-10: PHYSICO-CHEMICAL QUALITY CHARACTERISTICS OF MEAT

Learning objectives
- The learner will gain an understanding about the physico-chemical qualities of meat and their impact on meat sensory quality.

INTRODUCTION
- The most important physico-chemical qualities of meat include pH, Water Holding Capacity (WHC), colour, tenderness, tyrosine value (TV) and thiobarbituric acid number (TBA).
- Both pH and WHC play a major role in determining the quality of fresh meat.
- pH and WHC have a major impact on the yield, sensory qualities, of processed meat products also.
Both pH and Water holding capacity are influenced by the animal (species of animal, genetics), the manner in which the animal is handled peri –slaughter (immediately prior to and during slaughter) and post –mortem handling of meat.

Both pH and WHC vary from individual animal to animal and importantly muscle to muscle.

**WATER HOLDING CAPACITY**

- Water holding capacity is the ability of muscle to hold on to or retain its own water or added water under application of pressure.
- The pressure applied may be cutting, grinding, chopping, heating etc.,
- WHC determines weight of meat in fresh meat trade, as lower WHC would mean greater losses in water; the juiciness of fresh meat as well as processed meats, as greater WHC means that greater quantities of meat juices are retained; yield of processed meat products as WHC is directly related to cooking losses and emulsion stability in emulsion based meat products.
- WHC is closely related to pH of meat, both the rate and extent of fall in post-mortem pH.
- Water holding capacity is at its lowest when ultimate pH (the pH at about the time of completion of rigor, and there is no further drop in pH) is reached.
- Water exists in three states in the muscle
  - Free Water
  - Immobilized Water and
  - Bound Water
- Free water is about 10% of the total water present in muscle and this is held by capillary forces ante-mortem, which is lost as the animal dies and hence this fraction of water is inevitably lost, hence does not contribute to WHC.
- Bound water constitutes about 2% of the total water present in muscle and is called so because it is chemically bonded to the proteins of muscle, commonly by hydrogen bonds.
- About 50% of bound water cannot be removed from the muscle and it can’t be removed either in the form of steam by heating or can be frozen, and hence this fraction does not account for the variations in WHC from one sample and the other
- Immobilized water constitutes about 80% of total water in muscle and its state practically determines WHC. Immobilized water, as the name indicates is immobilized by the myofibrillar proteins in the inter myofibrillar spaces.
- The most important factors determining WHC are the ionic effect and steric effects.
- Ionic effects refer to the state of ionization of the proteins of muscle, which directly influences the hydrogen bond formation, as a small polarity is required for two molecules to engage in hydrogen bond formation.
- This is one of the reasons for WHC to be at its lowest when ultimate pH (pHu) is reached, as the pHu of meat is in the range of 5.2 -5.6, and the iso-electric point of myosin, the most important player in hydrogen bond formation is 5.5; hence myosin being neutral in charge, cannot form hydrogen bonds and as a consequence there is depression of WHC.
- Steric effects refer to spatial or more appropriately volume changes in the muscle. If the steric effect are such that the volume available for water to be held in the inter myofibrillar spaces due to close packing of the myofibrillar decreases, as is the case at pHu,WHC diminishes ( Rigor is at its peak as also are actinomyosin formation contraction which obliterates inter myofibrillar spaces).
- WHC is affected by genetics (Halothae gene of pigs prone to Porcine Stress Syndrome,and Rendement Napole Gene are both associated with Pale Soft Exudative (PSE)condition; handling of animals peri-slaughter, as stress of any kind results in PSE in pigs and Dark Firm Dry (DFD) meat in cattle; and post-mortem handling of meat(Quick freezing, and low temperature during chilling results in greater WHC, and cutting into thin and many cuts resulting in an increase in surface area results in decrease in WHC.
- Pale Soft Exudative pork is characterized by very low WHC a Dark Firm Dry beef is characterized by high WHC.

**pH**

- pH refers to the negative logarithm of hydrogen ion concentration.
- The pH of fresh meat, more precisely muscle at 45 minutes post slaughter is in the range of 6.8 -7.2, which reduces to about 5.2-5.6, at about 24 hours post slaughter in case of cattle, while it takes in about 4-8 hours in pigs
- This decline in pH is on account of the conversion of the glycogen stored in the muscle to lactic acid.
- In case of pigs, stress in the form of rough ante-mortem or peri-slaughter handling, high environmental temperature, fighting etc., results in the coming down of pH to pHu values within an hour of slaughter, when the carcass is still warm(35 ° C).
- This combination of high temperature and low pH results in changes in properties of the muscle proteins (protein denaturation) resulting in them being less capable of retaining water in the inter-myofibrillar spaces, and hence becomes soft and exudative. The loose network of muscle proteins allows more light to be absorbed hence pale in colour.
- In case of cattle, stress in the form of rough ante-mortem or peri-slaughter handling, resulting in physical exhaustion results in the depletion of glycogen and the ph does not come down and remains at above 6 even 48 hours after slaughter .

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This high pH results in the muscle protein lattice remaining undisturbed and hence appears dark in colour and firm in texture and dry on the external surfaces.

**MODULE-11: MICROBIAL QUALITY OF MEAT AND MEAT PRODUCTS**

**Learning objectives**
- The learner will gain an understanding of the role of micro-organisms in decomposition of meat and other deleterious changes as well as the end of this module.

**INTRODUCTION**
- Microbes in meat are a cause of concern on two counts:
  - Potential decline in keeping quality due to spoilage organisms
  - Potential hazards to the consumer due to food poisoning organisms and transmission of zoonotic diseases.
- The ensuing discussion will be concerned with spoilage organisms, the miscellaneous conditions caused by them and highlight organisms involved food spoilage.

**MICROBES INVOLVED IN DECOMPOSITION OF MEAT**
- Decomposition is the breaking-up of organic matter, chiefly protein but also fats and carbohydrates, by the action of bacteria, moulds and yeasts, which split the meat up into a number of chemical substances, many of which are gaseous and foul smelling.
- All forms of foods in their state remain in a fresh and edible state for only a comparatively short time.
- Foods rapidly acquire bacteria, moulds or yeasts, which are the main causes of spoilage or decomposition.
- Before terminal decomposition changes occur, however, other factors such as enzyme action (food and bacterial) and oxidation take place in some foods.
- Enzymes or ferments, which are present in all living cells, catalyze the complicated chemical reactions taking place in the cells.
- Enzymes essentially bring about the process of autolysis, self-destruction or self-degradation and at a rate, which varies markedly in the different tissues.
- In general it is highest in those tissues in which protein is synthesized in large amounts and which have high water contents, e.g. gastrointestinal mucosa, testes, pancreas and adrenals.
- Tissues such as the liver, kidneys and endocrine glands have slower autolytic rates and the tissues with lowest metabolic rates such as skin, muscles, bone, heart and blood vessels have the lowest autolytic rates of all tissues.
- The various forms of food preservation are designed to prevent decomposition by limiting the activity of enzymes, the process of oxidation and bacterial spoilage.
- All forms of food are subject to natural deterioration, their shelf life being dependent on their structure, pH, composition, water content, presence or absence of bacteria and /or damage and conditions of storage.
- Foods with high water content (e.g. meat and offal) are liable to spoil rapidly unless steps are taken to counter deterioration.
- In addition to microbial spoilage, physical damage, which occurs during handling, transportation and processing, can be regarded as a form of spoilage as can insects, rodents and other pests.
- Foods damaged in this way are more susceptible to change by microbial action.
- Fresh meats are initially contaminated from many different sources – soil, dust, faeces and water, equipment, hands and clothing of personnel subsequently adding to this pollution.
- Meat can harbour organisms, mostly of the Gram-positive mesophilic type.
- Depending on the types of bacteria present, meat-borne disease or spoilage or both may result, especially if standard handling methods are adopted.
- The main types of bacteria involved in the spoilage of meat belong to the following genera:
  - Gram-positive organisms
    - Micrococcus,
    - Staphylococcus (Staph. albus & Staph. aureus)
    - Streptococcus (Str. feacalis, Str. faecium, Str. durans)
    - Lactobacillus,
    - Leuconostoc,
    - Bacillus (B. subtilis, B. thermophilus & B. coagulans),
    - Clostridium (Cl. sporogenes, Cl.histolyticum, Cl. perfringens & Cl. butyricum),
    - Corynebacterium and
    - Microbacterium.
  - Gram-negative organisms
    - Pseudomonas
    - Flavobacterium
    - Acinobacter
    - Achromobacter
    - Alcaligenes
Halobacterium
Moraxella
Escherichia and
Klebsiella

**MICROBIAL COUNTS COMPUTED FOR ASSESSING QUALITY OF MEAT AND MEAT PRODUCTS**

- Meat being a highly perishable commodity requires strict quality control right from slaughter operations till ultimate consumption.

