Veterinary Public Health

Health: is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO,1978).

Food Hygiene:
Food hygiene is a subject of wide scope. It aims to study methods for the production, preparation and presentation of foods that are safe and of good keeping quality. It covers not only the proper handling of many varieties of foodstuff and drink but also all the utensils and apparatus used in their preparation, service and consumption. It also covers the care and treatment of foods known to be contaminated with food poisoning bacteria which may have originated from the animal host supplying the food. Food should be nourishing and attractive. It must be visibly clean and it must also be free from noxious materials.

Objectives
At the end of the course, the students will able to:
explain the purpose of food hygiene
Identify the comparative anatomy of food animals
Explain the main features of slaughterhouses
Elaborate methods of inspection of Food.

Veterinary Public health = Meat Hygiene + Milk Hygiene

Meat Hygiene:

Purposes of meat hygiene
:The **primary** purpose of good meat hygiene practice is:
To prevent the transmission of animal diseases to man
To provide safe, wholesome meat products for human consumption
:The **secondary** purpose is an economic aspect
The reduction of loss of meat and its by-products
The prevention of animal disease transmission to other domestic animals
The **tertiary** purpose is due to the adulteration of carcass meat, which

:is not required by consumers.
To prevent the sale and consumption of carcass meat, which is not demanded by consumer.
To prevent the sale and consumption of meat that is inferior in value

The Food Animals:

Meat is the edible parts (muscle and offal) of the food animals which consume mainly grass and other arable crops, these animals are; cattle, sheep, goats, buffalo, camel and others such as horse, deer, pigs, reindeer, musk oxen, moose, caribou, yak, alpaca, llama, guanaco, vicuna, seal and polar bear.
In addition, poultry have become a major meat producing species, while rabbits, guinea pigs and other game animals and birds provide a substantial amount of protein. Fish and other sea foods have also been an important part of human diet. Only those fish with fins and scales are wholesome.

It is true that some people eat pig, rabbit and hare but it is recognized that they are subjected to parasitic infestation. The dangers of trichinosis and of Cysticercus cellulosae were recognized 1400 years before the birth of Christ.
In many parts of the world , slaughter of horses for human consumption is now well established in Denmark, Belgium, Holland, Germany , and north of Africa.
Buffalo meat is more tender and leaner than beef with lower level of cholesterol.
All the above animals, including fish, are converters, i,e they utilize vegetable material with varying efficiency to produce protein. Even micro-organisms can be classified as converters in that they use carbohydrates from plants to make protein from simple nitrogenous compounds. Especially when an animal eats something which is inedible for man or could not easily be made into food for man, it is considered valuable as a source of food, so when poultry and even other species are

used as scavengers to eat scraps, by-products, etc, they are very useful indeed.

The future for meat products will depend mainly on consumer demand and the prices at which they can profitably produced. Factors such as the cost of production, feed conversion efficiency, land use and availability, consumer taste, price to consumers, diet, attitudes of people to meat production methods, use of protein from non-animal sources, etc., will all play a part in determining future demands.

Procedures such as genetic engineering, embryo transfer, cross breeding and twinning will continue to be utilized in attempts to produce more productive livestock with improved milk and meat quality. Already foreign genes, including a human estrogen receptor gene, have been implanted into cattle to make progeny grow faster and leaner. Other genes used in this experiment were insulin- like growth factor and the bovine growth hormone gene, four calves were born at Marquez, Texas, USA. But if close attention is not paid to the vital importance of disease resistance, we may see the development of stock susceptible to existing conditions some of which may have serious public health implications.

Dietary factors:

Concern about the amount of fat, especially saturated fat, in the diet, has been given prominence in the USA and UK particularly. The incidence of ischemic heart disease (IHD) in USA has decreased due to the reduction of fat intake. In the UK a report on Diet and Cardiovascular Disease was produced by the Committee On Medical Aspects of Food Policy (COMA) in 1984. This recommended that saturated fat consumption should be reduced by 25% but some increase in polyunsaturated fat would be acceptable , in which case the total fat intake need only be reduced by 15%. Already steps are being taken to have legislation which will require total fat and saturated fatty acid content labeling on a wide variety of foodstuffs.
If people respond to the COMA recommendations, there will be major changes in food consumption which will inevitably have an impact on production methods in agriculture, especially in milk and livestock production, despite the fact that not all is known about the etiology of IHD , it is the commonest cause of death in most industrialized countries. In UK 30% of all deaths in men and 22% of all deaths in women are the result of IHD. Factors such as heredity, blood pressure, obesity, blood haemostasis, physical inactivity, water hardness, smoking and alcohol consumption are also involved in the causation of this serious condition.

Table 1 Average British diet – sources of fat

Food groups	% total fat
Milk and dairy products	18.9
Total meat	27
Total fish	1.1
Eggs	2.7
Cooking fat, butter, margarine..etc	36.6
Vegetables	2
Fruit	9
Cereals	9.6
Beverages	0.1
Other foods	1.1
Total , all foods	100

All the EEC countries have reduced the consumption of meat per head of population.

Table 2 Annual consumption of meat (kg/head)

	Beef	sheep/goat	pig	poultry	total
Belgium	24.3	1.5	45.5	16.3	101.3
Denmark	15.8	0.8	66.3	11.7	104
Germany	23.7	0.9	62	10.5	103.5
Greece	25.9	14.1	24.6	15.6	87.4
Spain	11.4	5.8	39	20.7	86
France	31.6	4.6	36.5	18.5	108.2
Ireland	22.6	6.8	32.7	20	90.6
Italy	26.9	1.6	29.1	18.5	84.9
Holland	19.7	0.6	43.7	15.8	85.6
Portugal	12.1	2.9	25.4	16.7	84.3
UK	23	6.7	25.2	18.4	77.9

Recently there have been attempts to increase the use of potentially cheaper non-meat proteins in human foods, i.e vegetable protein derived mainly from soya beans , cotton seeds, ground nuts, sun flower, and sesame. These vegetable protein products, usually based on soya, are meat analogue .

Food Animals:

Cattle breeds:

Holstein Friesian
Aberdeen angus
Charolais
Brown Swiss
Santa Gertrudis
Shorthorn
hereford
Brahman
Buffalo
Etc.

Growth promoters:

Many different factors are associated with growth and the muscle / bone ratio in animals, including nutrition, hereditary factors and certain hormones. Growth hormone (GH) is the most important regulator of growth before puberty is reached, and androgenic and estrogenic hormones are not active.

Androgens stimulate the growth of all body tissues. They are responsible for the characteristic development of the male with its well developed forequarter and neck and greater size. Estrogens also appear to exhibit anabolic effects, causing early maturation of muscles and bones.

The main purpose of using growth promoting compounds is to replace the metabolic growth action lost at castration. Much controversy surrounded the use of these compounds, a lot of it in response to the illegal use of diethylstilboestrol in veal calf production with the occurrence of carcinogenesis in human beings. Despite these enactments , designed to protect the consumer and promote consumer confidence in meat, hormones are still being used in some quarters, implants being injected into cattle sites other than the ear and even liquid hormone combined with antibiotic being used by unscrupulous owners.

Probiotics :

Are benign bacteria which are administered by mouth to animals (calves , lambs and piglets) at one or two critical stages in their development. The introduction of probiotic into the digestive tract is to ensure more efficient food conversion , earlier slaughter and a healthier animal. Unlike antibiotics which often kill useful intestinal microorganisms and create undesirable residues , probiotics are said to be natural products without any side effects.

Beta-agonists (B-adrenergic blocking agents):
These are drugs normally used in human medicine to block the effects of adrenaline (epinephrine) and nor adrenaline (nor epinephrine) in, e.g peripheral vascular disease, cardiac arrhythmias and hypertension. There have been reports of the alleged misuse of these compounds, e.g propanolol, chlorpromazine and acepromazine, in livestock farming to produce lean meat. While approved for therapeutic purposes they are not authorized as growth promoters.

Definitions:

- bull : uncastrated bovine
- heifer: female up to its first calf
- cow : female with one or more calves

Steer or bullock: castrated male at 6-12 weeks old.
Stag: castrated male late in life (more masculine conformation than the steer).

Sheep:

The ability of sheep to eat plants of little use to man and to exist in places which cannot easily be cultivated is very much in their favor. On the other hand, low reproductive rates, difficulties with husbandry (e.g fencing and labor) and the disposition towards carcasses of fairly high fat content are definite drawbacks. It has recently been shown that by housing ewes and subjecting them to artificial photoperiods and hormone treatment they can produce a lamb crop every eight months and an average of 4.5 lambs per ewe yearly.

Sheep breeds:
See classification of sheep in Animal Management textbook.

Goats:
consumer demand for meat with a low saturated fat content has seen an increase in the number of goats which are naturally lean. In France , they developed broiler goat units in which 3-7 –day-old kids are reared on high vitamin milk powder to alive weight of 10 kg at one month of age, when they are slaughtered. The average carcass dead weight is 6.3 kg.

Breeds of goats
See Animal Management textbook.

Poultry:

Concentrated efforts have been put into the breeding of poultry for both egg and meat production, not only to enhance productivity but also to control diseases which are a serious problem in the poultry industry. Instead of pure breeds, commercial poultry are now represented by hybrids often involving four – way crosses. Using modern strains of fast - growing birds , the majority are raised until they are 6 weeks of age when they are harvested preventive inoculations are required against many diseases such as Newcastle disease , infectious bronchitis, and medications such as coccidiostats, antibiotics, etc are carried out on a large scale. While many of the drugs used to protect against low-grade disease, they are seldom proof against heavy infections, the keeping of huge numbers of birds together further aggravating the situation. Very close supervision of the birds is essential and correct treatment/ management changes must be prompt. It is vital that detailed records be kept since it is usually from these that early signs of disease are detected, e.g reduced food intake, weight gain, egg production in layers.

The turkey industry underwent great technical development. A wide range of weights of turkey is produced, depending on the particular trade, and these may be as low as 2kg and as high as 9 kg or more (some large cocks can be as heavy as 18kg).

Other poultry forms such as ducks, geese, Guinea fowl , pigeon are also reared for meat production.

Rabbits:

Rabbits have high fertility rates (some breeds can produce 30 offspring per year), fast growth rates (1.8 - 2.25 kg at 8 weeks of age) and a food conversion efficiency of 2.5 :1. fat percentage is 3.8, killing-out percentages of 60-62. rabbit meat is low in fat 3.8% and high in protein 20.7% which compare with beef 18.9% fat and 18.3% protein, lamb 17.5% fat and 18.7% protein.

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Anatomy , Meat Composition and Quality

Anatomy:

The basic building blocks of all living matter are the cells. There are different types of cells which form the tissues of the body, each type is distinct in shape and function. Tissues in animal bodies are classified to four main types:

1. Epithelial tissues (external and internal surface)
2. Muscular tissues (voluntary, involuntary , cardiac)
3. Connective tissues (include the skeleton)
4. Nervous tissues

Bones:

The skeleton, consists of some 200 bones. The proportion of bone in the dressed carcass of beef varies between 12 and 28% (average 15%). There are two types of bone marrow: the red and the white. In the fetus and new born animal the marrow has an important blood forming function and is red in color . Later, in the adult, the bone marrow becomes white or yellowish and rich in fat.
Carcass bones are valuable means of identification of the different species of food animals , e.g. where substitution is suspected. Where the teeth of a bovine animal are unavailable for examination, the age can be estimated by examination of the carcass bones. This estimation is based on the degree of ossification of certain parts of the skeletal system, the most valuable for which are the cartilaginous extensions of spines of the first five dorsal vertebrae. Similarly, the red bone marrow of the vertebrae is gradually replaced by yellow bone marrow. In sheep the break at the knee joint is a valuable guide as to age.
In poultry, the bones of the skeleton are very light in weight and contain air sacs. The skeleton also differs from that of other animals. There is a pectoral girdle which consists of a clavicle or wishbone, scapula and coracoid and a fused pelvic girdle. Other differences are also noticed in wings and legs (four digits).

Digestive System:

1. Tongue:

Ox :
The filiform papillae are horny and directed backwards, they have a rasp-like roughness which aids in prehension of food. The posterior part of the dorsum is prominent and defined anteriorly by a transverse depression

which is frequently the seat of erosions due to actinobacillosis. On either side of the midline on the prominent dorsum are 10-14 circumvallate papillae; the epiglottis, if left on the tongue, is oval in shape. Black pigmentation of the skin of the tongue is frequently observed but is quite normal and of no pathological significance.

Sheep and goat:
The tongue is similar to that of cattle, but the center of the tip is slightly grooved and the papillae are not horny. The sheep tongue is narrower than that of calf, and the dorsal eminence is more marked , the surface is smoother and the tip more rounded. Black pigmentation of the surface of the tongue is common in black skinned sheep.

Horse:
It is long and flat with a spatulate end. There is no dorsal ridge and only one circumvallate papilla is present on each side. The epiglottis is pointed. Pigmentation is never seen.

Pig:
It is long and narrow and there is no dorsal ridge. One or two circumvallate papillae are present on each side of the midline near the base of the tongue and surface is studded with fungi- form papillae.

2. **Stomach**:
Ox:
The esophagus is short and wide , measuring about 1 mt long and 5 cm wide . the voluntary muscle which performs the reverse peristaltic action in rumination is used for sausage meat. After removal of this muscle the serous covering of the esophagus is used for sausage casings.
The stomach consists of four compartments: rumen, reticulum, omasum and abomasums, which is the true digestive stomach and secretes gastric juice. The rumen occupies 75% of the abdominal cavity. The reticulum , which is placed transversely between the anterior extremity of the rumen and the posterior surface of the diaphragm to which it is adherent, causes a depression on the posterior aspect of the thin, left lobe of the liver. The omasum and abomasum are attached to the posterior surface of the liver by means of the omentum the anatomical relations of the bovine stomach play an important part in the etiology of traumatic pericarditis. The average capacity of the stomach is 150 liters.
Mucous membranes:
Rumen: brown or black in color studded with large papillae.
Reticulum: honey comb like appearance with four, five or six-sided cells.

Omasum: the prominent longitudinal folds, about 100 in number. Sometimes called the Bible.
Abomasums: some 30 prominent oblique folds in the body of the abomasums. A feature of the calf stomach is the relatively large size of the abomasums as compared with the small size of the rumen.

Sheep and goat:
The stomach is similar in structure to that of ox and has an average capacity of 18 liters.

Horse:
The stomach is a simple one , the average capacity is 12 liters.

Pig:
The stomach is a simple one and semi lunar in shape.

3. Intestines:

Small : duodenum, jejunum, ileum.
Large: caecum, colon , rectum.
The average length of the intestines (in meters) – see the table.

Spp	small intestines	Large intestines
Cattle	36.5	9
Sheep	24.3	6
Horse	25.6	6
Pig	17.1	4.8

Poultry:

The alimentary tract of poultry consists of esophagus, fusiform crop, proventriculus or glandular stomach, thick muscular gizzard, , small intestines, large intestines (two caeca and a rectum) and a cloaca. Bursa of fabricius is found in the dorsal aspect of the cloaca in young birds and is composed mainly of lymphoid tissues.

4. Liver:

With exception of horse, the livers of all the food animals are reddish brown in color. The liver, the largest gland in the body, lies mainly to the right of the midline in all animals.
Functions;

1. concerned with formation and destruction of RBC (it is a site of RBC formation in the fetus).
2. removes bilirubin from the blood and excretes it via the bile duct into the duodenum.
3. manufactures blood-clotting factors (prothrombin and fibrinogen) and heparin.
4. manufactures plasma protein .
5. manufactures glycogen from protein and fat and stores it along with fat and protein.
6. maintains the normal blood sugar level (100 mg%) and converts galactose into glucose.
7. detoxifies certain foreign substances in the blood.
8. deaminates surplus amino acids.
9. produces salts for the digestion of fats. Forms and stores bile, vit.A , D and B12, copper and iron.

Ox:
The liver is poorly divided into three lobes, a thin left, a thicker right, and a caudate lobe or thumb piece. The left and right lobes are divided by the umbilical fissure. In the cow the left lobe is thin, elongated and often markedly cirrhotic. Running transversely across the upper border is the posterior vena cava , and on the posterior aspect are the root of omentum, gall bladder, portal vein and portal lymph nodes.
The tenderness of liver and its freedom from parasitic diseases and other pathological conditions , as well as its therapeutic value in the treatment of anaemia ensures the highest price.

Sheep:
The liver is similar in shape to that of ox, but the caudate lobe is more pointed and its edges are well defined. This useful distinguishing feature between sheep and calf liver.

Horse:
Horse liver has three lobes and a thumb piece which terminates in a point. A notable feature is the absence of gall bladder . the horse liver is purple in color.

Pig;
Pig liver has five lobes. The identifying feature is the large amount of visible interlobular tissue, that is why pig liver is less friable than in the other food animals.

5. Pancreas (gut sweetbread):

Two hormones , insulin and glucagons are produced by the islet cells of Langerhans in the pancreas. These hormones control the levels of blood sugar, an excess of insulin causes the blood sugar to drop, while excess of glucagons raises it. Lack of insulin causes diabetes mellitus in which there are high blood glucose levels and reduced fat and protein formation in the body.
The ox pancreas is reddish brown, loosely lobulated and roughly the shape of an oak leaf.

6. Spleen:

The spleen is not essential to life. In fetus it forms red and white cells, lymphocytes being produced during the life of the animal. It also acts as a store for RBCs and for destruction of old red cells and platelets. Antibodies are formed in the spleen which in certain disease, e.g. anthrax, trypanosomiasis , becomes very enlarged.

Ox:
The spleen is related and adherent to the left dorsal side of the rumen and diaphragm. It is reddish-brown , elongated and slightly convex with rounded edges.

Sheep:
It is attached to the pluck and adherent to the rumen.

Horse:
It is flat, sickle-shaped and bluish.

Pig:
It is elongated, tongue-shaped and triangular in cross section.

Respiratory system:

The thoracic cavity (containing lungs, heart and associated large vessels) is separated from the abdominal cavity by the diaphragm. The respiratory system comprises the nose, nasal cavity, part of the pharynx, larynx, trachea and lungs. The pleura lines the chest cavity and in the healthy animal is a smooth and glistening membrane divided into a right and left sac. Each sac covers the chest wall and the lung. The two sacs join in the central mediastinal space in which are situated the mediastinal lymph nodes and which is traversed by the aorta , esophagus and trachea.

Lungs:

Ox:
The cartilaginous rings of the ox trachea meet at an angle and form a distinct ridge along the dorsal aspect. The left lung has three lobes, while the right lung has four or five lobes.

Sheep:
Similar to those of ox, but they are duller in color and the lobulation is less distinct.

Horse:
Lobar divisions are very distinct , only two left lobes and three right lobes can be distinguished. The lungs are long and may be further differentiated from those of the ox by the absence of surface lobulation and the absence of an accessory bronchus, while the ends of the cartilaginous rings of the trachea overlap each other.

Pluck:
In sheep , goat and calf the internal organs comprising the larynx, trachea, lungs, heart and liver (and spleen in sheep) constitute the pluck.

Circulatory system:

Heart, arteries, capillaries and veins.
Heart:
1. Ox:
ox heart shows three ventricular furrows on its surface. Two ossa cordis, which are cartilaginous until 4 weeks after birth, develop at the base of the heart in the aortic wall.

