ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY

B. Tech (Food Technology)

Course No.: FDST 312 Processing of meat and poultry products

Credit Hours: 3 (2+1)

THEORY STUDY MATERIAL

Prepared by

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Theory Lecture Outlines

1. Introduction: Sources and development of meat and poultry industries in India and importance of meat and meat industries in national economy
4. Pre-slaughter care-requirements - different modes of transport of meat animal.
5. Ante-mortem examination of meat animal; principles and judgements.
7. Dressing and cutting of carcass in sheep, pig and buffalo.
8. Post mortem examination of carcass and principles of judgement.
9. Grading of meat and packaging of meat
10 Postmortem changes in meat - Rigormortis - Biochemical changes associated with rigormortis which lead to the conversion of muscle to meat - Factors - Ph decline, resolution of rigor-autolytic proteolytic enzymes - microbial invasion and loss of structural integrity
11. Meat quality parameters - Meat color - Water holding capacity - Marbling - Quantum of connective tissue - firmness and storage conditions
12. Palatability characters of meat and factors affecting meat quality
13. Methods of tenderization - aging, enzymes and curing - factors affecting tenderness
14. Spoilage of meat - Sources of contamination, growth of microorganisms – Deteriorative changes in meat - Identification of spoilage
15. Principles of various meat preservation techniques - Chilling - Freezing- Curing - Smoking - Thermal processing - canning - Dehydration - Irradiation and Hurdle concept
17. Cured meats - Process of curing, methods of curing - commercial processing of ham and Bacon - Sausage processing - Production of Intermediate moisture and shelf stable meat products
18. Restructured meat products - tumbling - massaging - chunking - forming - tearing and forming
19. Value added meat products like luncheon meats - meat patties - meat loaves - meat balls and meat nuggets
20. Safety standards in meat industry - Meat food product order - HACCP-ISO-9000 standards
21. Meat plant sanitation and hygiene
22. Structure of egg - different parts of an egg
23. Composition of egg - Proteins of Egg white, Yolk proteins and lipids and nutritive value of egg
24. Egg quality characteristics - Internal Quality - Haugh’s unit - Terms indicating defective quality and Egg grading
25. Antemortem and post mortem examination of poultry birds - principles of judgement
26. Preslaughter care, handling, Transport and dressing of a poultry bird
27. Cuts of poultry bird and Indian Standards of a dressed chicken
28. Microbial spoilage of eggs - types of spoilage in eggs - indications - organisms causing spoilage
29. Preservation and maintenance of eggs - Preservation of shell eggs - Egg cleaning – Oil Treatment - Cold storage - Thermo stabilization - Immersion in liquids
30. Preservation of Albumin and yolk-powder production
31. Preservation of poultry meat - Chilling, Freezing, Curing, Smoking, Dehydration, Canning and Radiation
32. Processing of value added products - Chicken barbecue, chicken sausage, meat balls and pickling
Lecture 1

India is an agrarian country where more than 65% population lives in 5.8 lakh villages wherein about 75% people have their own livestock. Thus, livestock rearing constitutes an integrated and important segment of rural economy accounting for 14-405 of the total farm household income. In general, important meat producing species are largely those animals which consume food of plant origin. The flesh of carnivorous animals is rarely used as human food. In India goat, sheep, pig, buffalo and cattle meat constitutes nearly 75% of the total meat production. Meat of these species is often referred as white, po: k is intermediate in colour.

Our livestock population exceeds 500 millions. During 2001, nearly 4800 thousand MT of meat was produced from the slaughter of 107.64 million animals and 413.4 million chicken. In spite of vast livestock resource, India produces only about 2% of the total world meat production. The export of meat and meat products are very meagre, i, e. 1.4% of the total world meat trade. Frozen meat accounts for 65-75% of the total export. At present access to markets in developed countries does not exist because of animal health issues.

The per capita meat availability in India is 4.26 kg per year which is further expected to increase in the coming years. The annual protein supply is 9.5g per head /day in our country against Asian average of 15.7g and the world average of 24.6g. Thus, we have to take up enormous development programme in meat
production sector even to achieve the target recommended intake of 11g per head per day.

Fresh students should note that carcass yield of meat animals is calculated as percentage of live weight.

\[
\text{Dressing\%} = \frac{\text{Dressed weight}}{\text{Live weight}} \times 100
\]

It varies with species, breed, age, sex and plane of nutrition. High dressing percentage is desirable only if the increase is brought about by muscular growth rather than deposition of excess fat.

“Goat

Goat is referred as Asian Animal’ in the world livestock arena because almost 95% of goat population belongs to the developing countries of Asia. India ranks second in the goat population which is more than double to that of sheep. Though regarded as poor man’s cow, goat has the distinction of being the most important meat animal of India because it provides choicest of all meats fetching maximum retail price in the home market. However, of late relative contribution of goat and sheep meat to total meat production has gone down.
There are nearly 20 recognized breeds of goats, although it is very difficult to demarcate them into milk and meat breeds because of their dual nature.

However, attempt has been made to classify them on the following lines.

<table>
<thead>
<tr>
<th>Meat Breeds</th>
<th>Fiber breeds</th>
<th>Dual breeds Milk and meat</th>
</tr>
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<tbody>
<tr>
<td>Sirohi</td>
<td>Gaddi</td>
<td>Jamunapari</td>
</tr>
<tr>
<td>Malabari</td>
<td>Marwari</td>
<td>Jakhrana</td>
</tr>
<tr>
<td>Black Bengal</td>
<td>Pashmina</td>
<td>Osmanabadi</td>
</tr>
<tr>
<td>Zalawadi</td>
<td>Chegu</td>
<td>Beetal</td>
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<tr>
<td>Sangamneri</td>
<td></td>
<td>Surti</td>
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<tr>
<td>Ganjam</td>
<td></td>
<td>Barbari</td>
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</table>

Jannupari, Beetal and Jakhrana breeds are large in size. They have comparatively high milk production also. But 80% of the goat breeds are medium sized, Mehsan, Surti, Gaddi, Marwari etc. attain 18 to 20 kg weight at 56 months of age which is ideal for optimum meat yield. The dressing percentage of an animal of good conformation varies from 43 to 48%. Black Bengal and Barbari are small sized breeds that attain about 12-13 kg of pre-slaughter weight. However, dressing percentage of Barbari comparatively fugh (47 to 50%) because of its compact body and start stature. Sirohi and Marwari breeds of goat have meaty conformation. Marwari males are specifically reared for meat.
Out of about 124 million goats, almost 38% are slaughtered yearly to contribute nearly 10% to the total meat production. Goat meat is light red in colour and is very firm in consistency. If imparts typical goat odour. Goat carcasses has an abundance of kidney fat which is white in colour. Chevon has practically no intramuscular fat. Due to low saturated fat content the demand for chevon is on the increase.

**Sheep**

In India, sheep are primarily reared for wool and meal in grid. Semi-arid and mountainous areas mostly unsuitable for crop farming besides, pelt (skin) and sometimes milk are also obtained from sheep. In fact, skins from sheep and goats are fairly valuable and about 90% are recovered from their slaughter. As far as meat production is concerned almost 15% derived from this species by slaughter of 33% sheep population every year.

India stands third in sheep population in the world with vast genetic resource of as many as 40 breeds. Hairy breeds of sheep are reared primarily for mutton in the entire peninsular region of India. Of these, Nellore breed has small bones with well developed musculature and is good only for mutton. Trichy Black is a very good breed for mutton. Madras Red is reared specifically for mutton only. Out of dual purpose breeds, Coimbatore and Marwari breeds are small whereas Deccani and Magra breeds are large in size. Among exotic breeds, Polworth produces mutton of the most desirable quality whereas Corriedale is the most important dual purpose breed important in India.
In general, sheep weigh 13 to 16 kg at 6 months of age expect for Decani and Magra which weigh about 20kg at 12 months of age, sheep weigh 18 to 22 kg expect for Muzaffarnagri and Magra which weigh 25 and 28 kg, respectively. A healthy sheep should give a dressing percentage of about 45 to 48 which may go up to 50% or more in exceptionally well bred stock. A sheep carcasses having less than 40% dressing percentage (Table 1.3) is viewed with suspicion. Meat from sheep of less than 12 months of age is referred as lamb and that of more than 12 months of age is called mutton. It should be noted that in trade, eather refers to male sheep castrated early in life whereas gimmer is a female sheep which has not yet borne a lamb. Mutton has light to dark red colour with a firm and dense consistency. It has got a ammonical odour. Male sexual odour is sometimes felt. Sheep fat is white in colour with herd and firm consistency. A sheep carcase has very less quantity of fat around its typical bean shaped kidneys.

**Pig**

Pigs are reared for the production of pork. These are highly prolific producing two litters per year, each time farrowing up to 10-12 piglets. Their growth is also very fast. Pigs have the capacity to convert inedible feeds and garbage into nutritious and costly meat. The specific is largely maintained by the economically weaker sections of the society. In fact, pig rearing has traditionally provided livelihood to millions of landless and downtrodden people where it served as
backyard enterprise. Indigenous or desi pig formed the basis of farming. These are small in size

However, in the last three decades, breeding with the two imported breeds--yorkshire and landrace have been widely used for crossbreeding in India and the breeding Programme has shown very good result around bacon factories. Further breeding of desi pigs with these crossbreds has brought about a significant improvement in the overall stock within the country. Middle sized crossbreeds now form the basis of big production in our country. Sound piggery units are now being established because of support being provided by the government. Pig population has maintained an encouraging growth during the last over one decade. Pig rearing for meat is very common in North Eastern Region of the country. Almost every rural household rears them and thus pig farming is playing a vital role in improving the socio-economic conditions of the rural population.

Pigs should be slaughtered at 6to 7 months of age. A ideal slaughter weight is approximately 50kg for desi pigs and 60-70kg for crossbred pigs. Dressing percentage varies from 65-70 in case of desi pigs and 70to 75%of the live weight in case of crossbred pigs. The yield is more from pigs as compared to other species due to the presence of skin on the carcass. Almost 98% of pig population is slaughtered every year which contributes to about 12.5% of the total meat production. Pork is grey pink in colour with very soft consistency. It emanates a urine like colour. There is a huge subcutaneous deposition of fat which is white in
colour and soft greasy in consistency. Consumption of Pork is prohibited for Muslims as religious restriction.

**Buffalo**

India ranks first with 59% of the world buffalo population. Indian water buffalo is primarily a milk animal and as such there is no organized rearing of buffaloes for meat. However unproductive and uneconomic buffaloes after 5-6 Lactations find their way to the slaughter house. It is noteworthy that after independence annual growth rate of buffaloes fax exceed that of cattle. The demand for buffalo meat is on the rise to meet the Export requirement to Middle East countries Malaysia. Male Buffalo calves with proper feeding and management offer vast potential for good quality and better priced meat for export. A dressing percentage of about 50 is obtained from well maintained male buffalo calves of less than 3 months of age which are slaughtered for high priced veal

Indian buffalo show a wide variation in dressing percentage and generally figures vary from, 50 to 55&% of the live weight depending on the condition of the animals. Ideal age for slaughter of buffalo calves for meat has been recommended as 18 to 24 months. Out of a total of 90 million buffaloes, almost 11%, mostly unproductive and uneconomic animals are slaughtered every but they contribute nearly 29% of the total meal production
Buffalo meat is mainly times referred as care beef. It is light red to bright chery red in colour and firm consistency. It is leaner than beef and has a reasonable degree of marbling. Buffalo fat is normally white in colour and farm in consistency.

**Cattle**

In India, Cows are reared only for milk production. Slaughter of cow is banned by law in most of the slates expect the ones ruled traditionally by communists such as west Bengal and Kerala. However, slaughter of bullocks does take place at specific places having predominantly Muslim population. Carcass yield varies from 50tlo 54% depending on the condition of the animal.

It should be noted that in trade sleer referes to the bullock which is castrated at 6-12 weeks of age. Stage is also bovine male but it is castrated in late life allowing the development of better musculature.

Indian poultry industry has made a phenomenal progress in the fast few decades. It was transformed into a sophisticated industry quite rapidly after the establishment of several franchise hatcheries in 1970s.This growth coincides with the rapid demand for white meat in the wake of ongoing campaign for low fat, low cholesterol meat. Due to intensification of poultry industry, traditional breeds have lost their commercial importance and modern chicken is the product of several cross breeding and strain crossing. The only exception is White Leghorn which forms the backbone of egg industry with hen house production of 260
eggs per annum. Rhode Island Red produces 220 eggs or so. White Cornish, New Hampshire and White Plymouth Rock have been crossbred at many places to produce broiler strain. These days live weight of broilers at the age of 6 weeks and 8 weeks are about 1.20kg and 1.60kg respectively. The boilers have a dressing percentage of 65 to 68 kg, whereas white Leghorn and Rhode Island Red have a dressing percentage of nearly 70. Broiler meat is true delicacy while it is available at comparatively lower price than chevon. Cockerel raising is emerging as an alternative.

**LECTURE 2**

The skeletal muscle is the principal muscle tissue in meat, although very little of smooth tissue is also present. The main connective tissue types are adipose tissue (fat), bone and connective tissue proper.

**STRUCTURE OF MUSCLE TISSUE**

Animal musculature is mostly of Mesodermal origin. There are more than 300 muscles in the animal body. These muscles constitute about 30-45% of the live weight or 35-60% of the carcass weight of meat animals. In addition to the skeletal muscle, which forms the bulk of meat, a little of smooth and cardiac muscles are also present in blood vessels and heart respectively. Smooth and cardiac muscles are involuntary in nature. Skeletal and cardiac muscles are sometimes referred as striated muscles due to their specific microscopic appearance.

**Skeletal Muscle and Associated Connective Tissue**
In general, skeletal muscles are directly attached to the bones, although some attach indirectly via ligament, cartilage, fascia and skin. Each muscle is surrounded by a sheath of connective tissue known as epimysium. From the inner surface of epimysium, a septum of connective tissue penetrates into muscle and surrounds
the bundles of muscle fibres or fasciculi. This connective tissue is
called perimysium. It contains major blood vessels and nerves.
Muscle fibres or specialized muscle cells are the structural units of the
skeletal muscle tissue. Each muscle fibre is surrounded by a
connective tissue layer called endomysium, beneath which is delicate
sarcolemma or muscle cell membrane. It transmits nervous signals
along the surface of muscle fibre.

Skeletal muscle fibres are long, narrow, almost tubular
multinucleated cells which may extend from one end to the other
end of the muscle. The nuclei are distributed peripherally close to the sarcolemma. Muscle fibres are usually 10-100µ in diameter with conical or tapering ends and their length ranges from 1-40 mm. The individual fibre may also be classified as red, intermediate and white. Most animal muscles contain a mixture of these three types. Red muscle fibres have smaller diameter, lower glycolytic metabolism and ATPase activity but higher oxidative metabolism as compared to white muscle fibres.

Myofibrils have a number of elongated unbranched contractile muscle fibre that occupy almost 80% of its volume. They are responsible for the cross-striated appearance of the muscle fibre. Each myofibril is about 1µg in thickness and may run the length of muscle fibre. The cross-striated myofibrils remain embedded in the cytoplasm of the muscle fibre called sarcoplasm. The myofibrils are surrounded by a complex system of membrane tubules. The longitudinal tubules called sarcoplasmic reticulum run parallel to myofibrils. Another series of tubules run transversely as invaginations of the sarcolemma. The sarcoplasmic reticulum and T-tubules are arranged in a sequence and play an important role in generating Ca++ fluxes in the excitation-contraction mechanism. Sarcoplasm also contains glycogen particles, lipid droplets etc.

At low magnification (2000×), myofibrils, the intracellular contractile elements, show characteristic banded or striated pattern). This situation arises due to the orderly arrangement of dark or A-band and light or I-band. A clear area in the centre of dark band called H-zone is bisected by a dark M-line. The light or I-band is also bisected by a dark Z-line. The distance between two adjacent Z-lines is called sarcomere. In fact, the sarcomere is the functional unit of myofibril.

At 20,000× magnification, the myofibril itself is seen to be composed of a number of thick and thin filaments. Thick filaments traverse the entire width of A-band whereas thin filaments extend from Z-line to the edge of H-zone. Thus, only thick filaments are
present in the H-zone. These thick and thin filaments consist of contractile proteins myosin and actin respectively.

Connective tissue serves as the major supportive element of the animal body. It envelops the muscle fibres (endomysium) and bundles (perimysium) and finally the entire muscle (epimysium) connective tissue fibres form the bulk of tendons and ligaments. The tendons attach muscle with bone whereas ligaments connect two bones or support organs. Connective tissue which is primarily made up of cells storing fat droplets. It is seen around kidneys, omentum and in and around various muscles and organs.

**Smooth Muscles**

Smooth muscles are found in the gastro-intestinal tract, blood vessels, lymphatics and skin in close association with the connective tissue layers. These are 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 sarcoplasmic reticulum is also not much developed.

**Cardiac Muscles**

The cardiac muscles found in the heart are also involuntary. Their muscle fibres are rounded to irregular in shape and give off branches which get mixed up with those of nearby fibres. The nuclei are 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 muscles. The intercalaged discs are present at the position of Z-lines.
Fig. 2.4: Myofibril depicting
(a) Typical dark (A) band, light (I) band, H-zone, M-Line and Z-lines.
(b) Thick and thin filaments

Fig. 2.5: Sketch showing one myosin molecule
LECTURE  3
COMPOSITION OF MUSCLE TISSUE

Muscle tissue contains approximately 75% water and 25% solids, of which 19% are proteins. Lipids constitute about 2.5 to 5% of muscle.

Water

This is the largest component comprising two third to three fourth of the muscle tissue. Due to polar behavior, water molecules are attached with the electrically charged groups of muscle proteins. About 40.5% of the total water in muscle is so tightly bound that it is almost impossible to dislocate it. The attraction of molecules keeps on decreasing as the distance from the reactive groups increases. Thus, most of the water exists in immobilized and free forms. When pH of meat is more than isoelectric point, the enhanced negative charge increases the interfilamental space resulting in retention of excess water. It may be noted that almost 70% of water content in fresh meat is located within the myofibrils. Further, an increased water holding capacity is associated with juiciness and tenderness of cooked meat.
Protein

Muscle proteins have been broadly classified into three categories:

i) Myofibrillar proteins -- soluble in dilute salt solution
ii) Sarcoplasmic proteins -- soluble in water or very dilute salt solution.
iii) Stroma or connective Tissue proteins -- almost insoluble

Myofibrillar proteins:

These proteins constitute contractile part of the muscle and make up about 60% of the total protein in the skeletal muscle. Thick filaments constitute the A-band of the sarcomere and consist of the protein myosin. There are 100-400 molecule of myosin in each thick filament. Myosin is a long asymmetrical molecule containing a globular head and two identical polypeptide chains. It has a relatively high charge and shows a strong affinity for the divalent cations, calcium and magnesium. Tryptic digestion splits myosin into two large pieces— heavy and light mesomyosin. Heavy meromyosin head portion carries the ATPase activity and possesses actin binding ability. This ATPase activity of myosin is stimulated by Ca$^{++}$ ions and inhibited by Mg$^{++}$ ions. 

The thin filament constitute I-band of the sarcomere and extent on either side of the Z-line beyond I-band also into the A-band between the thick myosin filaments. Actin is the main protein of the thin filament. Actin occurs in two different forms. Globular or G-actin is a monomer form, each molecule of which binds one molecule of ATP or ADP with high affinity. Further, each molecule of G-actin binds one Ca$^{++}$ ion very tightly. At high ionic strength and usually in the presence of ATP, G-actin is polymerized to a high molecular weight fibrous or F-actin. At low ionic strength, F-actin depolymerises to yield G-actin usually with bound ADP.
Table 2:1: Chemical composition of a typical animal muscle

<table>
<thead>
<tr>
<th>Component</th>
<th>Per cent (wet basis)</th>
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</thead>
<tbody>
<tr>
<td>1. Water</td>
<td>75</td>
</tr>
<tr>
<td>2. Protein</td>
<td>19</td>
</tr>
<tr>
<td>a) Myofibrillar proteins</td>
<td>11.5</td>
</tr>
<tr>
<td>Myosin</td>
<td></td>
</tr>
<tr>
<td>Actin</td>
<td></td>
</tr>
<tr>
<td>Troponins C, I and T</td>
<td></td>
</tr>
<tr>
<td>Connectins</td>
<td></td>
</tr>
<tr>
<td>Desmin</td>
<td></td>
</tr>
<tr>
<td>b) Sarcoomplasmic proteins</td>
<td>5.5</td>
</tr>
<tr>
<td>Myoglobin</td>
<td></td>
</tr>
<tr>
<td>Glycolytic enzymes</td>
<td></td>
</tr>
<tr>
<td>c) Stromal or connective tissue proteins</td>
<td>2.0</td>
</tr>
<tr>
<td>Collagen</td>
<td></td>
</tr>
<tr>
<td>Elastin</td>
<td></td>
</tr>
<tr>
<td>Sarcolemma</td>
<td></td>
</tr>
<tr>
<td>Sarcoplasmic reticulum</td>
<td></td>
</tr>
<tr>
<td>3. Lipids</td>
<td>2.5</td>
</tr>
<tr>
<td>Neutral lipid</td>
<td></td>
</tr>
<tr>
<td>Phospholipid</td>
<td></td>
</tr>
<tr>
<td>Cerebrosides</td>
<td></td>
</tr>
<tr>
<td>Cholesterol</td>
<td></td>
</tr>
<tr>
<td>4. Carbohydrates</td>
<td>1.2</td>
</tr>
<tr>
<td>Glycogen</td>
<td></td>
</tr>
<tr>
<td>Glucose-6-phosphate</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td></td>
</tr>
<tr>
<td>Lactic acid</td>
<td></td>
</tr>
<tr>
<td>5. Miscellaneous soluble non-protein subs</td>
<td>2.3</td>
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</table>
Relatively small quantities of other proteins generally referred as regulatory proteins are associated with major myofibrillar proteins. Tropomyosin is a fibrous protein which occurs as a double helix. These helical strands are present in close association with in filaments, extending through the grooves of action helix. Troponin is another important regulatory protein which is present in association with thin filament cementing the long chain of tropomyosin thread into the grooves of actin at a regular interval. Troponin is composed of three sub-units:

Troponin T -- binds to tropomyosin and links it to F-actin filaments
Troponin C -- binds to calcium ions
Troponin I -- inhibits or prevents the interaction between actin and Myosin in relaxed state. It allows their interaction only in the presence of calcium ions. Actinin is a globular protein having similar amino acid composition as actin. It has two subunits. The alpha-actinin is a constituent of Z-line and has been shown to accelerate the polymerization of G-actin to F-actin. The beta-actinin regulates the length of thin filament.

Myofibrillar proteins are of special interest to the technologists because they contribute to approximately 95% of the water holding
capacity, 75% of the emulsifying capacity and to a large extent the tenderness of meat.

Sarcoplasmic proteins:

These proteins make up about 30-35% of the total proteins in the skeletal muscle.

Myoglobin is a conjugated protein consisting of a prosthetic heme moiety and a protein moiety (globin). It provides red colour to the muscle and serves as a carrier of oxygen to the muscle fibre. It is the most important pigment of meat colour. Cytochrome enzyme, flavin etc. contribute very little to meat colour.

Stroma or connective tissue proteins:

The connective tissue is composed of an amorphous ground substance or matrix in which formed elements mostly fibres and a few cells are embedded. The ground substance is a viscous glycoprotein solution. The extracellular connective fibres are:

a. Collagen
b. Reticulin
c. Elastin

Collagen is the main fibrous protein the muscles and significantly influence the meat toughness. It makes up to 40-60% of the total stroma protein and 20-25% of the total protein in the body. A fine network of collagen fibres is present in almost all tissues and organs including skeletal muscles. It is the most common constituent of tendons. White coloured collagen fibres are straight, inelastic and non-branching. These fibres shrink or shorten at a temperature of 60°C but higher temperatures or boiling causes transformation to water soluble gelatin. Acid or alkali treatment results in the marked swelling of these fibres. Collagen is the only protein possessing a fair
amount of hydroxyproline (approximately 14%) and low concentration of hydroxylsine. The smallest unit of collagen molecular structure is tropocollagen which aggregate to form more massive structures—the fibril, primitive fibre and mature fibre. High tensile strength and insoluble nature of mature collagen fibres is due to increased intermolecular linkages.

Reticulin is composed of small fibres which resemble that of collagen except for its intimate association with a lipid containing myristic acid.