- The basic objectives of quality control are:
  - Protection of public health
  - Extension of product shelf life
  - Provision of consumer satisfaction
  - Compliance of regulatory legislation
  - Competitive edge in the trade

- The general principles of meat product quality control involve:
  - Raw material control
  - Control of processing operations
  - Finished product inspection and control

- It is very difficult to examine meat and meat products for every pathogenic, toxigenic and spoilage microorganisms.

- However, a product cannot be improved unless some objective assessment of its quality is available.

- But the methods adopted should be simple with quick results.

- Hence, the following indicator organisms are relied upon to determine the sanitary and safety status of these items.

**Total viable count (TVC)**

- These are estimates of mesophiles and psychrophiles and serve as useful indicators of handling history and state of freshness or spoilage of meat.

- TVC is also referred to as Aerobic Plate Count (APC) and Standard Plate Count (SPC)

- These counts provide meaningful guidance to streamline the processing operations.

- However, if these counts are less, most probable number (MPN) is enumerated.

**Coliforms**

- These consist of *E. coli* and *Aerobacter aerogenes*.

- Their presence indicates faecal contamination due to unhygienic handling during or after processing of meat products.

- Coliforms can be distinguished because of their property to produce gas from lactose at 44°C.

- However, out of two organisms in this category, *E. coli* is a better indicator of faecal contamination.

**Enterococci**

- These are members of faecal streptococci (group D), which consist of:
  - *S. faecalis* (and its varieties)
  - *S. faecium* (var durans)
  - *S. bovis*
  - *S. equines*

- These organisms indicate poor hygienic quality of frozen meats and inadequate heat treatment of canned meats.

**Other indicators**

- Besides above indicators, specific organisms like *Staph. aureus*, *Salmonella*, yeast and mould counts are also important.

- Heat-treated meats should also be screened for the presence or absence of *B. cereus* and Clostridia.

- Canned meat products are generally subjected to sterility test.

- For this purpose, cans are incubated at 30° C and 55° C for 15 days.

- Swollen or disfigured cans show the product spoilage.

**MISCELLANEOUS UNDESIRABLE CHANGES CAUSED BY MICROBES IN MEAT**

**Spoilage due to bacteria**

**Bone taint**

- Bone taint is that spoilage that takes place in the deep musculature of carcasses that are heavy, well endowed with fat and also cooled very slowly, and putrefactive bacteria, of anaerobic spore forming type is responsible for this condition

- The most commonly affected joint is hip joint and putrefaction is evident both in the femur and its surrounding musculature.
• Stress at slaughter predisposes those animals to this condition.
• Taint in hams are also encountered and Clostridium putrificiens and Cl. putrificum are the most common bacteria incriminated
• Rapid cooling can prevent these conditions.

Phosphorescence
• Phosphorescence is a condition caused by Pseudomonas phosphorescens, in which meat contaminated in the cold stores, which became originally contaminated by sea fishes stored therein (organism is found in the sea water) shows luminous areas scattered over the surface of carcasses and it appears as though stars were studded on them.

Miscellaneous colour changes on meat surfaces caused by bacteria
• Serratia marcescens – Red colour similar to beet root juice
• Pseudomonas cyanagenus – Blue colour
• Pseudomonas cutirubra – Red mould on charque.

Spoilage due to yeast and moulds

Black Spot
• A condition caused by Cladosporium herbarum in which black spots appear on carcass surfaces stored above -8 ⁰ C. Rhizopus and Pullaria may also be involved.
• This is not a mere surface phenomenon and may extend into the muscle even necessitating condemnation of entire quarters

White spot
• A condition caused by Sporotrichum and Chrysosporium in which white woolly spots appear on carcass surfaces stored above -8 ⁰ C and plentifully at -2.5 ⁰ C and profuse if above 0 ⁰ C. This is an entirely superficial condition.

Whiskers
• Whiskers is a condition caused by Thamnidium and Mucor and their hyphae project about 2.5 cm beyond the surface of meat. They cease to grow at temperatures below -7.5 ⁰ C, but retain viability and proliferate, if exposed above freezing point. Hence whiskers is an indication of temperature abuse.
• Bluish green moulds such as Penicillium spp also cause surface discolouration in meat which is also superficial.

MODULE-12: BASICS OF SENSORY EVALUATION OF MEAT PRODUCTS

Learning objectives
• At the end of this module the learner will become conversant with the considerations that need to be addressed in conduct of sensory evaluation, the basic tests involved in sensory evaluation, and uses of sensory evaluation.

EATING QUALITY OF MEAT
• Few foods can match the extraordinary gustatory satisfaction derived by the consumer, consuming meat, a fact well exemplified by the continued existence of meat as the central item of the diet in most affluent societies despite the advent of several nutritionally comparable meat analogues.
• Meat palatability includes factors such as colour, flavour, juiciness, tenderness and texture
• Species, breed, animal, age, sex, diet and postmortem handling techniques influence these factors.
• The factors of sensory characteristics may be classified as follows:

Eating quality characteristics

Tenderness
• Tenderness is the primary essential and the most important sensory attribute of meat.
• Tenderness is perceived as three components by the consumer:
  o Ease of initial penetration
  o The number of bites for complete disintegration of meat
  o Amount of residue left behind after complete chewing.
• Tenderness is influenced by the animal (age, sex, breed, species of the animal), state of rigor of the meat, handling of the animal peri-slaughter, manner in which meat is handled(cold shortening, thaw rigor), ageing etc.,

Juiciness
• Juiciness is perceived as two components:
  o The initial purge
  o Sustained juiciness due to marbling
• Juiciness is also influenced state of rigor of the meat, handling of the animal peri-slaughter, manner in which meat is handled(cold shortening, thaw rigor), ageing etc.,
Juiciness is a reflection of water holding capacity (WHC) of meat.

Flavour
- Flavour is a complex sensation.
- It involves odour, taste, texture, temperature and pH.
- Of these the odour is the most important.
- It is sensed jointly by the oral and olfactory senses.
- The odour and taste of cooked meat arise from water or fat-soluble precursors and by the liberation of volatile substances that exist in the meat.
- Meat samples should be smelled first followed by tasting for a rational and sound flavour perception of several volatile components present in meat.
- These components are significantly marked when meat is cooked.
- Flavour has been shown to have a profound effect on the overall acceptability of meat products.
- The duration and temperature of cooking influences the nature and intensity of odour and taste in meat.
- This is a gradual loss of flavour during storage; this may occur even in frozen conditions.
- Flavour of fresh raw meat is weak, salty and serum-like.
- Fresh meat fat also has almost indistinct taste and odour.
- It is during cooking that flavour get pronounced and become meaty.
- Fresh cooked beef is metallic and astringent.
- Veal flavour is sweet and flat.
- Pork flavour is regarded sweet and bland.
- Sex odour is more pronounced in male.
- Pork from boar has defined piggy odour or boar taint.
- During long-term storage, most meat develop rancid odour due to fat oxidation.
- It may be putty, tallowy for beef and stale, cheesy or fishy for pork.
- In case the meat is spoiled during storage, it emanates putrid odour due to protein decomposition.
- When cooked meat is stored for a long time, myoglobin catalysed fat oxidation takes place yielding a distinct warmed-over flavour.
- Canning imparts canned-meat flavour to meat products due to severe heat treatment.

Colour
- The pigment of muscle, myoglobin, is responsible for the colour of meat.
- The appearance of meat surface to the consumer depends, however, not on the quantity of myoglobin present but on its chemical state.
- Factors responsible for the variations in the quantity of myoglobin in the muscles are the activity of the muscle during life.
- The differences may also be due to species, breed, sex, age type of muscle and training.
- In fresh meat, before cooking, the most important chemical form is oxymyoglobin.
- It occurs in the surface and is bright red in colour.
- The colour of myoglobin is purplish red.
- Consumer relates the appearance and colour of meat to safety and healthiness.
- Consumer relates the colour of cooked meat to doneness.
- The final colour of cooked meat is dependent to the pigment changes brought about by temperature, time and method of cooking.
- When meat is cooked there is gradual change of colour from dark red or pink to a lighter shade and finally at higher temperatures to grey or brown colour.
- Pressure-cooked or boiled meat will discern a grey colour whereas roasted; broiled or canned meat turns brown.
- The brown colour of thoroughly cooked meat is due to denaturation of heme pigments and polymerization of some proteins and fats.
- The colour of fresh pork, mutton and buffalo fat is white and undergoes very little change during cooking.