2. sheep:
There are three ventricular furrows, while in later years a small os cordis may develop on the right side.

3. Horse:
The heart has two ventricular furrows, the aortic cartilage becoming partly ossified in older animals.

Lymphatic system
Lymphatic system is the vessel that carries lymph from the body through all lymph glands or lymph nodes to all the body tissues, in the same way as the animal blood circulates throughout the circulatory

networks. Lymph is the medium by which oxygen and nutritive matter are transferred from the blood to the body tissues and waste products .removed.

Lymph glands or nodes are small, oval structures, varying in size and color. They are located all over the body. Lymph nodes are nearly always embedded in fat. The study of the normal condition and

position (site) of the lymph node is of great importance in meat inspection. If lymph nodes are found swollen, it is an indication of an .abnormal condition in the animal body, due to diseases, bruising etc ،On dissection of these nodes various types of lesions may be found .such as tuberculosis

The normal size of the lymph nodes varies from a pinhead to a bird's egg. The mediastinal lymph nodes of the ox may reach a length of 20 cm. In a horse the nodes are small in size and occur in large numbers, while in ruminants their number is few and are of a large size. Generally the nodes are smaller in older animals than in .younger ones. The shape or form of these nodes is oval or spheroid In texture the nodes are firm and hot soft. The color of animal lymph nodes during life is pink or reddish brown but when the animal is killed the color changes to gray or yellowish brown

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:**The sites of the principal lymph nodes are:**

Internal lymph nodes of bovines

(Prepectoral glands ,Lower cervical)

Superficially lying on the entrance to the thorax, in front of the 1st ribs embedded in little fat

Deep and lie just beneath the super facial gland, covered by a thin layer of muscle

Supra sternal glands

Situated between the costal cartilages of the first 6 ribs near to ،their junction with the sternum. They are very small glands .usually embedded in fat

Thoracic glands

Situated just beneath the dorsal vertebrate and partly in the inter coastal spaces joining the ribs with the vertebrate. These .are also very small in size

Renal glands

Lie in the kidney hilum embedded in fat

Lumber glands

Situated close to the lumbar vertebrae, partly covered by the .lumbar muscles. These are small glands lying in series

Iliac glands
These are two separate glands
Internal illial gland, situated near the vertebral column and close to the external iliac gland
Ischiatic gland, lies between the anus and other portion of the ischium, near the tail that has been removed
(**Supra mammary gland** (in the female
Lies above and behind the udder, while the inguinal gland is situated in the neck of the scrotum, at the side of penis in male .animals

External lymph nodes of Bovines
Pre scapular gland
Lies immediately in front of the shoulder joint that is at the junction of the humerus and the scapula. This is a large gland embedded in front; it can be exposed by a deep incision in .front of the head of the humerus
(**Precrural gland (pre-femoral gland**
‹Situated at the anterior edge of the tensor facia lata muscle immediately above the patella of the hind-leg. This is also a .large gland. Needs to be exposed by an incision
Popliteal gland
Lies deep in the popliteal cavity or half way down the back of the thigh. When the joints are cut from the hind leg the gland .is usually exposed between the two joints, embedded in fat
Head lymph glands of bovines
Parotid glands
Situated on the posterior part of the masseter muscle or at the root of the ear. The paratoid salivary glands must be incised to .expose them

(**Pharyngeal glands**
Lie at the back of the pharynx, on either side. They are most .easily examined after the removal of the tongue
Sub mandibular or sub-maxillary glands
Situated on the inner side of the mandible (jaw bone). They are usually attached to the tongue. When this organ is carefully removed it may be found attached to the tongue but .may sometimes be left on the inner side of the jaw bone
Lungs lymph nodes of Bovines
Bronchial glands
Lie embedded in fat on either side of the tracheas, near its point of bifurcation. The left bronchial gland lies deeper than

.those on the side

Mediastinal glands

These are chains of glands that lie in mediastinal tissue between the lungs close to the esophagus.

Urogenital system:

Urinary organs:

Two kidneys, two ureters, bladder and urethra.

Genital organs:

Female- two ovaries, two uterine (fallopian) tubes, uterus, vagina, vulva, clitoris and mammary glands.

Male- two testes and epididymes, two vasa deferentia, seminal glands, prostate, bulbo-urethral (cowpers) gland, urethra and penis.

Kidney :

In addition to its functions in the excretion of urine and in acid-base balance, the kidney produces two hormones, rennin and an erythropoietic factor.

Ox:

Kidneys are reddish brown and composed of 15-25 lobes, when the rumen is empty the left kidney lies to the left of the vertebral column , but as the rumen becomes filled, it propels the kidney towards the right side of the body. The left kidney is three-sided and of twisted appearance, while the right kidney has a more regular , elliptical outline.

Sheep and goat:

The kidneys are dark brown, bean-shaped and unlobulated and possess a single renal papilla. The left kidney is also freely movable.

Horse:

The right kidney is triangular or heart-shaped. The left is bean –shaped and longer than broad.

Reproductive system:

Uterus

Cow:

It consists of small body, less than 2.5 cm long., and two horns about 38cm long. The uterus of cow and ewe has a characteristic cotyledons on the mucous membrane of the body and horns, these are oval prominences , about 100 in all, and in the non gravid bovine uterus are about 13 by 6.3 mm. During pregnancy and as the fetus develops, the cotyledons hypertrophy, becoming pitted or sponge-like, and they measure up to 10-12.5 cm in length and 4 cm in width. Evidence as to whether a slaughtered female is a heifer or a cow may be established by opening each uterine horn and cutting transversely through the wall, including the diameter of cotyledon. Generally, in the uterus of heifer the cotyledons are surrounded by a shallow moat which usually disappears in the cow. The blood vessels in the exposed wall of the uterus in the cow are contorted and bulge from the surface. In the heifer the blood vessels can be seen clearly but do not bulge and show little contortion. The blood vessels in the cotyledons are the most valuable guide; in the heifer they are very fine and straight, whereas in the cow they are distinct, contorted and bulge slightly from the cut surface. This method assumes that the cotyledons enlarge if the animal is in-calf and regress in the non-pregnant uterus.

Ewe:
The uterine horns are relatively long, the cotyledons being circular, pigmented and much smaller than in the cow, while in advanced pregnancy the center of each is cupped or umbilicated.

Udder:
Cow:
The right and left sides of the udder is separated anatomically by a tendinous septum. Although a strong septum does not exist between the fore and hind quarters of the same side, all four quarters are anatomically distinct and injection of different colored fluids into the four teats shows that they each drain separate and distinct areas.The smooth udder of the heifer , which is composed almost entirely of fat, must be distinguished from the pendulous fleshy udder of the cow in which glandular tissue predominates and which is grey to yellowish –white in color.

Ewe and goat:
The udder is composed of two halves , each with one small teat. in the goat the udder is similar but the halves are more pendulous and the teats are more strongly developed and directed forwards.

Estimation of age of bovine fetus:

By the end of first month of pregnancy the bovine fetus is about 1cm long. At the end of the second month the fetus is 5-6.5 cm long and digits and depressions for mouth and nose appear. After 3 months the fetus is 14.2 cm long, stomach divisions are present and hoofs and horns appear.

In the fourth month there is little change except growth, but towards the end of fifth month hair appears and the testes descend into the scrotum. At the end of 5 months the fetus is 30.5 cm long.
During the next 3 months the fetus attains a length of 61 cm. by 8 months the eyes are open, the limbs covered with hair, and the hoofs hardened. At the end of ninth month the fetus is full size, about 91 cm long, and weighs 36 kg which is an average for a newborn calf.

Testicles:
In the bull the testes have an elongated oval outline. In the sheep the testicles are large, pear-shaped and more rounded than in the ox.

Ovaries:
The ovaries , in addition to producing ova, secrete three hormones: estradiol, progesterone and relaxin. The ovaries also control cyclical changes in the reproductive system which ensures development of breeding seasons when weather conditions, temperature, food, etc. are suitable.

Muscular system:

The muscular system comprises voluntary muscle which together with inter-muscular fat and connective tissue , forms flesh or butcher meat and represents about 25-40% of the live weight of the animal There are some 300 muscles in the animal body which all made up of numerous tiny spindle shaped multinucleated muscle cells or fibers.

Connective tissue:

It is present in two forms in the animal body, the white and yellow. A typical example of white connective tissue is the fascia connecting the muscular bundles. The main constituent of white connective tissue is collagen, which is converted into gelatin by boiling. Yellow connective tissue , as seen in the yellow fascia covering the abdominal muscles or in the ligamentum nuchae, consists of elastin which cannot be softened by boiling.

Fat:

It develops in connection with connective tissue and has an important influence on both the odor and flavor of the different meats. The amount of fat in carcass affects the rate of chilling, a greater amount slowing it down owing to its insulating property. The deposition of fat between the muscle fibers is known as marbling. It occurs only in young , well nourished cattle and not in older animals where fat tends to be deposited subcutaneously. Marbling of fat doesn't occur in horse. In some way the eating of saturated fats has a bearing on the development of coronary heart disease in man and the general tendency today is to reduce their level in the diet.

Determination of Age by Dentition:

Age and sex determination is important in:
1. the keeping of records of disease found on routine examination , and also in recognition of the carcass of the cow, ewe, animals in which dangerous affections of a septic nature are the most likely to occur.
2. it is also of value where a system of mutual insurance of animals intended for slaughter exists and an inspector may be called upon to pass expert judgement as to the age and sex of any animal in dispute.
3. it is chiefly to prevent substitution of cow meat or other aged female-meat for that from heifer or other young animal meat.

In the food animals , age may be estimated with reasonable accuracy by the teeth. See tables below.

Table; Dental formula for ox and sheep

Temporary teeth

Incisors	pre-molars	molars	
$\frac{0}{4}$	$\frac{3}{3}$	$\frac{0}{0}$	= 10x2 = 20

Permanent teeth

$\frac{0}{4}$	$\frac{3}{3}$	$\frac{3}{3}$	= 16x2 = 32

Table : Ages at which permanent teeth appear

	1st pair	2nd pair	3rd pair	4th pair
Ox	1.5-2ys	2-2.5ys	3ys	3.5-4ys
Sheep	1-1.5ys	1.5-2ys	2.5-3ys	3.5-4ys

Horse 2.5ys 3.5ys 4.5ys canine 4-5ys

Determination of sex:

Cattle:

Bull:

The outstanding characteristic in the bull carcass is the massive development of the muscles of the neck and shoulder, forequarter and the crest. In the dressing of the bull - carcass the testicles and spermatic cord are removed., leaving an open external inguinal ring partly covered by scanty scrotal fat. The pelvic cavity is narrow , while the pelvic floor is angular and the pubic tubercle strongly developed. The bulbocavernosus muscle is also well developed.

Heifer:

The udder remains on each side and is characterized by its smooth, regular convexity and predominance of fat and lack of evidence of glandular tissue. The absence of bulbocavernosus muscle may be noted and a useful feature in differentiation. In the cow and heifer the bone is slim and rather straight, but in the bull it is markedly enlarged . in the heifer and cow remains of the broad ligament of the uterus are apparent on the inner abdominal wall.

Cow:

The cow carcass is more slender and less symmetrical than that of the bull and shows a long tapering neck, a wide chest cavity, curved back and prominent hips. The pelvic cavity is wide, while the pelvic floor is thin. No bulocavernosus muscle, while both external and internal fat is irregularly distributed and yellowish in color.

Sheep:

Ram:

The carcass has strong muscular development of the forequarter, the inguinal rings are open, and the scrotal fat is sparse or absent.

Lamb;

The carcass is usually well proportioned, with evenly distributed fat and abundant, lobulated scrotal fat. The root of the penis can be exposed by an incision.

Ewe:

The carcass is angular in shape, with long thin neck and poor legs. The udder is brown and spongy , it is removed in dressing leaving roughened area with portions of the supra-mammary lymph nodes.

Horse and Ox Differentiation:

Carcasses of horse and ox may be differentiated by the following details:
1. in the horse the unusual length of the sides is noticeable, together with the great muscular development of the hind quarters.
2. the thoracic cavity is longer in the horse, this animal possesses 18 pairs of ribs, whereas the ox has 13 pairs.
3. the ribs in the horse are narrower but more markedly curved.
4. the superior spinous processes of the first six dorsal vertebrae are more markedly developed in the horse and are less inclined posteriorly.
5. in the forequarter, the ulna of the horse extends only half the length of the radius; in the ox it is extended and articulates with the carpus.
6. in the hindquarter, the femur of the ox possesses no third trochanter; the fibula is only a small pointed projection, but in the horse it extends two-thirds the length of the tibia.
7. in the horse the last three lumbar transverse processes articulate with each other. The sixth articulating in a similar manner with the sacrum. They do not articulate in the ox.
8. the horse carcass shows considerable development of soft yellow fat beneath the peritoneum, especially in the gelding and mare, but in the stallion the fat is generally of lighter color and almost white. In the ox the kidney fat is always firmer, whiter and more abundant than in the horse.
9. horse flesh is a dark bluish red, beef lacking bluish tinge. Horse meat has a pronounced sweet taste and well defined muscle fibers.

Sheep and Goat Differentiation:

Differentiating features of the carcasses of the sheep and goat are shown in the table below:

Table: Differentiation of carcasses of sheep and goat.

Feature	Sheep	goat
Back and withers	round , well fleshed	sharp, little fleshed
Thorax	barrel-shaped	flattened laterally
Tail	fairly broad	thin
Radius	1.25 times length of Metacarpus	twice as metacarpus

Scapula	short and broad, superior	has distinct neck,
spine		
	Spine bent back	straight and narrow
Sacrum	lateral borders thickened	lateral borders thin
and		
	In form of rolls	sharp
Flesh	pale red and fine in texture	dark red , coarse,
with goaty		
		Odor. Sticky sq
tissue with		
		Adherent goat hairs.

Characteristics of meat and fat:

Beef:
In young bulls the flesh is light red meat and attractive, but the muscle becomes darker due to testosterone secretion, in later life. It also becomes coarse and shows little intramuscular fat and in old bulls the dried surface of the meat appears very dark. In bull and young cows the fat is white or whitish yellow and firm. In older cows the fat tends to be yellow and looser in consistency.

Mutton:
It is light to dark red in color with fine, firm fibers. In the well nourished animal there are fat deposits which lie between the various muscles. Mutton fat is firm, white and odorless.

Goat:
Goat's flesh resembles mutton, but the kidney fat is always abundant even where the subcutaneous fat is sparse, there is particularly no fat between muscles. The typical goat odor is invariably transferred from the skin to the carcass during the process of dressing.

Horse:
Horse flesh is dark red or even bluish after cutting, that blood of horses being almost black. The odor is sweet and repulsive. The connective tissue fascia is more strongly developed than in other food animals. The fat may be yellow, soft and greasy. After some hours horse flesh develops a rusty color.

Chemical and Biological Differentiation of meats:

The differentiation of the muscle and fat of animals is of importance in connection with the possible substitution of inferior, and at times repugnant , meat for that of good quality.

Chemical tests:

A number of differential chemical tests based on the fact that horse flesh is richer in glycogen than the flesh of other food animals. Glycogen , however, starts to disappear from meat at the time of slaughter and, unless the examination is made soon after the carcass is cut up, very little may be found.

A method of identifying horse fat when admixed with beef and mutton fat is by demonstrating the presence of 1-2% of linoleic acid. In other animal fats this not present in proportions higher than 0.1%.

A valuable test for horse fat depends on estimation of the iodine value. This test is based on the amount of iodine absorbed by the unsaturated fatty acids present in the fat, and varies in the different animals. In the horse the iodine value of fat is 71-86, in the ox 38-46, and in sheep 35-46. a further valuable test for fats is by estimation of refractive index. All liquids including oils, possess a specific refractive index; that of horse fat is 53.5, ox fat less than 40.

Biological tests:

Three main biological tests are employed for the differentiation of the flesh of various animals, the precipitin test, the complement fixation test and the ELISA (enzyme linked immunoabsorbent assay) test. The tests are applicable to mince or sausage meat.

The precipitin test depends on the fact that certain antibodies develop in the blood of an animal which receives repeated injections of blood serum from another animal. complement fixation utilizes a normal component of serum, complement, which is a thermolabile mixture of substances capable of reacting with any antigen – antibody system to lyse the antigen agglutinated by the antibody. The ELISA technique relies on the ability of antibodies to bind with specific antigens, this can be applied to meat identification because of the differences in protein composition in the food animals.

Meat Composition and Quality:

Meat is valuable part of the human diet because:
1. it contains the amino acids essential for human life.
2. it assists the body in the production of heat and energy.
3. meat contains fat and therefore remains in the stomach for some hours and allays hunger.
4. meat has a palatable flavor , acts as a stimulant to gastric secretion and is readily digested.

Composition:
The approximate composition of lean bovine muscle are given in Table:
Table . composition of beef

	% net weight
Water	75
Protein	19
Lipids	2.5
CHO(glycogen)	1.2
NPN	1.65
Minerals	0.65
Vitamins	minute qtys

Protein:
It is the most important muscle constituent and is made of myofibrillar, sarcoplasmic and connective tissue proteins. Myofibrillar protein gives rigidity to the muscle and forms about two thirds of the total protein, the most important types being myosin and actin. Sarcoplasmic proteins are the water soluble proteins of the fluid cytoplasm of the muscle cells and include myoglobin muscle pigment, hemoglobin blood pigments and soluble glycolytic enzymes. Connective tissue proteins include collagen and reticulin.

Lipids:
The lipids are mostly composed of triglycerides which are fats and oils, both of which are insoluble in water but soluble in ethyl ether. The lipids also include phospholipids, saturated, monounsaturated and polyunsaturated fatty acids and other fat-soluble substances including cholesterol.

Carbohydrate:
It is represented mainly by glycogen (animal starch), which has a major influence on muscle changes after death. Most of it is converted by glycolysis into lactic acid, which causes the pH of the meat to drop from

7.2 to 5.5. the rate of fall of pH is influenced by many factors including the initial glycogen level, genetic factors, species of animal, type of muscle, feeding of animal and degree of stress prior to slaughter. Glycogen also occurs in the liver and is especially abundant in horse meat and in the fetus.

Non protein nitrogen;
It is mainly represented by free amino acids, creatine, nucleotides, inosine monophosphate and carnosine, some of which give the meat its flavor.

Minerals:
The main elements of inorganic minerals (ash of muscle) being in order of importance: S, K, P, Na, Cl, Mg, Ca, Fe, Cu, Cr, Se, Co (as Vitamin B12) and Zn.

Vitamins :
Vitamins occur in the form of the water soluble B vitamins; B1, B2, niacin, B6, pantothenic acid, biotin, folic acid and B12, along with some vitamin A (lipid soluble) and vitamin C (water soluble).
Meat is our most important source of vitamin B12 which is not found in vegetable foods. This vitamin is essential for cell division and nuclear maturation as well as the formation of RBC. Liver is another good source of B vitamins , especially thiamine (B1) as well as vitamin A. the level of vitamins in meat is reduced by cooking, the amount depending on the temperature and time employed.

Quality:

Physical and chemical changes:

Considerable changes occur in the nature of meat within 1-2 days of slaughter. Shortly after death the meat appears dark and is sticky and adherent when minced, water can only be squeezed from it with difficulty; it is resistant to the penetration of salt and sugar and its electrical resistance is high. A day or so later the meat is lighter in color and is wet but not sticky when minced. Over 30% of fluid can be squeezed and the electrical resistance drops to one fifth of its initial value. The rate at which the meat undergoes such changes depends on the atmospheric temperature and adequate amount of glycogen in the muscle. For this reason meat of exhausted animals , in which glycogen content is depleted, remains dark and fiery.