Elastin fibres are branched and do not hydrolyse on boiling. Elastin fibres are branched and do not hydrolyse on boiling. Elastin contains two unique amino acids—desmosine and isodesmosine which contribute to its highly insoluble nature. The nutritive value of elastin is practically nil due to its resistance to digestive enzymes.

**Lipids**

Lipid is a major component of the carcass of a meat animal. It is highly variable and is inversely proportional to the moisture content.

**Carbohydrates**

Immediately after slaughter, muscle normally contains a very small amount (nearly 1%) of glycogen. It is a macromolecule of glucose residues which serves as a reserve polysaccharide of animal tissue. However, it gets worked up before the completion of rigo mortis and plays a key role in attaining the ultimate muscle pH. Both the rate and amount of glycolysis influence the colour, tenderness and water holding capacity of meat. Insulin deficiency results in decreased tissue glycogen. Glucagon administration causes rapid degradation of liver glycogen to glucose. Besides, several mucopolysaccharides are widely distributed in animal body. Their quantity is less but many of them
like heparin, hyaluronic acid, chondroitin sulphate, keratosulphate and glycoproteins are biologically important substances.

Minerals

About 3.5% of the total body weight is inorganic matter. Most of the total body inorganic material is located in skeletal tissue primarily as salts of calcium and phosphorus and some other minerals especially magnesium. In living meat animal, essential minerals like calcium, phosphorus, sodium, potassium, sulphur, chlorine, magnesium, iron etc. and trace elements like manganese, copper, iodine, zinc, cobalt etc. Serve a variety of important functions. These functions may be physical, chemical or biological depending on the chemical form and the location in body tissues and fluids.

In the conversion of muscle to meat, inorganic elements play an important role. Their main function relates to development of rigor mortis and alteration of fluid balance which cause a drop in pH and water holding capacity. Inorganic constituents also influence the meat colour and tenderization. Several inorganic ions act as catalysts during oxidation of meat fat, enhancing the process for rancidity development.

Vitamins

The vitamin content of meat is variable, depending on the species and age of the animal, the degree of fatness and type of feed received by the animal. Water-soluble vitamins are localized in lean tissues whereas fat-soluble vitamins in fatty tissues. Variety meats have substantial amounts of B-complex vitamins. Pork contains 5-10 times more thiamine content as compared to mutton. The exudates from cut meat surfaces and drip loss during thawing of frozen meat contain an appreciable amount of B-complex vitamins and amino acids. Most of the vitamins in meat are relatively stable during processing or
cooking. However, thiamine or to some extent vitamin $B_6$ are susceptible to heat treatment.

Lecture 4

Preslaughter Care, Handling and Transport of Meat Animals.

It is not enough to produce healthy meat animals, it is equally important to ensure that these animals reach the point of slaughter in sound condition. Preslaughter care and handling can markedly influence the quality and quantity of meat. Ways of loading and unloading, means of transportation and average distance covered by the animals from the point of production to the point of slaughter has definite bearing on the keeping quality of meat. Excited, stressed, bruised and injured animals are not expected to yield wholesome meat.

The underlying principles for preslaughter, care, handling and transport of meat animals are:

1. To avoid unnecessary suffering of animals during transport.
2. To ensure minimum hygienic standards
3. To prevent spread of diseases.

TRANSPORT OF MEAT ANIMALS

The mode of transport should be decided on the basis of ground situation. Unless price differences are significant, the animals should be taken to the nearby slaughter house or abattoir avoiding long journeys. It will protect the animals from possible injury during loading and unloading as also adverse
weather and inadequate ventilation during transport. Various modes of transport may be

1. Driving on hoof
2. Transport by road truck
3. Transport by railroad
4. Transport by sea
5. Transport by air

**Driving on Hoof**

Animals reared within 6-10 k.m from the point of slaughter can be driven on foot. This distance can be covered in 4 to 5 hours. The time can be adjusted in early morning during summer and late morning during winter season. This mode is especially suitable for animals accustomed to pasture grazing. It allows them to browse on indigenous grass or shrubs and take water en route. So the animals suffer minimum weight loss or shrinkage due to travel.

**Transport by Road Truck**

Distance up to 500 km or 12-15 hours journey may be negotiated by road truck. Such vehicles should have non-slip floor. It is also important to provide temporary or permanent protective overhead coverings, making provision for adequate ventilation. Proper partitions should separate unequal sized animals or different species. The partition height may vary from 25 to 120 on depending on the size of animals. Before the commencement of journey, the animals should be offered
adequate feed and water. If the journey is required to be continued after 12 hours, the animals should be unloaded and offered enough feed and water.

Transportation by road trucks allows convenience of loading and unloading at the appropriate places.

**Transport by Rail Road**

For distances over 500 km, it is advisable to transport animals by railways. It is economic on maintenance and easy to handle. Besides, there is a saving on extortions and other incidental expenses. Animals should be provided as lib water and feed at least for an hour before the journey commences. It will be beneficial if water troughs are provided within the roofed rail wagons. Railway wagons meant for this purpose should have a non-slip floor and a free flow of air. Arrangement can be made to unload the animals after bout every 1000km and offer feed and water before reloading. This made ensures comparatively less losses due to shrinkage and death. In fact, shrinkage losses may come down to as low as 5 percent.

**Transport by sea**

Ships are used only for international transport.

**Transport by Air.**

It is very rare and used only for highly expensive animals.


**EFFECT OF TRANSPORT ON MEAT ANIMALS**

1. Stress and fatigue: These conditions are inevitable sequel to transportation and do have a bearing on meat quality. These conditions may at times lead to shipping fever and transient to tany. Shipping fever develops due to pasteurella and requires proper treatment, otherwise virus may act as secondary invader and aggravate the condition.

2. Loss of weight or shrinkage: Shrinkage takes place due to dehydration (Loss of water) and depletion of muscle glycogen during the period of journey. In general, it ranges from 3 to 10 percent depending on the conditions and duration of transport.

3. Bruises, torn skin and broken bones: Brushes are noticed in most of the species due to transportation. The instances are particularly high in sheep and pigs. Muscular bleeding may occur especially in pigs.

4. Death: It may occur during long transportation. Sheep and pigs are particularly susceptible if animals of unequal age and size are loaded in road trucks without partitions due to suffocation. Sheep and goats could also die in long distance transportation by ship due to non-inflammatory diarrhea.

**Effect on Meat Quality**

Stress and fatigue lower the quality of meat in several ruminant species due to depletion of glycogen in the muscle. Due to low acid production, the ultimate pH of the muscle remains high causing a condition called dark cutting meat or
dark, firm and dry (DFD) meat. Thus, keeping quality of meat is reduced and it looks dark due to higher water content. Such meat is unusually tender cooking.

In pigs cute stress or excitement before slaughter causes another abnormal condition wherein low ultimate pH is achieved within 45 minutes due to rapid glycolysis even when the temperature of muscle is quite high. Such pale, soft and exudative (FSE) pork has higher drip and cooking losses.

In sheep, dehydration impairs with the skinning process and produces a sticky textured meat. Transportation injures such as bruising affect quantity of carcasses in all species particularly Sheep and pigs.

**PRESLAUGHTER HANDLING AND CARE OF ANIMALS**

Handling of animals should conform to humane standards at every stage. It will safeguard the animal welfare as well as meat quality. Rough handling of animals before slaughter can result in several physiological stresses. It is particularly important in hot weather when lot of heat builds up in stationary trucks.

Preslaughter shearing and washing of sheep is quite stressful leads to bruises. It is advisable not to mix strange animals shortly before slaughter in order to avoid fighting amongst them, especially males.
Lairage serves as resting ground for the tired and stressed animals. Resting period depends on the length and mode of journey, animal species, age, sex, condition. Undue holding is also not advised.

Lairage should have adequate litter and drainage to avoid faecal soiling of skin. The fed of animals should be withheld for 12-18 hrs before slaughter whereas ample drinking water should be made available during this period. It lowers the bacterial load in the intestine and facilities easy removable of the hide or skin during dressing of carcasses. Stunning made more effective and brightness of the carcass is also improved.

**Lecture 5**

**Ante-mortem Examination of Meat Animals**

Ante-mortem Examination of meat animals awaiting slaughter is very necessary in order to produce wholesome meat and thus safeguard the health of meat consumers. It should be conducted 12-24 hrs before slaughter by qualified veterinarians in fairage pens. Hence, layout and construction of large should be such that it provides proper light and provision of an isolation pen for diseased and injured animals. It should be ensured that animals are not subjected to any kind of cruelty. A number of para-veterinary staff should also be at hand to help in the Examination. All animals meant for slaughter should be rested at least for 24 hours and should not be fed for at least 12 hours before slaughter but they should be provided with plenty of water.
**Objectives**

1. Detection of animals suffering from scheduled infectious diseases which are communicable to man.

2. To detect certain diseases which are toxic or contagious and whose identification is either difficult or impossible during post mortem, e.g. tetanus, rabies, farcy, listeriosis, septic metritis, sturdy in sheep etc.

3. To prevent food poisoning outbreaks e.g. in salmonellosis carcass or organs show little noticeable change on post mortem.

4. To make postmortem examination more efficient, accurate and less laborious.

5. To protect the health of butchers and slaughter house personnel.

6. To prevent unnecessary contamination of building and equipment of the abattoir.

7. To implement disease control programme with more precision by tracing back the source of disease.

**Ante-mortem Examination procedure**

It should be carried out in two stages

**Stage I**

**General examination** : Meat animals should be observed in the lairage pens during rest as well as in motion. The general behaviour, reflexes, fatigue,
excitement, gait, posture. Evidence of cruelty, level of nutrition, symptoms of diseases, or any other abnormalities should be closely observed.

**Stage II**

**Detailed examination:** Suspected or diseased animals should be segregated for detailed examination. Their temperature, pulse rate and respiration rate should be recorded. Animals showing elevated temperature and systematic disturbance should be detailed for further inspection and treatment in the isolation pen.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Temperature</th>
<th>Pulse min</th>
<th>Respiration min</th>
<th>Gestation period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep and Goat</td>
<td>39.5c</td>
<td>75</td>
<td>12.20</td>
<td>147 days</td>
</tr>
<tr>
<td>Pigs</td>
<td>39c</td>
<td>75</td>
<td>10.16</td>
<td>112 days</td>
</tr>
<tr>
<td>Cattle and Buffaloes</td>
<td>39c</td>
<td>50</td>
<td>12.16</td>
<td>280 days</td>
</tr>
</tbody>
</table>

**Principles of judgement in Antemortem Examination**

1. Fit for slaughter- Animals which are normal and free from any symptoms of disease should be sent for sacrifice
2. Unfit for slaughter- highly emaciated, skin bound animals and those affected with tetanus or communicable diseases like rabies etc. or diseases which can not be treated should be declared unfit for slaughter.

3. Suspects- All suspected animals need further attention. Some animals with localized condition and recovered cases should be passed for slaughter as suspect with instructions for careful postmortem examination.
   
   i. Detained animals Some animals need to be detained for specified period of time for treatment of disease or excretion of known toxic residence.
   
   ii. Emergency slaughter It is recommended in cases where the animal is in acute pain or is suffering from a condition where any delay in slaughter would be contrary to the welfare of animal. It is done under strict supervision so that there is no hazard to the consumer health.

Specific diseases encountered to different meat animals during ante-mortem examination and their judgment.
<table>
<thead>
<tr>
<th>S.NO.</th>
<th>Disease</th>
<th>Sailent symptoms</th>
<th>judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Emaciation</td>
<td>Pathological condition due to chronic illness</td>
<td>Unfit for slaughter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher metabolic rate</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Rabies</td>
<td>Acute infective disease due to bite of an infected animal manifested by neurological disorder.</td>
<td>Unfit for slaughter to be destroyed.</td>
</tr>
<tr>
<td>3</td>
<td>Anthrax</td>
<td>Acute manifested by fever, bloody diarrhea and red dark blood discharge from natural openings.</td>
<td>Unfit for slaughter (to be destroyed)</td>
</tr>
<tr>
<td>4</td>
<td>Foot and mouth Disease (FMD)</td>
<td>Most contagious, causing dullness, depressed appetite, lameness, salivation etc.</td>
<td>Unfit for slaughter</td>
</tr>
<tr>
<td></td>
<td>Disease</td>
<td>Description</td>
<td>Classification</td>
</tr>
<tr>
<td>---</td>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>5</td>
<td>Actinobacillosis</td>
<td>Chronic granulomatous disease diagnosed by humpy jaw</td>
<td>Suspect</td>
</tr>
<tr>
<td>6</td>
<td>Actinobascillosis</td>
<td>Marked development of fibrous tissue causing enlargement and hardening of tongue (wooden tongue)</td>
<td>Suspect</td>
</tr>
<tr>
<td>7</td>
<td>Black Quarter</td>
<td>Acute infection characterized by severe inflammation</td>
<td>Unfit for slaughter (removed once)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Of muscles followed by crepitant swelling on shoulder, neck, breast, loins or high.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Tetanus</td>
<td>Acute highly fatal infectious disease characterized by spasmodic contraction of voluntary muscles</td>
<td>Unfit for slaughter (remove at</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>especially masseter muscle often causing lock jaw condition</td>
<td></td>
<td>once)</td>
</tr>
<tr>
<td>9</td>
<td>Mastitis</td>
<td>Inflammation of teats</td>
<td>Suspect</td>
</tr>
<tr>
<td>10</td>
<td>Tuberculosis</td>
<td>Chronic inflammation of lungs, swelling of retropharyngeal lymph gland</td>
<td>Generalized unfit Localized suspect</td>
</tr>
<tr>
<td>11</td>
<td>Sheep Scab</td>
<td>Parasitic disease caused by sucking mites, crust formation on the skin coupled with progressive emaciation.</td>
<td>Suspect</td>
</tr>
<tr>
<td>12</td>
<td>Caseous</td>
<td>In sheep and goat, externally placed lymph nodes enlarged and contain a greenish yellow gelatinous pus.</td>
<td>Generalized unfit</td>
</tr>
<tr>
<td></td>
<td>Condition</td>
<td>Description</td>
<td>Status</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>13</td>
<td>Pneumonia</td>
<td>Lungs are severely affected</td>
<td>Suspect</td>
</tr>
<tr>
<td>14</td>
<td>Swine fever</td>
<td>Acute highly contagious disease Symptoms of septicaemia in the form of multiple hemorrhages.</td>
<td>Unfit for slaughter</td>
</tr>
<tr>
<td>15</td>
<td>Gut Oedema</td>
<td>In swine, in coordination of movement, staggering</td>
<td>Suspect</td>
</tr>
<tr>
<td>16</td>
<td>Swine Ery-sepalus</td>
<td>Characterized by different forms such as acute septicemia, skin form, chronic arthritis and vegetative endocarditis</td>
<td>Suspect</td>
</tr>
<tr>
<td>17</td>
<td>Atropic Rhinitis</td>
<td>In pig, snout becomes dished with wrinkling of skin over the affected area. Nasal septum distorted with bloody nasal discharge.</td>
<td>Suspect</td>
</tr>
<tr>
<td>18</td>
<td>White Scour</td>
<td>Calves, a large abscess in the abdominal wall near umbilicus which becomes hard and swollen.</td>
<td>Unfit for Slaughter</td>
</tr>
<tr>
<td>19</td>
<td>Calf Diptheria</td>
<td>Characterized by evil smiling dipheric patches and ulcers in mouth, tongue, gums and pharnx</td>
<td>Unfit for slaughter.</td>
</tr>
<tr>
<td>20</td>
<td>Salmonellosis</td>
<td>Sever diarrhea with foul smell, many contain blood, fever, loss of appetite, dullness, dehyradition</td>
<td>Unfit for Slaughter</td>
</tr>
<tr>
<td>21</td>
<td>Listeriosis</td>
<td>Stiffness of neck, incarinated movement of limbs, paralysis of muscles of jaw and pharynx</td>
<td>Acute case- Unfit for slaughter</td>
</tr>
</tbody>
</table>
|   | Fluorine poisoning |   | Unfit for slaughter
|   | Unfit for slaughter
|   | Recovered animal suspect
| 22 |   | Peeling of skin
| 23 | Selenium poisoning |   | Unfit for slaughter recovered animal suspect.

Antemortem examination of meat animal is of prime importance from public health point of view. It is the initial step in detection of any sign of disease, distress, injury etc. which helps in taking appropriate decision before slaughter of animal. It should be done properly and systematically by qualified and experienced veterinarian which will in turn help in maintaining high standards of meat quality.
Lecture 6

Slaughtering and Dressing of Meat Animals

Slaughtering means pulling the food animals to death and thereafter preparing the carcasses for human consumption. The essentials in the slaughter of food animals are that it should not cause unnecessary suffering to the animals and bleeding should be as efficient as possible. Besides, it should be safe for the beast handles also.

There are two main types of slaughter methods.

I. Scientific or Humane slaughter.

II. Ritual slaughter

Scientific or Humane Slaughter

Such a slaughter avoids unnecessary pain and cruelty to the food animal and ensure as complete bleeding as possible. It is also ensure speed of operation and safety of the personnel.

Stunning is a process employed to create s state of immobility or unconsciousness at the time of slaughter to 1 minute. Immediately, the animal is hostel and bloods the animal to death. In USA and European countries, stunning has been made mandatory by legislation in abattoirs, excepting those where ritual slaughter is followed.
Stunning Techniques and Devices

They fall into three main categories

i. Mechanical instruments: Instruments such as captive bolt pistol (Fig. 5.1) percussion stunner or free bullet cause damage to the brain so the animal immediately loses the consciousness. In Brain, use of captive bolt pistol is common for stunning cattle and sheep and several models of pistols are in vogue.

In captive bolt pistol, by using an explosive cartridge, the bolt is driven in the frontal bone of the animal causing immediate immobility by destruction of the cortex and deeper parts of the brain. In pneumatic stunner bolt is activated under pressure to cause concussion without penetrating the frontal bone. Use of free bullet pistol may become necessary for large bulls having very thick skully. Application point of captive bolt pistol differs with species. In adult cattle or if employed for buffalo, it should be positioned in the meddle of the forehead where two lines drawn from the medial canthus of each eye to the base of opposite horn cross. In horned goat and sheep, the pistol point is placed just behind the ridge running between the collapsed followed by tonic spasms and then movement of the hind legs.

Pithing is also done sometimes in adult cattle after stunning with captive bolt pistol. In this process a thin steel rod (approx 0.5 m) is inserted into the hole made in the skull by the captive bolt pistol. It will destroy the medulla.
oblongata and reflex muscular action will not take place during sticking and initial dressing. Thus pithing enables the slaughter man to proceed quickly and with safety.

ii. **Electrical stunning:** It is conveniently employed in stunning of small ruminants, pigs and poultry. The instruments Either apparatus (Fig 5.2) with a pair of tongs carries electrodes by which alternating current (AC) is passed through brain. A high frequency current (250mA) of comparatively low voltage of usually 75 volts is used for 10 seconds by way of application of electrodes or tongs at the base of the ears on either side of the head. The electrodes are kept wet in a 20% saline solution to enable the current to pass easily through hair and skin. It produces instantaneous unconsciousness for about 30 seconds. Bleeding is very much efficient and the power consumption is extremely low. If the current remains low missed shock may occur resulting in paralysis of the animal, although it remains fully conscious. It affects the quality of meat besides compromising the safety of the handler. On the other hand, too tugh current may cause splash. It refers to the appearance of pathetical haemorrhages throughout the subcutaneous tissue in pigs. The capillaries get ruptured due to excessive increase in blood pressure.

iii. **Chemical stunning:** Carbon dioxide gas stunning is most suitable for pigs and is followed in many European countries. Co2 is heavier than
air and can be contained in a tunnel. The gas blocks the nerve endings. Animal is exposed to 65% carbon dioxide concentration through oval type to 65% carbon dioxide concentration through oval type tunnel, dip lift system or revolving wheel for 45 seconds. On exposure to gas, pigs become anaesthetized that are then shacked and bled. Bleeding is quiet efficient since carbon dioxide stimulates respiration favouring blood circulation. However, it requires more space and is not fast.

**Sticking or Bleeding of the Animal**

**It can be done by any of the two methods;**

i. After hoisting on the overhead rail, carotid arteries and jugular veins and jugular veins of both the sides are severed across the throat region caudal to the larynx.

ii. On the flour skin is incised along the jugular furrow and carotid artery and jugular vein of one aide are severed. The knife is then passed to the chest severing the anterior aorta and anterior venacava. Sometimes, knife reaches too far in the chest puncturing the pleura and the blood may be aspirated into the thoracic cavity. This blood adheres to the parietal pleura especially the posterior edges of the ribs. This contamination of lungs is called back bleeding or over sticking. It requires to be washed immediately.

The yield of blood is as follows:
Buffaloes and cattle: 10-12 kg in 6 minutes

Sheep and goat: 1-1.5 kg in 5 minutes

Pig: 2.3 kg in 56 minutes.

**Ritual Slaughter**

Slaughter without prior stunning of food animals as per religious rites are referred to as ritual slaughter. There are widely practical in many countries. In India and Far East, practically all the meat animals are slaughtered in conscious state.

Jewish method of Slaughter or Schechita. The regulations for Jewish slaughter came into existence around 500 AD. Consumption of pork was strictly prohibited for Jews, probably as a safeguard against tapeworm.

a. Animals to be slaughtered should be active. Moribund animals which lie quite and also do not get up even by striking with a stick must not be slaughtered. A blow on perforation of the membranes of the brain constituted a mutilation. Therefore, this method envisages slaughter of animals without prior stunning.

b. The incision across the neck is made by single rapid thrust of sharp knife which severs the skin, muscles, oesophagus, trachea, carotid arteries and jugular veins. This incision should be completed without pause, pressure, stabbing or tearing.
c. The dressing of the carcases should expose the diaphragm and allow manual examination of thoracic organ.

d. The blood vessels must be removed before the retail sail of meat is undertaken. It is for this reason that only forequarters are normally eaten. Hindquarters containing lot of butchers (Schochet) and are thus rarely eaten.

e. Kosher meat must be sold and consumed within three days of slaughter. Jewish slaughter (Schechita) is undertaken by a Schochet (cutter) Carcass fit for jewish consumption is stamped with kosher seal on the brisket while unfit is pronounced as terepha.

**Muslim method of Slaughter or Halal** Some practices relating to slaughter of animals and consumption pf meat by the members of Jewish faith match with those of Muslims. In both cases, consumption of dead animals, blood and pork is forbidden. The vertebral artery enclosed in the spinal cord is not severed.

In this method, neck of the animal is served by cutting the four major blood vessels-carotid arteries and jugular veins with a sharp knife. The spinal cord is left intact. So the nerve centers controlling the heart and lungs remain functional and an efficient bleeding is ensured. It also enhances the keeping quality of meat.

Unlike Schechita, Muslim method of slaughter is not controlled by a central board but is overseen by the local Islamic authorities (Musftis) Here,
stunning may be permitted in some cases if it permits the heart to beat for some time. Since animals has to struggle for sometime before in India, buffaloes and most of the sheep and goat are slaughtered by Halal method.

II) Jhatka or Sikh method of Slaughter In this method, the head of the animal is chopped off with one big stroke of a sword. In some part of northern India, skilled workers can decapitate even buffaloes by a single stroke of a special sword. Since medulla oblongata is damaged in the process, bleeding remains incomplete. Due to presence of some blood in tissues, the keeping quality of meat may be affected.

Evermaizine or Neck Stab method. It is followed in Spain, some parts of Italy, Mexico and some South American countries. In this method, cattle are slaughtered by plunging a short double edged knife (puntilla) into occipito – atlantal space at the nape of the neck severing the medulla oblongata

Lecture:7
DRESSING TECHNIQUES FOR DIFFERENT ANIMALS

Dressing techniques and sequence of dressing operations vary from place to place and are very much influenced by the equipment and facilities available in the abattoir. The present equipment and facilities available in the abattoir. The present trend in organized abattoirs is towards line dressing whereby once the animal has been hoistred to the bleeding rail, it is not lowered to the floor till the entire dressing operation is completed. The carcases is conveyed by gravity or power driven along an overhead rail. Equipment such as brisket saw, hock cutter, hide
puller, aitch-bone cutter etc. facilitate the dressing. The text hereunder describes the typical sequence operations.

**DRESSING OF BUFFALO/CATTLE**

1. After stunning, the animal is hoisted by one leg to the overhead rail, it is brought above bleeding trough or gully and an incision is made just in front of stwenum cutting the main blood vessels.