Texture
- Texture is one of the most important eating quality attributes in the acceptance of meat.
- The overall impression of texture is perceived by the senses of touch, sight and hearing.
- Texture is a direct consequence of the grain in fresh meat.

**SENSORY EVALUATION PRINCIPLES AND MAJOR CONSIDERATIONS**

**Sensory evaluation** is defined as a scientific discipline used to measure, analyze and interpret reactions to those characteristics of food as they are perceived by the senses of sight, smell, taste, touch and hearing.
- It is the conscious effort to identify and judge different sensations and components in an object, be it a piece of food, a beverage, or a perfume.
- Sensory evaluation encompasses all of the senses.

By- Manuprabh, Naveen, Pradeep
It takes into account several different disciplines but emphasizes the behavioral basis of perception. It involves the measurement and evaluation of sensory properties of food and other materials. Human judges are used to measure the flavor or sensory characteristics of food. In short, sensory evaluation is a very "Gestalt" approach to product assessment.

Major Considerations in Sensory Evaluation

The major factors that influence the effectiveness of sensory evaluation are:

1. **Sample**
2. **Panelists**
3. **Environment**
4. **Presentation**

Considerations Pertaining to Samples in Sensory Evaluation

1. Temperature of Samples
2. Serving Utensils
3. Sample Size
4. Sample Coding
5. Order of Presentation
6. Number of Samples
7. Time of Testing
8. Rinsing

Considerations Pertaining to Panelists in Sensory Evaluation

- Selection of panelists is based on the following criteria:
  1. Age
  2. Gender
  3. Ethnicity
  4. Illness – Individuals with any ailment that will adversely affect the skills of sensory evaluation are not selected.
  5. Ability to sense food
  6. Smokers – Individuals who are smokers are not selected.
  7. Availability
  8. Willingness to serve

- Panelists are selected after they demonstrate their skills in:
  1. Tests
  2. Thresholds
  3. Discrimination
  4. Ability to taste the four basic tastes

- Screening tests are conducted to determine panelists’ sensory acuity and ability to listen and follow directions.

Screening of potential panelists should be conducted in four phases:

1. Conduct scaling tests to determine if panelists can follow direction and make judgments;
2. Evaluate sensory acuity or the individual’s ability to discriminate using sniff tests and triangle tests;
3. Conduct tests to determine an individual’s ability to rank or rate sensory differences; and
4. Conduct a personal interview to ascertain a panelist’s continued interest.

- During the screening process one of three decisions should be made at the completion of each of the four phases listed above:
  1. accept the individual for the next phase of testing;
  2. reject the individual; or
  3. continue testing.
- An individual should be accepted for all four phases before acceptance for sensory training.

Considerations pertaining to Environment in Sensory Evaluation

- The following environmental factors have a bearing on sensory evaluation:
  - Temperature
  - Lights
  - Comfort
  - Private

Considerations pertaining to Presentation in Sensory Evaluation

- Random
- Numbering or labeling
- In presentation of samples the following criteria are to be met
  - Utensils: Stainless Steel
  - Plates: White or Paper

By- Manuprabh, Naveen, Pradeep
Glasses: Clear  
Carrier: Pie Crust  
Accompaniment: Ketchup

**DIFFERENT METHODS AND USES OF SENSORY EVALUATION**

- The three major types of tests utilised in undertaking sensory evaluation are
  - Discrimination Tests
  - Descriptive Tests
  - Affective Tests

**Discrimination Tests**
- Discrimination Tests are used to determine whether a difference exists between samples. The panelist does not allow his personnel likes and dislikes to influence his response. Laboratory difference panels are used to determine if there is a difference among samples.
  - Examples of these tests include
    - Paired Comparison
    - Triangle tests
    - Duo-trio
    - Ranking Tests

**Descriptive Tests**
- Descriptive tests are used to determine the nature and intensity of the differences. It requires trained panels.
  - Examples of these tests include
    - Rating or Scoring
    - Texture and Flavour Profile Analysis
    - Quantitative Descriptive Analysis

**Affective Tests**
- Preference tests are affective tests based on a measure of preference from which relative preference can be determined. Examples of these tests include
  - Hedonic test - This is the one most commonly utilised in assessing meat.

**Uses of Sensory Evaluation**
- In the food industry, sensory evaluation is used for:
  - Grading
    - Foods can be graded and standardized; this is often done completely by a sensory judgment.
    - We are familiar with this in the wine industry; an expert will designate wines. In the coffee industry we utilize expert cuppers.
  - Quality Assurance
    - We need to understand variations in natural products but do not tolerate them in processed foods.
    - If the flavor of a candy is changed, we may reject it.
    - Sensory evaluation is a critical tool for Quality Assurance personnel.
    - It can be used to test for off-flavors, changes due to reformulation, the effects of changes in processing, the effects of storage under various conditions (shelf life studies), the effects of packaging, etc.,
    - In coffee, we need to understand the scope of natural variation in our product.
    - It is used to discern natural variance in new crop vs. past crop coffee or to want to distinguish new crop acidity from possible taint.
  - If you are going to look at changes in your business in any part of the process, from growing to packaging, you’ll want to use sensory evaluation to note differences in the final product.
  - Correlate Sensory & Chemical/Physical Properties
    - What specific characteristics in an item give it its taste and smell and are there ways we can manipulate these? (E.g. what are the chemical changes that take place when a wine matures? Which ones affect the flavor? Can they be accelerated?)
  - Marketing
    - Sensory information can be vital in making marketing decisions.
    - Data is needed about product preferences, product optimization, consumer acceptance, etc.
    - There is a difference between what you do to assess product quality and process and what you do to look at consumer’s preferences.
    - You never want to use trained experts to predict consumer behavior because by virtue of their training they are no longer reflective of the general population.

**MODULE-13: CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF EGG**

**Learning objectives**
- At the end of this module the learner will become conversant with the chemical composition and nutritive value of eggs.
• It will also enable the learner to understand significance of eggs in the diet of human beings.

CHEMICAL COMPOSITION OF EGGS

• Egg is a nutritious, unadulterated natural food with high digestibility coefficient.
• It is a rich source of animal protein with well-balanced amino acid profile imparts it a very high biological value (one of the highest among various foods)
• The biological value of egg protein is 96 when compared to 85 of milk and 80 of meat
• It is used as a standard protein to measure the quality and nutritive value of any human food.
• An average egg will supply around 7g of wholesome protein of high biological value and 6g of easily digestible fat rich in mono and polyunsaturated fatty acids, cholesterol and vitamin E.
• Nearly two thirds of egg is water and the remaining is dry matter.
• Dry matter consists of organic and inorganic matter.
  - Inorganic matter: Inorganic matter consists of minerals like calcium, phosphorus, sodium, potassium, chlorine, magnesium, sulphur and minerals like manganese, zinc, iron, copper, cobalt, iodine and selenium.
  - Organic matter consists of carbohydrate, protein, fat, vitamins, pigments and enzymes.

CARBOHYDRATES AND LIPIDS OF EGGS

Carbohydrate
• Egg is a poor source of carbohydrate and a standard sized egg (58g) contains only 0.5g of carbohydrate, of which 0.3g is seen in albumen and 0.2g in yolk.

Lipids
• These are exclusively present in yolk only.
• A standard sized egg contains 6g of lipids and these are present in an emulsified form which facilitates easy digestion and absorption.
• Of the total lipids 62% is true fat or triglycerides.
• Oleic acid is the major fatty acid and it constitutes around 50% of the total fatty acids.
• Palmitic acid forms 27%, linoleic acid 11%, stearic 6% and the remaining 6% is made up of other fatty acids.
• Phospholipids constitute around 33% of the total yolk lipids.
• The different phospholipids present in yolk are phosphatidyl choline, phosphatidyl ethanolamine, lyso - phosphatidyl choline, lyso - phosphatidyl ethanol amine, sphingomyelin, plasmalogen, inositol phospholipids etc.
• Sterols form 5% of total lipids and the chief sterol is cholesterol.
• An egg contains 200 – 300mg of cholesterol.
• Cerebrosides (ovokerasine and ovophrenosin) are present in traces in egg.