Rigor mortis :

The first and most considerable post mortem change which occurs in muscle is rigor mortis. It is characterized by hardening and contraction of all voluntary muscles , by a loss in transparency of the surface of the muscle, which becomes dull, by stiffening of the joints, and it is accompanied by a slight rise in temperature of the carcass to 1.5C, which then gradually dropping to that of the surrounding atmosphere. Rigor mortis affects first the muscles that have been most active and best nourished prior to death and starts at the head and neck, extending backwards to involve the body and limbs. The heart is affected very early usually within an hour of slaughter. In a physiologically normal animal , rigor in the skeletal muscles does not appear for 9-12 hrs after slaughter, and maximum rigidity is attained at 20-24 hrs and then gradually declines.

The development of rigor mortis is influenced by:

1. the atmospheric temperature, a high temperature accelerating its onset.
2. the health of the animal. Rigor mortis is absent in febrile condition. Some drugs may encourage the early onset of rigor such as sodium salicylate , alcohol and ether.
3. the degree of muscular acidity prior to slaughter.

Rigor mortis occurs when muscles lose their extensibility when the supply of coenzyme , adenosine triphosphate and glycogen is used up. A bond is formed between the myosin and actin which forms actomycin. The process of conversion of glycogen to lactic acid is known as glycolysis.

In the meat trade the occurrence of an adequate degree of rigor mortis and a low ultimate pH of the flesh are desirable characteristics . the low pH inhibits bacterial growth while the lactic acid present brings about the conversion of the connective tissue into gelatin and the meat when cooked is more tender. During maximum rigor mortis the lactic acid concentration is ten times that of living muscle.

Absence of rigor mortis may result from unfavorable ante-mortem treatment such as fatigue or the fear and excitement occurred during transport, or it may result from an illness.

Debasement of food (adulteration and substitution):

Regrettably many opportunities exist from the farm to the retail outlet for adulteration, accidental or malicious, and misrepresentation , to occur. The chief substitutions of inferior flesh for that which is highly valued are those of horse(or donkey) for beef, goat for lamb, rabbit for poultry and cat for rabbit. Another form is the replacement of steer and heifer meat of high quality with lower quality cow. A widespread racket involving the use of unfit meat and the meat from animal species other than that specified has been in existence. In some cases the analytical technology does not exist to enable the analyst to make a true calculation. For example, in trying to determine if there is sufficient meat in a sample , the analyst calculates the amount of nitrogen present. In some cases however, it is not possible to differentiate between meat nitrogen and non-meat nitrogen. Analytical techniques have had to be updated and refined constantly to keep pace with the intricate types of fraud being practiced.

Ingredients used:
Many different types of non-meat proteins and animal-based proteins are used in an attempt to disguise the true meat content on analysis. These ingredients are often referred to in the trade as meat extenders or meat substitutes; it is their illegal use which results in fraud.
Non-meat proteins:
Include vegetable protein, e.g. soya bean
Cereal :
It is an ingredient which has the ability to absorb water giving meat product a drier appearance more like its natural form.
Animal-based protein:
Often include those parts of the carcass which are of low value, e.g. bone protein, urea, dried blood, and plasma.
Water

Food tampering:

Malicious tampering with food has become a major concern for food companies and authorities. The display of various kinds of food products on supermarket and other shelves is an opportunity for the criminal to introduce deleterious materials on and into food usually for extortion purposes.

Influence of feeding on animal tissue:

The effect of feeding on the color and texture of animal tissue is much more evident in fat than in muscle. The fat in grass-fed cattle is a rich yellow color, which is due to the presence of carotene , a pigment converted in the animal body into vitamin A and abundantly present in fresh young grass, maize, carrots, and linseed. Mammalian fat consists of

three substances – olein, stearin and palmitin- which are present in varying proportions. Palmitin acts as a solvent of carotene so that animals such as cattle and horses which have a large proportion of palmitin in their fat, will accumulate carotene if fed on carotene – containing foods and produce fat of a yellow color. Where , however, such animals are fed on foods such as grain , hay or straw, which contain little or no carotene, the fat remains white in color.
In the case of sheep, goats and buffaloes very little palmitin is present in their fat that is why it remains white in color.

Abnormal odors and taints:

Abnormal odors are commonly encountered in meat, and may often be acquired from outside sources, as from certain foodstuffs, from drug administered as medicine or by the absorption of the odor of strong-smelling substances whilst the meat is stored. Abnormal odors may also be intrinsic , as in the odor of acetone in the carcass of cow affected with ketosis, or in the sexual odor of certain male animals. The causes of abnormal meat can be classified as follows:
Feeding:
Such as fishy odor from excessive feeding on fish meal.
Turnipy odor from feeding cattle on turnip.
Garlic odor in meat , resulting in carcass condemnation, has followed the feeding of vegetable waste containing decomposing onions to cattle.
Various food factory wastes, e.g. orange skins are sometimes used as feed for livestock, usually cattle and can give rise to undesirable odors in meat. The eating of young garlic leaves by cattle gives the carcass a strong odor resembling phosphorus.

Absorption of odors:
Abnormal odors and taste of flesh due to the administration of drugs are commonly encountered in cattle, particularly dairy cows, and attention should be paid in emergency-slaughtered animals to the stomach contents; detection of a drug odor calls for an examination as to whether the odor is also present in the flesh. The odor of drugs persists longest in the thickest parts of the carcass. Drugs which may affect meat adversely in this way are linseed oil , turpentine, carbolic acid, ether, chloroform , asafetida, nitrous spirits of ammonia and aniseed. The drinking of water impregnated with tar may render the flesh unmarketable, as may chlorine leaking from refrigeration system. chlorinated hydrocarbons including DDT used as Insecticides may accumulate in the fat as a result of spraying or by animal consuming contaminated feeds.

In the imported meat trade the absorption of abnormal odors by refrigerated meat during transport or storage is a common cause of depreciation and even condemnation. Contamination by the odor of citrus fruit may occur during a sea voyage if the fruit becomes over-ripe or unsound. Similarly odors of oil or tar in meat may also occur.

Products of abnormal metabolism:
The existence of a peculiar odor, described as sweet but repugnant, is frequently observed in the flesh of cattle which have been affected with fever or which were close to parturition prior to slaughter; it is also apparent in cows suffering from milk fever. This odor caused by appreciable amounts of acetone present in the flesh. The odor which does not disappear from the meat even when grilled, may be sufficient to render it unfit for sale and for this reason a boiling test should always be applied on the flesh of animals slaughtered while suffering from fever or in an advanced stage of gestation, especially where the liver shows evidence of fatty change.

Sexual odor:
In male animals the meat may possess an abnormal odor and taste, which may be so marked as to lower its marketability and depreciate its value. This sexual odor , which is specific for each animal and may be described as resembling stale urine , is markedly apparent in male goat., though of little or no significance in bulls and rams. The sexual odor is caused by a steroid substance, androsterone and it can be prevented by treatment of the animal with estrogens. Male sexual odor is most apparent in the meat immediately after slaughter, particularly in the fatty tissues and while the animal is still warm. The odor largely disappears as the carcass cools but may reappear when the meat is boiled or fried.

Judgment of abnormal odors:
Flesh with a pronounced odor of drugs or disinfectants must be regarded as unfit if abnormal taste and smell are still apparent by a boiling test after the carcass has been detained for 24hrs. a marked fishy odor may regarded as sufficient to render it unmarketable and it should be condemned. In imported meat ,the odor caused by absorption of gases from cargoes of fruit during storage, and also superficial taint in meat due to oil or tar, can be removed almost entirely by subjecting the meat to long periods of ozonization.

Meat Plant Construction, Equipment and Operations:

Since the cost of providing and maintaining an abattoir is very high, it is essential at the outset to ensure that there is a need for a new plant and that it will operate at maximum throughput. Construction, layout and equipment must all be geared to promote efficient and hygienic operation. The first step in planning is to ascertain the ultimate maximum daily kill of each class of animal and the proposed disposal and treatment of the edible and inedible by-products. The actual system of operation must also be determined. It may comprise a complete meat plant including full processing facilities on one or more floors or an abattoir adapted solely for slaughter and dressing. The factory abattoir requires full time operatives to deal with all livestock; it is a method that ensures economic handling of the by-products including hides, offals, glands, blood and condemned materials , and also reduces overheads on buildings, equipment and labor.

The overall number and location of abattoirs in any country should be geared closely to the demands of livestock production , transport and for casualty slaughter.

Site:

A suitable site for an abattoir should have the following facilities:

1. mains water and electricity supply (daily water can be 10000liters /ton dressed carcass weight).
2. mains sewerage.
3. contiguity with road and rail system.
4. proximity with public transport.
5. proximity to supply of varied labor.
6. freedom from pollution from other industries, odors, dust, smoke, ash ,etc.
7. ability to separate clean and dirty areas and access.
8. freedom from local housing , rural sites are preferable.
9. good availability of stock nearby.
10. ground suitable for good foundation.
11. sufficient size for possible future expansion.

Area size:

Generally, a small abattoir (up to 30000 units/year) will occupy 1-2 acres, a medium plant (50000 units/year) will occupy 2-4 acres, and a large meat plant handling over 100000 units annually about 4-6 acres (one adult bovine is equivalent to 3 calves or 5 sheep).

Submission of plans:
It is usual to submit two sets of drawings and four sets of specifications to the responsible authority for approval. It must include details of building construction, water supply, plumping, drainage, sewage disposal, hot water supply, refrigeration, lighting, ventilation, equipment and operations.

Facilities:
The following basic facilities for cattle , sheep and goats are required:
1. adequate lairage
2. slaughter premises large enough for work to be carried out satisfactorily.
3. a room for emptying and cleansing stomachs and intestines.
4. separate rooms for storage of fat and hides, horns and hooves.
5. separate room for preparing and cleaning offal and heads.
6. lockable premises for accommodation of sick or suspect animals.
7. large chilling or refrigerating rooms.
8. room for veterinary services.
9. changing rooms, wash basins, showers.
10. facilities enabling the required veterinary inspections to be carried out efficiently at any time.
11. access to and exit from the slaughterhouse.
12. adequate separation between the clean and the contaminated parts of the building.
13. adequate ventilation
14. adequate lighting which does not distort color.
15. adequate cold and hot water supply, and proper waste water disposal system
16. in the work rooms , adequate equipment for cleansing and disinfecting hands and tools.
17. equipment such that dressing can be carried out as far as possible on the suspended animal.
18. an overhead system of rails for the further handling of meat.
19. appropriate protection against pests.
20. special section for manure
21. a place for cleansing and disinfecting vehicles.

Buildings:

Lairage:
A knowledge of animal behavior is fundamental to lairage design. A period of rest before slaughter has a markedly beneficial effect on the appearance and subsequent marketability of the carcass .Lairage space

sufficient for 3 days, supply of cattle and 2 days supply of sheep is regarded ample. The lairage should be roofed to protect animals and staff , particularly during identification , handling and sorting of stock. The following pen size of housing of livestock in abattoirs are recommended:

Cattle	2.3-2.8 m2
Calves and sheep	0.7 m2

Ante-mortem inspection facilities:

The essential task of veterinary examination requires ample natural and artificial lighting, and an isolation pen where a suspect animal can be clinically examined.

Cattle lairage:
Accommodation for cattle may be of the tie-up type and this type is essential for bulls and cows. A suitable alternative lairage has a series of pens with wall or tubular partitions and 2.4m wide gates can be used. Pens may be 7.6 m x 6 m large enough to hold 20-25 cattle. Drinking water must always be available to animals, and the animals must be fed twice daily except on the morning of the day of intended slaughter.

Sheep lairage:
Sheep pens should be 0.9 m high with passage 0.9 m wide between them.

Slaughter Hall:

The transference of animals from lairage to slaughter hall is easy if the abattoir is well designed. If an upper kill floor is used and the site is on a slope, the animal can be walked directly on the slaughter floor, alternatively, a ramp of easy gradient can be provided. Many abattoirs spray the cattle from above as they move towards the stunning pen. Cleansing of bellies, legs and feet by water sprays fitted on both sides. The size and type of slaughter hall for cattle depends on which of the slaughtering systems is adopted, but in all cases it should be an open hall, with generous floor space , and well ventilated and lighted.

Stunning area:
Stunning boxes which are approached by narrow V-sided races are used for cattle. In case of sheep and goats excellent V-shaped restrainer-conveyors have been evolved which permit satisfactory stunning. Stunning boxes for cattle should be of durable construction, uncomplicated in design, noiseless in operation and capable of being easily and safely used by the operator. They should be provided with a

sloping floor which ejects the stunned animal to the shackling area to lie with the leg to be shackled uppermost.

Bleeding area:
No meat plant should be built today without careful consideration being given to the full utilization of by-products, edible and inedible. The bleeding trough should be at least 1.5 m wide, possess a good gradient, side walls of the same height, and two drains, one for blood only and the other for water when cleansing only. The bleeding trough for sheep should be preferably be enclosed on both sides as for cattle and have a width of 1.1-1.2 m with the overhead bleeding rail 2.7 m high, and dressing rails 2.3 m high for sheep .

On-the-rail dressing:

The carcass is conveyed by gravity or power along an overhead rail; after stunning and bleeding. Most plant use the traditional one man-one job approach. There are four main types of line dressing for cattle:

- gravity rail system:
The carcass is suspended from a spreader and single wheel trolley or runner, are gravitated to each station and stopped by a manually operated stop on the overhead rail.

- intermittent power system:
It involves the mechanical moving of the carcass suspended on a spreader and trolley along a level rail at intervals.

- continuous power system;
In this method the dressing line is in continuous motion and is used for higher rates of kill.

- canpak system:
This is a continuous conveyorized method in which the carcasses are suspended by heavy beef trolleys or runners from the overhead rail, no spreader is used.

A typical sequence of operations on a modern line system would be;
1. drive, pen cattle, stun
2. slaughter
3. shackle and hoist
4. remove forelegs
5. skin first hind leg

6. remove first hind leg
7. skin second hind leg
8 remove second hind leg
9. skin belly
10. skin first half of belly, chest and neck.
11. skin second half of belly, chest and neck
12. skin right fore leg
13. skin left fore leg
14. chain hide for hide puller
15. operate hide puller
16. remove and hang head
17. drop tongue
18. wash head
19. loosen trachea
20. remove caul fat and eviscerate abdomen
21. eviscerate thorax
22. remove reeds
23. remove plucks
24. split carcass
25. shape neck
26. remove tail
27. trim and position for weighing
28. weigh and tag
29. high (hindquarter) wash
30. low (forequarter) wash.

Advantages of line dressing:
1. since carcasses are conveyed to each dressing station there is no need for operatives to be idle while carcasses are being hoisted or positioned.
2. the line system is safer for operatives
3. dressing is hygienic
4. elimination of handling of heavy shackles, trolleys and spreader.
5. it saves space
6. it increases throughput

Meat inspection is sometimes made more difficult and possibly less efficient. An efficient system of meat inspection on a line system involves proper carcass and offal conveyor synchronization , a good identification system , adequate , efficient and conscientious inspection staff , proper inspection points with ability to co-ordinate findings and an efficient recording set up. At the higher rates of slaughter, separate recording staff should be utilized , particularly for detailed information. A system of audio links can be used for communication between inspectors and recorders, one of whom is required for each line. A line system of slaughter with a rate of 60-75 cattle/hr needs approximately nine meat inspectors and one veterinarian for initial and final inspection.

Sheep slaughter hall:

A portion of the cattle hall can be adapted for slaughter and dressing of sheep. Sheep are driven to a passageway adjoining the slaughter hall, carried by hand into the slaughter hall and placed on crates (cradles, crutches) preparatory to stunning and dressing. Line slaughter is frequently carried out on sheep and a line employing 17 operatives with a potential production of 150 sheep/hr would have the following stations:
1. pen sheep and stun
2. slaughter
3. shackle and hoist
4. de-elevate to crutch conveyor
5-9. conveyor dressing
10. elevate to overhead rail
11. clear tail
12. back and chute fleece
13. remove head
14. eviscerate abdomen
15. wash
16. eviscerate thorax
17.weight and tag
18. final wash

The isolation block (emergency slaughter unit):

This is a miniature abattoir with a lairage for up to 4 cattle, a slaughter hall and hanging room. It should be situated near to the suspect meat detention room. Animals that are sick or suspect must be segregated and lairaged apart from other animals.

Refrigeration accommodation:

For the approval of slaughterhouses there must be sufficiently large chilling or refrigerating rooms. Fresh meat must be chilled immediately after the post-mortem inspection and kept at a constant temperature not more than 7C for carcasses and cuts or 3C for offal.

Detained meat room:

Carcasses detained for further examination should be routed by a special rail to the detained meat room which should be located adjacent to the main slaughter hall inspection points in order to achieve close liaison over disease findings. From this detained meat room the overhead rail must reconnect with the main slaughter line for direction of the carcasses either to the chill room or to the condemned room.

Condemned meat room:

In order to arrange for proper sorting and holding of materials unfit for human consumption prior to dispatch, adequate space , refrigeration and drainage along with the supply of durable and lockable containers and weighing facilities are essential.

Veterinary Office:
An adequately equipped lockable room for the exclusive use of the veterinary service is essential for meat plant and meat inspectors. The rooms should be provided with hand washing and shower facilities and meat inspection equipment.

Veterinary laboratory:
A well equipped laboratory is essential , not only for preliminary diagnosis of animal disease but also to maintain the overall hygiene standards. These premises are also utilized for the training of meat inspectors and other employees.

Other facilities:

Hide and skin store:
Offal room
The edible fat room
Cutting rooms
Inedible area
Fresh meat dispatch
Manure bay
Vehicle washing
Facilities for personnel
Abattoir effluent treatment

Preservation of meat

The primary purpose of food preservation is to prevent food spoilage . whether food spoilage is mild or extreme, the primary cause is the action of microorganisms, bacteria, moulds or yeasts aided by enzymes. These are living organisms and they can survive and develop only under particular environmental conditions; under unfavorable conditions they die or fail to develop.
The underlying principle of all food preserving methods, then, is the creation of conditions unfavorable to the growth or survival of spoilage organisms by, for example, extreme heat or cold, deprivation of water and sometimes oxygen, excess of saltiness or increased acidity**. The methods by which meat foods may be preserved are : *drying, curing, cold, heat, chemicals and irradiation***.
Preservation by chemicals may be by artificial means, e.g. the addition of sulpher dioxide to foodstuffs, but the addition of antiseptics and other chemicals is now very greatly restricted by food regulations and does not come within the scope of a work on meat inspection. Chemical preservation by natural means, as in the smoking of meat and fish is, however, of importance and is employed widely as an adjuvant to commercial salting and pickling.

Physical changes in stored meat:
Meat undergoes certain superficial changes as a result of storage, chief of which are shrinkage, sweating and loss of bloom.

Shrinkage:
It is loss of weight occurs as a result of evaporation of water from the meat surface. A freshly killed carcass dissipates body weight slowly,

losing 1.5-2 % of weight by evaporation during the first 24 hrs of hanging. Further loss of weight during storage depends on the humidity of the storage room, the drier the air the greater being the evaporation. Avoidance of all evaporative weight losses by high humidity facilitates the formation of moulds.