2. A bleeding time of 6-8 minutes is allowed.

3. A cut is made across the larynx, the weasand (oesophagus) is tied off and the head is skinned and detached at the atlas joint.

4. Now the forelegs or the shanks are removed.

5. The hind legs are skinned and removed while the carcass is hung by tendons on the spreader.

6. Deskinning (flaying) is carried forward from hind and forequarters and hide is now pulled with the help of hide puller.

7. Brisket is opened along with the midline and the pelvic cavity is opened along the abdominal cavity. Evisceration commences and pluck as well as viscera is removed. These are taken to their respective offal for cleaning and examination.

8. Now the carcasses is sawn into two halves along the vertebral column.


10. Transfer to the chilling room
Dressing of Sheep and Goat

1. After stunning the animal is hoisted to overhead rail and an incision is given in the jugular furrow near the head severing both carotid arteries. The head is jerked backward to rupture the spinal cord, thereby checking the involuntary movement.

2. A bleeding time of 5 minutes is allowed.

3. The forelegs are knuckled and a cut is made to the front. The forelegs are removed at knee.

4. The neck and checks are skinned along with the shoulder.
   The throat is opened up and oesophagus is tied.

5. The hind legs are knuckled and a cut is made to the root of the tail.
   The legs are skinned.

6. The skin is incised in the middle of the belly and skinning proceeds towards the flank. Now skin is pulled down over the backbone and base of the head.

7. The head and hindlegs are removed.

8. A small cut in the abdomen is extended to the brisket and the breast bone is also split.

9. The pluck and viscera are removed Kidney and its fat are left in the carcass.

10. Spray washing of the carcass is done followed by transfer to the chilling room.
Dressing of Pig

1. sticking: After stunning the pig hoisted to the overhead rail. An incision of 5to 10 can is made at the mid point of neck facing breast bone. The knife is inserted in this incision at an angle of 45″ and is faced down and back at least 12-15 can to a point below the front of the breast bone. The knife is given a slight twist before it is withdrawn. Care should be taken not to insert the knife into the chest cavity.

2. Bleeding: A bleeding time of 5 minutes is allowed.

3. scaling: After 6 minutes or so, the animal is dropped in the scalding tank maintained at a temperature of 60-62c for about 6 minutes.

4. Scrapping or Dehairing: Raise the animals on the overhead rail and pull of the dew claws and toes while hot. Scrap the loosened hair with the help of ahog scrapper or dull knife hindquarter downwards. Then rinse the carcass with warm water.

5. Singing: It is done with the help of a blow lamp in which a big temperature is achieved and all the remaining hair are burnt. Besides singeing sterilizers the cuticle and firms up rind giving it better appearance and keeping quality.

6. Removal of head: Done at atlas joint before the carcass is opened.
7. Evisceration: Viscera is removed and examined. Lean fat is also collected.

8. Splitting of the carcasses.


10. Spray washing of the carcasses and transfer to the chilling room.

Apart from religious rituals considerations, the suitability and effectiveness of different slaughter and dressing methods very from species and even the age within the same species of the animal. Regional variations are also quite common.

**Meat Cutting and Packaging**

Meat cutting refers to the skill of separation of carcass into wholesale primal cuts in order to facilitate requirements of meat trade, cater to the consumer preference and convenient handling by the butchers.

Different cutting methods are followed in various countries. Hence, terms, like British cutting method, American cutting method, French cutting method etc. are common.

Basic requisites in meat cutting are:

i. The carcass has to be essentially chilled for proper meat cutting and trimming job.

ii. Meat cutting room should be maintained at a temperature of 15-20 °C and relative humidity of 80%. This environment is wholesome for meat and convenient to workers.

iii. All meat cutting equipments and machinery such as meat cutting tables, various types of knives, manual as well as electrically...
operated saws should be made up of stainless steel and be sufficiently sharp.

iv. Meat cutting operation has to be done by adequately trained and experienced butchers. It is important to maintain uniformity in cuts and economy of merchandising.

v. Approved meat cutting method should be followed step by step as per standard specifications.

vi. Thumb rules for meat cutting techniques are:
   a. More valued primal cuts are separated from the less valued counterparts.
   b. The muscular portion is cut with a sharp knife.
   c. The bony structure is severed with a manual or mechanized saw.
   d. A limited force is applied while disjointing whenever joints are involved.

vii. In line operations, in a meat cutting room should be fully synchronized. Different cuts, fat, trimmings etc. should be transferred to their natural destinations.

Wholesale Cuts of Lamb Carcass

USDA and many other international standards specify the division of lamb carcass into fore saddle and hind saddle by cutting between the last two ribs. The right and left sides are not separated (Fig. 5.1). However, BIS specify the division of carcass into right and left sides.

Fore saddle (53%)

1. Neck -- cut at last cervical vertebrae where it blends with Shoulder
2. Shoulder -- cut between 5th and 6th ribs
3. Rack -- portion from 6th to 12th rib
4. Breast -- cut forward from midway of the last rib to ½” above Elbow joint
5. Foreshank -- cut containing foreshank bones

Hind saddle (47%)

1. Lion -- cut hind quarter by sawing in front of hip bone in Between last two lumbar vertebrae
2. Leg -- remaining portion of hind quarter
3. Flank -- thin meat without bone from the natural seam Starting from breast.
4. Suet and kidney
   In India, people generally go for six cuts only – neck, shoulder, rack, foreshank and breast, loin and leg (Fig.5.2).
holesale cuts pork Carcass

Port carcass is divided into right and left sides. Then front feet are removed 1” above knee and hind feet at the lower edge of the hock and each side is subjected to six cuts(Fig. 5.3).
Anterior part called rough shoulder is separated from the posterior by cutting between 2nd and 3rd ribs. This is made into three wholesale cuts – jowl, butt and picnic.

1. Jowl - cut close to the neck line
2. Boston butt - upper 1/3 of the skinned shoulder
3. Picnic shoulder - lower 2/3 of the shoulder
4. Ham - cut between 2nd and 3rd sacral vertebrae at Right angle to the line of leg.
5. Lion - Upper middle portion
6. Belly - lower middle portion between picnic Shoulder and ham.

Wholesale Cuts of Buffalo or Beef Carcass

A. Carcass sides are separated. The right side is called closed (kidney close) side whereas left side is called open (kidney free) side (Fig. 5.4).
B. Each side is now subjected to quartering or ribbing. The fore quarter and hind quarter are separated by making a cut between 12\textsuperscript{th} and 13\textsuperscript{th} ribs.

C. Fore quarter is cut between 5\textsuperscript{th} and 6\textsuperscript{th} ribs to have shank, brisket and chuck in the anterior part and rib and plate in the posterior part.

1. Rib and plate - From the posterior part separate the Upper rib from the lower plate by a straight and parallel cut to the backbone.

2. Shank and Brisket - Place the anterior part on the table With rib side down. The shank is removed by cutting parallel to the underline and just dorsal to the lower extremity of the humerus. The brisket is removed by continuing the same cut through the breast bone and lower ends.
3. **Chuck** - This is the remaining large square cut with ribs.

4. **Flank** - Cut below the aitchbone following the natural seam up to thick muscle of the flank and then extending straight upward cut up to 4 cm below the eye muscle.

5. **Round** - Start with a cut 4 cm anterior to the pelvic bone and go parallel to the rib and loin.

6. **Lion** - Left over cut which can be further sectioned into anterior short loin and posterior sirloin by making a cut between lumbar and sacral vertebrae.

D. From the hind quarter first remove kidney knob i.e. kidneys along with the adjoining fat.

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**Lecture 8**

**Postmortem Inspection of Meat Carcasses**

Many diseases and abnormal conditions not detectable on Antemortem, necessitate a careful postmortem inspection. It should be conducted as soon as possible after carcass dressing is complete, as setting of carcass may render it difficult to expose and examine the lymphnodes afterwards. It has to be carried out in a hygienic manner avoiding unnecessary cuts. However, character and extent of disease lesions whether localized or general or
whether condition is acute, sub-acute or chronic ahs to be properly
determined. It will involve palpation of organs and tissues, incisions where
necessary and laboratory tests in certain conditions. All these aspects are
taken into consideration before passing the final judgment.

Objectives

i. To detect and eliminate abnormalities from the carcass and organs including
contamination, thus ensuring that only meat fit for human consumption is
passed for food.

ii. To check the efficiency of slaughter and carcass dressing.

iii. To diagnose disease conditions for control purpose.

iv. To ensure that carcasses, parts or organs marked unfit for human
consumption are properly disposed of or destroyed.

Facilities

i. Inspection points should have sufficient and well distributed light of 540
lux or 50 foot candles.

ii. Adequate hand washing units with supply of hot and cold running water,
liquid soap and towels.

iii. Meat inspection knives.

iv. Sterilizers for complete immersion of knives, saws, cleavers etc.
v. Stamping ink – A solution containing 1 to 2% of fuchsine in acetic acid is used as stamping ink for carcasses. Alternatively, it can be prepared according to the following formula: Methyl violet 35g, Cane sugar 450g, Ethyl alcohol 1363 and water 1636 ml. Sugar is first dissolved in water and methyl violet is added at the end. The stamp generally bears the head of the animal.

**General principles**

Postmortem inspection involves visual perception and palpation of organs and tissues, incisions where necessary and laboratory tests wherever confirmation is required. It should always proceed in a systematic and hygienic manner. Examination of lymph nodes is of paramount importance in postmortem inspection, since these glands drain different parts of the body, condition of the particular part drained by it. A meat inspector must have the knowledge of topography and normal appearance of lymph nodes, colour, shape, size etc. in a particular animal. The size of a lymph node generally depends on the area drained by it. A swelling or enlargement or discolouration of a lymph node indicates a pathological condition. Some lymph nodes, which drain lymph from important muscles, are of special interest in meat inspection and these are referred as ‘meat lymph nodes’. In buffalo and cattle these lymph nodes are prescapular, axillary, prefemoral, ischiatic and popliteal whereas in pig, these are prefer medial and popliteal. In postmortem inspection, lymph nodes are
exposed and examined by population for size and consistency and if necessary, incised to observe colour and diction of lessons.

As a thumb rule, viscera and head should remain identifiable with the carcass until the inspection is completed. The carcass should not be subjected to any mutilation. The final decision about the fitness of the carcass and offals must rest only with the veterinarian. He should be armed with enough powers to stop the slaughter and dressing operations and size the carcass, if there are sufficient ground to do so.

Based on the postmortem examination, meat inspector can given any of the four judgements.

   a. Passed.
   b. Total condemnation
   c. Partial contamination
   d. Conditionally passed..

Procedure

In general, postmortem inspection of buffalo and swine carcasses should proceed in the following order.

Head

An examination of surface of tongue is done for FMD and other form of stomatitis. Palpation of tongue from dorsum to lip is carried out to detect actinobacillosis.
Masseters are incised to examine for Cysticerus bovis. A detailed examination of retropharyngeal, sub maxillary and parotid lymphnodes becomes necessary to detect tuberculosis and actinobacillosis. In case of pigs, the portions of muscles from tongue are examined under microscope or trichinellosis and inspection of sub maxillary lymph node is done as matter of routine.

**Viscera**

All viscera should be inspected as they are removed from the carcass. Every organ and associated lymphnodes are examined. In case of any abnormal condition, the organ are incised not to contaminate other organs or carcass parts.

**Lungs:** Visual inspection followed by palpation is carried out for evidence of pleurisy, pneumonia, tuberculosis, fascioliasis and hydrated cysis. Bronchial and, edoastinal lymphnodes should be incised to detect tuberculosis.

**Heart:** pericardium is opened and looked for tuberculosis pericarditis. Heart is incised to detect petechial haemorrhages or cysts.

**Liver:** The surface and substance of liver is examined for fatty changes, actinobacillosis, and abscesses, parasitic infections like Cysticercus bovis, fasciollliasis, hydatid cysts or larval stage of Oesophaostomum.

**Kidney:** Renal lymphnodes and adrenal glands should be anthrax, tuberculosis or presence of artifacts.
**Spleen:** The surface and substance of spleen is inspected for anthrax, tuberculosis or presence of artifacts.

**Stomach and intestine:** The serous surface of these organs could indicate tuberculosis or actionbacillosis while interior part reticulum could show penetration of foreign body. Mesenteric lymph node is incised as a routine to look for tuberculosis.

**Urinary bladder:** The outer and inner surfaces of urinary bladder are observed for diseased condition.

**Uterus and ovaries:** These are opened for examination of septic conditions.

**Udder:** This is examined for septic mastitis or abscesses, Suprammary lymphnodes are incised for evidence of abscesses or tuberculosis.

**Testicles:** the outer surface substance and superficial inguinal lymphnodes are inspected.

**Carcass** The carcass should be inspected for evidence of bruising or haemorrhage of discoloration. Local or general oedema (drops) swelling or other abnormally of bones, joints ot musculature. Age of bruise can be determined by using bilirubbin test. Inspection of thoracie and abdominal walls should be done for inflammation, abscesses or tuberculosis. Diaphragm should be lifted and examined carefully for tuberculosis.
After the carcass is spilt, cut surfaces of sternum, ribs, vertebrate and spinal cord should be examined. Incision should be made on each quarter in the musculature near the shoulder joint and near the pelvic bone for detection of cysts (Cysticircus bovis and Cysticircus cellulosae). Simultaneously, prescapular, popliteal and prefomoral, iliac and supramanuatory lymphnodes and also observed and if necessary, incised for inspection.

**Postmortem Inspection of Sheep and Goat Carcasses**

The Examination is carried out on the above lines. However, Sheep and goat do not require much detailed examination. The cutting of head, heart, pulmonary lymphnodes and body lymphnodes should be carried out only in case of suspicion. Carcass is, therefore, examined for satisfactory bleeding, liver for fascioliasis and lungs for parasitic infections like nematodes or hydrid cysts etc.

**Post mortem inspection of Swine Carcass (Some Specific precautions)**

Although PM examination follows as the same pattern as in buffalo/cattle, skin lesions serve as important diagnostic feature of erysipelas, swine fever and urtica, feet for abscess formation, under for mastitis or actinomycosis and tail for necrosis. In places where Cysticercus celluloses is common, the external master muscles and root of tongue are incised. It trichosis is known to occur in a particular area or suspected, muscle sampling should be done for appropriate examination. Besides, visceral organs should be examined for pneumonia, pericarditis peritonitis and also sub maxillary lymphnodes for tuberculosis.
Extended Examination

Carcasses of buffalo/ cattle are further examined if affections with Cysticurcus bovis (Measly beef) or tuberculosis are suspected. In case some cysts are noticed in the carcass, check muscles, tongue, diaphragm and heart should be incised and closely examined. If more than 10 clear or degenerated cysis are recovered accompanied by emaciation, the carcass is totally condemned; otherwise it is conditionally passed with instructions for proper cooking. Similarly, even if single TB lesion is present, the carcass should be split and vertebrate, ribs are closely examined. Beside, additional lymphnodes such as lower cervical, presternal etc. are also examined. In generalized TB, the carcass is totally condemned. The lesions for tuberculosis are considered generalized. If any two of the following organs and concerned lymphnodes are effected lung, spleen, kidney, uterus, udder, ovary testicle, adrenal gland and brain or spinal cord etc. Besides, lesions of tuberculosis in muscles, bones or joints are also bring it in generalized category, An organ or a part of carcass is condemned if the lesion is localized.

Swine carcasses are also subjected to extended examination when trichinosis or tuberculosis is suspected. Small pieces of tissue form diaphragm and muscles and muscles of larynx, abdomen and intercostals spaces are observed under trichinoscope after predigestion with trypsin. Carcasses showing heavy infection are totally condemned while those with mild infection are totally passed. For further examination of tuberculosis, the carcasses and head are split and bone surfaces and spinal cord are closely examined. In addition to lymph nodes
examined earlier, posterior cervical and lumbar lymph nodes are also examined and generalized cases are totally condemned. In case of localized TB of head, it should be condemned and associated lymph nodes are also associated.

Lecture: 9

JUDGING AND GRADING OF LIVE MEAT ANIMALS

Meat Industry aims at producing animals with large amounts of highly priced and palatable lean and least amounts of fat and bone. Judging and grading of meat animals ready for slaughter is a widely practiced art for evaluating their value at market. It is based on visual appraisal and body measurement in live animals for desired carcass characteristics. During judging, type defines all characteristics of the animal raised for specific purpose whereas conformation refers to the form and shape of the animal. A good judge should be familiar with the anatomy of meat within the animal body. He should possess keen observation and analytical mind besides ability to make a comparative assessment and arrive at a logical decision.

A systematic method of judging and grading involves.

i. Initial observation of the meat animal from distance,

ii. determination of conformation of the animal by degree of fleshting and firmness of finish by having side, front and rearview.
iii. Making the animal walk for some distance and looking for qualities, commonly accepted for the standard grades.

iv. Feeling the animal along the top of the shoulder, ribs, back, rump and round etc.

**Judging and Grading of Sheep and Goat.**

Meat animals are judged on the basis of type, conformation and finish. Conformation gives an overall assessment of muscling. A broad forehead, short thick neck short legged deep wide blocky body with symmetrical conformation are the desired traits. Flank fullness and firmness is also an important parameter which is determined by taking hold of the flank muscle with hand. Special care is taken to look for wide chest, hind legs, wide and thick back and join along with long rump and bulging stifle. Thigh and loin form the highest priced cuts on the mutton carcass.

Lamb and mutton quality grades may be prime, choice, good and utility whereas yield grades from the highest to lowest may be 1 to 5.

**Judging and Grading of Swine.**
A meat type swine encompasses all the characteristics and contribute maximum in terms of valuable wholesale cuts. Swine judging card developed by USDA considers general appearance, form, finish, quality and expected dressing percentage. General appearance as observed from a distance should take note of general length, depth and width, strength of arch and development over back, loin and rump, fullness of ham and neatness of head and neck. Fairly high and uniform finish is important to get firm, high quality pork cuts. Back and loin should be of good length and moderately wide with uniform arch. An ideal ham should be wide from front to rear, plump, smooth firm and trim at the base. A belly that is neat, trim, firm and smooth contributes to a good dressing percentage. Length of legs should be medium.

During grading, sex classes of swine need to be described several times. Boars and sows are older breeding animals. Barrow is the male pig castrated early in life whereas stag is the male pig castrated after it has developed boar like characteristics is Gilts are younger females that have not produced any young ones. Grades for gilt and barrow are assigned on the basis of expected combined yield of four major cuts that in turn depends on degree of muscling and back fat thickness.

**Judging and grading of Buffaloes and Cattle.**

Conformation and age play major role when these animals are judged for meat production. Age has a significant effect on tend mess. Veal is obtained from
young calves of 1-3 months age whereas calf is from animals ranging between 3-10 months in age. Mature animals over 12 months of age produce beef on car
beef (Buffalo meat.) A desirable conformation of meat type animal should be
long, trim, deep - sided body, heavy muscled forearm and maximum
development of round, rump, loin and ribs. There should not be Excessive fat on
brisket and flanks. Besides, there should be no extra hide around the throat,
dewlap and sheath. Highest USDA quality grade start from prime and yield
grades from I

**Grading**

There is lot of variation in the carcass conformation, size and meat quality depending on the breed, age group, body conformation and health status of meat animals. Meat grading refers to the sorting or grouping of meat carcasses and cuts on the basis of their conformation, finish and overall quality. Although this concept is yet to develop in our country, it is beneficial to the animal raiser at the farm, processor at the packing plant, purchaser at the retail outlet and above all to the quality conscious consumers. Carcass conformation, trimming, meat to bone ratio, colour etc. play an important role in grading. Carcasses of buffalo, goat, sheep or calf may be graded for meat quality as **prime, choice, good or poor**. Pork carcasses are generally graded on the basis of yield in most of the developed countries.

Grading of meat carcasses and wholesale cuts is still confined in India at the export points, that too as per the agreement between the exporter and importer. Directorate of Marketing and
Inspection, Government of India has already evolved its grades but the same are still to be implemented.

**PACKAGING**

Packaging refers to the scientific method of containing a food for optimum protection till it reaches the ultimate consumer. Modern concept treats packaging as an important marketing tool also. Proper packaging helps in maintaining the quality of a product during storage, transport and provides convenience for easy handling by the consumers.

Packaging of fresh meat is required for the following reasons:

i. To prevent moisture loss during storage
ii. To offer meat in a most desirable colour to the consumers
iii. To prevent further microbial contamination
iv. To check the pick up of foreign odours by meat
v. To prevent lipid oxidation.

The following packaging materials and techniques are in vogue for primal and retail cuts of fresh meats.

**Overwraps**

Primal and subprimal cuts of fresh meat are overwrapped with thermoplastic films having excellent optical properties. Low density polyethylene (100 gauge) is the most widely used and cheapest film for this purpose. However, rubber hydrochloride, nylon-6 or 11 film, highly plasticized PVC film (70 gauge) is the most widely used and cheapest film for this purpose. Cellophane coated with nitrocellulose on one side has been in use for wrapping fresh meat for a considerable period. The uncoated side is kept in contact with meat. Another grade of
cellophane coated with polyethylene can be used for irregular shaped meats.

**Tray with Overwrap**

The most common packages for retail fresh meat cuts in western countries are polystyrene foam or clear plastic trays overwrapped with a transparent thermoplastic film. These trays offer and aesthetically appealing background. Provision of absorbant cotton within the pack eliminates the chances of excessive meat juice accumulation. This meat has a shelf life of 10 days at $0^\circ$C. However, it can retain the desirable bright red colour for 5 days only.

**Shrink Film Overwrap**

These films are biaxially oriented to stay stretched at room temperature but shrink on exposure to hot air or hot water for a few seconds. Shrink films are good water vapour barriers and have high structural strength. These films are used for wrapping large and uneven cuts of fresh meat. These are also frequently recommended for storage of carcass quarters under frozen condition. Shrink films offer neat appearance, contour tight package and are easy to handle. Heat shrinkable polypropylene, irradiated polyethylene or polyvinylidene chloride (PVDC) can be used for this purpose.

**Vacuum Packaging**

This technique is recommended for long term storage of primal and sub primal cuts of buffalo meat and beef. It ensures a shelf life of 8-10 weeks at $0^\circ$C. Vacuum packaging of lamb and pork is avoided for different reasons. Lamb may have a shelf life of 3 weeks only because of comparatively high pH. Pork starts with a large load of bacteria and pork cuts are reported to have a shelf life of 2 weeks only at $1^\circ$C.
Vacuum shrink packaging in cryovac barrier bags may provide a means of storage and transport of frozen carcasses, sides or quarters to overseas destinations. Vacuum packaging is done either in laminates or co-extruded films. Typical laminates in use are:

Aluminium foil/Polyethylene
Polyester/Polyethylene
Polyamide/Polyethylene
PVDC/Polyester/Polyethylene

Modified Atmosphere Packaging

In this technique, atmosphere inside the package is modified to extend the shelf life of meat while retaining its colour, flavor and weight. The package air can be suitably replaced by gases usually nitrogen, oxygen or carbon dioxide alone or in combination. Different meats have varying modified atmosphere requirements. Buffalo meat and beef need a high oxygen content to maintain a bright red colour. Pork needs less oxygen due to high fat content. Nitrogen serves as an inert filler to balance a gas mixture. However, its use increases the cost of packaging.

Lecture: 10

Postmortem Changes

Slaughter of food animal is followed by a series of physical and chemical changes over a period of several hours or even days resulting in the conversion of muscle to meat. There is immediate loss of oxygen supply to the muscle due to exsanguinations (bleeding). As the stored oxygen in myoglobin gets depleted, there is inhibition of aerobic pathway through citrate cycle as well as cytochrome system.
The store of creatine 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. This resynthesis of ATP by anaerobic pathway is not enough to maintain the required ATP level and as it depleted, there is formation of actomyosin resulting in the onset of rigor mortis. The important changes that take place during postmortem period are as follows.

**Loss of Homeostasis**

Homeostatic 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 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:

\[
\text{Glycogen} \xrightarrow{\text{Anaerobic conditions}} \text{lactic acid} + 2 \text{ ATP}
\]

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 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 cross bridges begin to form and muscle gradually becomes less and less extensible under an externally applied force.

During the period immediately following exsanguinations, 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. 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 due to 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 degradation or ageing, meat again 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 defence mechanism stops operating and membrane properties are altered. So, during conversion to meat, muscle is quite susceptible to invading microorganisms. Except for low pH, most of the other postmortem changes favour bacterial growth. Hence, utmost handling precautions are necessary to prevent contamination of meat.