PROTEINS, VITAMINS, AND PIGMENTS OF EGGS

Proteins
• Egg is a rich source of protein and the protein is of high quality.
• Proteins are present both in albumen and yolk.
• The predominant protein of albumen is ovalbumen which constitutes 54% of the total albumen protein.
• The other proteins present in albumen are conalbumin, ovomucoid, ovomucin, lysozyme, G2 globulin, G3 globulin, flavoprotein, avidin, ovomacroglobulin, ovoglycoprotein etc.
• The major protein in yolk is ovovitelline which constitutes 75% of the total yolk protein and the remaining 25% is constituted by ovolivetin.
• Ovolvetine is rich in phosphorus and one-third of phosphorus content of yolk is present in this fraction.
• Ovolvetin is rich in sulphur and contains nearly one-third of the total sulphur of yolk and a very small proportion of phosphorus.
• Proteins of vitelline and shell membranes are ovokeratin and ovomucin.
• Shell proteins are mainly collagen in nature.
• The proteins of egg contain all essential amino acids in correct proportions.

Vitamins
• Egg contains both water and fat soluble vitamins.

Enzymes
• Egg albumen contains the enzyme lysozyme, which is antimicrobial in nature and the yolk contains small amounts of catalase, peptidase, tributyrase, amylase, phosphatidase etc.

Pigments
• Shell pigments of egg include ovoporphyrin, which is responsible for the brownish tint of some eggs.
• Ovocyan gives bluish tint to eggs (in Araucana breed of chicken).
• Some poultry egg shell membrane has a pinkish pigment porophyrin.
• Albumen pigment is ovoflavin which has a creamy tinge.

By- Manuprabh, Naveen, Pradeep
Yolk pigments are of two types – water soluble pigment or lyochromes that resemble ovoflavin of albumen and fat soluble pigments or lipochromes which include carotenoids and xanthophylls.

Carotenoids include α and β-carotenes which have vitamin A activity.

Xanthophylls include cryptoxanthene, zeaxanthene and lutein which have pigmenting property alone.

Nutritive Value of Eggs

The quality of egg protein is of good excellent and has a very high biological value of 96.

It is considered as a reference protein.

It has all amino acids in correct proportions.

Yolk contains 16.5 per cent and albumen contains 10.5 per cent protein.

From a standard sized egg, we will get 6.5 g protein from albumen and 3.0 g from yolk.

The fat of egg is well emulsified, easily digested and absorbed.

Eggs are good sources of vitamins and minerals.

- Vitamin A – 200-1000 IU/egg
- Vitamin B1 – present in yolk alone 50-70 µg/egg
- Vitamin B2 – 200 µg/egg (in yolk and albumen)
- Niacin – 40 µg/egg
- Pantothenic acid – 600 µg/egg

Module-14: Preservation and Packaging of Eggs

Learning Objectives

At the end of this module, the learner will become conversant with the various methods of preservation and packaging of eggs and also their advantages and limitations.

Packaging of Shell Eggs

Nature has given the egg a natural package - the shell.

Despite its relative strength, the egg is an extremely fragile product and even with the best handling methods, serious losses can result from shell damage.

Economical marketing generally requires that eggs be protected by the adoption of specialized packaging and handling procedures.

Functions of packaging

- Packaging is an important component in delivering quality eggs to buyers.
- It embraces both the art and science of preparing products for storage, transport and eventually sale.
- Packaging protects the eggs from:
  - micro-organisms, such as bacteria;
  - natural predators;
  - loss of moisture;
  - tainting;
  - temperatures that cause deterioration; and
  - possible crushing while being handled, stored or transported.
- Proper handling and storage, help control moisture loss, but appropriate packaging may also help prevent it.
- Eggs also need to breathe, hence the packaging material used must allow for the entrance of oxygen.
- The material used must be clean and odourless so as to prevent possible contamination and tainting.
- Authentic egg packaging materials can be reused, but careful attention must be paid to possible damage, odours and cleanliness.
- The packaging must be made to withstand handling, storage and transport methods of the most diverse kind and to protect the eggs against temperatures that cause deterioration and humidity.
- Finally, consumers like to see what they are buying, especially if it concerns fresh produce.
- An egg package should be designed so that the customers not only recognize the product as such, but can also see the eggs they are buying.
- Many factors must be taken into consideration for packaging eggs. It is important to obtain information regarding the necessary requirements for a particular market, such as:
  - quality maintenance;
  - storage facilities;
  - of transport;
  - to be travelled;
  - climatic conditions;
  - time involved; and
  - costs.

Egg Packages

There are many different types of egg packages, which vary both in design and packaging material used.
Grain by-products

- Packing eggs with clean and odourless rice husks, wheat chaff or chopped straw in a firm walled basket or crate greatly decreases the risk of shell damage. It is also possible to pack eggs in a simple basket. The basket has no cushioning material such as straw and therefore damage to the eggs may occur more easily. This kind of packaging may be fit for short distance transport.

Filler Trays

- A very common form of packaging is the filler tray. The fillers are then placed in boxes or cases.
- Filler trays are made of wood pulp moulded to accommodate the eggs. They are constructed so that they can be stacked one on top of the other and can also be placed in boxes ready for transport.
- Filler trays also offer a convenient method for counting the eggs in each box, without having to count every single egg.
- The cases used may be made of sawn wood; however, they are more commonly made of cardboard.
- When using cardboard cases, special care must be taken in stacking so that excessive weight is not placed on a case at the bottom of a stack.
- Fillers can also be made of plastic as seen in.
- The advantages of using plastic egg fillers are that they can be reused and are washable.
- The fillers can be covered with plastic coverings and be used as packages for final sale to the buyer.
- More importantly, however, plastic transparent fillers allow for the inspection of eggs without handling or touching the eggs.

Retail Packages

- Eggs can also be packed in packages that are smaller and specific for retail sale.
- Each package can hold from two to twelve eggs.
- These cases can be made of paperboard or moulded wood pulp, or can be made of plastic.
- It is also possible to pack eggs in small paperboard cases and cover them with plastic film.
- Egg cases have also been developed from polystyrene.
- The advantages of using polystyrene are superior cushioning and protection against odours and moisture.
- The package is also resistant to fungus and mould growth.
- The use of small cases is restricted by availability and cost considerations.
- However, small cases are good for retailers and customers.
- They are easy for the retailers to handle and customers are able to inspect the eggs.

Labelling

- Labels are a source of important information for the wholesaler, retailer and consumer and not just pieces of paper stuck onto cartons or boxes.
- The important facts on the label contain information for buyers concerning the eggs, their size and weight and quality/grade description - AA, A or B.
- Labels may also indicate the producer, when the eggs were laid, how to store them and their expiration date.
- Persuading the buyer to purchase the product without tasting, smelling or touching is another function of labelling.

Preservation of Eggs

- In order to preserve eggs only good quality eggs should be produced. Therefore any method of preservation starts from the point of production itself.
- The following practices are recommended as routine for the production of quality eggs on the farm.
  - Collection of eggs at least 3 times daily.
  - Using a clean receptacle with ventilated sides and bottom, preferably filler flats.
  - Careful handling of eggs during collection and while keeping in filler flats etc.,
  - Cooling the eggs quickly to 50°F or less at 75-85% relative humidity.
  - Marketing the eggs at least twice weekly.

Preservation

- The shell of an egg normally carries a wide range of microorganisms on its surface which are mostly responsible for spoilage of eggs.
- Many methods have been used in the past to counteract this and extend the shelf life of eggs. These include:

Dry packing

- Eggs are kept in an earthen pot with clean dry packing material and the pot is buried in wet sand.

Immersion in liquids

- This is fairly an old method and it primarily prevents the evaporation of moisture from the egg.
- Depending on the liquid used it may also inhibit bacterial decomposition by chemicals action or by physical means such as occlusion of air passages/pores.
Meat Science (LPT-321)

By Manuprabh, Naveen, Pradeep

- **Lime water treatment**
  - Lime water is prepared by mixing about 0.5kg of quick lime (calcium oxide) in about 1 litre of boiling water.
  - The mixture is left to settle overnight and the clean supernatant liquid is poured out into a jar.
  - Sodium chloride of 112 grams per litre may also be added to increase the specific gravity of water and will minimise the chance of breakage of eggs.
  - In this solution, 2.5 liters of cold water is added and filtered through muslin cloth.
  - Keep the eggs to be preserved in a glass jar or earthen pot and pour the lime solution over the eggs till all the eggs are completely immersed.
  - Eggs have to be kept in this solution for 24 hours to get maximum beneficial effect.
  - After 24 hours they are taken out, dried and arranged in filler flats.
  - Eggs can be kept for 2-3 months in a good edible condition at normal ambient temperature.
  - The only disadvantage however, is the taste of lime can be detected in the eggs.

- **Water glass method**
  - A 10% solution of sodium silicate is prepared in hot water and allowed to cool.
  - The cooled solution is poured into a jar containing the eggs till they are immersed completely.
  - The jar is covered and kept in a cool place where the temperature should not exceed above 70°F.
  - Eggs preserved by this method are usually punctured before boiling to avoid the breakage of shell while boiling and it also helps for easy peeling of shell.