Sweating:
This denotes the condensation of water vapor on meat brought from a cold store into ordinary room temperature. The condensation occurs because the cold refrigerated carcass lowers the temperature of the air to below the dew point.

Loss of bloom:
It is defined as the color and general appearance of a carcass surface when viewed through the semitransparent layers of connective tissue, muscle and fat which form the carcass surface. If these tissues become moist , the collagen fibers in the connective tissue swell and become opaque and the meat surface assumes a dull , lifeless appearance.

Chemical changes in stored meat:

The chemical changes that take place after slaughter are indicative of a slight degree of breakdown in protein , due to either to endogenous enzymes or to those of microorganisms. The storage life of meat is more dependent on the chemical changes that take place in fat rather than in muscle, for fat rancidity, even in slight degree , is objectionable.

Methods of meat preservation:

1. **Drying**:
Although drying plays a minor role in preservation today, the whole vast process of refrigeration is largely based on the principle of drying, i,e the removal of water available for microbial growth. Salting largely owes its preservative action to the extraction of water by osmosis. Strips of meats are first cured in salt, sometimes immersed in vinegar, and then dried.

2. Meat Curing:
It is the addition of salt and nitrate/nitrite or nitric acid to the meat, which results in conversion of the meat pigments, predominantly myoglobin, to the nitroso or cured form. The osmotic pressure of the strong salt or sugar solution removes the water necessary for bacterial growth from the meat. Myoglobin in freshly cut uncured meat is in the reduced form (purple), which in contact with air is rapidly oxygenated to oxymyoglobin, which

is bright red and responsible for the bloom of meat. If oxidized, these pigments are converted to metamyoglobin, which is unattractive and gives a brown or grey color. Under suitable conditions these pigments can be converted to the nitroso form (nitrosomyglobin) by the addition of nitric oxide. During the curing process nitric oxide is formed by reduction of nitrites formed by bacteria from nitrates. Nitrosomyoglobin gives freshly cut cured meat its bright red color.

Effect of curing on pathogenic microorganisms and parasites:
Pickling is of some value in destroying parasitic infections of meat, but cysticercus in beef is only destroyed with certainty by thorough pickling in a strong salt solution composed of 25 parts by weight of salt to 100 parts by weight of water. The effect of pickling on pathogenic bacteria is unsatisfactory and cannot be relied on as a method of rendering suspect meat safe for human food.

Smoking:
The purpose of smoking is to preserve color and flavor the meat. The chief bacteriostatic and bacteriocidal substance in wood smoke is formaldehyde . varying amounts of heat are applied in the smoking room, and the combination of heat and smoke usually causes significant reduction in the surface bacterial population. In addition , a dehydration , coagulation of protein and the absorption of resinous substances.

3. Cold:

The cold method, the basis of the great industry of refrigeration, is the simplest for the preservation of food. Efficient refrigeration can preserve meat in a condition approaching its natural state for periods adequate for commercial requirements, its appearance, weight and flavor are little altered, and no substance is added to the meat nor any is extracted.
Refrigerants are liquids or liquefied gases with low boiling points, e.g. ammonia, ethyl chloride or Freon which , in the refrigeration cycle, extract heat at low temperature when evaporated and give off this heat to the outside air when condensed.
The preservative action of refrigeration is based on the prevention of multiplication of harmful bacteria , yeast and moulds by the artificial lowering of the temperature. The failure of bacteria to grow at or below freezing depends mainly on the removal of the available water as ice; about 70% is removed at -3.5 C and 94% at -10C. a further factor is the inhibition of the life processes of spoilage organisms at low temperatures, though the actual lethal effect is but slight. Meat must be chilled immediately after post-mortem inspection and kept at constant

temperature of not more than 7 C for carcasses and cuts and 3 C for offal.
In relation to refrigeration , make the following practical points:
1. meat passed as fit for human consumption should be removed from the dressing area without undue delay and placed under refrigeration under close supervision of the inspector.
2. the following provisions should apply where carcasses are placed in the chilling rooms or frozen storage:
a. entry should be restricted to personnel necessary to carry out operations efficiently.
b. doors should be closed immediately after use.
c. it should not be loaded beyond its designed capacity.
d. temperatures should be read and recorded at regular intervals.
3. where carcasses are placed in a chilling room for chilling:
a. there should be a reliable method of monitoring the chilling.
b. meat should be hung or placed in trays with adequate air circulation.
c. drips from one piece of meat to another must be avoided.
d. temperature, relative humidity and air flow should be maintained at suitable level.
e .Condensation should be avoided.
4. meat should not be stacked directly on the floor but on pallets.

Chilled meat:
The meat exporter aims to present a product which has undergone as little change as possible in regard to appearance and palatability, but which shows at the same time an appreciable increase in tenderness, this aim is met by exportation of beef in storage chambers which keep the meat cold but not frozen. Freezing produces an inferior product and, as meat freezes at -1.5C , the temperature in chilling is maintained slightly above this , usually at -1.1C . Though , bacterial growth is usually inhibited at chilling room temperature, the meat continues to lose water by evaporation, and the air, becoming humid creates a condition which is suitable for the growth of mould.
In commercial experience the storage life of chilled beef is only 35 days, so that if the period between slaughter and shipping of the meat is 7 days and the period on board ship 21 days, child beef can only have a safe life of some 7 days. beyond this time deterioration becomes apparent (mould, bacterial slime and taint) and chilled meat requires a quick sale.

Bacterial spoilage:
Though mould formation is the commonest type of spoilage encountered in chilled meat, bacteria of the Achromobacter group may also set up a condition known as bacterial spoilage. The optimum temperature for the growth of these organisms is between 20C and 30 C , but they will

continue to grow at 0C. The affection is manifested by small glistening brown droplets which eventually coalesce to form a brownish slim on the surface of the meat, with the production of a characteristic odor described as sour or " cold store taint" ; the slime is much more prone to occur on moist lean surfaces of cut joints than on uncut carcasses and becomes visible when the number of organisms exceeds 30 million/cm2.

Ozonization:
A short period of treatment of meat with ozone restricts the growth of moulds and yeasts on the meat surface, but its action on bacteria is significant only when the moisture content of the superficial tissues of the meat has been considerably reduced. The addition of ozone to the air in chilling rooms destroys surface organisms and obviates the stale odor often associated with chilling rooms, but it is not a suitable method where the storage time is to exceed a few days, for it produces discoloration of the lean meat and rancidity of the fat from oxidation. Ozonization , however, is particularly valuable in the treatment of most forms of taint in frozen imported meat , including oil or fruit taint but not ammonia taint. Ultraviolet lamps have been used to control microbial spoilage , especially in the ripening of meat at higher temperatures. The bactericidal effect is only superficial as there is little penetration into the muscle tissue.

Carbon dioxide:
Great success in mould inhibition has been achieved by a process that depends on the ability of CO_2 , when present in high concentration , to prevent the growth of moulds. Lactic acid bacteria and anaerobes are virtually unaffected. On the other hand, the highly aerobic bacteria and yeasts and moulds are selectively inhibited by CO_2, and the storage of meat in an appropriate concentration of this gas will therefore retard surface decomposition, though it will not inhibit deep-seated anaerobic spoilage. Mould growth can be arrested completely at 0C if 40% CO_2 is used.

Liquid nitrogen:
This refrigerant is being increasingly used in the food industry, especially for freezing and particularly in automated production lines. A moving belt carries the food through a tunnel and under a liquid nitrogen spray at the outlet. The food is frozen and the vaporized nitrogen extracted by fans and discharged to the atmosphere.

Refrigerated meat transport:

Only refrigerated transport can be considered adequate. A well designed refrigerated road vehicle should have the following qualities: high standard of insulation, internal lining that is impermeable, easily cleaned, durable, air-tight door seals, water-tight flooring, rigidity of construction, efficient light refrigeration unit, economical, provision of indicators in driving cab, and properly spaced overhead rails.
Solid CO_2 is sometimes used , either as solid blocks or crushed, and provides a temperature of 0-10 C . the van is provided with a fan which blows the cool air over the CO_2 and load.

Changes in frozen meat:

Two unfavorable changes take place as a result of the freezing of meat:
1. the physical state of the muscle plasma (globulin and albumen proteins) is considerably altered.
2. during freezing , the water present in the muscle fibers diffuses from the muscle plasma to form crystals of ice.

Weeping or drip:

It denotes the presence of a watery blood-stained fluid which escapes from frozen meat when thawed and consists mainly of water, together with salts, extratives , protein and damaged blood cells, the latter is responsible for the pink coloration of the fluid. Weeping is undesirable feature and is caused partly by the rupture of the muscle cells and tissues by large crystals of ice, and partly by the permanent irreversible changes in the muscle plasma which prevent frozen muscle from reabsorbing water on thawing.

Durability:

Frozen meat stored too long becomes dry, rancid and less palatable, the most important change being the breaking down of the fat into glycerin and free fatty acids with production of rancidity. Under suitable conditions beef will store for a year, mutton for 8 months and lamb for 7 months. Under exceptionally favorable conditions the fats of beef and lamb are resistant to oxidative rancidity and may still be good for 18 months storage at -8.5C. With regard to the storage temperature of frozen beef, -12C is considered suitable commercially, but scientifically a lower temperature of -18 to -15 C is preferable on all meats.

Effect of freezing on pathogenic micro-organisms and parasites:

Some bacteria are destroyed by freezing, but in others low temperatures merely inhibit their growth and multiplication until conditions favorable to their growth appear. Freezing is therefore of no great value in rendering a carcass affected with pathogenic bacteria safe for human

consumption, nor are the bacteria commonly found on beef carcasses destroyed by slow or sharp freezing.
Anthrax bacilli can withstand a temperature of -130C , while Salmonella can withstand exposure to -175C for 3 days, and tubercle bacilli have been found alive after 2 years in carcass frozen at -10C. The virus of foot and mouth disease can remain viable for 76 days if carcasses of animals slaughtered during the incubative stage of the disease are chilled or frozen immediately afterwards.
Freezing is however a valuable method for the treatment of meat affected with certain parasitic infections. Beef with cysticercus bovis can be rendered safe if held for 3 weeks at a temperature not exceeding -6.5 C, or for 2 weeks at a temperature not higher than -10 C.

Imported meat:

Identification and inspection:
Frozen beef is cold, moist, possesses no sheen , and on thawing exhibits a considerable amount of weeping or drip. The muscular tissue is a bright red color in home-killed beef, a bright red and occasionally blue in chilled, and pale red in frozen beef.
A characteristic feature of imported frozen mutton and lamb is the ragged, dirty appearance and grey color of the carcass surface, which is in marked distinction to the light sheen on the surface of home –killed mutton or lamb.

4. Heat – Thermal Processing:

The underlying principle of all food preserving methods is either the creation of unfavorable environmental conditions under which spoilage organisms cannot grow, or the destruction of such organisms. In commercial canning, carefully selected and prepared foods contained in a permanently sealed container are subjected to heat for a definite period of time and then cooled. In most canning processes, the heat destroys nearly all spoilage organisms and the permanent sealing of the container prevents re-infection.
Recently a new method of canning, known as aseptic canning, has been developed which involves the use of high temperatures for shorter period. The food is sterilized at 120C for 6 sec to 6 min, depending on the food, before it enters a sterilized can which is then closed with a sterilized lid. This method is to improve flavor and vitamin content.
More recently aluminum or coated aluminum has been used in the fabrication of cans. While it has the advantage of lightness and freedom from sulphiding and rust, it buckles fairly easily.

When bacteria in a suspension are exposed to heat, the number remaining alive follows a logarithmic course (survivor or thermal death rate curve) against the length of heating time at a constant temperature. The decimal reduction time is the time taken at a constant temperature to reduce the surviving bacteria in a suspension to 10% of their original number. Total sterility is never achieved and the effect of any thermal processing is measured against the activity of the spores of Cl. Botulinum , the most heat-resistant pathogenic form known.
In modern canning operations there must be sufficient heat to reduce the population of cl. Botulinum spores by a factor of 1000,000,000,000. i,e a heat equal to twelve times the decimal reduction time of Cl. Botulinum spores. Foods with a pH of less than 4.5 , in which Cl. Botulinum spores do not germinate, may be subjected to milder heat treatments.

Treatment of food to be canned:
The food to be canned must be clean and of good quality. Use of any material showing obvious signs of spoilage will result in deterioration in quality of the product. A firm dry pack is required for meat foods without any excess of free liquor in the can, the moist content of meat is therefore reduced by parboiling in steam-heated water which produces up to 40% shrinkage in corned beef. Highly fattened animals are unsuitable for corned beef.

Canning operations:
Cans may be filled either by hand or by automatic machinery, the next process being exhaustion or removal of air from the can before it is sealed.

Exhausting:
It is necessary for the following reasons,
- to prevent expansion of the contents during processing.
- to produce concave can ends so that any internal pressure may be readily detected.
- to lower the amount of oxygen in the can and prevent discoloration of the food surface.
- to reduce chemical action between the food and container, and hydrogen swells.

Exhaustion can be carried out in two ways:
1. heat exhausting
2. vacuumizing

Processing:

All canned foods are processed, i,e. given final heating, after hermetic sealing. The term processing is an exact one , it is not sterilization as certain canned foods after processing may still contain living organisms. In non-acid foods , such as meat, the destruction of bacterial spores is slow, temperatures of about 115C are required for adequate processing within a practical time limit. In commercial practice , the cans are placed in metal baskets in closed retorts and processed by steam pressure.

Cooling:
Prompt cooling after processing is important, as it checks the action of heat and prevents undue change in texture and color. In addition , cooling quickly reduces the considerable internal pressure of the cans which builds up during processing.

Bacteria in canned foods:

It was at one time thought that the keeping qualities of canned foods depended upon the complete exclusion of air. Later it was suggested that the heating destroyed all micro-organisms, while the sealing of can prevented the entry of others, and that decomposition , when it occurred , was due to faulty sterilization or to entry of bacteria through a fault in the can. Neither of these views expresses the whole truth because living bacteria can often be found in sound and wholesome food, and bacteriological methods showed that many canned meats or meat products contain living organism, even after modern processing methods; the mere presence of living organisms is of little or no significance in assaying the soundness of canned foods.
The organisms responsible for spoilage in canned foods may be spore-forming and therefore resistant to commercial processing. Aerobic spore forming bacteria may be present in sound samples of canned goods. Spores probably remain dormant under the anaerobic conditions of a properly sealed tin but, if supplied with air through faulty sealing, may develop and produce enzymes which decompose the foodstuff.
Non- sporing proteolytic or fermenting bacteria, e.g. Proteus and E. coli, may cause decomposition of canned foods; no single type is responsible for microbial spoilage. Yeasts and moulds are of great importance as a cause of unsoundness in acid substances containing sugars, e.g. canned fruits, they are of less importance in canned meats and marine products. The presence of yeasts, moulds and non-sporing bacteria in canned meats is evidence of leakage after sealing and can make the food unsound; canned foods which, on opening show such evidence should be condemned.

Types of spoilage:

Canned foods are classified as spoiled when the food has undergone a deleterious change, or when the condition of the container renders such change possible. Spoiled cans may show obvious abnormalities such as distortion, blowing, concave ends or slightly constricted sides; or they may present a perfectly normal external appearance.

A can with its ends bulged by positive internal pressure due to gas generated by microbial or chemical activity is termed a *swell* or *blower.*

A *flipper* has a normal appearance but one end flips out when the can is struck against a solid object but snaps back to the normal under light pressure. A *springer* is a can in which one end is bulged but can be forced back into normal position, whereupon the opposite end bulges. All blown cans pass successively through the flipper and springer stages and these two conditions must be regarded as suspicious of early spoilage of the can contents. A change in the appearance of the gelatin surrounding meat packs is usually associated with the formation of gas, the gelatin being discolored and more liquid in consistency, however, in hot weather the gelatin of meat packs is likely to be of a more fluid nature. These abnormal cans are brought about by imperfect canning operations such as inadequate exhaustion of air before sealing, overfilling and the so-called " nitrite swell" which arises during thermal processing and is recognized during subsequent cooling but whose nature is not fully understood.

A *leaker* is a can with a hole through which the air or infection may enter or its contents escape.

An *overfilled can* is one in which the ends are convex due to overfilling, but most tins classified as overfilled are actually in the early stage of blowing. Though an overfilled can cannot properly be regarded as a spoiled can, it must be differentiated from a blower, and it emits a dull sound when struck, whereas a blown tin emits a resonant note.

Spoilage of canned foods may be microbial or chemical origin or due to deleterious influences such as rust or damage.

Microbial spoilage:

Bacteria of decomposing or fermenting type are the most important as regards canned foods, while spore forming bacteria are the most resistant. There are three main types of spore forming organisms which can resist normal processing and may cause spoilage in canned foods:

- gas producing anaerobic and aerobic organisms with an optimum growth temperature of 37C
- gas producing anaerobic organisms growing at an optimum temperature of 55C

- non gas producing aerobic or facultative anaerobic spore forming organisms with an optimum growth temperature of about 55C , which produce flat sours.

Microbial spoilage may result from under-processing or leakage through the seam. Leakers can be detected by the disappearance of the vacuum from the sides and ends of the can, and bubbles appear if the can is held under water and squeezed. Mould formation on the surface of canned meats is also indicative of leakage, but cannot be detected until the can is opened.

Chemical changes:

Hydrogen swell may occur quite independently of fermentation or bacterial decomposition, and is associated with the formation of hydrogen gas in the can following internal corrosion. Imperfections or scratches on the inner tin coating may expose small areas of iron , and where the contents are acid , an electric couple may be set up, the reaction producing hydrogen gas. Cans affected with hydrogen swell may show varying degrees of bulging from flipping to blowing. If the tin is punctured, there is emission of hydrogen gas , which is odorless and burns on application of a flame.

Purple staining on the inner surface of cans in which sulphur-containing foods are packed may occur with all fish and meat products, especially liver, kidneys and tongue. It is due to the breakdown of sulphur containing proteins at high temperature processing by the thermophilic Clostridium nigrificans, hydrogen sulphid is liberated and a thin layer of tin sulphide is formed on the inside of the can.

Rust or damage:

Cans showing external rust require careful consideration, and it is a condition particularly liable to occur beneath can labels when the *adhesive contains hygroscopic substances. Cans in which the external* surface is slightly rusted without noticeable pitting of the iron may be released for immediate sale and consumption but if the rust is removed with a knife and inspection with a hand lens reveals the iron plate to be definitely pitted, there is danger of early perforation and the cans should be condemned.

considerable significance should be attached to cans *damaged* by rough handling, the important factor in their judgment being the extent of location of the damage. Marked deformation of the seam of the can is attended by a considerable risk of leakage and such cans should be condemned. Slight indentation on the can body are permissible , but severe dents on the body may cause seam distortion and such cans should be rejected.

The public health aspect of canned foods:
Food poisoning is usually the result of improper handling of food during preparation or storage, and with the exception of botulism, food poisoning outbreaks are nearly always caused by bacteria which would be destroyed during processing. Salmonella are destroyed with certainty by the temperatures attained in commercial processing.
The minimum standard of processing now universally recognized by reputable canners ensures the destruction of Cl. botulinum spores in low and medium acid foods.
Staphylococci, and streptococci are now recognized as a cause of food poisoning. The main source of these organisms is the human or animal body where they are normally present on the skin, in the intestine and in the respiratory tract. Staphylococcal enterotoxin may withstand a temperature of 100 C for 30 minutes.