**Degradation due to Proteolytic Enzymes**

Several autolytic lysosomal enzymes called cathepsins which remain inactive in a living muscle tissue, are activated as the muscle pH declines. These enzymes initiate the degradation of muscle protein structure. In fact, catheptic enzymes are capable of breaking down
even collagenous connective tissue of the muscle and cause tenderization 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. The resolution of rigor mortis is known to occur due to disintegration of Z-line structure. A rapid decline in muscle pH also causes denaturation of collagenous connective tissue.

Lecture : 11

Meat Quality Parameters

Fresh meat can be referred as a product which has undergone imminent postmortem changes following gslaught but has not been subjected to any processing. However, fresh meat which has undergone freezing can be conveniently termed as raw meat. Some characteristics of fresh and raw meat need to be properly understood in order to achieve the best results in processing.

Meat Colour

This is the total visual perception of meat. The hue (primary colour), chroma (intensity) and the value (brightness) of meat colour are based on the quantity of principal muscle pigment—myoglobin and its chemical state. It is for this reason that meat colour varies with species, sex, age and even among different muscles of the same species. Myoglobin content of more active species and muscles is higher than the passive ones. Typical colour of meat from various species is:

Mutton and chevon : Light to dark red
Pork : Greyish pink
Poultry : Grey white to dull red
Buffalo meat and beef : Cherry red

Myoglobin constitutes about 80-90% of the total meat pigments. The role of haemoglobin in meat colour is negligible in a properly bled muscle. Catalase and cytochrome enzymes are of little consequence as far as meat colour is concerned. Myoglobin molecule has a protein portion (globin) and a heme (iron containing) ring. It is one-fourth in size as compared to structurally similar haemoglobin molecule. In intact meat, iron in the heme ring of myoglobin exists in the reduced form. Upon cutting, grinding or exposure to air, myoglobin is oxygenated to form oxymyoglobin within 30-45 minutes. Oxymyoglobin has a bright red colour (bloom) which is very much desired by the consumers. However, this pigment is comparatively unstable. In conditions of less oxygen, partial vacuum or semipermeable package, myoglobin as well as oxymyoglobin is oxidized to brown coloured metmyoglobin. At the time of meat purchase, brown colour is usually associated, by the consumers with meat that has been stored for long although it is not always true. In order to prevent the formation of brown colour, fresh meat is often packed in films with very good gas (oxygen) transmission rate.

**Water Holding Capacity**

Water constitutes about 76% of fresh meat. It is a universal solvent and takes part in a large number of biological reactions. In muscles, water molecules carry positive and negative charges. The location of these molecules allows water to exist in three different forms—free water, immobilized water and bound water. The water molecules held by capillary forces on the surface make up free water which can be removed by application of even minor physical force. The middle layer of water molecules remain in contact with proteins and make up immobilized water, a large part of which can be removed by
application of severe physical conditions. However, 4-5% of water molecules are so tightly bound to the charged hydrophilic groups on the muscle proteins that they do into allow this bound water to escape by application of any physical force.

The capacity of meat to retain its water during the application of physical forces in known as water holding capacity (WHC). This property of meat has a special significance because it contributes to the juiciness of cooked meat besides influencing the texture and colour. Fresh meat with a good water holding capacity is less prone to shrinkage during storage. WHC of meat is very important in processing where meat is subjected to physical forces such as cutting, grinding, filling, pressing, heating etc.

**Marbling**

It refers to the intramuscular fat which can be visibly detected when the muscle surface is cut. The solidification of this fat during chilling contributes to the firmness of meat. Marbling prominently figures in the USDA quality grades for meat because of its merchandising value. During handling of chilled meat, some special retail cuts like chops and steaks retain their uniform thickness and typical shape due to marbling. Besides, marbling also enables meat to bear the impact of comparatively high cooking temperature. During thermal processing, moderately marbled meat yields a juicy and flavourful product whereas too little marbling yields a dry and flavourless product. Excess marbling neither enhances the eating satisfaction nor desired in a fat conscious society.

**Quantum of connective Tissue**

The amount of connective tissue in meat has a direct bearing on its textural characteristics. During animals life time, more active muscles tend to deposit more connective tissue to gain strength. The quantum
of connective tissue per unit muscle does not increase with age and is not responsible for tough meat of older animals. In fact, it is the increase in muscle fibre diameter and consequent increase in muscle fibre bundles which account for the coarse texture of such meat.

Most meat cutting practices are based on separation of coarse textured meat from the tender meat, so as to facilitate the right kind of cooking procedure and derive maximum palatability pleasure.

**Firmness**

The firmness of meat is a good quality parameter which plays an important role in carcass setting, fabrication, aging, processing, slicing and product display. During carcass chilling, the firmness increases due to loss of extensibility associated with the completion of rigor mortis. Fresh meat having a high water holding capacity shows good firmness and tight structure. It can be objectively measured by shear force apparatus or penetrrometer. Meat with a good degree of firmness yields a comparatively better quality processed meat products.

**Meat Storage Conditions**

**Cold shortening:**

When prerigor meat is fast chilled below 15°C, there is shortening of muscles. This shortening or contraction is more at 0°C and still more at -2°C. At 40% shortening, which is quite common, meat becomes very tough and large quantity of meat juices are exuded. However, in case cold shortening exceeds more than 40%, Z-lines are disrupted and meat becomes soft and tender. Otherwise also, cold shortening is a reversible phenomena and is resolved when glycogen content of muscle is exhausted. In the meat plant, cold shortening can be
avoided by keeping the meat above 14°C for sufficient time to pass the rigor stage.

**Thaw rigor:**

When prerigor meat is frozen, a severe type of rigor mortis ensues during thawing. The shortenine 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 a tough meat and heavy drip losses.

**Ante mortem Factors Affecting Meat Quality**

Various stress factors such as extremes of environmental temperature, overcrowding, prelaughter transportation, struggle during immobilization and bleeding etc. have ultimate bearing on the quality of meat. Exposure to low temperature may cause shivering which results in reduction in muscle glycogen level. During any environmental stress, susceptible pigs, show porcine stress syndrome which is characterized by muscle tremors, anxious behavior and reddening of skin. In such animals antemortem temperature rise, lactic acid build up and ATP depletion are the general features and postmortem changes are rapid. So conversion from muscle to meat is also fast due to a sharp fall in pH and muscle denaturation. Ultimately, meat becomes pale in colour, soft in texture and exudative or moist during chilling itself. Stress resistant animals are able to withstand exercise, fasting, fatigue, fight etc. but at the expense of their glycogen reserves. Slow and limited glycolysis often result in high ultimate pH and excellent water binding capacity. So meat appears dark, firm and dry.

Preslaughter handling such as long distance transportation and overcrowding in trucks is also stressful to the animals. This treatment causes shrinkage of muscular tissue and comparatively low dressing
percentage. So holding of such animals for resting and feeding can be helpful in restoring their depleted glycogen level. However, basic principle of feed withdrawal and adequate water supply for 24 hr. before slaughter has to be followed for ease of evisceration and to reduce microbial contamination of carcass from intestinal contents.

Like other livestock products, meat is also quite prone to the absorption of off-odours from the surrounding environment. Hence, meat should not be stored in the presence of other strong smelling substances.

**Lecture :12**

**Palatability Characters of Meat**

3 major palatability attributes are:

* Juiciness
* Flavour
* Tenderness

1. **Juiciness:**
   
   → Difference in juiciness in meat may be attributed to amount of bound/Intermediate Moisture & intramuscular fat concentration.
   
   → Major factors responsible for Juiciness
   
   * Water holding capacity
   * Intra muscular lipid

2. **Meat flavor → associated with 2 factors**

   * Water soluble Myofibrillar proteins
   * Associated with typical meat flavor (Metallic serumy)
Tenderness depends on contractile state of muscle and amount of connective tissue. Tenderness also depends on ante mortem and postmortem factors and is found to be heritable (45%)

**Factors Responsible for Tenderness in Meat**

1. **Genetics (45%)**: In Beef it has been noticed that 45% of observed variation in tenderness of cooked Beef is due to genetics/parents of the animal.
2. **Species & Age:**
   → Tenderness – Variations in tenderness is observed to a great extent in Beef followed by lamb & pork.
   → Tenderness depends on age of the animal at the time of slaughter
     * Beef – 20 month,
     * Lamb – 8 month
     * Pork – 5 month
   The decrease in tenderness with increasing age is due to charging nature of collagen (gristle), connective tissue protein found in meat.
   Collagen becomes complex & stronger with advancing age
3. **Feeding:**

   Feed of the animal influences tenderness

   Eg: Beef → Grain fed animals usually are slightly more tender because they are slaughtered at a slightly younger age

4. **Muscle to Muscle:**
There is considerable difference in tenderness among muscles within any species. Eg: Tenderloin is more tender than fore shark

5. **Suspension of carcass:**
   → Stretching of muscle during chilling of the carcass affects tenderness.
   → It has different effects on different muscles acceding to their anatomical location in the carcass.

6. Usually carcasses are hung from hind leg in which major muscle in rib/lion is stretched & more tender than cuts from round. But this has been replaced by hanging from pelvic/hip bones.

7. **Electrical Stimulation: (High Voltage/1 min)**
   → Speeds up postmortem conversion of muscle to meat.
   → Reduces the incidence of Cold Shortening
   → ↑ses tenderness in Beef from older Animals

8. **Chilling Rate:**
   Rapid chilling leads to cold shortening and if frozen before completion of rigor leads to Thaw rigor/shortening on thawing which will affect the tenderness

9. **Aging:** Progressive Tenderization due to natural enzymatic changes after Rigormortis due to enzymes like cathepsins

10. **Mechanical:**
    * Grinding - ↑ses tenderness & produces uniform texture
    * Cubing (cuber) – Blades of the cuber cuts the connective tissue (small fractions)
* Blade / Needle tenderization – cuts & punctures connective tissue in the lean tissue

11. Chemical
Salt curing and usage of vegetable enzymes like papain, bromelin, ficin degrade connective tissue like collagen & elastin to yield tender meat.

12. Marinading:

→ Basic Ingredients of a Maranade
  * Salt/soy sauce
  * Acid (vinegar/Lemon/Italian salad dressing
  * Enzymes (papain/Bromelin/Ficin/Fresh ginger/garlic
  * Alcohol (wine/Brandy)
  * Olive oil

→ Tenderising action occurs through softening of collagen by salt, increased uptake of water and hydrolysis of crosslinks by acids & Alcohols
→ Earthen ware mostly preferred due to acids used in marination
→ Marination employs Freezing (4-hr)
→ Marination results in sustainable losses of Fe, Zn & Mg.

13. Freezing
→ Rapid freezing → small crystals
→ Slow freezing → Large crystals – disrupt muscle fiber components

Rapid freezing yields meat with better texture

14. Thawing:
* Thawing meat slowly in the refrigerator generally results in greater tenderness compared with cooking frozen meat without thawing.

15. **Cooking:**

As cooking progresses contractile proteins in meat become tender. For cuts that are low in connective-tissue. “Dry heat” methods like pan fry/barbequing.

For cuts with high amount of connective tissue, moist heat methods eg: Braising are used.

16. **Carving:**

* Meat should be carved at right angles to the length of muscle fibre for maximum tenderness.

**Lecture :13**

**Ageing of Dressed Carcasses**

In the absence of microbial spoilage, the holding of unprocessed meat above freezing point is known as ageing. It is also frequently referred as conditioning and sometimes ripening. During this period of holding at 0 to 3°C i.e. above freezing point several changes occur in meat at a subtle rate. Atmospheric oxidation proceeds very slowly in the dark. Bacterial action is retarded to a large extent. Proteolytic enzymes (proteases) within muscle fibres remain active and fragment myofibrils in natural course. Cathepsins or autolytic enzymes also play their role. Maillard reaction also proceeds to a varying degree. A combination of these alterations bring about desirable changes in the sensory attributes of meat system especially increase in tenderness, flavour and to some extent in the juiciness. Increase in tenderness is
relatively rapid during first 3 to 7 days postmortem and tenderization rate diminishes after that.

Two types of postmortem ageing procedures are commercially practiced-dry and wet ageing. Dry ageing is the traditional procedure in which entire carcass or wholesale cuts, without any packaging, are hung in the chilling room at 0 to 1°C for 3 to 4 weeks at relative humidity of 86% and air velocity of 0.5 meter/sec. These conditions can vary widely at commercial level. Wet ageing is the predominant commercial practice these days wherein wholesale or primal cuts are put in vacuum bags and held at 0 to 1°C for 7 to 10 days. In such a situation, humidity and air velocity provisions become superfluous.

Some of the significant changes in the meat system during ageing are:

i. Protein denaturation: Denaturation refers to physical rearrangement of chemical bonds in the amino acids of protein polypeptide chains without involving any hydrolysis. During postmortem ageing myofibrillar and sarcoplasmic proteins denature to a varying degree. There is detachment of actin filaments at Z-lines resulting in the fragmentation of myofibrils. It enhances tenderness, although muscle proteins manifest some loss of water holding capacity. However, connective tissue proteins like collagen and elastin do not undergo denaturation.

ii. Proteolysis: Denatured proteins are particularly susceptible to the action of proteolytic enzymes. So myofibrillar proteins are very prone to these enzymes. During ageing, sarcoplasmic reticulum looses the capacity to retain Ca++ ions and their release initiate a water-soluble enzyme called calcium-activated sarcoplasmic factor (CASF). This factor
degrades desmin (a Z-line protein), connectin (gap filaments), troponin T (above pH 6), tropomyosin and M line proteins causing tenderization of meat. Cathepsins or lysosomal enzymes become active at low ultimate pH or comparatively high temperature and bring about degradation of myosin and actin to fragments. Besides, they also degrade cross-links of non-helical telopeptides of collagen and mucopolysaccharides of ground substance. Some lysosomal enzymes operate during postmortem ageing to cause hydrolysis of sarcoplasmic proteins to peptides and amino acids. Proteolysis, thus, brings about some improvement in water holding capacity of meat.

Some collagen fibres appear to swell during ageing suggesting partial damage to cross links in perimysial and endomysial collagen and solubilization to a limited extent.

In meat industry tenderization of meat is brought about not only by aging and cathepsin initiated proteolysis but by using certain meat tenderizing enzymes like papain(papaya)Ficin(figs)Bromelain(pineapple). They act on the gristle(tough collagen) and hydrolyse it to make the meat much tender.

Lecture :14

Microbial and Other Deteriorative Changes in Meat and their Identification

Sources of Microbial contamination of Meat
There are a number of potential sources of contamination of meat within the abattoir itself. These include:

i. Hides/skin and feet
ii. Gastrointestinal contents
iii. Instruments such as knives, cleavers saws, hooks etc.
iv. Water used for washing carcasses and instruments
v. Airborne contamination
vi. Hands and clothing of the personnel

Contamination of meat may also take place during chilling, ageing, processing, packaging and distribution.

**Growth of Microorganisms in Meat**

The microorganisms that occur in meat may be bacteria or fungi. Fungi may be multi-cellular filaments (mold) or large single cells with buds (yeast). Molds are capable of producing minute spores under unfavourable conditions. Fungi gain upper hand over bacteria in meat when it is semi-dry. Bacteria are unicellular microorganisms which are spherical or ovoid or rod shaped and may occur in chains or clusters. Bacterial growth or multiplication takes place in phases:

- **Lag phase**: Bacterial cells increase in size under favourable Conditions
- **Log phase**: Bacterial cells multiply and increase in number
- **Stationary phase**: Growth rate becomes relatively constant due to Environmental limitations
- **Decline or death phase**: There is destruction of bacterial cells either Due to nutritional depletion or application of Some preservation technique.

An understanding of growth curve enables the meat technologists to apply suitable preservation technique to prolong the lag phase.
so that bacterial multiplication is retarded or if conditions have already favoured some growth, then to hasten the death phase. Microbial growth activity in meat depends on various extrinsic and intrinsic factors. The extrinsic factors are temperature, oxygen and physical stage of meat. Different groups of bacteria have their own growth optima. Psychrophiles have their optimum growth temperature below 20°C, thermophiles above 45°C and mesophiles an optima ranging between these two. A refrigerated temperature of nearly 5°C greatly retards the growth of most psychrophilic organisms responsible for the spoilage of meat. These bacteria generally belong to genera Pseudomonas, Achromobactor, Flavobacterirum (G+rods), Micrococcus, Streptococcus (G+rods), in cured or vacuum packed meat products. The growth of bacteria on meat is usually characterized by slime formation. It should be noted that total bacterial population is above 10^7 when most signs of
spoilage appeal on meat. Effective freezing damages or kills most of the bacteria present on meat. It may be remembered that meat spoilage molds are also psychrophiles. On the contrary, food pathogens generally belong to the thermophilic group of bacteria.

Oxygen environment around the mat will determine the type of micro flora that will find favourable conditions for growth. Bacteria found in meat may be either aerobic or anaerobic or sometimes facultative. Bacteria that grow on the surface of fresh meat are generally aerobes, whereas it is a different flora in the interior of meat. All molds and yeast that grow in meat are aerobic in nature. Use of different barrier packaging films restricts the activity of aerobic microorganisms. Physical state of meat such as whole carcass or primal cuts or retail cuts or comminuted form also influence the rate of microbial growth. Microbial load increases with the increase in exposed surface area of meat.

Important intrinsic factors which affect the growth of microorganisms in meat are water activity, pH and redox potential. The amount of water available in a food system for the growth of microorganisms is generally expressed in terms of water activity. In fact, water activity ($a_w$) is defined as vapour pressure of the solution ($p$) in a food system divided by vapour pressure of pure solvent or water ($p_0$). Fresh meat generally has a water activity of 0.99 or more. Most meat spoilage bacteria can grow only up to a water activity of 0.91 but most spoilage mold and yeast can grow up to a water activity of 0.86. This factor is commercially exploited in the production of intermediate moisture meat products. Meat pH is yet another intrinsic factor which influences the growth of microorganisms. Bacterial growth is best at neutral pH (i.e. pH 7.0). It keeps on diminishing as meat pH goes down. If ultimate pH is 6.0 or so, a large number of bacteria can still grow in meat. However, when normal ultimate pH of nearly 5.5 is achieved in meat, bacterial growth is reduced to a large extent and the growth of mold and yeast is
favoured. Redox potential refers to the reducing or oxidizing conditions prevailing in meat and this factor also influences the growth of microorganisms.

Deteriorative Changes in Meat

When meat depicts signs of decomposition and putrefaction, it is referred as spoiled and becomes unfit for human consumption. Besides microorganisms, intrinsic enzymes and insects also contribute to the spoilage of meat. Microbial spoilage of fresh chilled meat is generally on the surface whereas it is within meat at higher temperature. The causative agents and deteriorative changes are quite different in aerobic and anaerobic spoilage.

Under aerobic conditions, most significant symptom of meat spoilage by bacteria and yeast is the slime formation on the surface which results due to coalescence of a large number of individual colonies. There may be discolouration of meat due to oxidizing agents produced by bacteria or growth of colonies of coloured organisms. The production of off-odours is also usually encountered. Bacterial action causes proteolysis of meat proteins and lipolysis of meat lipids. The end products of proteolysis are simple peptides and amino acids under aerobic conditions whereas sulphur dioxide, ammonia and other obnoxious compounds like amines and ketones under anaerobic conditions. Residual carbohydrates yield skatol and indole. Molds may grow on semi-dried meats causing surface stickiness and whiskers.

Under anaerobic conditions, meat decomposition is more offensive. There may be putrefaction in the deep tissues such as lymphnodes and bone joints, which is always accompanied by foul odours or taints. Souring may also develop due to accumulation of organic acids.

Identification of Meat Spoilage
The identification of meat spoilage is based on the deteriorative changes brought about by microorganisms, intrinsic enzymes and insects. During spoilage process, several utilizable substrates are consumed by microflora and new products are formed which can be measured or determined in meat. Thus, meat spoilage can be detected by any of the following physical and chemical methods:

i. Some physical observations such as discolouration, slime formation, stickiness, whiskers etc. give a clear indication of spoiled meats.

ii. At low temperature, meat spoilage is accompanied by the formation of many off-flavour compounds. Many of them owe their origin to free amino acids and related substances. The production of $\text{H}_2\text{S}$ and mercaptans can be measured to ascertain meat spoilage. Chemical determinations for the presence of ammonia, indole, skatol, di- and trimethylamine etc. can be carried out to detect microbial spoilage in meats.

iii. The extract release volume (ERV) determination is particularly helpful in detecting the incipient spoilage in meats. ERV refers to the volume of aqueous extract released by a meat homogenate when it is passed through a filter for a given period of time. As meats undergo microbial spoilage, there is a complete hydrolysis of proteins which significantly decrease the ERV.

iv. Dye (usually resazurin) reduction test is many times used to detect spoilage in meats. Spoiled raw or cooked meat homogenate prepared from stomacher could bring about resazurin reduction within 2 hours. This method shows a very good correlation with bacterial numbers.

v. Incipient spoilage in meat shows a simultaneous rise in pH, bacterial counts and water holding capacity of meat proteins. At the time of incipient spoilage, pH value is more than 6.5 in ground meat but it may even increase to 8.5 in putrid meats.
vi. High thioarbituric acid and peroxide values indicate chemical spoilage of meat and meat products.

**Lecture : 15**

**Various Methods of Meat Preservation**

Meat is a highly perishable commodity due to nearly neutral pH (low acid food), high moisture content and rich nutrients.

Various methods employed to prolong the shelf-life of meat are:

1. Chilling /Refrigeration
2. Freezing
3. Curing
4. Smoking
5. Thermal processing
6. Canning
7. Dehydration
8. Irradiation.

**Chilling/Refrigeration**

This is the most widely used method of preservation for short term storage of meat because chilling or refrigeration slows down the microbial growth and enzymatic as well as chemical reactions. Storage of fresh meat is done at a refrigeration temperature of 2 to 5°C. Refrigeration of meat begins with the chilling of animal carcasses and continues through the entire channel of holding, cutting, transit, retail display and even in the consumer household before ultimate use. The relative humidity is generally kept 90% in order to check excessive shrinkage due to loss of moisture. Carcasses are first held in chill coolers (15°C) to remove their body heat and then passed on to holding
coolers (5°C). It is important to maintain proper spacing between carcasses so as to allow thorough air circulation.

The refrigerated storage life of meat is influenced by species of origin, initial microbial load, packaging and temperature as well as humidity conditions during storage. Pork and poultry start with a comparatively high microbial load. Irrespective of species of origin, utmost care should be taken during handling of meat in order to check further microbial contamination. Since convenience of meat plant workers is also important, the temperature in cutting and packing halls generally exceeds 5°C. As such, operations should be accomplished by specialised hands within the minimum possible time. Refrigerated temperatures favour the growth of psychrophilic organisms causing spoilage of meat in due course of time.

Generally, fresh meat is maintained in good condition for a period of 5-7 days at a refrigerated temperature of 4±1°C. Processed meat products are also stored under refrigeration till these are finally consumed. These meat products are less perishable as compared to fresh meat. The refrigerated shelf life of these products depends on the processing steps followed in each case.

**Freezing**

Freezing is a method of choice for the long term preservation of meat. It stops the microbial growth and retards the action of enzymes. It has the advantage of retaining most of the nutritive value of meat during storage, although a very little loss of nutrients does occur in the drip during thawing process. Since drip is not possible in cooked meat products, proper freezing conditions result in retention of most of the nutritional and sensory properties.
It is utmost important to wrap fresh meat in suitable packaging film before freezing, otherwise meat undergoes freezer burn. This abnormal condition occurs due to progressive surface dehydration resulting in the concentration of meat pigments on the surface. This discolouration in frozen meat due to sublimations of ice crystals, is irreversible condition. On cooking, freezer burn meat is quite tough and lack juiciness.

The quality of frozen meat is also influenced by freezing rate. In slow freezing, extracellular water freezes more quickly due to low solute concentration as compared to intracellular water. Thus, there is formation of large extracellular ice crystals which may cause mechanical damage to the muscular tissue, giving it a distorted appearance in the frozen state. Contrary to this, in fast freezing, numerous small ice crystals are formed uniformly throughout the meat tissue. Besides, drip losses during thawing are considerably low as intracellular water freezes within the muscle fibre itself. Numerous small ice crystals on the surface of fast frozen meat also impart it a desired lighter colour as compared to slow frozen meat.