- **Shell - Sealing treatments**
  - When the shell is sealed through this treatment the water vapour and CO₂ do not escape and microorganisms are unable to penetrate the shell.
  - **Coating with oil**
    - The rate of CO₂ escape is considerably reduced.
    - This is a fairly successful method of rendering the egg less permeable.
    - It can be done by simply dipping the egg in a bowl of tasteless, odorless, colourless edible oil, having a specific gravity of about 0.855 to 0.870 at 15°C; viscosity should not be more than 70 to 90 and having a high boiling point so that at lower temperature it remains in the liquid form.
    - The eggs are immersed only for a moment and are then removed and the excess oil is allowed to drain.
    - If oil treatment is to be effective it should be done preferably at the point of production the day after the egg is laid.
    - Oiling is not a substitute for refrigeration.
    - These eggs must be held at a low temperature.
    - Cotton seed, linseed and groundnut oil are good sealing agents but mineral oils are preferable since they are less subject to oxidative changes during storage. oil immersed eggs and these eggs are not likely to absorb foreign odours.
    - The oil treatment can also be done by spraying using a hand or electric sprayer.
    - Eggs can be sealed under vacuum.
    - Oil may be successfully used in vacuum impregnation method.
    - The egg is first immersed in oil and then subjected to reduced atmospheric pressure, when normal pressure is restored the tendency of the air to enter the pores of the shell causes the solution also to be drawn in.
    - The oil does not penetrate through the egg membranes.
  - The commercial egg treatment with oils are
    1. Heavy paraffin oil (Central Food Technology Research Institute
    2. Myvacet 9-40 (developed at CFTRI - Mysore)
    3. Myvacet 5
    4. Myvacet 7
    5. Petroleum jelly
    6. Liquid paraffin
    7. Paraffin wax
    8. Coconut oil
    9. Dalda
    10. Carboxyl methyl cellulose
    11. Technical white oil.
  - **Thermostabilization**
    - This method is good for fertile eggs since it kills the embryos and therefore is also known as 'defertilization' method.
    - It essentially consists of immersing shell eggs in hot water at 130°F for 30 minutes which tend to coagulate the albumin and then the egg is cooled under tap water.
    - Treated eggs remain edible for 3 to 4 weeks even during summer months.
    - Though this method has many advantages such as stabilizing of the albumin and sterilization of the egg shell, the egg looses the property of foaming to a remarkable extent.

By- Manuprabh, Naveen, Pradeep
Moreover, embryonic development in fertile eggs is completely arrested.

- Over-wrapping
  - For over wrapping of eggs polyethylene, cellophane, polyvinylidene and other transparent, thin but sufficiently strong, films are used.
  - These films should be impervious to gases and moisture.
  - Over wrapping of eggs in different atmosphere like carbon dioxide, vacuum etc. have been tried.

**Cold storage**

- This is the best and most efficient method for commercial storage.
- Eggs for cold storage must be clean, unbroken, and free from fungus and other infections.
- A temperature of 0°C or 30-32°F and relative humidity of 85-90% is recommended for cold storage of eggs to preserve them for 5 to 8 months.
- For short period of preservation of 2 to 3 months, eggs can be stored at 10-12°C or 50-55°F with a relative humidity of 60-70%.
- Intact eggs are held at the lowest possible temperature that will avoid freezing and bursting of the shells.
- It has been observed that intact eggs do not freeze at temperature between -1.5°C and -2°C and the relative humidity must not go beyond 90%.

**Dried and frozen eggs**

- This is another method of preserving egg contents or edible eggs.
- Egg products of commercial utility are prepared by drying or freezing eggs.
- Albumin flakes, yolk and egg white powder can be produced by drying process.
- Frozen yolk or frozen egg white can be produced by freezing.
- For egg white powder production the best known method is spray drying and for albumin flakes, pan or cabinet drying method is mostly adopted.

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**MODULE-15: LAWS GOVERNING NATIONAL/INTERNATIONAL TRADE IN MEAT AND MEAT PRODUCT**

**Learning objectives**

- At the end of this module the learner will become conversant with the laws governing national and international of meat such as BIS, ISO standards and ICMSF and EEC regulations.

**INTRODUCTION**

- Regulation of the quality of meat placed in trade is essential to ensure uniformity in quality; and pricing of meat and meat products based on their quality,
- Microbial standards are necessary to ensure safe meat is made available to consumers. The various terms in vogue to address this concern of the meat industry are microbial standard, specification and guideline.
- A microbial standard is a microbiological criterion that is part of a law, or regulation, mandatory and enforceable by the regulatory agency involved.
- A microbial specification is a microbiological criterion that is applied as a condition of acceptance for a food or ingredient by a food manufacturer. Microbiological specifications are generally contractual agreements between a manufacturer and purchaser to check whether the foods are of required quality.
- Microbiological guidelines, which are non-mandatory criteria usually intended as a guide to good manufacturing practice.
- The major law involved in governing meat trade in India is Meat Food Products Order, 1973 and the most recent development governing Food Safety in India is the Food Safety and Standards Act, 2006 over and above standards set out with respect to Meat by Bureau of Indian Standards.
- The major standards governing international food trade is ISO 22000 standard and microbial standards are set by International Committee on Microbial Specification on Foods (ICMSF), and European Economic Community.
- The ensuing discussion presents a detailed description of the above standards.

**MEAT FOOD PRODUCTS ORDER (MFPO)**

- Meat is one of the oldest food items of human being.
- Initially, it was being taken raw but later it began to be processed to satisfy the palate and to provide preservative action.
- But meat is a highly perishable commodity and sanitary conditions and utmost hygienic measures are necessary to safeguard the quality of processed meat food products.
- With the advent of centralised meat processing units, the responsibility to maintain the quality of meat food products became a central concern.
- In 1973, Government of India promulgated an Order to enforce strict quality control on the production and processing of meat food products under Essential Commodities Act 1955.
- The responsibility to enforce this order was entrusted to Directorate of Marketing and Inspection, Ministry of Agriculture and Rural Reconstruction.
The Agricultural Marketing Advisor to the Government of India was made the ex-officio Chairman of meat Food Products Advisory Committee with 10 members who aid and advise ministry in any matter pertaining to this Order.

The Order aims at maintenance of sanitary conditions in the slaughterhouses, ensuring proper antemortem examination, postmortem inspection of carcasses, in-process inspection and final product checking.

No person could carry on business as a manufacturer except under and in accordance with the terms and conditions of licence granted to him under this Order.

Every application for grant of licence shall be made as per the proforma set out in the First Schedule of this Order.

All meat-processing units, which produce meat food products for, sale within the country come under its preview.

Restaurants and hotels that prepare meat food products for consumption within their premises are exempted.

Any food item which is made from flesh or any other edible part of the carcass through the process of curing, smoking, cooking, drying or any other processing technique is referred as meat food product.

The Order does not apply on raw (chilled or frozen) meat.

It may be noted that no dealer, agent, broker or vendor can sell or expose for sale or despatch or deliver any meat food products unless the same are manufactured by a MFPO licencee.

Powers of MFPO Officers

The Veterinarian inspecting officers of the Directorate are issued necessary authority cards to seek compliance of MFPO.

These officers are authorized:
- To enter and inspect the premises of meat food products manufacturers with a view to satisfy themselves that the requirements of this Order are being complied with.
- To seize or detain on giving proper receipt of raw materials, documents, account books or evidence connected with the manufacture of meat food products in respect of which they have reasons to believe that contravention of the Order has taken place.
- To dispose of all meat food products and raw materials so seized or detained as they deem fit.

Categories

MFPO, 1973 initially categorises the meat food manufacturers into the following three broad heads on the basis of source of raw meat:
- Category A : Includes those manufacturers or licencees of meat food products who possess their own slaughterhouse.
- Category B : Includes those manufacturers of meat food products who purchase meat from approved slaughterhouse.
- Category C : Includes those manufacturers of meat food products, who purchase raw meat from any other source.

The licence fee for each category differs and is collected every year at the time of renewal of licence.

Schedules

Meat Food Products Order, 1973 contains four schedules:

- **The First Schedule**
  - Deals with application for licence or renewal of licence under MFPO.
  - The information related to applicant, address of factory, source of raw material, description of meat food products which the applicants proposes to manufacture, installed capacity, a plan of factory and a list of equipments has to be provided.
  - Application for renewal of licence should invariably contain the statements pertaining to the quality and value of meat food products manufactured in the previous year.