Microbiological examination of canned meats:

Where suspected outbreaks of food poisoning attributed to canned food occur the normal laboratory procedures for isolation of the responsible organisms (Salmonella, Staphylococcus, Clostridium, etc.) are adopted , care being taken in the sampling, transport, etc. of the suspect food. Attention is directed to the standards of methods used at the point of production, viz. hygiene levels, temperatures of heat treatment, water supply, etc.
Examination of the quality of containers is important to ensure that there no damaged, rust, blown, etc cans. Five containers are examined visually and their contents examined microbiologically.

5. Other Methods of Meat Preservation:

Antioxidants:

Any substance which delays, retards or prevents the development in food of rancidity or other flavor deterioration due to oxidation. Some antioxidants are permitted in foods, e.g. propyl gallates, BHA, BHT, ethoxyquin.

Preservatives:

Any substance which inhibits , retards or arrests the process of fermentation , acidification or other deterioration of food. Many different substances could be included in this definition , e.g. herbs, spices, vinegar, antioxidants, smoking, etc. however, the list of permitted

preservatives is relatively short and consists of eight substances, some of which are widely used while others have a very limited application. They are sulphur dioxide, sodium nitrate, sodium nitrite, benzoic acid (all widely used), porpionic acid , sorbic acid , tetracyclines, copper carbonate.
In the assessment of any additive for use in a food, three criteria have to be considered:
1. benefit or need accruing to the food industry, retailers and consumers.
2. safety in use
3. satisfactory standard of purity of the chemical.

Irradiation:

Electromagnetic radiation is known to inhibit the growth of micro-organisms . attention has been paid to the effect on the nutritional value of the treated foods, as well as the possible production of carcinogens and induced radioactivity.
***Infrared rays**:*
High energy lamps can produce temperatures in the range of 760-980C .

***Ultraviolet**:*
These occur at wavelengths of radiation between 100 and 3000 A and are invisible(A, Angstrom) , a mercury –vapor lamp can be used for this purpose. They have a bactericidal action which is especially valuable for destroying air-borne bacteria, and are utilized in storage vats and other tanks to destroy micro-organisms on or above the surface of foods.

***Ionizing radiation**:*
Irradiation of food can be achieved by using either gamma-rays produced by a radionuclide, usually cobalt 60, or high energy electrons generated by machines. Both the gamma rays and electrons produce ions which induce a sequence of chemical changes in food, thus causing the particular effect for which the irradiation was applied, e.g. the killing of bacteria. Some of the uses of ionizing radiation are as follows:
- decontamination of food ingredients such as spices.
- reduction in the numbers of pathogenic micro-organisms
- extension of shelf- life.
--Insect disinfection .

Treatment and Disposal of By-Products:

By- products of the meat industry may be defined as everything from the abattoir or butcher's shop that is not sold directly as food. The need for

efficient treatment of these products is based on the necessity for their rapid hygienic disposal, thus avoiding decomposition, the formation of obnoxious odors and contamination of fresh meat. Efficient processing of abattoir by-products secures and economic return on material which would otherwise be wasted.
Products other than carcass meat, hides and skins may be divided into edible and non-edible offals, but this distinction is not rigid. For example, while sound liver is a valuable edible product, it is classed as inedible when affected with fascioliasis, although it can still be utilized for pharmaceutical purposes. Examples of edible by-products are offals such as liver, kidneys, thymus, pancreas, edible blood and fat, while inedible, raw bone, horns, hooves and inedible raw blood and fat.
Efficient methods of handling by-products will result in a larger amount of edible products of high quality, particularly in larger meat plants, and better meat plant economy.

Buildings:

Premises should be situated so that raw material can be conveyed to them with minimum handling, they should be spacious, well lit and ventilated, with impervious walls and floors. Floors should be sloped to open channels leading through fat traps to the drains. The secret in the production of high-grade animal by-products lies in prompt treatment of the raw material. Animal offals decompose rapidly, depreciating markedly as a result, and it is therefore essential that no raw material is left untreated after a day's slaughtering.

By-product treatment:

The by-products that must be undergo some form of processing before final use are: fat (edible and inedible); stomach and intestines; blood; bone (edible and inedible); hooves; horns, hair; bristle; hides; skins; glands; condemned carcasses; and offal.
It has been calculated that of 170 kg of bovine by-product going for inedible rendering there is 45 kg carcass bone, 10 kg head, 7 kg manifold, 30 kg intestines, 10 kg feet and 5 kg spleen, thymus, spinal cord and tonsils.

Fat:

With the exception of hide the most important abattoir by-product is the fat trimmed from the intestines, kidney, channel and other internal organs of cattle. Fats are graded 1, edible fat, and 2-6, inedible fat. The grades are dependent on free fatty acid (FFA)and color. Caul (omentum and its contained fat droplets) and kidney fat are rendered to produce premier jus, which is separated into oleo oil and oleo stearin. Dripping is made from caul, kidney and body fat. Grades 2-6 are used in animal feeds, soaps and the chemical industry.

Edible fat rendering:

High quality fats have low FFA values and are usually stable. Efficient rendering processes ensure that the FFA content remains low by means of initial cold storage of the raw material , followed by keeping the processing temperatures as low as possible and the cooking time is minimized. There are three main methods of processing edible fat; wet rendering, dry rendering and continuous low temperature rendering.
The wet rendering method involves the use of pressure batch cookers in which the pre-cut raw material is injected with live steam to a temperature of 140 C under pressure , for 3-4 hrs.
The dry rendering process uses heat in the form of steam and water over a period of 1-2 hrs at atmospheric pressure to drive off water indirectly from the fat in the cooker.
The continuous low-temperature rendering system uses heating, separation and cooling on a continuous basis, and is usually regarded as the ideal process.

Stomach and intestines:

The manufacture of pet-food utilizes the stomachs of cattle and sheep. Attempts are being made to use stomach contents for cattle feed, following suitable treatment.
There are two forms of gut cleaning: fresh cleaning in the abattoir immediately after slaughter and dressing, which is the ideal method; and overnight soaking in water at 21C before further treatment.

Blood:

Edible blood:
This is forbidden according to our Muslim beliefs. Blood is easily contaminated with stomach ingesta, urine or any other foreign materials. It must also originate from healthy animals which have passed veterinary inspection . If an animal is condemned , its blood must also be condemned. Moreover, blood is a perfect medium for most micro-organism growth.

Inedible blood:
Blood collected without due care is inevitably contaminated , often contains fresh water , has a high water content (as much as 85%), low dry solids value and is often haemolysed. Drying into blood meal by removing the water is carried out in three main ways:
1. one stage drying to a final water content of 8-10%
2. coagulation in batches of blood, draining, pressing and final drying.
3. preheating, coagulation, and separation in a continuous process followed by drying.

Bones:
Bone may be classified as edible and edible depending on its source and its handling. The end products of bone processing are fat, bone meal and gelatin with meat-and-bone meal being produced when there is meat in the original raw material.
Owing to its high calcium and phosphorus content, bone meal is used as a constituent of poultry feeds and as a fertilizer. Special bone powders are employed for the removal of fluorine from drinking water. Gelatin is produced from edible bones subsequent to the extraction of fat under carefully controlled pressure. It is used in brawn, pies, ice cream and capsules for medicines, in photography, as a culture medium for bacteria and in the production of smokeless gun powder.

Hoofs and horns:

Hoofs are removed from the feet by steeping in hot water and then drying. White hoofs are sold to manufacturers of horn articles such as combs and buttons. Black hoofs are dried in a steam drier and ground into hoof meal fertilizer. Horns are used for manufacture of combs , buttons, knife handles, and fertilizer. Horn and hoof meal are widely used for making foam-type fire extinguishing fluids.

Hair and bristles :
Used as a binding agent and as felt for placing beneath carpets as well as for brush making.

Hides and skins:
Hides arrive at the tannery either fresh from the abattoir or salted and dried to prevent putrefaction. After soaking in water to cleanse and soften them they are placed in pits filled with milk of lime for 1-4 weeks to loosen the hair and open up the fibers. The hair on the outside , and flesh and meat on the inside, is then scraped off and, after removal of lime by washing in weak acid, the hides are tanned.

Treatment of Condemned Meat and Offals:

Meat and offal that are dangerous , or that show such a deviation from the normal as to render them repugnant or innutritious to the consumer. Such meat must undergo varying treatment before it is released for sale, such meat is subjected to heat treatment by boiling, but in some cases it is rendered safe by adequate refrigeration, pickling or other means.

Processing of inedible material:

The production of end-products from these wastes, e.g. bone meal and meat-and-bone meal, and the use of these for animal feed purposes may cause problems unless safe methods of treatment are employed. Salmonellosis and anthrax have occurred in livestock because of their presence in bone and meat-and-bone meals. The practice of recycling animal wastes as food for animals can produce other health risks. For example, poultry manure is used as cattle feed. In addition to the possibility of salmonellosis and botulism there may be a problem of chemical residues occurring in cattle as a result of this practice. The vast pet-food industry is also involved in this matter.

It must also remembered that the personnel employed in the animal by-product industry are especially at risk and the greatest care must be taken to safeguard their health with proper codes of practice, good hygiene facilities, health inspections and vaccination programs where necessary.

Inedible rendering plants:

The best and most economical method of processing unfit meat and offal is by heat treatment in a jacketed cylinder, which gives complete sterilization and maximum return from the rendered material. A number of different methods are available for handling inedible material, all of which are concerned with separation of three main constituents, fat, water and fat-free substance, and the production of sterilized technical fat and meat-and-bone meal.

Pre-slaughter Handling and Veterinary Ante-mortem Inspection:

A proper meat inspection service consists of a veterinary examination of the live animal or bird, an examination of the carcass and offal and , where necessary , laboratory tests (pathological, microbiological and chemical) of body tissues and fluids. All advanced meat inspection regulations specify the need for an examination of the live animal or bird. Where this is not performed, the situation cannot be regarded as an adequate protection of the public health nor can any contribution be made in the promotion of animal health.

The purpose of the ante-mortem inspection is twofold. The public health significance enables the veterinarian to separate the animals into three classes:

1. animals able to progress for normal slaughter.
2. animals which should not enter the plant or which should be removed from slaughter.
3. animals which may be slaughtered but may need special detailed post-mortem examination .

Ante-mortem also enables the veterinarian to assess the welfare conditions in which the animal is placed.

The details of the ante-mortem inspection being given as follows:

1. animals intended for slaughter shall undergo ante-mortem health inspection within 24 hrs of arrival at the slaughterhouse.
2.the ante-mortem inspection should be made under adequate natural or artificial lighting.
3. the ante-mortem inspection shall determine:

a. whether the animals are showing symptoms of disease which can be transmitted through the meat to humans or animals.
b. whether they are showing symptoms of a disease or disorder which would be likely to make the meat unfit for human consumption.
c. whether they are injured, fatigued or stressed.
d. whether there is visible evidence that substances with pharmacological effects have been administered to them or that they have consumed any other substances which may make the meat unfit for human consumption.

4. animals shall not be slaughtered for production of meat for human consumption if they:

a. show any of the conditions mentioned in paragraph 3 (a), (b) and (d) of this schedule.
b. have not been rested for an adequate period of time, which for fatigued or stressed animals must not be less than 24 hrs.

5. an animal which shows any of the conditions mentioned in paragraph 3 (a) and (b) of this schedule shall be taken to and kept in that part of the

lairage provided for the isolation of animals which are diseased or injured or suspected of being diseased or injured.

Experience has shown that full ante-mortem inspection can represent at least 50%of meat inspection , making the post-mortem examination much more efficient and less laborious.
Ante-mortem inspection is of special importance in the handling and examination of casualty and emergency slaughtered stock. Ante-mortem inspection is of great value in the detection of animals suffering from scheduled and infectious diseases , particularly anthrax, and rabies which are communicable to man. It is also important in the recognition of diseases such as septic metritis and mastitis, sturdy in sheep, tetanus, rabies or tuberculous meningitis in young cattle which are difficult to detect in the carcass and organs after slaughter and other diseases which cause locomotor dysfunction , e.g. lead poisoning.

Inspection facilities:
Adequate identification of the live animal is legal requirement and is essential for farm use for accurate disease information. Animals are required to be properly identified under identification, marking and breeding records. Many different forms of identification exist including metal, plastic or nylon ear tags, ear tattoos, neck, tail and leg brands, freeze brands, and marking aerosols and paints for cattle, some of which are also used for sheep. Ante-mortem facilities must also include properly designed and well-lit lairage pens which must possess an isolation pen and a crush for the examination of individual animals.

Ante-mortem inspection procedure:

-Ante-mortem inspection procedure specifies that animals must be examined on the day of arrival at abattoir.
-Livestock should be inspected in lairage pens while at rest and in motion.
-Sick or suspect diseased animals , and those in poor condition, the species, class, age, condition, color and markings are recorded.
-Special attention must be paid to casualty and emergency slaughter, none of which should escape ante-mortem.
-The general behavior of the animals, whether fatigued or excited, their level of nutrition, cleanliness, obvious signs of disease and any abnormalities should be observed.
-In addition to the segregation of diseased and suspected stock, females in estrus, aggressive animals, and horned stock should be isolated.
- The same general principles apply to poultry as for the larger animals.

Decisions:

The immediate main purpose of ante-mortem inspection is to separate normal and abnormal stock. Normal animals are sent forward for slaughter, abnormal animals being classified as either unfit for slaughter or affected with a localized condition or one which will show post-mortem lesions.

Stock unfit for slaughter will include emaciated animals, those affected with certain diseases, such as tetanus, or a communicable disease, e.g. rabies, and those known to be carrying toxic residues. Fatigued and excited animals inadequately rested also come into the category of delayed slaughter, as do those requiring treatment.

Animals showing evidence of *localized conditions* such as injuries, fractures, abscesses , benign tumors (e.g. papilloma) which will show up lesions on post-mortem inspection need to be segregated and given a detailed examination. Such animals are passed forward for slaughter as part of regular kill , or slaughtered separately and given a thorough post-mortem exam.

Animals which show evidence of a disease which on P.M inspection would justify total condemnation of the carcass and offal or which represents an unacceptable risk for plant personnel or which would contaminate the premises and meat therein, should be condemned

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Thus the decisions to be taken by the veterinarian at ante-mortem inspection are as follows:

1. approval for slaughter,
2. condemnation,
3. slaughter authorized under special precautions,
4. delay of slaughter,
5. casualty slaughter.

Suspect animals sent for slaughter must be clearly marked and accompanied by a full veterinary report. Ante-mortem signs, P.M findings and the results of lab. Tests are all considered in making final judgment on the carcass and offal.

Special attention must be given to *recumbent animals.* The nature and extent of the disease involved will determine subsequent action, i.e.

immediate condemnation, passing for immediate slaughter or holding for further examination.
The greatest care must be taken in the handling , slaughter and dressing of animals which may represent a source of infection to plant staff.

On occasions, dead animals will be encountered during the ante-mortem inspection. Anthrax must always be borne in mind, when a blood smear should be taken , stained with polychrome methylene blue and examined for B. anthracis. When the possibility of anthrax is eliminated, hypomagnesaemic tetany should be considered, especially in cows in good condition.

In the case of *sick animals* the temperature should be taken, a rise in temperature may be the first indication of communicable disease, although in moribund animals the temperature may frequently be subnormal.

Suspect animals are those suspected of being diseased or affected with certain conditions that might result in condemnation of the carcass on P.M inspection. These animals are tagged as suspect until a final P.M exam is carried out. They include leptospirosis, anaplasmosis. T.B reactors, brucella - reactor goats, vesicular stomatitis, immature animals.

Animals that may be *condemned* include dead, dying and disabled livestock, any sheep, cattle, goats having a temperature of 106 F or higher, livestock in comatose or semi-comatose condition, livestock showing symptoms of certain metabolic, toxic, nervous or circulatory disturbances, infectious or certain parasitic diseases, and animals which have been injected with anthrax vaccines within 6 weeks.

Casualty and Emergency Slaughter:

It was found that 80% of the cases of food poisoning in Germany were associated with the consumption of the flesh of animals that had undergone emergency slaughter. It is important to distinguish between emergency and casualty slaughter:

Emergency slaughter is required when an animal is in acute pain or is suffering from a condition where a delay in slaughter would be contrary to animal welfare e.g. fractures, severe injuries, uterine prolapse and post-partum uterine hemorrhage in the bovine.

Casualty slaughter refers to the situation where an animal is not in acute pain or immediate danger of death , but affected with a more chronic condition, e.g. obturator paralysis and post – partum paraplegia following milk fever in the cow, or benign superficial tumors.

Slaughter of a food animal on account of accident or injury is fully justified on economic and humane grounds. The commonest injuries encountered in the food animals are fractures of the limbs or pelvis, while extensive bruising may occur as the result of an accident or when an animal has become recumbent during transport and has been trampled on by other stock. Severe laceration and bruising , particularly of the head, throat and hind limbs, is commonly seen in sheep worried by dogs.

Judgment will depend on whether the animal has been promptly bled and eviscerated.
Acute respiratory distress , with danger of asphyxia, may necessitate emergency slaughter and is seen in cattle as a result of tympanitis after consumption of fermentable fodder, or as the result of obstruction of the esophagus with a portion of root. The latter may frequently give turnipy odor to the carcass necessitating total condemnation , in addition rigor mortis passes off quickly and after 24 hrs the carcass is often soft , flabby and has lost its bloom. Asphexia in the cow may also result from an attempt to swallow the placenta.

Veterinary certificates:
Many countries in Europe prescribe that no case of emergency slaughter passed for food until bacteriological exam. has been made of the carcass and organs, and all cases of emergency slaughter must be accompanied by a veterinary certificate.

Categories of animals for emergency slaughter:

- The animal may arrive alive but in a moribund state:
Cattle and sheep in a moribund condition usually stiffen immediately after slaughter, especially when they have suffered from digestive disorders and have been generously dosed with medicine. In very severe injuries or bruising, the blood has a thicker and more viscous appearance, but in anaemia and red-water the blood is thin and watery**. Judgment of carcasses of animals which have been arrived at an abattoir but in moribund state warrants total condemnation.**

- The animal may arrive killed and uneviscerated:

Such animals may have been killed and bled , or they may be unbled, but in all cases of dead cattle arriving at an abattoir, no matter what explanation is offered by the owner as to the cause of death**, these carcasses must not be unloaded**. Coldness of the extremities and , in cattle, evidence of tympanitis in the left flank are indications that death has not been recent. The subsequent dressing of all dead animals , whether bled or not, should be forbidden.

-The animal may arrive in the form of a dressed carcass:
These carcasses frequently present great difficulty in judgment. Those unaccompanied by the internal organs must be condemned. In dead eviscerated cattle it is frequently observed that the two forelimbs have not contracted uniformly. Flexion of forelimbs together with a brownish – red coloration of the flesh is an indication that the animal was slaughtered after a long illness.
Judgment of the carcass of an animal slaughtered on a farm must be made by examination of the carcass lymph nodes for enlargement, hemorrhages or tuberculosis, and to the kidneys for the degree of bleeding. An incision should be made into the musculature to test for any abnormal odor and, if found , a portion of meat should be subjected to a boiling test.