Various type of freezers are employed to freeze meat and meat products. In plate type freezers, meat is placed in trays which remain in direct contact with metal freezer plates. A temperature of \(-10^0\text{C}\) or so is achieved. Blast type freezers are used in large meat plants. Such freezers render fast freezing of meat products due to rapid air movement. A temperature range of \(-10\) to \(-30^0\text{C}\) is generally achieved.

The quality of meat and meat products can be preserved for months together during frozen storage at \(-10^0\text{C}\). However, a storage temperature of \(-18^0\text{C}\) is recommended because at this level almost all water in meat is frozen and minor temperature fluctuations can all water in meat is frozen and minor temperature fluctuations can be
taken care of. At $-18^0\text{C}$, storage life of buffalo meat, beef, mutton and chevon is approximately 6 months, while that of pork and poultry is less (4 months) because of associated unsaturated fat, prone to rancidity development. Storage life of cured and salted meat products is still limited (2 months) as salt is a pro-oxidant. However, at $-10^0\text{C}$, storage life of these meats is reduced to half or even less. Thawing of meat should be done within the package itself preferably in a refrigerator so as to minimize the drip losses. However, if thawing is to be accomplished at a short notice, warm air or lukewarm water may be used. Refreezing a thawed meat is not suggested in tropical countries and repeated freezing should not be practiced.

At times, freezing and thawing of young chicken may pose the problem of bone darkening due to leaching of haemoglobin from the marrow of porous bones to the adjoining muscle tissue. This tissue appears grey or black after cooking, although other sensory attributes are not affected.

**Curing**

Preservation of meat by heavy salting is an age old practice. It was applied as a thumb rule because refrigeration facilities were not available. Later, curing by common salt and sodium nitrite resulted in comparatively improved products. These days mild curing of meat products is practiced mainly for specific flavor and colour development and preservative effects of curing ingredients is an added advantage. Sodium chloride, sodium nitrite, sodium nitrate and sugar are the main curing ingredients.

Sodium chloride (common salt) exerts its preservative action as follows:
i. It acts by dehydration and alteration of osmotic pressure that inhibits the growth of spoilage bacteria.

ii. Chloride ions in the salt directly act on the microorganisms.

iii. It slows down the action of proteolytic enzymes in meat.

Besides, sodium chloride interacts with fatty acids to enhance the flavor of the cured products. It also contributes to the tenderness of the product.

Sodium nitrates and nitrite: Serve to stabilize the attractive cured meat colour and impart characteristic cured meat flavor. Colour reactions of cured meats can be summarized as follows:

\[
\text{Nitrate} \xrightarrow{\text{Nitrate reducing organisms}} \text{nitrite}
\]

Absence of light and air

\[
\text{Nitrite} \xrightarrow{} \text{Nitric oxide (NO)}
\]

\[
\text{NO} + \text{Mb} \xrightarrow{} \text{Nitric oxide metmyoglobin}
\]

Favourable conditions (NOMMb)

\[
\text{NOMMb} \xrightarrow{} \text{Nitric oxide myoglobin (NOMb)}
\]

(undstable cured pigment)

\[
\text{NOMb} + \text{heat/smoke} \xrightarrow{} \text{Nitroso haemochromogen}
\]

(stable pink pigment)

Nitrites and nitrates at permitted levels of 500 ppm and 200 ppm respectively act as preservatives by inhibiting the growth of a number of bacteria especially Clostridium botulinum. These chemicals also retard the development of rancidity. Cured flavor
develops due to reaction between fatty acids and sodium nitrite resulting in the formation of benzo nitrile and phenylacetonitrile. However, nitrite has been found to be involved in the formation of nitrosamine which is supposed to be involved in the formation of nitrosamine which is supposed to be carcinogenic. Sugar counteracts the harsh hardening effect of salt, adds to the flavour development and also serves as an energy source for nitrate reducing bacteria in the curing solution or pickle. Sucrose or dextrose is mainly used for this purpose. Traditionally curing of meat is limited to pork (esp. ham and belly) and beef (esp. brisket and leg muscles).

There are several methods of curing:

i. Dry cure Dry ingredients are rubbed to meat, e.g. curing of bacon
ii. Pickle cure Meat cuts are immersed in ingredient solution (pickle), e.g. curing of pork shoulder
iii. Injection cure concentrated solution of the ingredients is pumped into the meat through artery or injected by needles in the muscular pork, e.g. curing of pork ham.
iv. Direct addition method Curing agents are added directly to finely ground meat, e.g. luncheon meat

The temperature of curing room is maintained at 3±1°C and curing process is allowed for 3 to 4 days depending on the strength of curing pickle.

**Smoking**

Meat smoking was known to man as an aid in preservation for a long time, although its chemical basis was a mystery. It is now wellknown that smoke contains a large number of wood degradation products such as aldehydes, ketones, organic acids, phenols etc. Which exert bacteriostatic effect besides imparting characteristic smoky flavor.
Preservation of smoked meat is also due to surface dehydration, lowering of surface pH and antioxidant property of smoke constituents. Curing and smoking of meat are closely interrelated and these days, curing is usually followed by smoking. Besides, smoking and cooking operations are accomplished simultaneously.

Smoke is produced in the specially constructed ‘smoke house’ where saw dust or hardwood and sometimes both are subjected to combustion at a temperature of about 300°C. High temperature is desirable to minimize the production of carcinogenic compounds. Smoke generation is accompanied by formation of numerous organic compounds and their condensation products. Aldehydes and phenols condense to form resins, which constitute 50% of the smoke components and contribute most of the colour of smoked meat products. Phenols act mainly as bacteriostatic and formaldehyde as the chief bactericidal compound.

These days many liquid smoke preparations are commercially available in the developed countries. Liquid smoke is generally prepared from hardwood wherein polycyclic hydrocarbons are removed by filtration. Application of liquids smoke on the product surface before cooking imparts it a smoky flavor which is very much liked by the consumers.

**Thermal Processing**

Unlike refrigeration of meat that slows or stops microbial growth, thermal processing as a preservative method is employed to kill the spoilage microorganisms. Two temperature regimes, that of pasteurization and sterilizations are generally used. Pasteurisation refers to moderate heating in the temperature range of 58°C to 75°C whereby most of the microorganisms present including trichinae
occasionally found in pork are killed. Incidentally, this is also the cooking temperature range of most processed meats. This heat treatment significantly extends the shelf life of meat, although such products also need to be stored under refrigeration. Sterilisation refers to severe heating at temperatures above 100°C whereby all spoilage microorganisms in meat are killed or their microbial cells are damaged beyond repair. This heat treatment renders the meat products commercially sterile because some bacterial spores may still survive. Such meat products have a recommended shelf life of two years in cans and one year in retort pouches at ambient temperature in tropics. However, exposure of meat to high temperatures imparts sulphydryl flavor in cans and modifies texture also.

Various meat products differ in water content, amount of fat and consistency. These factors have a definite bearing on the thermal processing schedule. For example, moist heat is much more effective in killing microorganisms and spores as compared to dry heat, so a meat product with higher moisture content will require comparatively less heat for sterilization.

**Canning**

It is a process of preservation achieved by thermal sterilization of a product held in hermetically sealed containers. Canning preserves the sensory attributes such as appearance, flavor and texture of the meat products to a large extent. Besides, canned meat products have a shelf life of at least 2 years at ambient temperature. Conventional canning is done in the following steps:

i. Preparation of meat and gravy Carcass is deboned and 4 cm meat chunks are prepared. Meat gravy is prepared using condiments, tomatoes, dry spices and salt etc.
ii. Precooking Meat and gravy, both are precooked at $70^0$C for 15 minutes. It causes the inevitable shrinkage of meat chunks and reduces the initial microbial load.

iii. Filling Filling in cans may be done manually or mechanically leaving proper headspace as per BIS specifications. Half of the gravy is filled first followed by meat chunks and finally the rest of the gravy. Special care is taken to avoid trapping of air during this operation.

iv. Exhausting It refers to the removal of air from the container before it is closed. It is necessary to minimize the strain on the can seams due to expansion of air during heat processing. Mechanical exhausting may vacuum seal the cans.

v. Seaming This is usually done by a double seamer machine.

vi. Retorting or thermal processing The product is subjected to high temperature under pressure for sufficient duration to achieve commercial sterility.

vii. Cooling Retorting is followed by very fast cooling up to $30-40^0$C to give a shock to the thermophilic bacteria.

viii. Storage Cans should be stored in a cool and dry place preferably at a temperature of about $20^0$C.

**Dehydration**

Removal of water from meat concentrates the water soluble nutrients making them unavailable to the microorganisms. The extent of availability of water to microbial cell is expressed as water activity ($a_w$). Dehydration lowers the water activity considerably to prevent the growth of spoilage organisms. Sun drying of meat chunks as a means of preservation was practiced even in ancient days but rehydration of such meat chunks used to be limited. Mechanical drying process
involves the passage of hot air with controlled humidity but here also there is difficulty in rehydration.

Freeze drying of meat is a satisfactory process of dehydration preservation due to better reconstitution properties, nutritive quality and acceptability. Freeze drying involves the removal of water from a food by sublimation from the frozen state to vapour state by keeping it under vacuum and giving a low heat treatment. Freeze drying of meat is carried out in three stages:

i. Prefreezing
ii. Primary drying
iii. Secondary drying

Meat is first frozen at $-40^\circ$C. Then it is dried under vacuum for 9-12 hours at low temperature in plate heat exchangers at 1 to 1.5 mm pressure of mercury. Ice crystals get sublimated to water vapour and there is no rise of temperature. In the first phase of drying, free and immobilized water of meat, which is freezable and constitutes about 90-95% of total moisture, is removed. Secondary drying is done at high temperature to remove remaining 4-8% bound water. Freeze dried products are packaged under vacuum and have very good storage stability. The process has been largely used for the preparation of dehydrated meat soup mixes.

**Irradiation**

Radiation is the emission and propagation of energy in the material medium. Electromagnetic radiations are in the form of continuous waves. These are capable of ionizing molecules in their path. These radiations can destroy the microorganisms by fragmenting their DNA molecules and causing ionization of inherent water within
microorganisms. Since microbial destruction of foods takes place without significantly raising the temperature of food irradiation is many times referred as cold sterilization among radiations, alpha and beta-rays charged particles and have limited use in food irradiation. However, lambda rays are electronic waves of short wave length and not the charged particles. These are easily obtained from isotopes like $^{60}$Co and $^{137}$Cs and have excellent penetration power. Gamma radiations produce desired effect only during food irradiation and have no effect after removal of source. These are widely used in food preservation. A dose of 50-100K rad (radurisation) can enhance the shelf-life of fresh meat cuts and poultry products by 19 days whereas a dose of 50-100K rad (radurisation) can enhance the shelf-life of fresh meat cuts and poultry products by 19 days whereas a dose of 4-5 Mrad (rad appertisation) can sterilize pork, poultry and fish. Among the nonionising radiations, ultraviolet radiations of 2650Å are most bactericidal in nature, but due to poor penetration power, these are used only for surface sterilization of meats. It may be mentioned that certain chemicals like ascorbates have been found to increase the sensitivity of the microorganisms to radiation.

In addition to the above mentioned preservation techniques, 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. Citric acid, propionic acid, benzoic acid, sorbic acid and their salts are effective mold inhibitors. Acetic acid and lactic acid prevent bacterial growth, whereas sorbate and acetate are capable of arresting the growth of yeast in foods. It may be noted that modern meat food processors do not rely on any single preservative factor or technique. They employ a combination of preservative factors (hurdles) in a balanced manner to derive maximum benefit. Technologist have exploited the hurdle
concept in the development and keeping quality enhancement of intermediate moisture and shelf stable food products.

Hurdle Concept

Intermediate moisture meat products mostly depend on lower moisture content and consequent decrease in water activity for their shelf stability. Use of high concentration of humectants including salt and sugar for desorption usually produces a disagreeable taste. This is true for Indian palate also. Leistner and Rodel (1976) coined the term hurdles for the parameters like chilling, heating, pH reduction, low water activity, enhanced Eh, use of preservatives and competitive microflora. Use of these hurdles or combination preservation technique in a balanced and judicious manner was named as hurdle concept and later the hurdle technology. It does not allow a single parameter to affect the product characteristics drastically. Thus, hurdle technology based meat products provide a desirable taste, juiciness, texture and safety.

Lecture : 16

Processing of Meat and Meat Products

Basic Processing Procedures:

i. Comminution: All processed meats can be classified as either non-comminuted or comminuted products. Non-comminuted products are generally processed from intact cuts. These products are usually cured, smoked and cooked, e.g. ham and bacon. Comminution refers to subdivision or reduction of raw meat into meat pieces or particles. The degree of comminution or particle size varies with the processing characteristics of products. Such meat particle size reduction
helps in the uniform distribution of seasonings and eliminates the toughness associated with meat of old animals and lowers the fuel cost for cooking (Padda et al, 1987). Comminution is done with the help of meat mincer for coarse ground products whereas bowl chopper is also employed for making fine meat emulsion.

ii. **Emulsification** A mixture of two immiscible liquids where one liquid is dispersed as droplets in another liquid is called emulsion. An emulsion has two phases—a continuous phase and a dispersed or discontinuous phase. These phases remain immiscible due to the existence of an interfacial tension between them. The emulsion remains unstable if interfacial tension is very high. The emulsion can be stabilized by reducing the interfacial tension with the help of emulsifying agents or emulsifiers. Homogenised milk is a good example of true emulsion in which fat droplets are dispersed in an aqueous continuous phase. The size or diameter of dispersed fat droplets in a true emulsion ranges from 1 to 5 micrometer (µm).

**Meat emulsion** comprises of a dispersed phase of solid or liquid fat droplets and a continuous phase of water containing salt and proteins. Here, continuous phase can also be referred as a matrix in which fat droplets are dispersed. Due to the presence of matrix, many people call meat emulsion as a multiphase system. For practical purposes, meat emulsion is an oil-in-water emulsion where solubilised meat proteins act as emulsifiers. The fat droplets are usually larger than 50 µm in size and remain coated with a soluble protein—either myofibrillar or sacroplasmic. The amount of fat that can be incorporated in a stable emulsion depends on fat particle
size, meat pH, temperature during emulsification and the amount and type of soluble proteins. It is very important to maintain low temperature during emulsion formation in order to avoid melting of fat particles, denaturation of soluble proteins and lowering of viscosity. This is done by adding ice flakes instead of chilled water during chopping.

For the preparation of a good meat emulsion, lean meat is first chopped with salt to extract salt soluble proteins and then fat and other ingredients are added. Salt soluble proteins have a relatively high emulsifying capacity. Once a good meat emulsion is formed, it has to be protected during cooking or heat treatment. The emulsion breakdown can occur due to sudden exposure to high temperature because of coalescence of finely dispersed fat particles into larger ones (fat pockets). The encased or moulded emulsion is first exposed to heat at 55°C so as to coagulate the coating proteins and stabilize the emulsion.

iii. Meat extension A lot of non-meat food items can be incorporated in meat products. These are generally termed as extenders, although these may be specifically referred as fillers, binders, emulsifiers or stabilizers depending on the purpose of their incorporation in the basic meat formulation. In developing countries, soy products, potato starch and flours of wheat, rice, pea, corn etc. are used as fillers to reduce the cost of formulations. Several milk products such as skim milk powder, dried whey, sodium caseinate etc. are frequently used as binders. Some gums like sodium alginate, carrageenan, gum Arabic etc. may be used to stabilize fragile meat emulsions. Due to high cost, extension of meat should
be taken up on a large scale in order to ensure the availability of meat products to the masses.

iv. **Preblending**: It refers to the mixing of a part or all the curing ingredients (salt, nitrite, nitrate etc) with ground meat in a specified proportion. This process allows better extraction of proteins which in turn helps in the formation of stable emulsion. It permits control of product composition by adjusting the desired fat content. Besides, processors get enough time for the analysis of meat samples.

v. **Hot processing**: It refers to the processing of carcass as soon as possible after slaughter (certainly within 1-2 hours) without undergoing any chilling. The term pre-rigor processing is used when muscular meat is processed in a pre-rigor condition. Though hot processing of meat has been a common practice in India, it is rather a new development in western countries. This technique has many advantages. It accelerates the processing steps and entire processing steps and entire processing time is reduced to a great extent. There is improvement in the cooking yield and sensory quality of the product. In addition, there are financial benefits due to reduced chiller space and labour requirement. Thus, lot of energy is saved if hot processing is adopted at a pilot scale.

vi. **Cooking**: Meat and meat products are cooked by any one or a combination of three methods—dry heat, moist heat and microwave cooking. Dry heat cooking is an accepted method for relatively tender cuts of meat such as pork chops, leg and chops of lamb, ground and comminuted meats etc. The product yield is relatively high due to comparatively less shrinkage. Dry heat cooking involves either broiling, roasting or frying. In broiling, meat held on a wire grill, is exposed to
heat from above as in electric and gas oven or below as in charcoal broiler. Meat is required to be turned for uniform and sufficient cooking of all sides. Roasting is also practiced on tender cuts of meats such as pork shoulder and loin; shoulder, rack and loin of lamb and cured ham etc. The roast piece, at least 8 cm thick, is adjusted in open roasting pan with fat side up and placed in hot-air oven at 115-150°C. Cooking temperature and time varies according to the cut. Roasting generally gives good browning and improves the flavor of the product. Frying – deep fat or shallow pan is also classified under dry heat cooking. This method is especially suitable for thin cuts of meat such as sliced steaks, mutton chops, chicken meat pieces etc.

Moist heat cooking is recommended for relatively tough cuts of meat. In this method, hot water or steam is continuously kept in contact with meat for cooking, so that moisture loss does not take place beyond a particular stage. Pressure cooking, stewing, simmering etc. are popular moisture cooking procedures. Higher cooking temperatures can be achieved in pressure cooking facilitating the tenderization of tough cuts of meat. In stewing, tough meat pieces are first browned in small amount of fat and then covered with water along with curry stuff and allowed to cook at simmering temperature in covered container. The final product becomes tender along with a curry. Simmering involves cooking in hot water at a temperature of 70°C for considerable time. Braising utilizes both dry heat as well as moist heat for proper processing of meat products. Several meat cuts like pork chops and steaks, mutton breast and shanks etc. are first fried
in a frying pan and then put in a covered container along with water and seasoning for cooking at 80-90°C.

**Lecture 17**

Processing of meat products is divided into the following groups for further discussion:

1. Cured and smoked meats
2. Sausages
3. Intermediate moisture and shelf stable meat products
4. Restructured meat products
5. Other popular meat products

**Cured and Smoked Meats**

All meat products belonging to this class are cured, whereas only some of them are smoked. The primal cuts of pork especially ham and bacon have been subjected to curing and smoking for a long time. These days, it is a general practice to accomplish cooking also during smoking except for Country ham, which is smoked without cooking.

**Hams**

These are classified in several ways:

- **According to weight**: light, medium and heavy
- **According to trimming**: rough, regular, skinned and skinless
- **According to presence of bone**: bone-in, semiboneless and boneless

**Commercial Processing of Ham**

Curing is usually done by artery pumping or stitch pumping to 10% of the green weight. However, best results with respect to colour and
flavor are obtained by keeping the hams in a cover pickle at 4\(^o\)C for 5 days. The hams are now shifted to smoke chamber which is maintained at 75-85\(^o\)C temperature and 30-40% relative humidity for 5-6 hours. Smoke generated from hardwood is preferred for good results.

**Cooked ham:** These hams are deboned and cured in the pickle but smoking is not done. Instead, these hams are stuffed tightly into metal moulds and cooked in a water tank at 75—85\(^o\)C for 2-3 hours depending on the weight of the ham. During cooking, the core temperature must reach 65-70\(^o\)C. After cooking, the mould-in hams are chilled in a tank maintained at 0\(^o\)C for 12 hrs. These hams are then sliced and packed.

**Country ham:** These uncooked hams are manufactured in USA by dry curing method. The curing mixture usually contains 8 kg salt, 1 kg sugar and 100g sodium nitrite. It is rubbed thoroughly at the rate of 30g per kg of ham on 1\(^st\), 5\(^th\) and 10\(^th\) day. The entire production schedule is divided into three phases:

(a) Curing is allowed to take place under refrigeration at a relative humidity of 70-90% for 30-40 days during which hams are overhauled atleast three times,

(b) Smoking is done at low temperature for 2-3 days till the hams become amber coloured and

(c) Aging is done for 6-9 months at a temperature of 20-30\(^o\)C and relative humidity of 50-60%.

During this period, Country hams become progressively harder and develop a unique flavor. These hams have a final salt level of 4-5% and a moisture content of 50-60%. The shrinkage loss during processing amounts t 18-20%.
**Proscicutto:** These hams are manufactured in Italy from certified trichinae free hams and traditionally consumed without being cooked. These are dry cured like Country hams. Curing continues for 45 days at 4°C, followed by smoking for 2 days at 55°C and finally ageing for 30 days at 20°C at a relative humidity of 65-75%. There is a shrinkage of 35% in weight during the entire processing schedule.

**Bacon**

Pork bellies are generally processed as cured and smoked bacon. There is no fixed criteria for the classification of bacon. However, many processors grade them on the basis of weights of green bellies.

**Commercial Processing of Bacon**

Green bellies are first cleared of rind and stitch pumped with a curing pickle. These are now transferred to smoke chamber maintained at a temperature of 60-65°C and a relative humidity of 30-40% for smoking as well as cooking. The cooking time depends on the size of bellies although an internal temperature of 55°C must be achieved. Cooking also helps to stabilize the cured colour. After smoking and cooking, bacon is chilled to 0°C to allow it to retain proper shape and facilitate slicing. These bacon slabs are processed in a forming machine to give uniform width and thickness. Bacon blocks are not sliced to 5-7 mm thickness with the help of slicer. The slices may be packed in a modified atmosphere if long term storage is desired.

Some variations in the processing of bacon in different countries are inevitable. Canadian bacon is not manufactured from bellies but from larger muscles of pork loin and sirloin. In Europe and U.K., Wiltshire bacon is produced from pork sides where shoulders, loin, ham and belly are processed as a single large piece.
Sausages

Sausage term was derived in the ancient times from the latin word ‘salsus’ meaning salt. It was literally coined to refer to ground meat which was salted and stuffed in animal casings. Presently, sausage may be defined as a meat product which is prepared from minced and seasoned meat and formed into cylindrical shape by natural or synthetic casings. Though sausages originated in the western world, these products acquired universal popularity due to variety and convenience to the consumers. Sausages are economical also because these are generally prepared from cheaper cuts of meat and by-products of industry.

Classification

Sausages are such a large number of varying kinds of products that it is not possible to cover them in any classification system. Some overlapping is always there. Some of the popular classification systems are:

i. Based on degree of chopping: a. Coarse ground sausage
   b. Emulsion type sausage

ii. Based on moisture content: a. Fresh sausage
   b. Smoked uncooked sausage
   c. Cooked sausage
   d. Dry and semi-dry sausage

iii. Based on fermentation: a. Fermented sausage
   b. Non-fermented sausage

Processing Steps
i. **Grinding** or mincing Lean meat and fat are minced separately in a meat mincer. The choice of mincer plate or sieve depends on the type of meat.

ii. **Mixing** Meat and fat to be used for the preparation of coarse ground sausage are mixed uniformly in a mixer. Extender, condiments and spices should also be run in the mixer for even distribution.

iii. **Chopping and emulsifying** For emulsion preparation, lean meat is first chopped for few minutes in a bowl chopper with salt to extract myofibrillar proteins. This is followed by addition of fat and running for a few minutes again to get desired emulsion consistency. Now, all other ingredients are added and chopper is run for sometime for uniform distribution. The entire operation is conducted at low temperature by addition of ice flakes in place of chilled water.

iv. **Stuffing** Sausage emulsion or batter is taken to stuffer for extrusion into casings. The casings are first collected on the stuffing horn or nozzle and released to coincide with the extrusion.

v. **Linking and tying** In small sausages, the encased mass is twisted to produce links either manually or mechanically whereas in large sausages, the encased mass is tied with thread at regular intervals.

vi. **Smoking and cooking** Sausage links are hung on the smokehouse trolley and transferred to smoke house. The temperature of smokehouse is usually maintained at 68-70°C which is enough for coagulation of sausage emulsion, cooking and requisite drying of sausages.

vii. **Chilling** The cooked product is showered with chilled water to an internal temperature of about 4°C.

viii. **Peeling and packaging** While artificial or synthetic casings are peeled off before the product is packed, small sized natural casings need not be removed. The product is generally unit packed for retail outlets.
Other examples of popular sausages

**Bologna:** It is an emulsion type sausage prepared from the meat of old animals.

**Hot dog:** It is a fairly spicy sausage in broader casings, usually weasand in India.

**Mortadella:** It is a dry sausage prepared in cattle bladder or artificial broader casings.

**Intermediate Moisture and Shelf Stable Meat Products**

Sundrying of meat was one of the earliest preservative techniques used by man. Such meat had meager rehydration 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 defence expeditions and stress situations like floods, famines etc. for air drop.