- **The Second Schedule**
  - Deals with the minimum sanitary requirements to be complied with by a licencee.
  - It contains detailed instructions regarding factory premises, construction, doors, windows and ceiling, plumbing and drainage system, equipment and manufacturing area, cold storage facilities, precautions against flies, rats and mice, water supply, personnel hygiene and vaccination of factory workers, provision of proper aprons and head gears, etc.

- **The Third Schedule**
  - Deals with hygienic requirements to be complied with by a licencee who also slaughters animals in his factory.
  - It contains detailed instructions regarding separation between clean and dirty sections within the slaughterhouse, provision of lairage, slaughter hall and refrigeration facilities, antemortem examination, humane slaughter, postmortem inspection and disposal of condemned carcasses or organs, etc.

- **The Fourth Schedule**

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- Deals with the requirements to be complied with as regards to packaging, marking and labeling the containers of meat food products.
- It contains detailed instruction with respect to proper packing and sealing of flexible containers, use of internal lacquers and hermetic sealing in tin plate cans, use of internal lacquers and hermetic sealing in tin plate cans, use of bottles and jars.
- As per MFPO standards, canned meat food products should not contain poisonous elements viz. lead, copper, arsenic, tin, zinc in excess of 2.5, 20, 2, 250 and 50 ppm respectively by weight.
  - In the process MFPO officers conduct inspection of meat food product factories and premises regularly.
  - They conduct frequent surprise visits to licensed units so as to enforce the implementation of MFPO regulations.
  - Samples of meat food products are collected and sent to regional and central Agmark laboratories for specified testing.
  - At present there are more than 220 licensed meat food products units under MFPO, 1973 throughout India.
  - These units manufacture as many as 185 different types of meat food products.
  - Thus, MFPO is playing a major role in safeguarding the interest of meat food products consumers.

**BIS STANDARDS FOR THE MEAT INDUSTRY**

- Quality control departments frequently utilise the reliable methods and techniques for establishing the standards.
- A standard can be referred as carefully drawn specification with respect to a food product.
- The specifications give comprehensive instructions to ensure correct and reliable process control.
- The compliance of specifications increases the confidence of top executives in the production and marketing of perishable food items.

**Bureau of Indian Standards (BIS)**

- Established in 1947 as Indian Standard Institution (ISI) as a joint venture of Government of India and Industry took up the responsibility of preparing and promoting the general adoption of standards in the country.
- The erstwhile ISI constituted the Meat and Meat products Sectional Committee, AFDC 18 under the Agricultural and Food Products Division Council in 1958 to prepare Indian Standards for meat industry.
- This committee represents the scientists, technologists, manufacturers, government agencies and consumers.
- The standards are prepared keeping in mind the needs of industry protecting the interests of both producers and consumers and are reviewed periodically.
- A list of relevant standards is given below:

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>IS No.</th>
<th>Title</th>
<th>Reaffirmed Date</th>
<th>Amendment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IS 1723:1973</td>
<td>Pork (first revision)</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>IS 1743:1973</td>
<td>Mutton and goat meat canned in brine (first revision)</td>
<td>11 2000</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>IS 1982:1971</td>
<td>Code of practice for ante-mortem and post-mortem inspection of meat animals (first revision)</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>IS 2475:1979</td>
<td>Smoked bacon (first revision)</td>
<td>11 2000</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>IS 2476:1963</td>
<td>Ham</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>IS 2536:1995</td>
<td>Mutton and goat meat(curvonn)-fresh, chilled and frozen (first revision)</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>IS 2537:1995</td>
<td>Beef and buffalo meat-fresh, chilled and frozen (first revision)</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>IS 3044:1973</td>
<td>Mutton and goat meat, curried and canned (first revision)</td>
<td>11 2000</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>IS 3060:1979</td>
<td>Pork sausages, canned (first revision)</td>
<td>11 2000</td>
<td>2</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>No.</th>
<th>IS Code</th>
<th>Description</th>
<th>Year</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>IS 3061:2001</td>
<td>Pork sausages, fresh (first revision)</td>
<td>1100</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>IS 4352:1967</td>
<td>Pork luncheon meat, canned</td>
<td>1100</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>IS 4393:1979</td>
<td>Basic requirements for an abattoir (first revision)</td>
<td>0305</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>IS 4674:1975</td>
<td>Dressed chicken (first revision)</td>
<td>1100</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>IS 4723:1978</td>
<td>Egg powder (first revision)</td>
<td>1100</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>IS 4950:1968</td>
<td>Bacon rashers, canned</td>
<td>1100</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>IS 4951:1975</td>
<td>Ham, canned (first revision)</td>
<td>1100</td>
<td>1</td>
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<tr>
<td>19</td>
<td>IS 5558:1970</td>
<td>Chichen essence</td>
<td>1100</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>IS 5960(Part 3):1970</td>
<td>Methods of test for meat and meat products: Part 3 Determination of total fat content</td>
<td>0305</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>IS 5960(Part 7):1996</td>
<td>Methods of test for meat and meat products : Part 7 Determination of nitrite content (first revision)</td>
<td>0100</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>IS Code (Part/Year)</td>
<td>Standards Title/Reference Method</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>-----</td>
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<td>----------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>IS 6557:1972</td>
<td>Albumen flakes, non-edible quality</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>IS 6559:1972</td>
<td>Code of practice for ante-mortem and post-mortem inspection for poultry</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>41</td>
<td>IS 6628:1972</td>
<td>Slide rails for use in abattoirs</td>
<td>03 2005</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>IS Code</th>
<th>Description</th>
<th>Date</th>
<th>Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>IS 6782:1972</td>
<td>Hog gambrels</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>IS 6950:1973</td>
<td>Pig hooks</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>IS 7049:1973</td>
<td>Code for handling, processing, quality evaluation and storage of poultry</td>
<td>11 2000</td>
<td>2</td>
</tr>
<tr>
<td>45</td>
<td>IS 7053:1996</td>
<td>Basic requirements for a stall for sale of meat of small and large animals (first revision)</td>
<td>01 2001</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>IS 7891:1975</td>
<td>Inedible offal trolleys</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>IS 7909:1993</td>
<td>Slaughter house equipment - Electrical stunning tongs for pigs (first revision)</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>IS 9800:1993</td>
<td>Day-old chicks (Layer/broilers) - Basic requirements (first revision)</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>IS 9810:1981</td>
<td>Method for evaluation of quality of fresh chicken eggs</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>52</td>
<td>IS 10382:1982</td>
<td>Edible egg albumen-powder</td>
<td>11 2000</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>IS 10697:1983</td>
<td>Chicken, canned in brine</td>
<td>11 2000</td>
<td>2</td>
</tr>
<tr>
<td>54</td>
<td>IS 11533:1985</td>
<td>Sheep dressing hook</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>IS 11631:1985</td>
<td>Gambrel for sheep and goats</td>
<td>03 2005</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>IS 11746:1986</td>
<td>Luncheon beef, canned</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>57</td>
<td>IS 11747:1986</td>
<td>Corned beef, canned</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>58</td>
<td>IS 11748:1986</td>
<td>Meat extract, food grade</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>59</td>
<td>IS 11771:1986</td>
<td>Soup stock medium (beef)</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>60</td>
<td>IS 12189:1987</td>
<td>Sheep spreader</td>
<td>11 2000</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>IS 12190:1987</td>
<td>Sheep bleeding shackle</td>
<td>11 2000</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>IS 12487:1988</td>
<td>Offal handling table for small animals</td>
<td>11 2000</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>IS 12541:1988</td>
<td>Chicken curry, canned</td>
<td>11 2000</td>
<td>1</td>
</tr>
<tr>
<td>65</td>
<td>IS 12542:1988</td>
<td>Canned ham, minced</td>
<td>11 2000</td>
<td>1</td>
</tr>
</tbody>
</table>
These BIS specifications are voluntary but an adherence to these guidelines definitely improves the quality of processed products.

However, Meat Food Products Order, which exclusively deals with quality control of processed meat products, is mandatory.

Microbiological standards help to improve plant sanitation, ensure safety of the products and prevent losses due to microbial spoilage.

Establishment of microbiological specifications is a very expensive and cumbersome task.

Lot of database is required in practical conditions at different locations, with a very good degree of reproducibility.

Microbiological specifications for meat processing plants as suggested by Marks and Spencer, UK, are presented in the following table.