Only where an emergency –slaughtered animal shows no evidence of disease , has a negative bacteriological and residue test, and the carcass sets and looks normal in every way, should one consider passing it for food.
On occasions animals which have been the subjects of scientific experiments may be consigned to the meat plant. This special category of casualty animal must be accompanied by a veterinary certificate which gives the full details of the procedures and compounds used in the experiment.

Humane Slaughter:

The essentials in the slaughter of food animals are that they shall be dispatched without unnecessary suffering and that the bleeding shall be as complete as possible. Good bleeding is only ensured if it is carried out immediately after stunning and if the animal is healthy, but is retarded in all affections which adversely affect the action of heart, lungs and muscles. In conventional slaughtering methods in most developed countries, it is normal practice to render the animal insensible by stunning, and then to kill it by bleeding.

The permitted humane slaughtering methods for farm animals at present are the free bullet, captive bolt pistol, concussion stunner, electrical stunning and carbon dioxide anesthesia. There is an overall proviso that slaughter by the Muslim method must not inflict unnecessary suffering.

Consciousness may disappear as a consequence of sleep, concussion, the administration of an anesthetic, lack of blood supply to the brain and thereby oxygen (anoxia), an electroconvulsive shock or death. In the act of slaughter it is essential that a state of unconsciousness or insensibility be instantaneously produced to ensure total freedom from suffering. Where cardiac arrest has been created there is immediate insensibility which is permanent. Although cardiac dysfunction results in this method, adequate bleeding also ensues , making this a most important development in the slaughter of animals.

Methods of stunning:

The stunning of an animal by means produces a rise in the blood pressure of the arterial , capillary and venous systems, and in sheep the normal arterial blood pressure of 120-145 mmHg may rise to 260 mmHg or over when the animal is stunned prior to bleeding. This is accompanied by a transitory increase in the heart rate. Both of these factors will facilitate immediate bleeding. If an undue interval is allowed to elapse between stunning and bleeding, the carcass may be imperfectly bled and may bear blood splashes.

The choice of a particular method of stunning depends on many different factors – class of animal , human aspects, capital and maintenance costs, efficiency of equipment, ease of operation, safety of personnel, effects on carcass and brain, along with religious and legal requirements.

- Captive bolt penetrative stunning:

Precludes the use of brains for human consumption. It does not produce an adequate length of insensibility and can produce brain and muscle hemorrhages. Many different types of captive bolt pistol are in use throughout the world, and they are generally operated by means of a blank cartridge. Bolts with sharp ends may penetrate the frontal bone of the animal or cause concussion without penetration.

- Non – penetrative percussion stunner:

Using mushroom head are sometimes used in calves where brains are collected for edible use. This method is capable of producing immediate insensibility which lasts for more than 30 seconds in calves. Care must be taken to hold the instrument reasonably firmly against the animal head at the proper point. In cattle the correct point is in the middle of the forehead. In hornless sheep and goats the pistol is placed on the top of the head, while for horned sheep and goats the muzzle is placed behind the ridge which runs between the horns.

- Electrical stunning:

This method consists of passing an alternating current through the brain / heart of the animal, the instrument most commonly employed being one which resembles a pair of tongs. The strength of the electric shock should be of sufficient magnitude, this is dependent on the strength of the current, which should not be less than 250 mA, and the voltage , which should not be less than 75 V, while the sufficient time 10 seconds is recommended. Since the brains of animals are relatively small, it is important that electrodes are accurately and firmly placed high up on the sides of the head.

Effects of stunning on meat quality:

Most of problems associated with penetrative percussive stunning (captive bolt) appear to be associated with an unduly long interval between stunning and slaughtering and/or inadequate penetration of the bolt, resulting in blood splashing in muscles.

Non- penetrative percussive stunning does not normally result in blood splashing but may induce intracranial hemorrhages in those animals with thin frontal bones.

An advantage of electrical stunning related to the period of tonic and clonic muscle spasm is an increase in muscle glycolysis and lowering of pH in sheep.

Stunning of poultry:

In poultry the speed of operations, which may be as high as over 6000 birds per hour, complicates the stunning procedures. Several types of electrical stunning devices are utilized for poultry depending on processing speed. In all cases bleeding is carried out immediately after stunning..

In ***hand stunning devices*** one manually operated instrument is fitted with a step-down double-wound transformer to give 50, 70 and 90 V and respective currents of 100, 200 and 250 A when connected to AC mains of 200 -240 V. this device appears to be satisfactory and humane when used on domestic fowls of an average weight of 2kg with a shock duration of 1-3 seconds. This method is only suitable for low rates of kill up to 1000 birds per hour.

Automatic stunning devices : may be of high or low voltage type, and are used on high-speed poultry lines.

In high voltage types, 400-1000 V are carried in a grid over which the shackled birds are conveyed. Usually only the comb touches the grid, but other parts of the body may be involved. Disadvantages of these devices include: a high percentage of cardiac arrest, severe muscle contractions, fractures, imperfect bleeding, and possible risk to employees.

Low- voltage electric stunners (50-60 V) markedly reduce the above disadvantages and there is satisfactory narcosis with no pain or stress. One form of low – voltage stunner utilizes a cabinet on the conveyor line through which the birds pass while suspended on shackles , electrical contact being made for a period of 5 sec. An automatic poultry stunner recently employed in Britain uses 50 V and 200 mA for broilers and 70 V for chickens , the birds heads being dawn through an electrified water-bath.

Effects of stunning on poultry –meat quality:

As with the larger farm animals deleterious changes sometimes occur in poultry carcasses after slaughter and are attributed to

defects in the slaughter methods. These frequently result in downgrading and even condemnation.
A broiler is said to be properly bled if it does not show redness on the surface of the
skin or engorgement of the visceral blood vessels. Redness of the wing tips and tail are evidence of poor bleeding, as is hyperemia of the carcass. Research work has shown that the highest blood loss occurs in broilers stunned at voltages between 50V and 80 V. Voltages higher than this generally result in lower blood loss.

Muslim Method of Slaughter:

The welfare of the animal is a major consideration in Muslim faith and the eating of dead animals, consumption of blood and of swine is forbidden. The Holy Quran describes the procedure of carotid – jugular- section as the " cutting and draining of blood".
Animals must not be slaughtered in the sight of other beasts and those to be killed are to be fed and watered beforehand. The act of cutting the skin with a sharp knife is regarded as painless , or almost so, and the rapid loss of blood is said to produce instantaneous insensibility. The opinion is held that the brain and the skin of an animal are less sensitive than those of man. Just as defective methods may be used in stunning by mechanical means so also can " throat cutting" be imperfectly performed with the result that not all four blood vessels are severed. Islamic law demands that the animal is alive at the time of slaughter and that it is slaughtered in the most humane manner. The Prophet Muhammad (salla Allah Alaih Wa Sallam) saying that " God who is blessed and exalted has declared that everything should be done in a good way; so when you slaughter, use a good method, and you cut an animal throat, you should use a good method; for each of you should sharpen his knife and give the animal as little pain as possible".
Muslim method of slaughter is not controlled by a central Board but is overseen by the local Islamic authority (Muftis) who

decide whether or not particular acts and thoughts conform to the tents of Islamic Law (Shariah). So in some instances prior stunning with electricity or captive bolt pistol is allowed. (A head only stun of 0.5 -0.9 A for 3 sec is performed, major blood vessels being severed within 6 sec of stun.) . It is also understood that percussive stunning has been permitted in some quarters. Provided it can be shown that the heart is still beating after stunning, prior anesthetization is approved , at least in some instances.

Meat Hygiene Practice:

The safeguarding of a country meat supply depends on the diligent implementation of legislation relating to abattoir construction and operations and meat inspection along with control of the following:
1. the use of chemical and pharmaceutical preparations of the farm.
2. the promotion of high health standards in livestock and their general care during transportation, at auction markets and in meat plant lairage.
3. ante-mortem examination to eliminate unfit animals and to make provision for special post-mortem exam.

4. post-mortem exam. of the carcass and offal immediately after slaughter, including lab. testing where necessary.
5. removal of material unfit for human consumption and its efficient destruction at processing plants located outside the meat plant.
6. high standards of hygiene at all stages from the farm to the meat plant, meat processing factory, cold store, restaurant kitchen and the consumer- home.

A good meat hygiene system not only results in the provision of a sound and wholesome product for human consumption with good keeping qualities but can also make an important contribution to the control of animal disease by making available to producers the valuable information obtained on meat inspection.

Production of clean healthy livestock:

The production of carcasses of high hygienic standards demands sound husbandry methods which pay close attention to animal health as well as cleanliness in the final stages of finishing. The following points should be given due attention by farmers producing stock for slaughter:
1. Housing structure and layout.
2. Bedding. Adequate bedding is essential.
3. Housing density, cattle should not be crowded.
4. Grooming.
5. Management. Close attention must be paid to management to ensure that the cattle do not become dirty.
6. Internal parasitism. Adequate nutrition and anthelmintic treatment should be provided , especially for sheep.
7. Transport and abattoir lairages. Clean conditions must apply during transportation and the wait for slaughter.

Vaccine and drug injections:

Careless and unhygienic use of hypodermic syringe is responsible for much unnecessary and considerable damage to carcasses and consequent partial condemnation due to the production of abscesses, and in some cases necrosis at the site of injection.
The site of injection has to be carefully selected and must not be an area which is associated with the more expensive cuts. Some anthelmintics which are injected sbq in cattle and sheep can cause a very severe reaction and staining at the site of injection. This makes it imperative that not only is sterile technique observed , but that the very long withdrawal period , of over 8 weeks in some cases, is also adhered to.

Livestock housing:

The basic requirements for the welfare and housing of livestock are:
1. Readily accessible fresh water and nutritionally adequate food are required.
2. adequate ventillation and a suitable environmental temperature.
3. adequate freedom of movement.
4.sufficient light for satisfactory inspection.
5. rapid diagnosis of injury and disease.
6. emergency provision in event of a breakdown of essential mechanical equipment.
7. flooring which neither harm nor causes undue strain.
8. avoidance of unnecessary mutilation.
9.effectively cleaned and disinfected.
10. a dry lying area. Straw or its equivalent if necessary.
11. no sharp edges or projections.

Transportation of livestock:

Having produced healthy animals in good condition and as clean as possible it is necessary to keep them free from contamination during the subsequent movement to the point of slaughter. It is of equal importance that they be kept free from injury, stress, loss of weight and disease during the journey. For all these reasons it is essential that livestock be slaughtered as near as possible to the point of production in order to avoid long journeys. The humanitarian aspects of the transportation of animals are intimately link with economic ones and these are of particular sequence in the case of young stock and casualty animals.

Conveyance of live poultry:

This prohibits exposure to inclement weather, the transport of injured birds, the use of unsuitable receptacles, mixed consignments and unnecessary long confinement in crates. It stipulates that there must be careful handling of receptacles and proper ventilation.

Transit of animals:

Animals must be protected from injury and unnecessary suffering while being loaded and unloaded and during transport, and this includes protection from inadequate and insecure fittings, inclement weather and inadequate ventilation. The transport of unfit animals and those likely to give birth during the journey is prohibited. The onus for the supply of food , water , general care and the provision of an attendant is placed on the owner or charterer of the vehicle. Receptacles for the conveyance of animals must be properly constructed, must not be overcrowded or liable to cause injury or suffering, and must be properly labeled indicating the species of animals contained therein and the upright position of the receptacle.

Stress:

During the process of loading at the farm, the journey to the abattoir or market, the period of holding in the market, the off-loading , the detention in the abattoir lairage and the subsequent

handling up to the point of slaughter, the animal is subjected to a wide variety of stressors, many of which may have adverse effects with subsequent deleterious changes in the carcass. Even death may ensue.
In addition to physiological trauma other stresses in the form of sound, light, heat, humidity, cold, wind and fear make excessive demands on the animal and may result in handling problems which may be reflected in abnormal bodily changes at slaughter. Significant changes in the thyroid hormone activity, corticoid, catecholamine and blood glucose levels ensue with increased respiratory and heart rates. Selye defined stress as a non-specific response in an animal attempting to resist or adapt to maintain homeostasis, i,e the tendency for the internal environment of the body to be maintained constant and in equilibrium.
There are two main reactions of the animal to stress: the alarm or emergency reaction and the general adaptation syndrome (together termed the fight-or-flight syndrome).
Changes in meat quality:
Changes in meat quality are mainly associated with levels of glycogen, lactic acid (pH), temperature , ammonia and amide nitrogen. Stress in any form seriously affects these entities; glycogene levels are decreased with the formation of less lactic acid after slaughter, a higher pH and poorer keeping quality of the meat. Should there be a rapid glycolysis and fall in pH immediately after death while the temperature of the carcase is still high, there is a reduced ability of muscle proteins to hold water and some proteins become insoluble in the acid tissue fluids, with the production of pale, soft exudative meat.
Similarly the dark, firm condition is associated with stressful situations prior to slaughter.

Bruising :

Time of bruising:
Although the presence of bruises at slaughter is apparent to the eye, knowledge of the exact time of infliction is necessary if

steps are to be taken to prevent bruising. At slaughter a bruise may be dated approximately by the following appearances:

Red and haemorrhagic	0-10hrs
Dark colored	24hrs
Watery consistency	24-38hrs
Rusty orange color (bilirubin) and soapy to touch	3 days+

A more specific method of dating is based on the formation of bilirubin from haemoglobin in the area of the bruise. A sample of bruised meat is soaked in Fouche,s reagent (trichloracetic acid and ferric chloride) ; bruises up to 50 hrs old give no reaction; those 60-72 hrs old turn the solution light blue, those 4-5 days old give a dark green reaction. The bulirubin test has shown 90% of poultry bruises to be inflicted 0-13 hrs before slaughter.

The age of bruising can also be estimated by measuring the electrical conductivity of the tissue, which increases up to maximum at 40 hrs.

Causes of bruises:

There are many causes of bruises such as rough handling, vehicle design and defects, presence of horns, temperament, stunning box design, mixing of animals, transport etc.

Loss of weight during transport:

All animals transported to slaughter will suffer some loss of live weight during the journey. The loss is mainly of water by sweating and respiration, and waste materials in the urine and feces. The factors affecting this loss are bodily condition , state of repletion, season, and journey time. Sheep lose 0.9-1.8 kg if kept in a lairage for 24 hrs and up to 3.6 kg during transport. A calf of 150 kg live weight loses 4 kg during its first day of travel and 1.8 kg on the second day. Broilers also lose weight during transit in proportion to the distance. In part this may be due to the high densities of stock in the crates, but it may also be ascribed to the inadequate protection from wind and heat. In

general therefore, there is a loss of total live weight and of tissue, which increases with the distance traveled.
The amount of weight loss is also increased with an increase in temperature and decrease in relative humidity.

Affections induced by transport:

Transit (shipping) fever is a catarrhal and often a fatal disease which chiefly affects store cattle in poor condition that have become fatigued by a long journey without sufficient food , particularly during the colder months. The disease probably consists of a number of related conditions of the respiratory tract in which viruses and bacteria play important roles.
The P.M. lesions take the form of lobar pneumonia with acute enteritis. The infection does not respond well to the treatment and early slaughter is advised before the onset of septic lung changes.
Transit tetany occurs under similar circumstances, almost invariably in cows, particularly those in advanced pregnancy and in the warmer months of the year. The disease has also been reported in pregnant ewes and associated with hypocalcaemia. Of 1625 pregnant ewes transported 456 km by road in USA , 41 died during transport and a further 41 over 4 days following transit. The disease bears a resemblance to milk fever and affected animals usually respond to calcium therapy.
Salmonellosis in young animals , especially calves and lambs , may be precipitated by transport stress and compounded by lack of food and water and by chilling.
Miscellaneous conditions following transport include heat shock, indigestion, abortion, post-parturient disorders, ketosis, foot diseases, enterotoxaemia, mastitis, and infertility.

Pre-slaughter treatment of animals resting in lairages:

It is necessary to rest fatigued and excited animals before slaughter, an inadequate rest period may reduce the keeping quality of flesh because of the incomplete development of acidity of the muscles and also the early invasion of the system by putrefactive bacteria from the intestinal tract. These bacteria are the essential cause of bone taint in cattle.

The actual duration of the resting period depends on many factors: species of animals, age, sex, class and condition, time of year, length of journey, method of transportation, etc.

Watering:

Animals should receive ample drinking water during their detention in the lairage as this serves to lower the bacterial load in the intestine and facilitate removal of the hide during dressing of the carcass. Stunning of the animals by electrical means is rendered more efficacious if they have received unlimited water during the detention period of slaughter.

Feeding:

It has been observed that fasted animals bleed better, that the carcass is easier to dress and that it has a brighter appearance. However, hungry animal does not settle as well as an animal that has been fed.

In sheep detained for 2,3 or 4 days there is a significant loss in carcass weight and up to 29% loss in weight of the liver. There is , however, justification for withholding food from cattle for a period of 6 hrs prior to slaughter as this minimizes the emigration of bacteria from the intestinal tract during digestion.

Fasting:

Besides the need for physiological normality in animals before slaughter, there is also a duty to ensure that they are not presented for slaughter with full stomachs. These requirements serve to prevent carcass contamination, wet hides and fleeces encourage the transfer of fecal material particularly to areas such as the shanks, brisket and hocks, full stomachs cause extensive contamination of carcass and offal if accidentally cut during the dressing procedure. The withholding of food, however, must be closely considered in relation to possible loss of body weight.

Lairage hygiene:

During the rest period in lairages animals must be kept under conditions which prevent any further contamination of feet, hides and skins.

Sources of bacterial contamination:

One of the main sources of carcass contamination in the meat plant is the live animal itself. Bacteria play an important role in the spoilage and decomposition of meat and also in food poisoning. Bacterial contamination of meat may occur in several ways:

1. The physiological condition of the animal immediately prior to slaughter has a profound effect on the carcass and subsequent development of deleterious bacteria. Early invasion of the blood vessels by micro-organisms from the intestines is likely in animals weakened by long journeys or ill prior to slaughter. In addition, the high pH of the flesh from exhausted or ill animals favors bacterial growth and prejudices carcass durability.
2. During the act of slaughter or sticking, bacteria can enter jugular vein or anterior vena cava and travel in the blood to the muscles, lungs and bone marrow.
3. Under ordinary conditions the heaviest and potentially the most dangerous load of bacteria is in the animal digestive tract. It is estimated that 28 gm of fresh bovine feces contains 1500 million bacteria. One serious source of contamination from digestive material is regurgitation which occurs when cattle are stunned and bled which causes severe contamination of the neck, throat and tongue.
4. contamination of the surface of the dressed carcass with bacteria from the outside of the hide is of considerable importance. It is estimated that 2.8 gm of soil can contaminate a whole side of beef to the extent of 200 000organisms per 6.45 cm2.
5. Actual contagion with dirty hands, clothing or equipment .
6. Muscles may be infected before slaughter by specific organisms responsible for illness of the animal. Some of these

organisms may belong to the group responsible for bacterial food poisoning in man.

Of the bacteria viable at 20C , about 50% were micrococci, 40% Gram-negative non-sporing rods and 10% Gram-positive rods, mostly non sporing. The organisms viable at -1C included Achromobacter, pseudomonas, Flavobacterium, Micrococcus and Chromobacterium. The moulds which occurred regularly are: Fusarium, Alternaria, Cladosporium, Mucor, Penicillium, Sporotrichum, Aspergillus and Thamnidium.