**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 range specifically permits the growth of moulds.

Basic Processing Techniques

A. Moist infusion or desorption it 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.
B. Dry infusion or adsorption it 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.
C. 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.

The thumb rules for the preparation of IMM are:
(a) Reduction of water activity by addition of humectants,
(b) Retardation of microbial growth by addition of antimicrobial especially antimycotic agents and
(c) Improvement of sensory properties such as flavor and texture through physical and chemical treatments.
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:

a. Limited breakdown of both myofibrillar and sarcoplasmic proteins. Collagen being more susceptible to degeneration results in more hydroxyl proline formation.
b. Degradation of haemo protein (myoglobin and haemoglobin) causing loss of colour.
c. Development of rancidity.
d. Non-enzymatic browning resulting in loss of colour, consumer appeal, nutritive value and possibly off-flavour.
e. Formation of lipid-protein cross links causing decreased water binding capacity and net protein utilization of meat products.

Lecture 18
Restructured Meat Products

It has now become possible to utilize less desired or secondary carcass cuts into the production of highly preferred meat products such as steaks, roasts, chops, cutlets etc. The less desired carcass cuts are carefully trimmed to remove sinews, excess fat and other connective tissue. Any one of the following three basic procedures can be adopted depending on the appearance and texture targeted in the finished product:

i. Chunking and forming
ii. Flaking and forming
iii. Tearing and forming

i. **Chunking and forming** The trimmed meat is put through a dicing machine and reduced to small chunks. One per cent common salt and 0.25% phosphate are added at this stage and meat is put in a tumbler run at medium speed. During
tumbling process, impact energy is utilized for the extraction of salt soluble proteins. The extracted proteins serve as cementing material when this meat is restructured by stuffing and pressing into suitable moulds. Restructured meat is frozen and then sliced to obtain uniform slices of desired thickness.

ii. **Flaking and forming** The trimmed meat is passed through a flaking machine to get flakes which are then mixed with 1% common salt and 0.25% phosphate. The material is run in a massager. During massaging process, frictional energy is utilized for the better extraction of salt soluble proteins. The meat mass is stuffed and pressed or formed into desired shapes-steaks, cutlets or chops. The restructured product is frozen and thawed just before cooking. The products have relatively good tenderness and uniform texture.

iii. **Tearing and forming** In this procedure meat fibres are torn apart. So, there is less damage to the membrane resulting in less chances of autoxidation. Further, the structural integrity of meat tissue is maintained, though it becomes tender. Efforts are on to mechanise the process.

**Tumbling & Massaging:**

- **Tumbling – massaging** process has revolutionized the manufacture of boneless cured meat products.
- This process promotes the extraction of salt soluble proteins from muscle tissues.
- These proteins bind the meat together when chunks are placed in a casing/mold & heat processed
- The finished pdt becomes a homogenous mass that can e cooked, sliced & served without falling apart.
- Tumbling & massaging are two different physical processes which accomplish the same end result.
* It is carried out in a relatively large rotating drum with paddles / baffles.
* As the meat tumbles & impacts against the paddles, side of the drum, & other meat chunks kinetic energy is transferred into the muscle tissue which increases the temperature of the tissue & disrupts the cellular structure allowing the weak salt solution of the curing brines to interact more directly with the muscle proteins & bring about solubilization.

⇒ Massaging: A less vigorous process
* Meat is placed in a large square tub.
* Rotating paddles move the boneless meat chunks
* Frictional energy results from the rubbing of meat surfaces together as well as contact with the paddles & walls of the tub.
* The physical action on the muscle tissue is similar to that observed in tumbling.
* Temp: 33°F – 35°F
* RPM of the tumbler: 10-12 rpm.
* Vacuum pumping into the tumbler:

It assures

→ Rapid movement of brine throughout the pieces of meat; eliminates air pockets or voids.
  * Vacuum can also be accompanied by flushing CO₂ or N₂
  → There by eliminating in the system to give a long shelf life.

Advantages:

→ Improves cure Distribution
Improves water retention in finished pdt
→ Improves tenderness
→ Improves Juiceness
→ Improves binding of meat chunks
→ Allows removal of ham seam fat.

Sectioned & Formed Meat products:

- These are technically restructured meat products as they are disassembled & then reassembled to form intact products.
- They are prepared from chunks/pieces of meat & are bonded together to form a single piece.
  The substances that bind these together are nonmeat additives, meat emulsions & extracted myofibrillar proteins.

Main steps:

* A protein meat surface interaction must be created to form a bond b/n adjacent pieces or chunks of meat.
* The meat must be made pliable & soft so that it can be pressed/ moulded into the desired shape.
* Heating is necessary to coagulate that proteins so that adjacent pieces of meat are strongly bonded together.

These steps are achieved by:

a. Creating surface protein matrix:
   → This can be achieved extracting the meat proteins or by adding non-meat proteins
→ The native meat proteins can be extracted by adding salt which derives the soluble proteins along with the exudates.

→ This is facilitated by tumbling & massaging actions

→ Myosin is the major protein that is extracted & the actomyosin, actin & other myofibrillar proteins also appear to have some binding effect.

→ The sarcoplasmic/water soluble proteins from the muscle appear to play a minor role on binding the meat.

b. Improving pliability & shaping of the product:

→ Tumbling & massaging improve the pliability of the product

→ When the product is soft & pliable, it can be shaped & formed.

→ Shaping is normally achieved by application of force using different molds/ casings.

c. Heating for stabilizing the bonds:

→ Application of heat leads to coagulation of tacky exudates & this binds the meat chunks together in the reformed shape.

Lecture : 19
Value Added Popular Meat Products

i. Luncheon meat It is a canned product usually prepared from pork along with some cereal component. The product contains not less than 80% pork including pork fat which should not exceed 30% in the final product. Besides, added water is limited to 3% and the cereal ingredients should not exceed 7% of the total formulation. Lean pork and pork fat are ground through 5 mm and 3 mm plate of the meat mincer, respectively. These are initially chopped along with
chilled water or ice flakes, common salt and nitrite followed by other ingredients such as refined wheat flour, condiments and dry spices. A simple formulation of luncheon meat is given below:

The batter or meat mix, maintained at 40\(^\circ\)C, is filled compactly in cans which are sealed under vacuum. Commercial sterilization is done in retorts at 121\(^\circ\)C for 75 minutes. Cans are now cooled with cold water shower until the contents reach 38\(^\circ\)C. Canned luncheon meat is stable at ambient temperature for a period of two years.

ii. **Meat patties** Meat 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. This product has a very good demand in big towns and cities in India. Patties are partially or completely emulsion based product, contain less than 30% fat and are moulded manually or mechanically. An optimum formulation is presented below:

Lean meat is minced twice through 6 mm plate and fat through 4 mm plate of a meat grinder. These are mixed thoroughly with all other ingredients in an electrically operated mixer or prepared into an emulsion. The batter weighing 80-100 g is moulded into 70-80 mm diameter and 15-20 mm thick patties. Raw patties may be frozen for future use or broiled in a preheated oven at 190\(^\circ\)C for 20 minutes. The internal temperature must reach 72\(^\circ\)C. These are deep fat fried in many commercial establishments. The patties are cooled and consumer packed.

iii. **Meat loaves** This important ready –to-eat comminated meat product is prepared from coarse ground meat or meat
emulsion or a combination of both. The formulation of a family loaf is given below: The meat mix or batter is tightly filled in aluminium or steel loaf pans which may be rectangular, cubical or cylindrical in shape depending on the requirement of slices for making the sandwiches. The pan-in mix is cooked in hot water maintained at $80^\circ$C or steam without pressure or broiled in hot air oven at $165^\circ$C for 2.5 to 3 hours. The internal temperature of $70^\circ$C must be achieved. It is then given a cold shower and chilled at $4^\circ$C. The chilled loaves are either packed as such or cut into slices of desired thickness and packed.

iv. **Meat balls**: Indian consumers are familiar with this food item by the name of meat kofta. The product, raw or cooked offers a great convenience to restaurants, hotels and housewives who can just put few balls in the gravy and serve the food within 10 minutes. The product is prepared from ground meat which is mixed with fat, bread powder, salt, condiments and spices in an electrically operated mixer. The dough portions of 15-20 g are rolled into balls manually or mechanically. These are either stored raw or deep fat fried in refined vegetable oil at $135^\circ$C for three minutes to get brown colour and fried flavor. Alternatively, these are cooked in hot water maintained at $80^\circ$C. Water cooked balls may be subjected to light frying to get golden brown colour. These are packed in polyethylene pouches and can be kept at $4^\circ$C for a week. Whenever required, the cooked balls can be simmered in gravy for a few minutes and enjoyed with rice or bread.

v. **Meat nuggets**: It is a ready –to-eat convenient product which is obtained by cutting cooked and cooled rectangular or cubical shape meat loaves into approximately $4 \text{ cm } \times 1.5 \text{ cm } \times 1.5 \text{ cm}$ pieces. The product is packed in unit pouches and can be stored at $4^\circ$C for a week. It is usually shallow fat fried before serving for breakfast or refreshment.
HACCP is a comprehensive food safety system right from the point of production to the point of consumption. This system analyses the hazards of raw material, identifies the points of potential contamination, monitors the processing operations and checks the risks arising from consumer abuse. It is a systematic approach to the production of microbiologically safe foods. It consists of the following steps:

i. Assessment of hazards and risks associated with raw materials, ingredients, processing, packaging, distribution and consumption of meat product on the basis of flow chart.

ii. Identification of critical control points (potential contaminants and their sources) to control and minimize a hazard.

iii. Establishment of critical limits or tolerance levels (Standards) at each control point.

iv. Defining the corrective action if a deviation is noticed during monitoring.

v. Maintenance of proper records or documents of HACCP plan.

vi. Verification of methods, procedures and tests to oversee the compliance of the plan.

HACCP system has proved very effective in identifying and preventing contamination. It is designed to check each step critically along the processing line to ensure the safety of a food instead of testing at the end.

ISO-9000 Standards

International Organization of Standardization (ISO), Geneva has issued ISO-900 series of quality standards to facilitate world trade. In this series,

ISO-9000 Provides guidance on the choice of specific model to be
ISO-9001 is meant for manufacturers having their own product.

ISO-9002 is for contract manufacturers without any product Research and development.

ISO-9003 is meant for commodity suppliers, having only final product Inspection and testing.

Thus, ISO-9000 is a very detailed quality management system. It has twenty elements for compliance by the manufacturers. Some of the important ones are management responsibility, design control, purchasing, product identification, process control, inspection and testing, corrective action, packaging, proper documentation and internal audit. ISO-903 requirements are comparatively less strict. Many food processing and packaging companies in the developed world have sought ISO-9003 certification. This certification can open up global market for food product suppliers. It has the potential for obtaining competitive advantage in the world food trade.

**Meat Food Products Order (MFPO)**

**Categories**

Meat Food Products Order, 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 licences 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 quantity 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 licensee 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:** Deals with the requirements to be complied with as regards to packaging, marking and labeling the containers of meat food products. It contains detailed instructions with respect to proper packaging and sealing of flexible containers, 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 process inspection of meat food product factories and premises is conducted by MFPO officers 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.

**Lecture 21**

**Meat Plant Sanitation and Hygiene**

The Contamination in slaughter house is mostly carried by animals. Overcrowding and improper cleaning of lairages further increase the possibility of carcass contamination. In the slaughter house bacteria spread as a result of contact with personnel, clothing, equipment and surfaces. Besides insects, vermins, birds etc. also contribute to the spread of bacteria. If the hides or fleece are heavily contaminated, it will transfer a lot of contamination to the carcasses during dressing. So, it is utmost important to keep the initial contamination on the animals to as low as possible and then
maintain strict hygienic conditions at all stages of abattoir operations. Besides above mentioned factors, abattoir hygiene will depend on its location, layout, construction, equipment, awareness among employees and facilities as well as routine of cleaning operations.

Sanitation is not only important from public health point of view but it also enhances the shelf life of the product, promotes consumer acceptance and increases the efficiency of workers. In fact, cleaning and sanitation denote a way of life. Cleaning refers to freedom from all foreign material. In order to be considered clean, the place, plant and equipment should look, smell and feel clean. On cost considerations also, sanitation should be considered as a necessary investment and not a luxury.

**Building**

The area surrounding the slaughter house building must be well maintained. It should be properly drained leaving no scope for water logging. Inedible material and manure should be collected in closed containers and removed regularly. Building proper should be vermin and fly proof. The junction between ceiling and walls should be rounded for convenient cleaning. Floor angles and corners should be imperviously sealed. Paint should be lead-free. The machinery installed in the building should be smooth and its functional surfaces should be easily accessible for cleaning. Wood fittings are not allowed. There must be adequate washing facilities for personal hygiene. Adequate facilities for disinfection of knives and tools should be there in the plant. Eating and smoking should be banned in the abattoir building.

**AGENTS USED IN SANITATION**
1. Water: Water is a general solvent. It wets the surface and floats away loose debris and dirt. It also washes away the traces of cleaning compounds. Water used in cleaning should be soft, otherwise dissolved salts may cause ‘water spotting’. Hot water (80-90°C) and steam alone or in combination can be used for cleaning utensils, food contact surfaces and small equipment. Steam is a suitable sanitizer for the conveyor belts. Cleaning with water alone is not enough. It becomes necessary to combine detergent/sanitizer with water for better results.

2. Detergents or surface active agents: They act by reducing the surface tension, thereby lowering the amount of mechanical energy required for cleaning. By definition a detergent is a cleansing substance which acting in combination with water can remove debris or dirt from surfaces. It may be natural or artificial and may be in powder or liquid form. In fact, water itself can be referred as natural liquid detergent but it has a poor wetting power or surfactancy due to high interfacial tension. A detergent reduces the tension at water surfaces. It floats the dust particles, breaks down the particulate and greasy dirt and keeps it in suspension with the help of agitation and internal electric forces. It may not have any bactericidal activity.

**Sanitizers or Disinfectants**

These compounds decrease the number of microorganisms to a level which is generally considered as safe.

**Properties of a good sanitizing agent**

i. It should be capable of rapidly killing microorganisms.
ii. It should be effective against gram positive and gram negative bacteria as well as majority of spores.
iii. It should be readily soluble in water.
iv. It should not be toxic.
v. It should not have an offensive odour.
vi. It should be stable during long and short term storage in concentrated and dilute forms, respectively.
vii. It should not be corrosive or staining to metallic equipment.
viii. It should be economic to use.

The sanitizing agents of common use in meat industry can be classified into four groups:

i. **Halogens** Among the halogens, chlorine and iodine are the main compounds used as sanitizer in meat and milk industry respectively. Chlorine compounds like sodium hypochlorite (concentrated liquid) when dissolved in water produce hypochlorous acid and hypochlorite ions. Out of these, hypochlorous acid has better efficacy. The recommended limit of chlorine as a sanitizer is 100 ppm for carcass washing, 15-200 ppm for abattoir sanitation and 250 ppm for clean equipment. However, prolonged exposure of chlorine is corrosive to metals.

ii. **Quarternary ammonium compounds** These are cationic detergents such as (a) cetyl trimethylammonium bromide (CTAB), (b) lauryl dimethyl benzyl ammonium chloride etc. Which are bacteriostatic mainly against gram positive bacteria. These compounds are not very suitable for meat industry because these are not very suitable for meat industry because these are most effective at neutral or alkaline pH. Their efficacy will be markedly affected in combination with anionic detergents or soaps or hard water.

iii. **Amphoteric compounds** Long chain substituted amino acids are surface active agents. These are less corrosive and their activity is not affected even with hard water.
However, these are quite expensive, so not of much use in food industry.

iv. **Detergent-sanitizers**: Several compatible and complementary ingredients make the cleaning and disinfection possible in a single operation. These are quite effective against a wide spectrum of soils and microbes. Some important detergent sanitizers are:
   a. Sodium hydroxide plus quarternary ammonium compounds.
   b. Hypochloric acid plus iodophores.
   c. Phosphoric acid plus hypochlorite.

**ORGANIZATION OF CLEANING SCHEDULE**

The entire sanitation team should be organized under a sanitary supervisor. All the persons working in the team should be trained in personnel, plant and environmental hygiene. The supervisor should work out a cleaning schedule with clear instructions for all areas and equipment. An intensive cleaning programme should be undertaken daily by the specially trained ‘hygiene gang’ immediately after the slaughter house operations are over. Hence, there should be provision of enough water, hose pipe points, high impact pressure water, detergents and sanitizers. Sanitation in abattoirs and meat processing plants can be carried out by adopting a six step cleaning process:

i. Physically pick up all the waste material from floor and equipment.
ii. Dry sweep the floor to remove all the particles of meat, fat, dung, scraps etc.
iii. Pre-rinse the floor and equipment with water (50°C).
iv. Wash with appropriate detergent at high pressure.
v. Rinse again with hot water (80°C).
vii. Apply appropriate sanitizer.

It should be noted that equipment are required to be rinsed again with hot water (80°C) before use to remove the sanitizer.

Automated Cleaning Systems

i. Central cleaning system (CCS) This system is suitable for abattoir and meat processing plant. It has a central pump which supplies cleaning solutions under pressure to remote areas in the plant. The unit works at very high pressure and flow rate.

ii. Cleaning-in-place (CIP) system: It is widely used in liquid food industry but has limited application in meat industry. It can be used to clean internal surfaces of equipment such as large mixers, choppers, processors, tanks etc. which can remain assembled. Cleaning is done by serial circulation of water, detergent and sanitizer through pipelines.

iii. Self contained cleaning (SCC) system: It comprises of a pump and chemical spray unit. Steam or hot water may be connected with foam production facility. It has better flexibility.

Lecture 22
Structure, Composition and Nutritive Value of Eggs is necessary to effectively preserve its quality during storage and marketing

There are four main components of hen’s egg:

a. Shell
b. Shell membranes
c. Albumen or white
d. Yolk
The yolk develops in the functional left ovary of the hen as an ovum largely during the final 10 days before release. After ovulation or release, fully developed ovum or yolk is engulfed in the oviduct where a gel of albumin or egg white is secreted to surround the yolk for a few hours. Finally, the shell membranes and the calcareous shell are deposited in the oviduct for nearly 10 hours before the egg is laid.

i. **Shell** The outer protective covering of an egg is shell which comprises around 1% of its total weight. It is mainly composed of calcium carbonate. The shell contains numerous minute pores on the entire surface, which are partially sealed by keratin. These pores allow loss of carbon dioxide and moisture from the eggs. However, a few of them (hardly 2-0) may permit bacterial penetration within the egg under specific circumstances. Thus shell structure consists of three basic units:

a. Outer cuticle made up of keratin  
b. Middle spongy or calcareous layer  
c. Inner mammary layer.
ii. Shell membranes The shell is attached to the shell membranes. The outer thick and inner thin membranes are usually inseparable except at the broad end of the egg forming an air cell. The shell membranes are a part of in-built defence mechanism in the egg because of their role as an effective barrier against bacterial invasion. The air cell continues to increase in size during storage due to loss of moisture and shrinkage of egg contents.

iii. Albumen The white or albumen portion of egg constitutes about 58% of the total weight of an egg. It occurs in four layers as follows:
   a. Outer thin layer
   b. Outer thick layer
   c. Inner thin layer
d. Inner thick white or chalaziferous layer.

The proportion of thin and thick white varies according to the breed and age of the hen. Thick content is comparatively more. The inner thick white layer surrounds the vitelline membrane of the yolk and its firm mucin like fibres continue as chalazae which has the specific function of keeping the yolk in the centre.

iv. Yolk The constitutes nearly 31% of the total egg weight. It consists of the following four structures from outside:
   a. Vitelline membrane
   b. Concentric rings of light and dark yolk material
   c. Latebra (cone like portion extending to the centre of yolk)
   d. Germinal disc (located in the cone of latebra).

Lecture 23
Chemical Composition of egg

As mentioned earlier, an egg consists of 11% shell, 58% albumen and 31% yolk. The cuticle of egg shell is composed of a foaming layer of proteinaceous matter especially keratin. It covers the calcified portion of the shell which is made up of calcium carbonate (94%) with minor quantities of calcium phosphate (1%), magnesium carbonate (%) and proteinaceous material especially keratin. The true cell membrane consist of protein fibres. The inner membrane is comparatively thick.

Chemical composition of egg

<table>
<thead>
<tr>
<th>Component</th>
<th>Total (%)</th>
<th>Water (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole egg</td>
<td>00 58 31</td>
<td>65.5 88.0</td>
<td>11.8 11.0</td>
<td>11.0 0.2</td>
<td>11.7 0.8</td>
</tr>
<tr>
<td>Albumen</td>
<td></td>
<td>58 31</td>
<td>11.0 17.5</td>
<td>32.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Yolk</td>
<td></td>
<td>94.0</td>
<td>1.0</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Shell</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Egg albumen or white contains approximately 88% water. Most of the solid content is protein. Lipid content is virtually absent. However, a very minute quantity of carbohydrate (0.5%) may be present. Albumen may be regarded as a protein system consisting of microscopic fibres in a solution of numerous globular proteins.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Relative amount in albumen (%)</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovalbumin</td>
<td>54</td>
<td>Phosphoglycoprotein</td>
</tr>
<tr>
<td>Conalbumin</td>
<td>13</td>
<td>Binds metals especially iron</td>
</tr>
<tr>
<td>Ovomucoid</td>
<td>11</td>
<td>Inhibits trypsin</td>
</tr>
<tr>
<td>Lysozyme (Globulin G&lt;sub&gt;1&lt;/sub&gt;, G&lt;sub&gt;2&lt;/sub&gt;, G&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>10</td>
<td>Lyses some bacteria</td>
</tr>
<tr>
<td>Ovomucin</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Flavoprotein</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Ovoinhibitor</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Avidin</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Egg yolk contains more than 50% solids, which are mainly lipids (32%) and proteins (16%). Yolk lipid is composed of mostly triglyceride (65%), a good amount of phospholipid (8%) and controversial cholesterol (5%). The ash content of yolk is about 1%. A little of carbohydrate, usually less than 0.5%, may also be present.

Nutritive Value

An egg contains about six grams of protein. Egg protein is of such a high quality that its biological value has been taken as 10 and it acts as a standard for evaluating the biological value of other food proteins. All the essential amino acids required in human diet are present in egg proteins. An egg also provides five to six grams of easily digestible fat, wherein the proportion of much desired unsaturated fatty acids (especially oleic acid) is more as compared to most other livestock products. Egg is an important source of fat soluble vitamins (A,D,E and
K) and water soluble vitamins of B-complex group. However, it does not contain vitamin C.