**MICROBIAL STANDARDS FOR MEAT OF ICMSF AND EEC**


<table>
<thead>
<tr>
<th>S.No</th>
<th>Product</th>
<th>Test</th>
<th>n</th>
<th>c</th>
<th>m</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Carcase meat, before chilling</td>
<td>APC</td>
<td>5</td>
<td>3</td>
<td>10^5</td>
<td>10^6</td>
</tr>
<tr>
<td>2.</td>
<td>Carcase meat, chilled</td>
<td>APC</td>
<td>5</td>
<td>3</td>
<td>10^6</td>
<td>10^7</td>
</tr>
<tr>
<td>3.</td>
<td>Edible offal, chilled</td>
<td>APC</td>
<td>5</td>
<td>3</td>
<td>10^6</td>
<td>10^7</td>
</tr>
<tr>
<td>4.</td>
<td>Carcase meat, frozen</td>
<td>APC</td>
<td>5</td>
<td>3</td>
<td>5x10^5</td>
<td>10^7</td>
</tr>
<tr>
<td>5.</td>
<td>Boneless meat, frozen (beef, pork, mutton)</td>
<td>APC</td>
<td>5</td>
<td>3</td>
<td>5x10^5</td>
<td>10^7</td>
</tr>
</tbody>
</table>
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6. Comminuted meat, frozen

7. Edible offal, frozen

8. Raw chicken, fresh or frozen

- **n** = number of samples to be taken from the lot,
- **c** = number of samples permitted to fail,
- **m** = microbial count below which the sample is considered to be satisfactory
- **M** = microbial count above which the sample is considered unsatisfactory.


<table>
<thead>
<tr>
<th>S.No</th>
<th>Organism</th>
<th>n</th>
<th>c</th>
<th>m</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Aerobic mesophile (total viable count) bacteria</td>
<td>5</td>
<td>2</td>
<td>5x10^2</td>
<td>5x10^6</td>
</tr>
<tr>
<td>2.</td>
<td>E.Coli</td>
<td>5</td>
<td>2</td>
<td>5x10^2</td>
<td>5x10^3</td>
</tr>
<tr>
<td>3.</td>
<td>Cl. Perfringens (sulphite-reducing anaerobes)</td>
<td>5</td>
<td>1</td>
<td>10^2</td>
<td>10^4</td>
</tr>
<tr>
<td>4.</td>
<td>Staphylococci</td>
<td>5</td>
<td>1</td>
<td>5x10^2</td>
<td>5x10^3</td>
</tr>
<tr>
<td>5.</td>
<td>Salmonella</td>
<td>5</td>
<td>0</td>
<td>Absence in 25g</td>
<td></td>
</tr>
</tbody>
</table>

- **n** = number of samples to be taken from the lot,
- **c** = number of samples permitted to fail,
- **m** = microbial count below which the sample is considered to be satisfactory
- **M** = microbial count above which the sample is considered unsatisfactory.

ISO STANDARDS FOR FOOD SAFETY

- The ISO 22000 international standard specifies the requirements for a food safety management system that involves the following elements:
  - interactive communication
  - system management
  - prerequisite programs
  - HACCP principles
- Critical reviews of the above elements have been conducted by many scientists
- Communication along the food chain is essential to ensure that all relevant food safety hazards are identified and adequately controlled at each step within the food chain.
- This implies communication between organizations both upstream and downstream in the food chain.
- Communication with customers and suppliers about identified hazards and control measures will assist in clarifying customer and supplier requirements.
- Recognition of the organization’s role and position within the food chain is essential to ensure effective interactive communication throughout the chain in order to deliver safe food products to the final consumer.
- The most effective food safety systems are established, operated and updated within the framework of a structured management system and incorporated into the overall management activities of the organization.
- This provides maximum benefit for the organization and interested parties. ISO 22000 has been aligned with ISO 9001 in order to enhance the compatibility of the two standards.
- ISO 22000 can be applied independently of other management system standards or integrated with existing management system requirements.
- ISO 22000 integrates the principles of the Hazard Analysis and Critical Control Point (HACCP) system and application steps developed by the Codex Alimentarius Commission.
- By means of auditable requirements, it combines the HACCP plan with prerequisite programmes.
- Hazard analysis is the key to an effective food safety management system, since conducting a hazard analysis assists in organizing the knowledge required to establish an effective combination of control measures. ISO 22000 requires that all hazards that may be reasonably expected to occur in the food chain, including hazards that may be associated with the type of process and facilities used, are identified and assessed.
- Thus it provides the means to determine and document why certain identified hazards need to be controlled by a particular organization and why others need not.
- During hazard analysis, the organization determines the strategy to be used to ensure hazard control by combining the prerequisite programmes and the HACCP plan.
- ISO is developing additional standards that are related to ISO 22000.
- These standards will be known as the ISO 22000 family of standards.
- At the present time, the following standards will make up the ISO 22000 family of standards:
  - ISO 22000 - Food safety management systems - Requirements for any organization in the food chain.
MODULE-16: ORGANIC MEAT

Learning objectives
- At the end of this module the learner will become conversant with the producing organic meat, raising meat animals the organic way and handling the meat harvested the organic way.

INTRODUCTION
- The philosophy of organic meat production is to raise the animal in a manner that befits the use of the term organic as well as handling the meat in such manner.
- The distinction between meat produced by conventional farming and organic farming is highlighted below

<table>
<thead>
<tr>
<th>Conventional</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply chemical fertilizers to promote plant growth.</td>
<td>Apply natural fertilizers, such as manure or compost, to feed soil and plants.</td>
</tr>
<tr>
<td>Spray insecticides to reduce pests and disease.</td>
<td>Use beneficial insects and birds, mating disruption or traps to reduce pests and disease.</td>
</tr>
<tr>
<td>Use chemical herbicides to manage weeds.</td>
<td>Rotate crops, till, hand weed or mulch to manage weeds.</td>
</tr>
<tr>
<td>Give animals antibiotics, growth hormones and medications to prevent disease and spur growth.</td>
<td>Give animals organic feed and allow them access to the outdoors. Use preventive measures — such as rotational grazing, a balanced diet and clean housing — to help minimize disease.</td>
</tr>
</tbody>
</table>

RAISING LIVESTOCK THE ORGANIC WAY
- Organic production of livestock is to provide conditions that meet the health needs and natural behavior of the animal.
- Thus, organic livestock are given access to the outdoors, fresh air, water, sunshine, grass and pasture, and are fed 100 percent organic feed.
- Any shelter provided must be designed to allow the animal comfort and the opportunity to exercise.
- **Organic practices prohibit feeding animal parts of any kind to ruminants that, by nature, eat a vegetarian diet.**
  - Thus, no animal by-products of any sort are incorporated in organic feed at any time.
  - In the United States, regulations specify that organic standards require oversight of production and handling systems.
  - For instance, production and handling operations must undergo onsite inspections and have farm or operating plans in place in order to be certified organic.
  - The standards also specify feed requirements, including what is and is not allowed.
  - For instance, in organic production, livestock cannot be fed plastic pellets for roughage, or formulas containing urea or manure.
  - They cannot be given antibiotics or growth hormones.
  - All of these are allowable practices in conventional agriculture.
  - For an animal to be raised for organic beef, its mother must have been fed organic feed for at least the last third of gestation.

HANDLING OF MEAT THE ORGANIC WAY
- In processing operations that handle both organic and non-organic meat products, processors must segregate their handling of organic and non-organic meat.
- There also are specified cleaning agents that are allowed and prohibited in such operations.

Traceability
- Organic certification, by a U.S. Department of Agriculture-approved agent, is required for the farm and the processing and handling facilities prior to delivery to retail outlets.
- Because farmers and handlers must keep extensive records as part of their farm and handling plans in order to be certified organic, **the organic production system offers traceability of the animal from birth to marketing of the resulting meat.**
Thus, when one purchases organic meat, there is a guarantee of traceability.

Marketing of organic meat
- Under national organic standards, when marketed as organic, meat by itself is 100 percent organic.
- If a consumer buys organic hamburger, it means that all of the meat has been produced organically.

MODULE-17: FOOD PRODUCTS OF GENETICALLY MODIFIED ANIMAL AND MARINE ORIGIN

Learning objectives
- At the end of this module the learner will become conversant with the meat produced from genetically modified organisms.