Methods of limiting or reducing bacterial contamination:

A considerable decrease in bacterial contamination of the dressed carcass may be ensured by subjecting the animals to an overhead spray in warm climates.
Measures to reduce contamination in the abattoir must follow those on the farm, during transportation and in markets. It is important that the flooring of the lairage pens and of the race leading to the stunning box should be non slip but at the same time readily cleaned.
In modern works cattle are bled while suspended, the skin of the neck reflected and the esophagus ligatured to prevent regurgitation of stomach contents. Skinning of the heads immediately after removal from the body and must be washed by high pressure water spray.. a circular cut should be made around the anus and the rectum enclosed by a polythene bag, secured with an elastic band , in order to prevent leakage of feces. The hide puller should operate with a downward action. The abattoir floor, walls, meat hooks and inspection tables must be washed down followed by normal disinfection to reduce the bacterial load to some extent, only intensive cleaning under mechanical pressure will bring about a substantial reduction in bacterial load.

Scalding and pressure cleaning:

Scalding and pressure cleaning of the slaughter floor, and frequent scalding of tools and equipment, are necessary if a low bacterial count is to be obtained.

Knife sheats:
Knife sheats made of plastic are unsatisfactory. A one peace stainless-steel sheat has been devised and gives excellent results.

Washing of the dressed carcasses:
The washing of the dressed carcasses by a fine spray of water will materially reduce the bacterial load of the carcass. Varying volumes , pressures and temperatures of water are in use at different abattoirs. The standard of purity of the water used for this purpose must be that of mains water. At Belfast meat plant, when washing of carcasses was carried out, water containing 15 ppm chlorine, temperature of 85-90 C applied through a fan shaped nozzle at a pressure of 100 psi, at a rate of 18 liters /min for cattle and 9 liter / min for sheep gave best results.

The washing of edible offal:
The washing of edible offal such as liver , kidneys, hearts, is another important issue of a satisfactory abattoir hygiene and it is essential that a continuous flow of clean water be used for this purpose.

Hand washing facilities and sterilizers:

Water should be sufficiently warm, and bactericidal soap along with disposable towels should be provided.

Chemical Residues in Meat:

A large number of drugs used to control or prevent infections or to promote growth are considered essential in modern animal production. Additional chemicals may be added to food to ensure maximum utilization and to delay deterioration. However, there is growing consumer resistance to the presence of unwanted residues in food. Detection of these unwanted residues presents a new challenge to meat hygienists. Traditionally , meat inspection has involved a visual ante-mortem inspection of the animal and P.M examination of the carcass and offal. Many of the drugs used in modern production however, are rapidly absorbed or are given orally and therefore do not produce lesions that can be observed post-mortem. Therefore, to reassure consumers, traditional meat inspection procedures need to be complemented by an increasingly wide range of laboratory procedures.

A *residue* is defined as a substance having a pharmacological action and of a conversion products thereof and other substances transmitted to meat and which are likely to be dangerous to human health. Almost all chemicals administered to animals result in some trace residue remaining in the carcass. Increasingly, laboratory technology is able to detect these minute traces. It is therefore important to differentiate between safe and unsafe residual concentrations rather than to insist on zero residues.

Clearance rates for drug can vary. Conditions that prolong the process can lead to tissue residues at slaughter. Even when drugs are used according to recognized dosages and routes of administration and when pre-slaughter withholding times are observed; other parameters , e.g. disease conditions, age of animal and husbandry practices, can result in violative tissue residues at slaughter. Drugs are also sometimes administered to food producing animals at a dose rate in excess of that recommended, by unauthorized routes or at more frequent intervals than specified. In all cases these therapies can alter the withholding time required to ensure that all tissues are clear of residues.

The pharmacokinetics (movement of drugs in the body) of specific preparations has a major effect on persistence in the animal tissue and is dependent on many factors. Formulation can give slow or rapid release. The chemical composition of some drugs prevent rapid metabolism. The route of administration , e.g by injection , orally or or other means , also affects the rate of excretion.

The therapeutic products that cause concern fall into a number of categories. The major ones are *antimicrobials* which are a diffuse group containing several classes of compounds used to treat or prevent bacterial infections. The *pesticides* are also a diffuse group including anthelmintics used for their activities against roundworms, tapeworms and fluke, ecto-parasiticides used to kill external parasites and antiprotozoals which are most commonly used for coccidiosis. *Hormones* are used for therapeutic purposes in various fertility treatments or for growth promotion when used by implant. One general category includes *tranquilizers and B – agonists.*

Animals are also exposed to many environmental contaminants including herbicides, heavy metals and fungicides. Some of these substances find their way into animal tissues via the feed.

In the preservation and processing of food, *additives* are employed to prevent the onset of spoilage , to promote binding properties and to enhance flavor and nutritive value. These additives include antioxidants, emulsifiers, humectants, firming agents, sequestrates, coloring agents, stabilizers, sweeteners, tenderizers, etc. at both production and processing stages, residues or contaminants may enter the food chain either from intentional or accidental exposure to these chemicals.

For all residues it is essential to have an acceptable level in the diet. Calculation of the acceptable daily intake depends on the toxicology of the compound. These toxicological effects are determined by conducting studies involving genotoxicity, carcinogenicity, mutogenicity, teratogenicity, and effects on the immune and reproductive systems.

Structured surveys:

It is both economical and practically impossible to sample all carcasses for all residues. *Quality assurance* is therefore based on *sampling procedures* . samples are collected from abattoirs in proportion to the annual throughput and on farms in proportion to the stock numbers. To avoid subjective selection of animals for sampling, a program that generates a list of random numbers is used. The officer in the
Meat plant is provided with a list of the samples that are required for his plant, and at a specified time , samples are taken from the next slaughtered animal of the species and type specified. The number of samples required from a species or type is chosen to ensure detection of a problem that affect a specific proportion of the population.

Maximum residue levels:

No chemical is safe under all conditions of use. It is therefore important that all are fully evaluated for safety either as the parent compound or as metabolites and that these determine acceptability. Toxicological studies involve both acute toxic effects of the chemicals and more chronic effects including carcinogenesis and mutagenicity. Increasingly, studies of fertility and fetal development and the effect on the immune system have been added to these assessments of safety.
As international markets become increasingly harmonized, standardization of acceptable residue levels is required. The maximum residue level (MRL) is a concept developed to estimate the maximum acceptable human intake over a lifetime.

It is generally accepted that the MRL of an analyte of any foodstuff is determined by three factors:
1. A minimum dose which produces detectable effects in experimental animals or which, in a therapeutic preparation used in human medicine, produces a recognizable effect.
2. a safety factor in the range of 10: 1000 and which is lower (1:100) if a preparation is already acceptable in human medicine

or higher (1:1000) if there is any evidence to indicate a special risk from experience with chemically similar compounds.
3. a series of factors to balance the proportions of the particular tissues in the average diet.
The MRL is a figure set for acceptable or tolerable intakes believed, on the evidence available , to be safe for man but which may be modified upwards or downwards in the light of any new toxicological hazards to humans.

Acceptable daily intake:
It is an estimate of the amount of a food additive, expressed on a body weight basis , that can be ingested daily over a lifetime without appreciable health risk.

Antimicrobials :

The most numerous and most frequently used drugs in this group are the *antibiotics*. An antibiotic is a chemical substance, produced wholly or partly by a micro-organism (usually a fungus or bacterium) which has the capacity to inhibit the growth of or to kill bacteria. These drugs can be used therapeutically in short courses of treatment to control disease in animals or, at lower concentration but over a longer time , to promote growth. The latter use occurs most frequently in young calves and poultry. In the adult ruminant, alterations in the rumen flora may reduce efficiency of digestion , growth and weight gain. When used therapeutically antibiotics can reduce the symptoms of the disease and may result in a failure to identify unhealthy animals at ante-mortem inspection.

Antimicrobials are a difficult group to detect chemically because they are diverse and show great variation in their chemical weights. They are also used in a wide range of formulations and are administered by many routes. A common characteristic is their antimicrobial activity and this has been used to develop test systems. However, not all antibiotic residues retain activity after metabolism in animal tissue.

Commonly used antimicrobial agents include the penicillins, the aminoglycosides (dihydro-streptomycin, streptomycin and neomycin), chloramphenicol, tetracyclines, (chlortetracycline, oxytetracyclin, tetracycline), tylosin, sulphonamides and furazolidone. The cephalosporins, spiromycin and erythromycin are of increasing importance for specific diseases. Nystatin and griseoflavin are useful fungicides and a range of other agents , avoparcin, virginiamycin, polymyxin B , bacitracin, nitrofurazone and some sulphonamides , have been used as additives in feed. The latter result in growth promotion and are considered economically worthwhile when incorporated at non-therapeutic concentrations. Examples of actual and proposed maximum residue levels in meat is shown in the below table.

Table : Antibiotic maximum residue levels that have been proposed for meat.

Compounds	concentration(ng/g)
Apramycin	100
Bacitracin	0.7(IU/g)
Cephalosporins	60
Clopidol	200
Dihydrostreptomycin	1000

Erythromycin	300
Lincomycin	200
Neomycin	500
Novobiocin	500
Nystatin	7100
Oleandomycin	300
Polymyxin B	5(IU/g)
Spectinomycin	500
Spiramycin	25
Streptomycin	1000
Penicillin	60
Ampicillin	50
Amoxycillin	50
Benzylpenicillin	50
Cloxacillin	300
Chloramphenicol	10
Dapsone	25
Nitrofurans	5
Dimetriadazole	10
Sulphonamides	100
Trimethoprim	50
Oxacillin	300
Tetracycline	500
Chlortetracycline	50
Oxytetracycline	250
Virginiamycin	100
Tylosin	200
Tiamulin	400
Monensin	50
Lasolocid acid	700
Griseofulvin	200

Antibiotic residues are considered undesirable for several reasons. They produce unsightly lesions when administered by injection. The sight of the injection is discolored, and may be hemorrhagic if treatment was administered shortly before slaughter. In many of these cases the antibiotic is still present in an unmetabolized form. Long standing injection sites, particularly those incorporate an oily base, may be hard fibrous nodules within a muscle. The tetracycline, when given as long acting preparations, may leave a yellowish stained area. Since these lesions result in trimming by inspectors, it is prudent to administer injectable antibiotics always in non edible areas. During meat inspection all carcasses with injection sites should be retained and judgments made according to case history, the time of treatment and laboratory results. Frequently, there is no history of previous therapy, so the best evidence on which to base a judgment is the visual appearance of the lesion and the laboratory result.

Antibiotics may interfere with further food processing if this depends on fermentation reaction. They may cause allergic reactions in sensitized consumers. A small number of antimicrobials are suspected of having carcinogenic properties. There is also considerable concern regarding the creation of resistant bacteria in farm animals which may then pass to the consumer. Studies have frequently demonstrated that subtherapeutic feeding of antimicrobials to livestock and poultry increases the prevalence of R+ enteric organisms some of which may be pathogenic for consumers.

The most frequently used tests for antimicrobial agents are based on detection of residual antimicrobial activity. The basic microbiological method is the four plate test (FPT) . it is an agar diffusion test. Meat samples are applied to four plates of agar medium, three of which are inoculated with Bacillus subtilis spores at pH 6 , 7,2 and 8 or Micrococcus luteus at pH 8. Trimethoprim is incorporated into the pH 7.2 medium to enhance the sensitivity of the test for sulphonamide residues. Diffusion of the active antibiotic is detected by the formation of zones of inhibition on one or more plates after overnight incubation. The reliability and sensitivity of the test is monitored by applying 6 mm-diameter filter paper discs containing standard quantities of known antibiotics in each turn.

Further evidence of the identity of the specific antibiotic can be obtained using high voltage electophoresis (HVE) bioautography. Two gels, agar and agarose are prepared, a piece of meat is placed on each and the antibiotic is allowed to diffuse into the medium. The high voltage is passed through the medium for a period of 2.5 hrs. the plates are then over-laid with media containing sensitive species of bacteria similar to those in the FPT and incubation is carried out overnight. The antibiotics inhibit the growth of bacteria over the area in which they are concentrated.

Hormones:

Hormones have been used for a variety of therapeutic and growth –modifying purposes in animals. They are particularly important group because of the reports from toxicological experiments claiming to show that they may be associated with cancer. The most commonly cited example is diethylstilbestrol therapy given to pregnant mothers with threatened miscarriages. A significant proportion of girls born after this therapy subsequently developed cervical adenocarcinomas.
When the ban was first introduced , producers had access to other growth promoting hormone implants (trenbolone, zeranol, natural hormones) which gave better responses at slightly higher costs.
Tests for growth promoting hormones have been implemented, samples are taken from animals that are suspected of having been implanted when these are presented for slaughter. In the live animal which is tested on farm, blood or feces are the most convenient samples to collect. At slaughter, blood , rectal feces, liver, kidney and muscle can be obtained from all animals.
Screening tests for residues of hormonal growth promoters are based on immuoassays. These tests are rapid , sensitive,

selective and cost-effective. Examples of typical limits of decision for these assyas are shown in below Table.

Table : Typical limits of decision for recognized growth-promoting hormones.

Compound	matrix	limit of determination (ng/g)
Diethylstilbestrol	urine	0.5
Hexoestrol	urine	0.5
Zeranol	serum	0.2
Trenbolone	bile	1.4
Estradiol	serum	0.03 (male)
Progesterone	serum	0.5 (male)
Testosterone	serum	0.3 (female)
Nor-testosterone	serum	0

The critical component of each assay is the antibody. These antibodies are prepared by linking the hormone to a larger protein molecule, thereby creating an immunogen which , when injected into laboratory animals , elicits an immune response. High-affinity antibodies can be produced which, when diluted , result in very sensitive and selective tests.

Pesticides:

Pest control chemicals must be toxic to some living organisms to fulfill their role. Depending on the pest being controlled they may be termed insecticides, fungicides, etc. The insecticides that are directly applied to food animals and the anthelmintics are regarded as the most important subgroups. A number of MRLs for common pesticides are shown in below Table.

Table : proposed MRLs of pesticides

Pesticide MRL (ppm)

Aldrin/dieldrin	0.2
Chlordane	0.05
Carbendiazim	0.1
DDT	1
Dichlorvos	0.05
Diflubenzuron	0.05
Endrin	0.05
Hexachlorobenzene	0.2
a-HCH	0.2
B-HCH	0.1
Y-HCH	1
Heptachlor	0.2
Diazinon	0.7
Chlorfenvinphos	0.2
Chlorpyrifosmethyl	0.05

HCH, hexachlorocyclohexane.

The chlorinated hydrocarbons are extremely durable, persistent and bio-accumulating compounds which find their way into the food chain usually through use in controlling environmental or animal pests. They are, however, frequently more toxic in small amounts as their biological activity is greater. Following its introduction , DDT was one of the most successful synthetic insecticides and continued in general use for many years. However, the bio-accumulation that occurred in various food chains eventually resulted in the banning of the organochlorine pesticides by the 1970s.

The organophosphates (e.g. coumaphos, melathion, dichlorvos, diazinon) are exteremly toxic to mammals but are highly efficient insecticides. They are less persistent in the environment than organochlorines because they can be hydrolysed chemically and enzymically. A number of the members of this group can be taken up by plants and can enter the food chain unless proper pre-harvest precautions are taken. Several

agrochemicals based on phenols are used as preservatives or herbicides.
Pesticides are detected by chemical techniques. In the laboratory , spectrographic methods of pesticide analysis using color producing reactions were the first to reach sensitivities at the ppm level but these methods have been replaced by chromato-graphic techniques.

Pesticides used to remove internal parasites such as liver fluke and nematodes are important in animal production systems. The salicylanide flukecides, oxyclosanide, closantel and rafoxanide are active against Fasciola hepatica. Thiabendazole was the first highly effective broad spectrum anthelmintics and are being used in the treatment of nematode infections. These anthelimintics are extensively metabolized in mammals after injection , they are generally short-lived and the metabolites predominate in the plasma, tissues and excreta.

In general these therapeutic drugs are used to control infections in farm animals therefore they are unlikely to be administered close to slaughter. A number are administered by injection which can be irritant, and many animals require to be examined so that the active drug, if any residue remains, can be identified.

Heavy metals:

Excess intakes of heavy metals in food have caused many intoxications in man. These are most often caused by contaminated cereals or by accidental additions during processing but occasionally toxic concentrations occur in animal tissues and products. These can be associated with soils naturally high in the element or through environmental contamination from local industry. They may also occur from feeding grain treated with the toxic metal or from excess amounts remaining in the environment following previous use in paints, etc. These toxic chemicals are detected by atomic absorption spectrometry.

Lead:

Lead can accumulate in the tissues of animals grazing close to smelting plants or in animal ingesting paints or substances with high lead contents. Acute cases occur most commonly after ingestion of lead containing paint. During chronic exposure the metal accumulates in the bones but in more acute exposure the highest values are found in the liver and kidney.

Arsenic:

Arsenic is the second most important poisonous hazard for farm animals. They may be exposed to inorganic or organic arsenic compounds when they are given feed, forage or liquid contaminated with arsenical herbicides, rodenticides or insecticides. Chronic toxicity can occur when arsenical compounds are fed at low levels because the metal accumulates in the liver , kidney and bones.

Mercury:

It has been most frequently associated with feeding to animals seed grain treated with mercury –containing dressings to prevent fungal growth.

Cadmium:

In farm animals the greatest concentrations occur in kidney and liver. Kidney mal-function in man begins when the concentrations are above 200 ug/g wet weight.

Copper:

The metal tends to be accumulated in liver and kidney.

Other metals such as fluorine and selenium.

Natural toxins:

Mycotoxins are products of toxigenic moulds growing in food and foodstuffs. These agents have caused many problems in livestock and the potential for residues in meat, poultry or dairy products is a cause of public concern.

Aflatoxins are produced by Aspergillus flavus and Aspergillus parasiticus. There are four major types of toxin labeled AFB1, AFB2, AFG1 and AFG2. AFB1 is the most commonly produced and the most toxic. Liver, kidney and milk are considered to be the most vulnerable to residue accumulation.

Ochratoxins are produced by some Penicillium spp. And some Aspergillus strains. Ochratoxin A is the most common and the most toxic to birds , mammals and fish. The kidney is the site for

The presence of these toxins and they can be detected by a range of commercially –produced *immunoassay KITS* ,and if positive animals are identified, they should be retained on a toxin-free diet for 4 weeks prior to slaughter to ensure that the levels in kidney have decreased.

Food poisoning and meat microbiology:

Food poisoning is an acute illness associated with the recent consumption of food, having normally a short incubation period and symptoms with gastro-intestinal features, although in some cases there may be neurological and other signs not connected with the alimentary canal.

Types of food poisoning:

Food poisoning includes Bacterial food poisoning, Chemical contamination of food, Plant toxin contamination of food, Food allergies and Food-borne viruses.
Food allergy, or hypersensitivity to certain foodstuffs, is not uncommon. They are generally protein in nature, e.g. milk, eggs, cheese, fish, shellfish, pork, but also mushroom, tomato etc. The tendency to be sensitive to some foodstuffs may be hereditary. It is stated that some 30% of all persons are allergic to some foodstuffs.
Chemical contamination usually occurs by accidental contamination or some unforeseen chemical action between a foodstuff and its container. The metal encountered may be copper, lead, arsenic.
Inherently poisonous substances can occur in normally edible plants and animals including certain fungi, berries, fish and shellfish.