Nutritive value of edible portion of a chicken egg

<table>
<thead>
<tr>
<th>Component</th>
<th>Whole</th>
<th>Albumen</th>
<th>Yolk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>50</td>
<td>33</td>
<td>17</td>
</tr>
<tr>
<td>Water (%)</td>
<td>73.7</td>
<td>87.6</td>
<td>51.1</td>
</tr>
<tr>
<td>Food energy (Cal)</td>
<td>81.5</td>
<td>16.83</td>
<td>59.16</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>6.45</td>
<td>3.60</td>
<td>.72</td>
</tr>
<tr>
<td>Fat (Total lipids, g)</td>
<td>5.75</td>
<td>Trace</td>
<td>1.65</td>
</tr>
<tr>
<td>Total saturated FA (g)</td>
<td>1.65</td>
<td>--</td>
<td>3.30</td>
</tr>
<tr>
<td>Total unsaturated FA (g)</td>
<td>3.30</td>
<td>-</td>
<td>2.2</td>
</tr>
<tr>
<td>Oleic (g)</td>
<td>2.2</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Linoleic (g)</td>
<td>0.5</td>
<td>-</td>
<td>230</td>
</tr>
<tr>
<td>Cholestrol (mg)</td>
<td>230</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>0.36</td>
<td>0.264</td>
<td>0</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>0</td>
<td>0</td>
<td>0.2890</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>0.5</td>
<td>0.231</td>
<td>23.97</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>27.0</td>
<td>2.97</td>
<td>1.117</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.5</td>
<td>0.033</td>
<td>2.72</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>5.5</td>
<td>.97</td>
<td>96.73</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>12.5</td>
<td>4.95</td>
<td>16.66</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>64.5</td>
<td>45.87</td>
<td>8.84</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>61.0</td>
<td>48.18</td>
<td>590</td>
</tr>
<tr>
<td>Vitamin A (IU)</td>
<td>590</td>
<td>0</td>
<td>253.0</td>
</tr>
<tr>
<td>Choline (mg)</td>
<td>253.0</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>Inositol (mg)</td>
<td>16.5</td>
<td>-</td>
<td>0.017</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>0.05</td>
<td>0.033</td>
<td>0.076</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.15</td>
<td>0.089</td>
<td>0.037</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>0.055</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Ascorbic acid (mg)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

With very little carbohydrates, egg has a remarkably low caloric value which justifies its inclusion in the food for people on restricted diet.
Egg is a very good source of important minerals such as iron, phosphorus, potassium and trace elements which are necessary for the formation of blood, bone and soft-tissues. Though cholesterol content of egg yolk is comparatively high, it is not likely to significantly influence the blood cholesterol level unless taken indiscriminately because cholesterol is found in blood, nerve tissues and other parts of the human body as a normal constituent of the cell.

CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF POULTRY MEAT

Poultry meat is a good source of protein. It has a balanced lipid content and low calorific value. It is palatable, tender and easily digestible. It is easy to prepare and can be served in a variety of ways.

CHEMICAL COMPOSITION

A quantitative proximate composition of poultry meat is presented in Table 1. The detailed composition of raw chicken meat is presented in Table 2, although it varies according to the age of the bird.

MOISTURE

This is the largest component of muscle tissue. It dissolves nutrients and serves as a medium for their transport. Raw chicken meat contains 70-74% moisture. In general, younger birds have a higher moisture to skeletal muscle ratio as compared to older ones. The fat content of meat is inversely proportional to the moisture content. So, as the fat increases, the moisture content decreases.

Protein

Poultry meat has a higher protein content than most of the red meats. This protein is of very superior quality with respect to biological value and essential amino acid contents. Male birds generally have a higher protein
content as compared to their female counterparts. Protein content of the body is less prone to change in comparison to moisture and fat contents.

**Fat**

Most fat in poultry remains confined underneath the skin in contrast to red meats where it is generally distributed throughout the tissues. The content varies widely depending on the species, age, sex and diet of poultry. The carcass fat invariably increases with a raise in dietary fat or high energy diet. The proportion of desired unsaturated fatty acids—oleic and linoleic acid is more than 60 per cent of the total meat fat. Poultry meat contains less cholesterol, a fatty alcohol associated with atherosclerosis, as compared to most other animal based foods.

**Carbohydrate**

Poultry meat has very little carbohydrate content, hardly 1-2 per cent of total edible tissue. Inositol, glucose and fructose are the major and mannose and ribose are the minor constituents of carbohydrate.

**Vitamins**

Poultry meat is a good source of may vitamins. Niacin is present in good quantity whereas thiamine (vitamin B₁), riboflavin (vitamin B₂) and ascorbic acid (vitamin C) are also present in fair quantity. Poultry liver is a rich source of vitamin A, vitamin B complex and vitamin C.

**Minerals**

Poultry meat contains nearly one per cent desired minerals. Some of the important ones are sodium, potassium, calcium, magnesium, iron, phosphorus, sulphur, chlorine etc.
Detailed composition of raw chicken meat

1. Amino acid content (% of protein)
   - Lysine: 7.5
   - Methionine: 1.8
   - Arginine: 6.7
   - Cysteine: 1.8
   - Tryptophan: 0.8
   - Tyrosine: 2.5
   - Leucine: 6.6
   - Isoleucine: 4.1
   - Histidine: 2.0
   - Valine: 6.7

2. Mineral content (mg/100 g)
   - Calcium: 5.8
   - Phosphorus: 4.07
   - Iron: 0.7
   - Sodium: 46
   - Potassium: 248
   - Magnesium: 29
   - Sulphurs: 268

3. Vitamin content (per 100 g)
   - Vitamin A: 730 IU
   - Thiamine (B₁): 0.07 mg
   - Riboflavin (B₂): 0.38 mg
   - Niacin: 5.6 mg

4. Lipid content (% of total lipids)
   - Phospholipids: 48
   - Neutral lipids: 52

5. Cholesterol content (mg per 100 g)
   - 60
NUTRITIVE VALUE

Poultry meat is a food of high nutritional value. It is higher in protein content as compared to red meats. Poultry meat proteins are classified under first class category because it contains all the essential amino acids in balanced proportion. Such high protein diet ensures overall development of the body and plays an important role in tissue repairs.

Chicken meat with low fat content offers good quality food to the consumers. It provides the much desired essential fatty acids which form necessary constituents of the cell wall, mitochondria and other cell constituents. Thus, it helps in maintaining the health of the consumers. Due to its low energy value, chicken meat is a good food for weight control diets. Chicken meat contains more phospholipids and low cholesterol than other meats, which minimizes risks due to diabetes and heart diseases.

Chicken meat is a good source of vitamins and minerals in human diet. It is rich in niacin and moderately rich in thiamine, riboflavin and ascorbic acid. Chicken meat is also a good source of iron and phosphorus. Due to high biological value and easy digestibility, it is a choice food for aged persons as well as children. Chicken meat carries a high class image because of its product variety and healthful nature.

Nutritive value of roasted chicken meat (100 g)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>24.5</td>
</tr>
<tr>
<td>Fat</td>
<td>6.2 g</td>
</tr>
<tr>
<td>Ash</td>
<td>1.04 g</td>
</tr>
<tr>
<td>Food energy</td>
<td>154 Calories</td>
</tr>
</tbody>
</table>


In general, poultry meat contains all the essential amino acids, fatty acids and minerals in an appropriate quantity. It has the ability to alleviate the nutritional stress conditions in the human beings. It has a good aesthetic
appeal. Poultry meat has no religious inhibition and its many products satisfy the variety quest of the consumers.

Lecture 24
U.S Grading of eggs

AA grade:

a) Clean, unbroken and practically normal shell
b) Air cell must not exceed 1/8th inch in depth, unlimited movement and may be free and bubbly
c) White must be clear and firm
d) The yolk must be practically free from defects.

A grade:

a) Clean, unbroken and normal shell
b) Air cell must not exceed 3/16th inch in depth, unlimited movement, free and bubbly.
c) Clear and reasonably firm white
d) Yellow also should be fairly well defined without defects

d grade:

a) Unbroken, may be abnormal and can have slightly stained areas.
b) Stained areas are permitted if they do not cover more than 1/32th of the shell surface if localized or 1/16th of the shell surface if scattered.
c) Egg surface should not be dirty.
d) White may be weak and watery
e) Air cell may be over 3/16th inch in depth, show unlimited movement, free and bubbly
f) Yolk outline is slightly visible
g) Yolk may appear dark, enlarged and flattened and may show clearly visible germ development but no blood
h) Small blood spots and meat spots may be seen.
Check:

a) Eggs that have broken shell/crack in the shell but with its shell membrane intact and the content do not leak
b) A ‘Check’ is low in quality compared to ‘Dirty’

Evaluation of Egg quality

Some important quality characteristics are
1. Colour of shell
2. Shell porosity
3. Shell strength
4. Albumin condition
5. Yolk
6. Presence of blood and meat spots
7. Nutritive value
8. Flavour
9. Cleanliness
10. Grading of eggs

Shell color:

Visual examination and Automated machines for sorting of eggs are used to detect soundness of shell colour. The device grades egg automatically based on percentage of reflectance.

Shell Porosity:

Shell pores are the channels of gas and water vapour exchange between egg contents and outer atmosphere which helps in maintaining good internal quality. Low porosity of eggs is better
for table eggs because it allows less loss of moisture during storage.

Methods of measuring shell porosity are many and could be divided into 3 groups-

a) By direct counting of pores
b) By measuring weight loss under standard conditions of temperature and humidity.
c) By measuring rate of liquid flow and gas under pressure

**Shell strength:** It refers to the ability of the shell to retain its soundness during transit from farm to the consumer. There are direct and indirect methods to measure shell strength.

Indirect methods include measuring shell thickness, specific gravity method and by measuring weight/unit area.

**Direct measurement**

a) Crushing: It is determined by using metal rods to crush placing the egg on a metal plate. Increase in load may be correlated to shell fracture.
b) Piercing strength: Determined by using a steel needle in place of metal rod or metal plate
c) Impact method: A falling ball can be used to determine breaking strength. The force of impact can be calculated by knowing the distance of free ball and weight of ball. 
Force of impact = Ht x Wt of ball
**Physical state of Albumen:**

On storage the integrity of albumin structure is lost, as a result albumin spreads thinly when broken on a cooking surface. The quality of egg albumin is measured by measuring Albumin index, Haugh’s unit

Haugh’s unit = 100 log (H+7.57 - 1.7W $^{0.37}$)

H.U is the function of height of thick albumin and weight of the egg. Measurement of height of thick albumin is done by using micrometer. H.U varies with storage – 82 at farm; 77 for whole sale; 60 for retail. For an egg of poor quality H.U ranges from 36-60 while for a egg of good quality HU is 72.

**Viscosity:** Viscosity of egg albumin is measured by using Viscometer.

Visual scoring of egg white is scored against standard charts like Van wagnen chart. This chart facilitates a scoring from 1-5. One refers to highest quality and 5 refers to lowest quality.

**Albumin Area Index**

It is the ratio of weight the albumin and width of the albumin.

**White index**

Measurement of height of thickest portion of white divided by diameter of an egg.

Firmness of egg white is correlated with albumin quality Length f storage and environmental conditions. Factors such as incorrect temperature, $R^H$, increase in loss of $CO_2$ from the egg which is governed by length of storage. On storage the integrity
of albumin structure is lost and as a result albumin spreads thinly when broken on a cooking surface.

**Yolk quality**

The important yolk characteristics are colour, spherical shape and strength of vitelline membrane.

a) **Colour**: Commonly measured by comparing against standard coloured charts like Roche Colour chart which is most commonly used by USDA.

b) **Spherical nature**: It is assessed by yolk index with or without separation from albumin

Yolk index = Ht of yolk / width of yolk

c) **Strength of Vitelline membrane**: It refers to the ability of vitelline membrane to withstand rupture during egg breaking operation. This is measured by capillary tube.

**Terms descriptive of the egg quality**

**Shell:**

1. **Clean**:
   - Free from foreign material, free from stains / discoloration
   - Considered clean if it has specks, stains not enough to detect.
   - Eggs that show traces of processing oil on the shell are clean

2. **Dirty**:
   - Unbroken, dirty with foreign material adhering to its surface
• Prominent stains (1/32 of the surface if localized and 1/16 of the shell surface) if scattered.

3. Practically Normal (AA/A)
   • Usual shape, sound and free from thin spots.
   • Ridges and rough area (not affecting shape and strength)
   • Free from spots

4. Abnormal
   • Unusual/irregular in shape
   • Faulty in soundness/strength
   • Pronounced ridges and thin spots

Air cell:

1. Depth of Aircell: The depth of air cell is the distance from its top to its bottom when the egg is held with the air cell upwards

2. Free Aircell: Air cell that moves freely towards the upper most point in the egg as egg is rotated slowly.

3. Bubbly Aircell: A ruptured air cell resulting in one or more small separate air bubbles usually floating beneath the main aircell.

Terms descriptive of the egg white:

1. Clear: White free from discoloration or any foreign bodies floating in it.

2. Firm (AA): Thick and viscous white with yolk outline being slightly defined as it is twirled. Haugh’s (72)Unit when measured at a temperature of an egg between 7.2-10.8°C.
3. **Reasonably firm (A):** Less thick and viscous but with a well defined yolk outline when twirled. Haugh’s unit ranges from 60-72 at a temperature between 7.2-10.8°C.

4. **Weak & Watery (B):** Weak and watery thin white with the weak yolk outline and comes in contact with the shell.

5. **Blood spots or meat spots (B):** Blood spot should not be more than 1/8 th inch. More larger or shows diffusion of blood into white usually classified as loss.

6. **Blood white:** Egg with diffused blood in white and considered as loss.

**Terms descriptive of yolk:**

1. **Outline slightly defined (AA):** Indistinct outline and appears to blend on twirling.

2. **Outline fairly well defined(A):** Distinct outline and do not blend easily

3. **Enlarged and flattened:** Yolk appears flattened and flat.

4. **Practically free from defects (AA/A quality):** No germ development and may show slight defects on surface.

5. **Blood due to germ development:** Seen in fertile egg and also appears as blood rings. Usually they are termed as inedible eggs.

**General Terms:**

**Loss:** Inedible, smashed, broken, leaking and often contaminated eggs are kept under this category.

**Inedible:** Eggs with Black rots, Yellow rots, Blood rings.

**Leaker:** Exudation of egg contents through the broken egg shell.
Lecture 25

Antemortem and Postmortem Examination of Poultry

It is essential to conduct proper antemortem inspection of live poultry in order to ensure that they are not affected with any disease or condition which may render their meat unwholesome. Postmortem inspection becomes essential to detect dressed poultry which might have been diseased, thereby rendering them unfit for human consumption.

Antemortem Inspection of Poultry

Live poultry should be subjected to antemortem inspection in the holding pens by a qualified veterinarian on the day of slaughter. Enough space and water should be provided in the holding pens. Adequate light is an essential requirement during inspection. The birds are carefully examined and those in good health and alert condition are declared fit for slaughter. In general, birds with abnormal conditions are categorized as follows:

i. Unfit for slaughter - Birds with morbid condition due to clinical evidence of a contagious disease, heat stroke or traumatic injury which cannot be treated are declared unfit for slaughter.

ii. Suspects - Birds affected with disease conditions not advanced enough to declare unfit are passed for slaughter as suspect. Such birds are slaughtered separately and both ante and postmortem findings are considered while taking a final decision.

Antemortem significance of poultry diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Unfit for slaughter</th>
<th>Passed for slaughter as suspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ornithosis</td>
<td>All affected birds</td>
<td>--</td>
</tr>
<tr>
<td>No.</td>
<td>Disease Name</td>
<td>Stage Description</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>2.</td>
<td>Ranikhet disease</td>
<td>Birds in acute stage - do -</td>
</tr>
<tr>
<td>3.</td>
<td>Chronic respiratory disease</td>
<td>Birds in advanced stage</td>
</tr>
<tr>
<td>4.</td>
<td>Infectious bronchitis</td>
<td>Birds in advanced stage with cyanosis</td>
</tr>
<tr>
<td>5.</td>
<td>Infectious laryngotracheitis</td>
<td>Birds in advanced stage</td>
</tr>
<tr>
<td>6.</td>
<td>Infectious coryza</td>
<td>Acute stage of disease with debilitation</td>
</tr>
<tr>
<td>7.</td>
<td>Neural lymphomatosis</td>
<td>All affected birds</td>
</tr>
<tr>
<td>8.</td>
<td>Coccidiosis</td>
<td>Anaemic birds</td>
</tr>
<tr>
<td>9.</td>
<td>Infectious enterohepatitis (Black head disease of turkey)</td>
<td>Birds showing symptoms</td>
</tr>
<tr>
<td>10.</td>
<td>Fowl dtyphoid</td>
<td>All affected birds</td>
</tr>
<tr>
<td>11.</td>
<td>Fowl pox</td>
<td>Birds in debilitated and febrile condition</td>
</tr>
<tr>
<td>12.</td>
<td>Fowl cholera</td>
<td>Birds with septicaemic form</td>
</tr>
<tr>
<td>13.</td>
<td>Botulism (limber neck)</td>
<td>All affected birds</td>
</tr>
</tbody>
</table>

**Postmortem Inspection**

The body cavity of every dressed bird is opened through the transverse incision and visceral organs are drawn out. Now, the carcass is inspected externally for signs of disease, bone abnormalities, wounds,
muscular atrophy, tumours etc. followed by body cavity. Liver is examined for consistency, texture, lesions and colour changes. Spleen is also palpated for texture and abnormalities. A cut is given on the hock to see synovial fluid for sinusitis.

Postmortem significance of poultry diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Unfit for food/condemned</th>
<th>Partially condemned/passed for food</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Avian leukemia complex</td>
<td>All affected carcasses</td>
<td>--</td>
</tr>
<tr>
<td>2. Erysipelas</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>3. Tupberculosis</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>4. Ranikhet disease</td>
<td>Carcasses with systemic involvement</td>
<td>If lesions are localized, only affected parts are condemned. Rest are passed for food</td>
</tr>
<tr>
<td>5. Infectious laryngotracheitis</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>6. Infectious coryza</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>7. Chronic respiratory disease</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>8. Fowl typhoid</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>9. Pullorum disease</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>10. Listeriosis</td>
<td>Carcasses with acute septicaemia</td>
<td>-do-</td>
</tr>
<tr>
<td>11. Salmonellosis</td>
<td>Carcasses with active septicaemic lesions</td>
<td>In chronic cases affected parts are condemned. Rest</td>
</tr>
</tbody>
</table>
12. Fowl pox  | Carcasses with progressive lesions and systemic changes | are passed for food

13. Fungal diseases  | --  | Recovered birds may be passed for food after removal of scabs

14. Fowl cholera  | All carcasses are condemned  | Only affected parts are condemned

All the condemned carcasses and parts thereof should be destroyed by chemical denaturing with crude carbolic acid or any phenolic disinfectant or completely destroyed by incineration.

**Lecture 26**

**Handling, Transport and Dressing of Poultry**

Several poultry dressing plants have come up in the country and many more are in the offing where large number of birds are to be handled and processed every day. These birds should be handled properly before slaughter. It reduces the changes of bruises, cuts and tears on the dressed birds. In fact, pre-slaughter care contributes a good deal to the wholesomeness of dressed chickens

**Pre-slaughter Care and Handling**

In the intensive housing system, a great care has to be exercised in catching and crating the birds. All feeders, waterers and other accessory equipment should be moved to one corner of the house before catching and assembling is undertaken. The broilers are generally caught at night under very dim light. Culled and spent hens
are caught in the cooler hours of the day, preferably in the afternoon. The birds are caught manually by the shank in a humane way.

**Transport**

Creates, coops or cages are used to transport birds in vans from the larm to poultry dressing plant. Special attention is paid to prevent overcrowding and suffocation. The loading of birds is carried out in dim light either early morning or late evening to avoid excitement and transported in the cool period without much exposure to sun to prevent excessive shrinkage. Bulk weighing of birds in creates is the general practice at the large sized dressing plants. A shrinkage of 3-4 per cent takes place during pre-slaughter handling and transport. Birds should be kept off feed for 12 hrs before slaughter but enough shrinkage water should be made available. This practice not only helps in early evisceration but risk of contamination of meat by the intestinal contents is also minimized.

**Dressing of Poultry**

**Slaughtering**

Slaughtering involves stunning and bleeding:

i. **Stunning**: Stunning prevents struggling and relaxes the muscles holding the feathers. However, it is generally not practiced in case for chicken. A low voltage electric stunning of 50 volts AC for 1 m has been found to be satisfactory.

ii. **Bleeding**: This process is carried out in an inverted cone shaped equipment to rest the body of the bird and keep the head out and down. There are several techniques of slaughtering poultry in order to seek proper bleeding. The technique most commonly used these days is “modified Kosher Method” in which jugular vein is severed just below the jowl taking care not to cut trachea
and oesophagus. Another technique for slaughtering the birds is decapitation which is not so common. Still another method which involves piercing knife through the brain has become obsolete. In general, a bleeding retards the keeping quality of dressed chicken.

Scalding

Scalding refers to immersion of birds in hot water for loosening the feathers. It should be done when all reflexes have ceased. The birds are transferred into the scalding tank. Broiler and young birds are scalded at 55°C for 1.5 minutes whereas culled birds and spent hens are scalded at 60°C for 2 minutes.

Defeathering

The process is carried out in a feather plucker consisting of two drums with rubber fingers which revolve in opposite directions pulling of feathers from the carcass. Any remaining feathers are picked up manually.

Singeing

The carcasses are now singed over a blue flame for 5 to 10 seconds to remove hair like appendages called filo plumes.

Washing

The singed carcasses are washed with spray water to remove dirt and reduce the microbial load.

Removal of Feet and Oil Gland
The next step involves cutting of feet from tarsometatarsal joint with a sharp knife and removal of oil gland.

**Evisceration**

The carcasses are hung by hocks to the shackles for evisceration. By a slit opening from the tip of breast bone, abdominal cavity is opened by means of a transverse cut. A circular cut is made around the vent. The viscera is drawn outside but allowed to remain attached to the carcass for postmortem inspection. Meanwhile, a slit is made in the skin of the neck for easy removal of crop and neck. After postmortem inspection, inedible offals, including trachea, lungs, oesophagus, crop, intestines, gall bladder and kidneys are removed whereas giblet consisting of heart, liver and gizzard should be collected, cleaned and packed in a wrapper.

**Chilling and Draining**

After washing, the dressed birds are chilled in a chilling tank containing slush ice or crushed ice for 30-45 minutes in order to cool the carcasses to an internal temperature of about 4°C. The chilled birds are kept on the draining rack for 10 minutes to remove the excess water.

**Washing**

Dressed birds are thoroughly washed again with clean spray water preferably maintained at 15±5°C. Special care should be taken to wash the interior and sides.

**Grading**

Dressed chickens are graded on the basis of conformation, degree of fleshing, bruises, cuts and other quality attributes.
Packaging

Before packaging, dressed chickens having gizzard without mucosal layer, heart without pericardium and liver without gall bladder are placed in the abdominal cavity of the carcass and packed in polyethylene bags (200 gauge). Shrink packaging may be adopted if dressed chickens are to be stored in a frozen condition.

Storage

Dressed chicken can be stored in a refrigerator at 2°C for 7 days and deep freezer at -18 to -20°C for a period of 4-6 months.

Lecture 27
Indian standards for dressed chicken

<table>
<thead>
<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>· Conformation</strong></td>
<td>Free of deformities that detract form its appearance or that affect the normal distribution of flesh. Slight deformities such as slightly curved or dented breast bones and slightly curved backs may be present. The breast is moderately long and deep, and has sufficient flesh to give it a rounded appearance with the flesh carrying well upto the crest of the breast bone along with its entire length. The fat is well distributed so</td>
<td></td>
</tr>
<tr>
<td><strong>· Fleshing</strong></td>
<td></td>
<td>Slight abnormalities such as dented, curved or crooked back, or mis-shapen legs or wings which do not materially affect the distribution of flesh or the appearance of the carcass or part. The breast has a substantial covering of flesh with the flesh carrying upto the crest of the breast bone sufficiently to prevent a thin appearance.</td>
</tr>
<tr>
<td>· Fat covering</td>
<td>that there is a noticeable amount of fat in the skin in the areas between the heavy feather tracts. Free of pin feathers, diminutive feathers and hair which are visible to the inspector or grader. Free of cuts and tears on the breast and legs. Free from discolouration due to bruising, free of clots; flesh bruises and discolouration of the skin such as “blue back” are not permitted on the breast or legs. May have an occasional pock marks due to drying of the inner layer of skin (derma), provided that none exceeded the area of a circle 0.5 cm in diameter on chickens.</td>
<td>sufficient to prevent a distinct appearance of the flesh through the skin, especially on the breast and legs. Not more than an occasional protruding pin feather or diminutive feathers shall be in evidence under a careful examination. The carcass may have very few cuts and tears. Discolouration due to bruising; free of clots; Moderate areas of discolouration due to bruises in the skin or flesh. May have a few pock marks due to drying of the inner layer of skin (derma), provided that no single area exceeds that of a circle 1.5 cm in diameter.</td>
</tr>
<tr>
<td>· Defeathering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Cuts and tears</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Discolouration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Freezer burn</td>
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<td></td>
</tr>
</tbody>
</table>

Cutting:

**Reqs:** Large cutting board, strong knives – POULTRY SHEARS with blood / juice groove

→ Giblets are removed from the chicken & set aside
→ Then the chicken carcass is rinsed & oriented such that the breast is facing up
Inedible parts:

Following parts of the bird are considered inedible:

→ They should be collected & discarded

* Oil sac
* Wind pipe
* Oesophagus
* Crop
* Entrails
* Vent
* Lungs
* Ovaries & Testis
* Head
* Gall bladder
* Gizzard lining
* Intestinal collections
* Membranes surrounding heart & arteries.
* Shanks

Steps

1. Removal of visceral parts (Inedible)
2. Separation of the Giblet
3. Rinsing the carcass & freezing for perfect cuts
4. Orienting the breast facing up
5. Removal of legs (Drumstick + thigh)
6. Removal of wings (wingette + Drummette)
7. Splitting up the Breast
8. Separating backbone
9. Depending upon the requirement whether

Eight piece: 2 drumsticks
2 thighs
2 wings
2 breast halves

Ten piece:
2 drumsticks
2 thighs
2 wings
2 breast quarters

Twelve piece:
2 drumsticks
2 thighs
2 wingettes
2 drummettes
4 breast quarters

Lecture 28
Microbial Spoilage of Eggs

It was widely believed in nineteenth century that contents of fresh eggs were always sterile. Studies conducted afterwards revealed that microorganisms can gain entry into the egg congenitally. However, most of the contaminants of eggs are of extragenital origin and come in contact with egg shell at oviposition from the dust, soil and faecal matter adhered to the nesting material. Since the cuticle and pores of the egg shell are moist at this stage, the possibility of invasion of the shell by some contaminants through a few pores cannot be ruled out. The microorganisms on the shell surface usually belong to a mixed group, but those causing spoilage of egg (generally called rot ) are gram-negative in nature which have very simple nutritional requirements.