FOOD PRODUCTS OF GENETICALLY MODIFIED ANIMAL AND MARINE ORIGIN
- A prominent area of contemporary animal biotechnology research is the development of transgenic animals through genetic engineering (GE) technology.
- Transgenic animals are produced by introducing an isolated DNA fragment into an embryo so that the resulting animal will express a desired trait.
- Transgenic animals may be generated by the introduction of foreign DNA obtained through animals of the same species, animals of different species, microbes, humans, cells, and in vitro nucleic acid synthesis.
- Potential applications for such genetic engineering in the food industry include improved feed use and faster growth; more resistance to disease; meat that is leaner or that has more of some other desirable quality; and possibly even animal waste that is more environmentally benign, synthesis of milk with pharmaceutical agents.
- The table below provides examples of animal biotechnology involving genetic modification applicable to the food industry.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Animal Model</th>
<th>Transgenic Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster Growth or leaner meat</td>
<td>Cattle, Swine,</td>
<td>Growth hormones/factors: Human, Bovine, Porcine, Rat, Chicken</td>
</tr>
<tr>
<td></td>
<td>Rabbits, Sheep</td>
<td></td>
</tr>
<tr>
<td>Altered milk composition (higher protein)</td>
<td>Cattle</td>
<td>Extra copies of casein genes; disruption of lactoglobulin gene</td>
</tr>
<tr>
<td>Anti-clotting drug production in milk</td>
<td>Goat</td>
<td>Human anti-thrombin gene</td>
</tr>
<tr>
<td>Faster Growth</td>
<td>Atlantic Salmon</td>
<td>Growth hormone regulating gene from Pacific Chinook Salmon and a promoter from an ocean pout</td>
</tr>
</tbody>
</table>

- The anti-clotting agent in goat milk is the first such application to be approved by the FDA in March 2009.
- The aqua advantage salmon is a genetically engineered salmon, whose growth rate has been enhanced and is meant for aquaculture. It is under consideration of the FDA for approval and is likely to be approved.

ATryn
- ATryn is the brand name of the anticoagulant antithrombin manufactured by the Massachusetts-based U.S. company GTC Biotherapeutics.
- It is made from the milk of goats that have been genetically modified to produce human antithrombin, a plasma protein with anticoagulant properties.
- Microinjection was used to insert human antithrombin genes into the cell nucleus of their embryos.
- ATryn is the first medicine produced using genetically engineered animals. GTC states that one genetically modified goat can produce the same amount of antithrombin in a year as 90,000 blood donations.
- GTC chose goats for the process because they reproduce more rapidly than cattle and produce more protein than rabbits or mice.
- On February 6, 2009, ATryn was approved by the U.S. Food and Drug Administration (FDA) for treatment of patients with hereditary antithrombin deficiency, who are undergoing surgical or childbirth procedures.
- Along with the approval from the FDA’s pharmaceutical regulatory board, the Center for Veterinary Medicine of the FDA also approved the genetic makeup of the goats that are used to manufacture ATryn.
- GTC has the sole rights to sell ATryn in the United States, and the drug will be available in the U.S. market in 2009.
- Earlier in 2006, the European Medicines Agency (EMEA) initially rejected and, after an appeal from GTC, approved the drug for use in the European Union countries.
- The company plans to acquire additional approval for treatment of those with non-hereditary antithrombin deficiency.

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The Humane Society of the United States has said of the process used to manufacture ATryn, "It is a mechanistic use of animals that seems to perpetuate the notion of their being merely tools for human use rather than sentient creatures."

However, the genetic change has no known ill-effects on the host animal.

**AQUADVANTAGE SALMON**

**Aquaadvantage Salmon**

- **Aquaadvantage atlantic salmon** is a genetically modified salmon, which is an Atlantic Salmon, modified by adding a growth hormone regulating gene from a Pacific Chinook Salmon and a promoter from an ocean pout to the Atlantic's 40,000 genes.
- These genes enable it to eat year-round, instead of only during spring and summer. The purpose of the modifications is to increase the speed at which the fish grows, without affecting its ultimate size or other qualities.
- The fish grows to market size in 16 to 18 months rather than three years.

**Concerns**

- Concerns raised about the release of genetically modified animals include potential negative human health and environmental effects.
- There are concerns that the genetically modified salmon could have an adverse effect on wild salmon populations should they escape from the farms.
- Aquaculture that uses naturally-occurring salmon, mostly Atlantic salmon, cultivates the fish in net pens.
- In North America, this occurs mostly in coastal waters along Washington State, British Columbia and Maine.
- Ocean-cultured fish can escape and compete with native (non-Atlantic) stocks. By some estimates, 400,000 to 1 million Atlantic salmon have escaped from the 75 or so operations in British Columbia.
- A Purdue University computer model showed that 60 transgenic medaka interbreeding in a population of 60,000 wild fish would leave the wild fish extinct in 40 generations.
- The fish’s developer has allayed these fears by publicly announcing the adoption of the following measures:
  - Cultivating only (99 %+) sterile females at inland farms.
  - Any escapees will not be able to reproduce, either natively or by interbreeding with wild stocks, because they are all triploid, with three sets of chromosomes.
  - They are to provide farmers with eggs rather than fish.
**GLOSSARY**

### A

**A band**

Striated muscles consist of alternating light and dark bands and thus presenting the striated appearance. Since, the dark band is doubly refractive, when viewed with polarized light, as it contains both actin and myosin filaments, it is described as being anisotropic, and thus designated the A band. The A band is bisected by M line.

### E

**Endomysium**

Endomysium is a fine connective tissue framework originating from the perimysium and covers each individual muscles fibres.

**Epimysium**

Epimysium is the outermost connective sheath covering each and every muscle.

### F

**Fenestrated collar**

The sarcoplasmic reticulum consists of several distinct elements. Thin tubules oriented in the direction of the myofibrillar axis, constitute the *longitudinal tubules* of the sarcoplasmic reticulum. In the H zone region of the sarcomere the longitudinal tubules converge forming a perforated sheet that is called a *fenestrated* (window-like opening) collar. The longitudinal tubules extend in both directions from the fenestrated collar to the terminal cisternae.

### H

**H zone**

H zone is an area in the central region of the ‘A’ band, which has slightly less density than the remainder of the A band. The H zone is less dense than the rest of the ‘A’ band because it is the centre region between the ends of the opposing actin filaments, containing only myosin heads. The H zone is completely obliterated when the muscle contracts fully, as the actin filaments are pulled towards itself by the myosin head.

### I

**I Band**

Striated muscles consist of alternating light and dark bands and thus presenting the striated appearance. Since, the light band is singly refractive when viewed with polarized light, owing to the fact it exclusively contains actin filaments only, it is described as being isotropic and is called the I band. The I band is bisected by Z line.

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Meat:

Meat is the post rigor aspect of muscle.

Motor end plate:

Motor end plate is the complex structure, a mound on the surface of the muscle fibre, formed at the myoneural junction, wherein the motor nerve fibre endings terminate on invaginations of the sarcolemma.

Muscle fibre:

Muscle cells are referred to as muscle fibre, which are highly specialized cells and are the structural units of muscle. Muscle fibres are long unbranched thread like multinucleate cells which taper slightly at both ends.

Myofibrils:

Myofibrils are unique organelles of the muscle. They are long thin cylindrical rods varying in diameter from 1 to 2 μm, whose long axis is parallel to the length of the muscle and they extend the entire length the muscle fibre. On microscopic examination the myofibrils appear as alternating light and dark bands. The myofibrils are composed of filaments which are referred to as myofilaments, which are chemically proteins.

Myofilaments:

Myofibrils are composed of filaments referred to as myofilaments, and these are of two types - thin and thick myofilaments which are almost completely composed of the proteins actin and myosin respectively.

Myoneural junction:

Myoneural junction is the invaginations of the sarcolemma in which the the motor nerve fibre endings terminate.

Perimysium:

Perimysium is the septa of connective tissue emanating from the epimysium and these aggregate muscle fibres into muscle fibre bundles and covers them.

Pseudo H zone:
Pseudo H zone is the region of relatively low density that appears within the H zone on either side of the M line. This zone contains the myosin tail only. The pseudo H zone is not obliterated by any amount of contraction.

**Sarcolemma**
Sarcolemma is the cell membrane of the muscle fibre. Sarcolemma is similar to plasmalemma of any other animal cell in respect of structure, composition and function and is endowed with great elasticity to endure the great distortion it undergoes during muscular contraction and relaxation.

**Sarcomere**
The functional unit of muscle contraction that extends between Z line and hence include two half I bands and one A band.

**Sarcoplasm**
Sarcoplasm is the cytoplasm of the muscle, in which as is the case of any other cell, organelles and colloidal substances are suspended.

**Sarcoplasmic reticulum**
Sarcoplasmic reticulum is the endoplasmic reticulum of the muscle, which is very well developed and servers as the reservoir for calcium in the muscle.

**Terminal cisterne**
Terminal cisternae are transversely oriented, tubular elements of the sarcoplasmic reticulum.

**Transverse tubules or T system**
Transverse tubules or T system are invaginations of the sarcolemma, that form a network of tubules which run along the entire length and around at the entire circumference of the fibre.

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Thank You