The microorganisms have to pass through a series of in-built physical-chemical barriers in the egg—the shell, the shell membranes, the albumen before reaching the yolk where they could easily multiply
causing rot. The mechanism of microbial spoilage can, thus, be divided into three serial steps:
1. Penetration of microorganisms through the egg shell and shell membranes.
2. Colonisation of microorganisms on the shell membrane.
3. Overpowering of the antibacterial factors present in the albumen.

Penetration of Microorganisms through the Egg Shell and Shell Membranes

Egg shell acquires a diverse microflora at the time of oviposition. Under normal conditions of handling and storage, shell gets dried soon and most of these microorganisms fail to survive. An egg shell contains more than 17000 pores. However, only ten to twelve pores allow the microorganisms to pass through. The microorganisms either succeed in when the egg contents contract on cooling or gain entry due to capillary action through pore canals when the shell surface is moist. The role of microorganisms remain passive in both situations. It is due to capillary action that incidence of rotting are comparatively high in washed eggs which have been subjected to dry abrasion. The cuticular plugs on the pore canals are opened during the process of abrasion of eggs.

After gaining entry through the shell pores, microorganisms come across shell membranes. These membranes act as bacterial filters and offer maximum resistance to the offending organisms which have succeeded in penetrating the shell. Some researchers believe that membrane lysozyme also has a limited role.

Mold may also cause rot in eggs under humid storage conditions. In such case shell is generally covered with mycelium (whisker) and hyphae penetrate the pores to reach shell membranes.

Colonisation of Microorganisms on the Shell Membrane
Once the microorganisms have an access to shell membrane, they are able to multiply and form colonies. However, the colonization is not instant. In the early stages, there is preferential selection of gram-negative organisms having low iron requirement from the initial population dominated by gram positive organisms which have high iron requirement. Thus initially there is a decline in the microbial numbers. In the later stages, multiplication of organisms takes place at a faster rate because by this time albumen becomes heavily infected. The pH of egg contents move towards neutrality and yolk comes in contact with inner shell membrane.

Overpowering the Antibacterial Factors Present in the Albumen

Egg white or albumen provides an unfavourable medium for microbial growth because of the defensive role played by many of its component proteins which have been listed under composition of albumen. The role played by lysozyme and conalbumen is particularly important. Lysozyme of albumen cause lysis of mucopeptide rich cell wall of gram positive organisms. This enzyme does not affect the complex cell wall of gram negative bacteria having coating of lipoprotein and lipopolysaccharide over mucopeptide.

Conalbumen which is uniformly distributed and constitutes more than 10% of albumen chelates iron and make it unavailable to the bacteria. Conalbumen is the principal antimicrobial factor present in the egg and its inhibitory action is more on gram positive as compared to gram negative organisms. This inhibition definitely delays the spoilage of eggs to some extent. However, as yolk contents migrate into albumen or gen mixed, multiplication of organism is very fast which results in the rotting of eggs. Some general type of rots may be summarized as follows:

<table>
<thead>
<tr>
<th>Type of rot</th>
<th>Changes in egg</th>
<th>Organisms</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Green rot</th>
<th>Albumen becomes green</th>
<th>Pseudomonas Fluorescens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black rot (Type 1)</td>
<td>Blackening of yolk with “faecal odour”</td>
<td>Proteus sp.</td>
</tr>
<tr>
<td>Black rot (Type 2)</td>
<td>Green coloured albumen but yolk is black with “cabbage odour”</td>
<td>Pseudomonas sp.</td>
</tr>
<tr>
<td>Red rot</td>
<td>Albumen stained red throughout, Yolk surrounded by custard like material</td>
<td>Serratia sp.</td>
</tr>
<tr>
<td>Fungal rot</td>
<td>Pink spots on egg contents</td>
<td>Sporotrichium</td>
</tr>
<tr>
<td></td>
<td>Black spots on contents</td>
<td>Cladosporium</td>
</tr>
<tr>
<td></td>
<td>Yellow or green spots on contents</td>
<td>Penicillium</td>
</tr>
</tbody>
</table>

Besides rots, eggs may develop various types of off odour due to bacteria without any apparent signs of spoilage. These off odours may be musty or earthy (achromobacter sp), hay like (Enterobacter sp), fishy (E.coli) or that of cabbage water (Pseudomonas sp.)

**Lecture 29**

**Preservation and Maintenance of Eggs**

A freshly laid egg can be assumed to have a highest quality. Since egg is full of essential nutrients, deteriorative changes soon start taking place which may pose a danger to the excellent sensory attributes of this nourishing and satisfying food item. Cleanliness and soundness of shell is the first step to assure the quality of egg to the consumers. The shell quality deficiencies mostly relate to the production practices adopted at the farm. Proper handling of eggs can delay the decline in the quality. Following precautions should be taken during handling of eggs:

i. Eggs should be collected 3 to 4 times per day. This will result in less dirty eggs and fewer breakages.
After collection, eggs should be shifted to holding room maintained at a temperature of about 15\(^\circ\)C and 70 to 80\% RH atleast for 12 hours.

Eggs should be properly packed in filler flats with broad end up. Bulk packing should be done in fibre board cartons.

Eggs should be rapidly moved through the marketing channel so as to reduce the period between production and consumption.

All preservation methods for shell eggs have been designed to retard one or more of the following physic-chemical alterations which lower the quality of egg as it ages:

i. As the surface of egg dries, the keratin cuticle shrinks and size of shell pores increases rendering it easier for gases and microorganisms to pass in and out of the shell.

ii. As the warm egg contents also contract, resulting in the formation of air cell.

iii. The breakdown of carbonic acid causing loss of carbon dioxide from the albumen is rapid during the first few hours after an egg is laid. The alkaline pH acts on the mucin fibres to disturb the thick gel of albumen making it thin or watery.

iv. As the egg ages, water migrates from the albumen to the yolk which may overstretched, weaken or even rupture the vitelline membrane.

Following preservation methods are employed to maintain the quality of shell eggs:

**Egg Cleaning**

Earlier, it was a general practice to dry-clean dirty egg shells by abrasive mounting on a mechanical wheel. This practice has now become obsolete because it weakens the shell. These days
washing in warm water containing a detergent sanitizer is an effective way of cleaning the eggs with dirty shells. A temperature difference of 10-15°C between eggs and wash water is ideal, otherwise there may be problem of crack shells. Besides, eggs should not be immersed in warm water for more than 3-4 minutes. After washing, the eggs should be dried promptly. Wash water should be changed after washing every five to six baskets of eggs. It should be emphasized that only dirty eggs are subjected to washing. It not only reduces the microbial load on the egg shell surface but also improves the appearance and consumer appeal.

**Oil Treatment**

Oil coating spray of eggs has become very popular for short term storage of this commodity. Coating oil forms a thin film on the surface of the shell sealing the pores. It should be done as early as possible, preferably within first few hours after laying of eggs because loss of CO₂ is more during this period and evaporation of moisture is also more during the first few days. Egg coating is done by dipping the eggs in the groundnut oil whereas for oil spray, the eggs are arranged in the filler flats with their broad end up. If the eggs need washing, oil coating should be done after washing. It is important to drain out excess oil before packaging. The temperature of oil should be in range of 15 to 30°C for ideal results. Oil treatment safeguards the quality of albumen for atleast 7 days because it effectively seals the shell pores.

**Cold Storage**

This method of preservation is suitable for long term storage of clean eggs in the main laying season and abundant availability. The temperature of cold store is maintained at 0°C (32°F) and relative
humidity between 80 to 85 per cent. An anteroom with intermediate temperature is generally provided to check condensation of water vapour on the eggs during removal. Use of new egg packing trays are advised for cold storage. Like all other animal products, eggs also pick up strong odour, so the same cold store cannot be used for storing onion, garlic or any other commodity with strong odour. The quality of shell eggs can be maintained for about 6 months in a cold storage. Oil coating of eggs prior to cold storage can further enhance their keeping quality. Such eggs could keep well at 14°C and 90% RH for a period of 8 months.

**Thermostabilization**

This preservation method involves stabilization of albumen quality by holding the eggs in an oil bath maintained at 55°C for 15 minutes or 58°C for 10 minutes. This process brings about coagulation of thin albumen just below the shell membranes, thereby blocking the passage of air and moisture. In addition, oil coating of shell pores also takes place. Thus keeping quality of eggs is maintained for sometimes and thinning of egg white is retarded. Alternatively, eggs are immersed in hot water at 71°C for 2 to 3 seconds. In this flash heat treatment, bacteria present on the surface of the shell are destroyed and a thin film of albumen just below the shell membrane is coagulated sealing the egg shell from inside.

**Immersion in Liquids**

Under rural conditions, lime-water or water–glass immersion are most useful. In lime-water treatment, a litre of boiling water is added to 1 kg of quick lime and allowed to cool. Now 5 litres of water and 250g of table salt are added to it. The solution is strained through a fine cloth when the mixture settles down. Eggs are dipped in the clear fluid overnight and then dried at room temperature. In this process, an
additional thin film of calcium carbonate is deposited on the egg shell and seals the pores. Such eggs can be stored for a month at ambient temperature. In water-glass treatment, one part of sodium silicate is mixed in 10 parts of water and eggs are dipped overnight. In this process, a thin precipitate of silica is deposited on the egg shell and partially seals the pores.

It is clear from the above discussion that eggs should be collected frequently, held initially at low temperature and then a suitable preservation method be employed to maintain its keeping quality for anticipated consumer acceptance.

Lecture 30

PREPARATION OF EGG POWDERS

↓

Fresh Egg collection

↓

Cold storage 4-5°C

↓

Candling & Inspection at 15°C

↓

Cleaning with disinfectant/sanitizing (2% sodium hypochlorite) solution
Water temp at 43°C for 3 in

↓

Breaking & collection

↓

Churning & filtration
Homogenization for 5 min
↓
Pasteurization (62.5 for 5 min)
(To destroy salmonella & other M.o)
↓
Desugaring is done by adding 0.5% yeast to prevent Maillard reaction
↓
Fermenting at 30°C for 1 1/2
↓
Repasteurization (62.5 for 3-5 min)
↓
Cooling & churning
↓
Drying (3 ways)
Changes in Egg powders on storage:

1. Discoloration of egg powder which may be caused due to
a. Reaction b/n phospholipids & aldehydes  
b. Due to oxidation of USFA  
c. Destruction of naturally occurring carotenoids  
d. Interaction b/n amines & aldehydes and  
e. Groups of lipids also contribute to discoloration  
   Called Lipid browning  
2. Loss of Nutritive value  
3. Off flavor are produced  
4. Loss of solubility  
5. Non-enzymatic changes.

Lecture 31
Preservation of Poultry Meat

The basic purpose of poultry meat preservation is to retard or prevent microbial spoilage and other physic-chemical changes which cause deterioration in quality. Thus, proper preservation safeguards the sensory quality and nutritive value of poultry meat. Various methods employed for preservation of poultry meat are as follows.

Chilling

Chilling extends the shelf-life of dressed birds by retarding the microbial growth. The efficiency of chilling depends on temperature, air circulation and moisture control. It is advisable to pre chill the carcasses at 15\(^{\circ}\)C to remove body heat. Dressed birds are usually chilled by immersion in ice water or chill packed in crushed ice for delivery to stores. Poultry meat can be safely stored at a temperature of 1 to 4\(^{\circ}\)C and relative humidity of 80-85 per cent for a period of 5 to 7 days. The effectiveness of refrigerated storage can be enhanced to several weeks by applying vacuum packaging.

Freezing
Chilled poultry carcasses can be packaged and stored frozen for quite sometime. Freezing of poultry meat can be accomplished either using refrigerated plates or in air. Slow still air freezing generally accomplished in home freezer, takes 4 to 10 hours to freeze depending on the size of the product. Quick air blast freezing is widely used for long term storage in commercial enterprises. Here the prepackaged carcasses are frozen at an air velocity of 1400 rpm to-30 to—40°C in 1-2 hrs. Quick freezing has distinct advantage over slow freezing because intracellular ice crystals formed in this case do not affect the appearance and other sensory attributes. In slow freezing there is formation of extracellular ice crystals which distort the musculature and increase drip loss upon thawing. The drip contains some water soluble proteins and vitamins. Quick frozen broilers could be conveniently stored for an year at-20°C, whereas cut up chicken and cooked chicken products could be stored for about four months at the same temperature.

**Curing**

Curing refers to the application of salt, sodium nitrite and cane sugar to meat with or without ascorbates, phosphates, glutamates etc. since chicken meat has a mild flavor, the amount of salt and other flavouring ingredients is kept comparatively low. Salt acts as a preservative besides influencing flavor and texture of meat. Curing salt has a high osmotic pressure which inhibits the availability of water to the microorganisms. Initially, there is outward flow of water and soluble proteins during curing. However, when salt diffuses inwards, it forms a complex with protein and achieves a higher osmotic pressure that the curing solution itself, causing some reverse flow of water. The final salt concentration attained is nearly 5 per cen. Sodium nitrite provides the much desired cured pink colour. Cane-sugar contributes to the flavor and counteracts the toughening caused by salt alone.
Chicken can be subjected to dry or wet curing. In dry curing, the carcass is thoroughly rubbed with curing mixture and then ages. In wet or pickle curing either the curing brine is injected in small quantities at several places in the carcass (stitch pumping) or the carcasses are immersed in a curing brine containing 15 per cent common salt, 7.5 per cent cane sugar, 150 ppm sodium nitrite plus nitrate and 0.05 per cent monosodium glutamate for 48 to 72 hours at 4°C and lighting should be minimum to retard the chances of rancidity development. After curing excess salt on the surface is removed by proper washing. Cured chicken has a shelf life of 4 days at 14 days at 4°C.

**Smoking**

Smoking is generally practiced along with curing. Smoke obtained by the slow combustion of hardwood saw dust contains lower alcohols, aldehydes, organic acids, carbonyl compounds, phenols etc. preserve meat by its bacteriostatic, bactericidal and antioxidant properties besides providing a protective film on the surface. Smoke also imparts characteristic flavor and stabilizes the cured colour. The temperature of smoke chamber is maintained at 50°C to produce ready-to-cook chicken whereas it is kept at 80°C for 4 hours at 30-35 per cent relative humidity to produce ready-to-eat chicken. In order to eliminate the carcinogenic components due to combustion of lignin especially benzopyrene, liquid smoke is produced these days through condensation. Liquid smoke can be directly sprayed over the cured chicken or added to meat emulsion to impart distinct flavor. Cured and smoked chicken has a shelf life of month under refrigeration (4°C) and 2 to 4,months in a freeze (-18°C).

**Dehydration**

Cooked chicken meat is sometimes dehydrated for specific supplies. Chicken chunks may be dried in a rotary air drier at controlled temperature to a moisture content of 4 per cent. Finely ground cooked
meat may be spray dried to yield chicken soup mix. However, the best results are obtained in freeze dehydration. In this process, chicken meat chunks are quick-frozen and vacuum dried at 1.55 mm Hg at low temperature for 12-24 hours. The final product containing hardly 2% moisture is packed in tins under nitrogen and has a shelf life of one year. The product retains its natural flavor and nutrients and can be reconstituted within minutes.

Canning

This process refers to extreme thermal processing of chicken meat in hermetically sealed cans. It involves precooking of chunks and gravy, filling in lacquered cans, exhausting, sealing under vacuum and cooking in retorts at 5 psi pressure for 35 minutes followed by rapid cooling. The canned chicken product has a shelf life of two years at ambient temperature.

Radiation Preservation

Poultry meat can also be preserved by using radiant energy. Radiation brings about lethal changes in the nuclear material of microorganisms and inactivate the enzyme system without raising the temperature. Cobalt-60 gamma radiation is generally utilized because of its adequate penetrating power. This method, usually called as cold sterilisation, is used as a supplement to other preservation methods such as refrigeration and freezing. For poultry meat, radiation sterilisation dose of 4.5 Mrad alone and pasteurisation dose of 0.5 Mrad in combination with other preservation methods have been successfully used.

High radiation doses may initiate several undesirable chanbes in meat such as discolouration, off flavor, loss of water holding capacity, rancidity development and loss of nutrients like thiamine, vitamin B_{12} and vitamin C. off flavor development may occur due to the productin of ammonia, H_{2}S and mercaptans from free amino acids. These
undesirable effects can be prevented by undertaking irradiation when the meat is in frozen condition and packaged under vacuum or inert gas atmosphere. Radiation preservation has the advantage of speedy operation. However, high cost restricts its use as a commercial practice.

Lecture 32
Processing of Some Convenience Poultry Products

Processing of Some Convenience Poultry in India. It is consumed far and wide in many forms of traditional and processed products. Convenience products do not require any preparation prior to consumption. The common traditional products are tandoori chicken, chicken sheek kabab, chicken shami kabab, chicken curry, chicken kofta, chicken tikka, chicken samosa etc. Other poultry products such as barbecue, chicken patties, chicken sausages etc. also have a good market in urban areas. The methods of preparation of some convenience poultry products have been described in this chapter.

Tandoori Chicken
Broilers at 6 weeks of age are preferred for tandoori chicken because of their tender meat and ability to sustain roasting. Dressed chickens with intact skin are rubbed with 4 per cent salt along with spices and seasoning and kept for 5 minutes. After draining, the carcasses are thoroughly marinated with sauce on the surface and in the interior. A marination time of 1-2 hours is allowed. The formulation of sauce depends on the consumers preference for taste and other sensory attributes. In general, dry and ground spices along with condiments are blended with vinegar (10%) and curd (10%).

The marinated chickens are roasted in a tandoori oven under smokeless, moderate and uniform heat for 20-30 minutes depending on the temperature of oven and size of the broilers. Care must be taken to keep the chickens away from the direct fire and avoid burning or blistering of the skin or extremities. During roasting, chickens are
occasionally removed from the oven and pasted with sauce or fat with the help of a brush. The doneness of tandoori chicken is tested by twisting one of the drumsticks when it dissociates easily from the joint. By this time, it also acquires slightly smoked flavour.

**Chicken Barbecue**

Broilers with about 750 g dressed weight are preferred for barbecuing. The dressed chickens are longitudinally halved for this purpose after removing the neck portion. The chicken halves are marinated with sauce containing spices, salt and seasonings according to the consumers' taste and preference and allowed to stay for an hour. The sides are then placed on the oven for barbecuing during which these are periodically turned and basted with sauce with the help of a brush to avoid drying. The cooking should proceed slowly at moderate temperature so that tender, golden brown and slightly smoked flavoured barbecue is obtained.

**Chicken Seekh and Shami Kababs**

Culled or spent chicken meat can be utilized for preparing sheek kababs. Lean meat is minced through an 8 mm plate of a meat grinder. Wheat flour (3 per cent) and whole egg liquid (5 per cent) should be incorporated as binders to provide sufficient strength to the mince. Fat, salt, dry spices and seasonings are added as per consumers' preference. The mince is pasted around specially made iron bars (seekh) and cooked over moderate and uniform heat, turning the bars and basting with vegetable oil from time to time till doneness with brown colour is achieved.

In the preparation of shami kababs, meat chunks and water soaked black gram dal are simmered in water for nearly 5 minutes before grinding. It is seasoned with salt, dry spices and condiment paste. Some people also add liquid egg to the mince. It is made into round
cakes which are shallow fried with edible oil on a girdle till both the sides are brown.

**Chicken Kofta**

Meat from spent or culled chicken can be utilized for preparing kofta (meat balls). Lean meat is coarse ground through 8 mm plate of a meat grinder. Ten to fifteen per cent vegetable oil is added to it. Wheat flour (3 percent) in combination with whole egg liquid (5 per cent) are incorporated to provide sufficient binding strength. Seasonings, salt and spices can be mixed as per consumer preference. The dough is rolled into 15 g balls with hands. The balls are deep fat fried for 5 minutes. Cooked balls, packed in polyethylene pouches have a keeping quality of 8 to 10 days at 4°C.

**Poultry Pickle**

Dressed chicken is trimmed off excess fat and deboned. Now meat is cut into 2.5 cm cubes, applied with 2 per cent salt and pressure cooked for 8 to 0 minutes. Cooked meat is taken out and fried at medium heat in mustard oil to get brown colour. Oil is decanted from the fried cubes and green curry stuff is fried in the same oil to get golden brown colour. This is followed by addition of dry spices, remaining 2 per cent salt and fried meat continuing frying for another 3-4 minutes. After sine cooling, it is thoroughly mixed with 0 per cent vinegar. The product has a shelf life of days at ambient temperature without any appreciable loss of quality attributes.

**Chicken Samosa**

Lean chicken is minced through 5 mm plate of a meat grinder. Condiments are fried in vegetable oil to get a golden brown colour and dry spices along with salt are added towards the end. Minced lean and cooked mashed potatoes are mixed with the fried spices and heating is
continued for another 4 to 6 minutes. The fried stuff is ready for filling. Dough portions of about 30 g are rolled out and divided into two halves. Each half is moulded into a triangular pouch and the fried stuff (20-25g) is filled in. The pouch is closed and samosas are deep fried in vegetable oil at medium heat to obtain a crispy product.

**Chicken Sausage**

The tough meat from spent hens can be utilized for the preparation of chicken sausages. Deboned chicken meat is minced once through 9 mm and then through 4 mm plate. Lean meat, ice flakes (0 per cent), salt and sodium nitrite are run along with fat in a bowl chopper to prepare a fine emulsion. Other ingredients like spices, condiments etc. are added to the emulsion in the final run for a minute. Meat emulsion is filled into casings with the help of a sausage filler and suitable links are made. The sausages may be cooked in water at 80°C for 5 to 20 minutes or steam cooked. Smoking along with cooking stabilizes the colour and imparts a characteristic flavor to the sausages.

**Chicken Patties**

Raw deboned chicken meat and fat are minced twice through a meat grinder. Other ingredients like wheat flour or texturized soy protein (binding agent), salt, condiments, spices etc. are mixed to the ground meat in an electrically operated meat mixer. The blended mass is divided into 00g portions and moulded into patties. These are broiled in a hot air oven set at 200°C for 15 to 20 minutes to get a core temperature of about 72°C. Hot patties may be used to prepare burgers or chilled in a refrigerator for latter use.

**Chicken Tikka**

Deboned chicken is minced in a meat grinder. Forty per cent of the mince is pressure cooked for 2 minutes. Besides, peeled and shredded
potatoes are partially cooked in boiling water separately. Now, mince meat (60 raw: 40 cooked), shredded potatoes, rice powder, bread crumbs, salt, spices and condiments are thoroughly mixed in an electrically operated meat mixer. The blended mass is divided into 70 g portions and moulded into tikkas. These are shallow fat fried in a girdle to achieve an internal temperature of 70°C. The product has a unique texture and is consumed as a hot snack.

The list of convenience chicken products is on the increase. These ready-to-eat products have a bright scope in India. These have already become quite common at the fast food corners and restaurants in the urban areas. With the vast availability of spent hens, comminuted chicken products are likely to surpass other meat products in near future.