Bacterial food poisoning:

Bacterial contamination by live bacteria or bacterial toxins is much the most important and frequent type of food poisoning. In literal sense diseases such as typhoid fever, dysentery, cholera, undulant fever might be regarded as examples of food poisoning. With the exception of botulism, it is customary to restrict the term to mean acute gastroenteritis from the ingestion with the food of certain microorganisms or of bacterial toxins resulting from the multiplication of those organisms in the food prior to its consumption.

Bacterial food poisoning, therefore, may take one of two forms: *infection with living organisms* or *intoxication by pre-formed bacterial poisons*. The feature which chiefly distinguishes the two types clinically is the interval between eating the food and the development of symptoms. Where pre-formed toxins are present the conditions are somewhat analogous to chemical poisoning and symptoms will develop very rapidly, usually within 4 hours or less. But if living organisms are ingested, some time will elapse before their multiplication in the body has proceeded sufficiently to provoke the usual reactions of diarrhea and vomiting, this period naturally depends to some extent on the initial dose , but is seldom less than 12hrs and may be much longer.

Organisms causing infections:

The main organisms responsible for food poisoning by infection are Salmonella, Escherichia coli, Campylobacter and Vibrio parahemolyticus (fish and shellfish). Those responsible for poisoning by toxin production include Staph. aureus, C. perfringens, C. botulinum, B. cereus (cereals) and Streptococci. Many other bacteria occasionally cause outbreaks of food poisoning, including streptococci, Proteus, Pseudomonas, Providencia, Citrobacter, Aeromonas hydrophilia, Y. enterocolitica, Shigella flexneri and Shigella sonnei. Viruses are sometimes implicated, as are toxins from fungi, such as Aspergillus flavus (producing an aflatoxin in groundnuts and cereals). And moulds such as Fusarium graminarum.

Salmonellae:

The Salmonellae constitute a large group of organisms of which more than 2000 different serotypes have been described. They are capable of causing disease in animals and man when taken into the body in sufficient numbers.
Salmonella food poisoning is characterized by symptoms which don not appear until at least 12 hrs have elapsed (incubation period 6-36hrs). The illness is due to the growth of the organisms within the body , tends to be prolonged and is sometimes fatal.
Salmonellae reach food in many different ways: either directly at slaughter from animal excreta or from human excreta transferred to food by hands, utensils, equipment, flies, etc.
Food poisoning is more likely to occur if the total number of organisms present is high, a small number may have no ill effect. If the temperatures and other conditions are suitable, there can be a great multiplication in numbers of organisms.
The following control measures have been shown to considerably reduce the Salmonella carrier rate in cattle , sheep and poultry and thereby the related incidence of cases of food poisoning:

1.the use on the farm of feeding stuffs free from salmonellae.
2. hygienic standards of animal husbandry, including proper control of slurry disposal and water supply and full protection from insects and rodents.
3. hygienic conditions of transport and lairagings , with the avoidance of stress at all stages from farm to slaughter.
4. proper design of slaughter lines and the adoption of efficient, hygienic methods of slaughter and carcass dressing which minimize cross-contamination.
5. suitable sewage treatment .
6. bacteriological monitoring
7. efficient refrigeration and hygienic methods of processing.
8. avoidance of consumption of raw meats , unhygienic handling in the home and the use of storage systems which contribute to the proliferation of bacteria of all types.

9. complete thawing of frozen meats and adequate cooking to ensure destruction of potential pathogens and spoilage organisms.

Campylobacter:

Campylobacteriosis is caused most often by Campylobacter jejuni but also C. fetus and C. coli. Poultry and cattle are the main reservoirs for human infection which is acquired by ingesting contaminated raw milk, undercooked chicken or other food contaminated in the kitchen. The incubation period is 1-10 days, usually 3-5 days. There is acute onset of fever, abdominal pain and diarrhea which may be blood stained but which usually resolves within 10 days. It may cause pseudo-appendicitis and, rarely , septicemia and arthritis.

E.coli:

It is normal inhabitant of the intestinal tract of man and animals, but some strains can cause disease. Hemorrhagic colitis or hemolytic uremic syndrome (HUS) is a newly recognized food borne disease which may lead to hemolytic anemia with renal failure. The causative agents are enterotoxin-producing strains of E.coli. the main source of infection are undercooked beef and raw milk and by person-to-person fecal-oral spread.
The incubation period is 1-12 days. Symptoms range from mild diarrhea to severe abdominal pain with profuse watery or bloody diarrhea with or without low-grade fever but of short duration. Hemorrhagic diarrhea may be followed by hemolysis and renal failure.

Yersinia:

Yersiniosis is usually a self-limiting enteric bacterial infection which can be food-borne. It is caused by Y. pseudotuberculosis and Y. enterocolitica. The incubation period is 3-7 days . There is an acute onset of fever followed by abdominal pain and diarrhea for 1-3 weeks. Pharyngitis is a common symptom. Symptoms similar to appendicitis also occur, occasionally followed by arthritis and erythema nodosum.

Vibrio parahymolyticus:

It is commonly found in sea creatures and sea food.

Listeria:

Listeriosis occurs mainly in pregnant women , neonates , immuno-suppressed patients and the elderly. It can cause fatal meningoencephalitis and abortion. The causative agent is Listeria monocytogenes. The agent is widely distributed in animals, birds , humans and soil. The organism is excreted in animal feces. Refrigeration of foods may encourage selective growth of listeria.
Preventive measures include, as for all food illnesses, the thorough cooking of all food stuffs derived from animal sources , especially poultry, heat treatment of milk, the prevention of recontamination after cooking, proper refrigeration , recognition , control and prevention of animal disease and high standards of hygiene.

Organisms causing intoxications:

The most commonly implicated organism in this respect is Stph. aureus, others are Streptococci, Cl. Perfringens and Cl. botulinum. In recent years B. cereus , an aerobic sporing organism found in cereals and other foods has caused food poisoning. The spores , like those of Cl. Perfringens, are very resistant and can survive cooking temperature to replicate and produce toxin in the food.

Staphylococci are commonly found on the skin and in the upper respiratory tract of man and animals and can easily contaminate foods of all forms. They produce toxin in the food before it is eaten and cause symptoms which develop rapidly (2-3 hrs) and usually disappear within 24hrs. these include vomiting , diarrhea, severe abdominal cramps and sometimes collapse. Though the organisms themselves are readily destroyed at pasteurizing temperatures, the toxin appears to be heat stable and is not activated by boiling or refrigeration for long periods.

Cl. Perfringens is a common inhabitant of the intestinal tract of man and animals, and can readily gain access to food, especially meat dishes. The spores are very resistant and can survive the usual cooking temperatures to produce toxin in the intestine after germination into vegetative forms. The symptoms develop within 8-24 hrs afterwards in the form of nausea, abdominal pain and diarrhea due to the production of toxin within the bowel lumen. Symptoms usually continue for 12-48hrs.

Botulism:

The causal organism, Cl. Botulinum , is an obligate spore-forming anaerobe of the putrefactive type. It is saprophyte and does not multiply in the human or animal body, so that cross-infection cannot occur. The organism is classified into six types, A,B,C,D,E and F , the toxins of which can be differentiated from each other , antitoxin prepared from one type of organism does not inactivate the toxins of the other types.

Pathogenesis:

Botulism is caused by a powerful exotoxin produced by the organism during its growth in food material, the exotoxin can resist the action of the gastric and intestinal juices but is destroyed in 30 minutes at a temperature of 80 C.

Botulinus toxin is one of the most powerful poisons known. Its calculated lethal dose for an adult man is in the region of 10Ug. It is about 25 times as toxic as its closest rival, the toxin of Cl. tetani. Among the most resistant of all micro-organisms are the spores of Cl. botulinum Type A which can survive temperatures of 120 C.

Method of infection:

The organism is a natural inhabitant of the surface layers of the soil and thus may easily contaminate fruit, vegetables or other cultivated produce. Where meat foods are infected, soil contamination is the most likely cause. The incriminated food has in most cases been smoked , pickled or canned, allowed to stand and then eaten without adequate cooking.
Meat is a favorable medium for the growth of Cl.botulinum , and as the spores vary in their resistance to heat and may withstand boiling at a temperature of 100 C for up to 22hrs, they are likely to survive any ordinary sterilization.
Symptoms:
The symptoms of botulism are produced by the action of a powerful exotoxin which possesses an affinity for nerve tissue. The period of incubation in man is usually under 24hrs, but may be longer, and is followed by a typical chain of symptoms which include thirst, nerve paralysis and great muscular weakness (no diarrhea , no vomiting).
Methods of prevention:
1. The spores of Cl. Botulinum are resistant to heat and can withstand boiling at 100C for 22 hrs, but are destroyed at a temperature of 120C for 20 minutes; the greater the acidity of the food the more rapid is the destruction of the spores. These factors are taken into account in modern canning procedure.
2. pickled foods are rendered safe if the brine used contains not less than 10% common salt.
3. preserved foods possessing rancid or other odors should be rejected. If a housewife tastes a faulty can of food which contains botulinum toxin and spits it from her mouth there is enough toxin remaining in her mouth to cause death.
4. the utmost care should be taken in the manufacture of cans, their transport, handling, storage and subsequent examination on purchase.

Factors controlling food-poisoning outbreaks:

The factors which chiefly determine the multiplication of pathogenic organisms are:

1. *Moisture:* food poisoning bacteria will grow on the damp surfaces of meat and in foods both damp and loosely packed, such as sausages, may penetrate and spread throughout the food.
2. *temperature range:* the majority of outbreaks occur in summer when the temperature favors bacterial growth.
3. *cooking:* most food poisoning bacteria grow more quickly on protein denatured by cooking and outbreaks often stem from reheated food. **Cooked foods should never be warmed slowly but heated thoroughly and allowed to simmer for 15 minutes.**
4. *time before consumption:* long storage and inadequate reheating are the factors most likely to increase the pathogenicity of food if the relevant bacteria are present. **The period between cooking and eating should never be longer than 1 hr unless food is stored above 60 C or in the cold.**
5. *treatment after cooking:* food should be cooled quickly and refrigerated if not eaten immediately.
6. *hygiene:* high standards of both personal and work area hygiene are essential.
7. *pests:* flies, mice , rats, etc. must be controlled.
8. *injuries:* personnel with septic lesions or excreting intestinal pathogens like salmonellae must avoid food areas.
9. *clothing*: suitable protective clothing which is easily cleaned must be provided for food personnel.
10. *medical facilities:* a well equipped medical department cannot only hygienically treat first-aid cases but also advise on health and hygiene practices.

Investigation of outbreaks of food poisoning:

The first step in the control of outbreaks of food poisoning of any communicable disease is its rapid identification and notification to the local health authority so that appropriate measures can be taken speedily to limit morbidity and mortality. Food poisoning outbreaks are usually recognized by the occurrence of sickness among several individuals within a relatively short time following the consumption of one or more foods in common. It is of great value to recognize the characteristics of the principal food poisoning bacteria since this will assist in the diagnosis. This applies especially to factors such as the incubation period which may suggest an infection or an intoxication.

The nature of the clinical features and an estimate of the incubation period are useful in determining the possible type of infection. Feces, vomits, and food samples must be collected with care for lab. examination. Any remaining of food should be withheld under refrigeration. It is important to identify the specific food eaten and not eaten and compare the attack rates. The implicated food items will have the highest attack rates; most of the sick persons will have eaten the contaminated food while those not affected will be fewer in number. Information on the preparation , storage, refrigeration, thawing, reheating, etc. of the food is important.

Possible sources of contamination must be looked for and the standards of general and personal hygiene assessed. Non-isolation of bacteria does not necessarily mean that heat resistant toxin is not present in the food.

Bacteriological examination of carcasses:

In the healthy and physiologically normal animal those organs which have no direct contact with the exterior may be regarded as virtually sterile, though the actual operation of slaughter and dressing may introduce bacteria to the blood, tissues and organs. These organisms are usually a mixed flora of a non-specific type but can include food poisoning organisms.
On the other hand, the bacteria present may be of a specific and pathogenic type and the presence of these in organs or tissues such as the spleen, muscular tissue or lymph nodes can only be attributed to the fact that a generalized septic or bacteremic infection existed in the animal at the time of slaughter.

Indications for examination:
There is no justification for conducting a bacteriological exam. when a carcass and its organs exhibit marked pathological changes of a non-infectious nature or evidence of severe systemic disturbance except in certain cases to determine the infecting organism. Such changes are themselves sufficient to justify condemnation of the carcass. Bacteriological exam is required in the case of animals which:
1. Have been slaughtered in emergency.
2. have been slaughtered on account of a disease associated with systemic disturbances.
3. have been slaughtered on account of acute inflammation of intestine , udder, uterus, lungs , pleura, joints, tendons, claws , umbilicus and peritoneum, or because of systemic illness associated with suppurative or gangrenous wounds.
4. have been slaughtered on account of fractures, external injuries, other lesions caused by external factors, or prolapse of

other organs and in which resultant symptoms of illness (e.g fever) have been detected.
5. show pathological changes on P.M inspection that lead to doubt as to suitability of the meat for human consumption , even though the animal was found healthy on ante-mortem inspection.
6. have not been eviscerated within 1 hr of slaughter or where parts of the slaughtered animal necessary for P.M exam are absent or have been handled in such a way as to make satisfactory judgment impossible.
7. where slaughter has taken place without the prescribed ante-mortem inspection.

Material submitted:

The following samples shall be taken for submission to the lab for bacteriological exam:
1. Two complete muscles, with their fascia, one from forequarter, and one from hindquarter, or cubes of muscle not less than 7.5 cm in diameter.
2. the prescapular lymph node (or axillary) and internal iliac node.
3. the spleen.
4. a kidney
5. liver with gall bladder.
6. parts showing pathological change .
7. a portion of small intestine together with mesenteric L.N.

Types of bacteria found:

The bacteria found may belong to the non specific group which comprises species that are non pathogenic or only potentially pathogenic, e.g streptococci, enterococci. E. coli in adult animals except serotype 0157:H7, clostridia , non hymolyic staphylococci. These species are present naturally in the intestinal flora.

The bacteria of the specific group include all species regarded as specific pathogens and include the hemolytic streptococci, pneumococci, hemolytic staphylococci, pasteurella, salmonella, E coli in newborn animals , Bacillus anthracis, Listerella monocytogenes and Corynebacterium pyogenes..
The time taken for a bacteriological report is 24-48 hr and carcasses are detained in a chill room pending the results of the exam.

Interpretation of results:

When the samples submitted prove to be sterile , the carcass and those organs that are unchanged may be released forthwith, provided the inspector is satisfied as to their fitness for food after a further visual exam.
When specific pathogenic bacteria are found in one or more samples, the carcass should be condemned , for this indicates generalized septicemia or bacteremia even though the bacteria demonstrated may not themselves be transmissible to man.
Condemnation of carcasses shown to contain non-specific, non-pathogenic bacteria is justifiable when the bacteriological results show an extensive infection.

Laboratory quality assurance techniques of microbiological examination:

The bacterial status of the meat is determined in superficial and deep samples.
Superficial samples:
Superficial samples may be taken by removing thin slices, by rinses, swabs or adhesive tape, or by the agar sausage and impression plate techniques. A rapid indication of the number and types of micro-organisms present on the surface is given by pressing microscope slides against the surface which are then either fixed and stained, cultured, or pressed on to a culture medium for culture.

Surface slices:
They are removed with sterile scalpels and forceps , then homogenized in a suitable diluent, e.g Ringer's solution, to provide a 1:10 dilution before plating on appropriate culture media.

Rinses and washes:
They are prepared by weight of the meat in ten parts by the weight of the sterile diluent. This method is suitable for sausages, beef burgers, etc. it is desirable also to prepare samples of 1:10 dilutions from comminuted forms of the meat.

Swabs:
The swabs are moistened in dilute (25%) Ringer's solution and applied to the meat surface, using the template; the exposed area is swabbed first in one direction and then at right angles to the original direction. The swabs are then placed in the tubes and, before plating out, 10 ml 25% Ringer's solution is added to each tube , the swab being rinsed in this solution ten times. One ml rinsings are used to prepare plate counts and dilutions can be prepared as required. Colony counts are recorded as the number per square cm of surface. The culture medium is usually cooled nutrient agar or other agar medium.
Special alginate swabs may be also used. The swabbing is carried out as before, and the swab then broken off aseptically into a small Macartney bottle containing 10 ml of a 1% solution of sodium hexametaphosphate in 25% Ringers solution . the bottle is shaken after replacing the cap. Plate counts are prepared from 1 ml and 0.1 ml and further dilutions if required, using special culture media. The counts are recorded as the number per square cm of surface swabbed.

Adhesive tape:

Adhesive tapes or labels are used to take superficial samples by pressing a standard area against the surface and then removing it immediately. The tape is pressed against the culture medium and then removed and discarded. The medium is incubated for 24 hrs at 37C.

The agar sausage:

It is simple, reliable and valuable method. The medium required is poured into a sterile cylindrical plastic casing to fill it. The sausage is then placed into a larger casing, the mouth of this also tied firmly and the whole sterilized by steaming for 30 minutes on 2 successive days.
Various media may be used: nutrient or blood agar for total counts, neutral red lactose agar for E coli, Brilliant green phenol red lactose agar for salmonellae, and malt agar for yeasts and moulds.
In the assessment of the efficiency of the hygienic procedures in an abattoir it may be considered that the essential tests should be for : a: total bacterial count, b: presence of Salmonella organisms and c: the presence of fecal coli. The method cannot be used for assessing contamination due to anaerobic organisms.

Impression plates:
They are sterile disposable plastic plates with an inner well filled with agar medium with a convex meniscus which can be pressed against the surface to be sampled. The well has a lid.

Deep samples:
Deep samples of meat must be taken with care in order to avoid superficial contamination. They can be obtained using sterile scalpels and forceps or, in case of frozen meat, a cork borer or an electrical drill fitted with a bore extracting bit. The surface can be sterilized by deep frying, followed by an aseptic dissection of about 10gm of meat.
The plates containing the specialized culture media are incubated aerobically and anaerobically to assess the total microflora and G+ and G- pathogens, the primary plates can be subcultured to purify bacterial colonies in order to help identify

the organisms; biochemical, physiological, serological and phage-typing tests are used to identify the bacteria positively.

Bacteriological standards for meat:
The general viable count at 35C (or at 20C in the case of chilled meat) should be less than 107/gm and that Salmonella should be detected in not more than one of five 25gm samples. It is also recommended that frozen poultry when examined by rinsing should give a count at 20 C of less than 107 ml of the rinsing solution and that Salmonella should be detected in not more than one of five 25 g sample of the poultry meat.
The above bacteriological techniques may also be used to assess the nature and degree of bacterial contamination on walls, floors, equipment and hands and clothing of personnel.
Although the common practice in the assessment of food quality has been to set limits on the numbers of different bacteria in it, their actual number really bears no relation to incipient spoilage or to hazards for human health. It is an offence to sell meat containing more than 5 million aerobic bacteria or 50 E. coli per gram with more strict limits for processed meats.

Decomposition and spoilage :

Decomposition is the breaking up of organic matter , chiefly protein, but also fat and carbohydrates, by the action of bacteria, moulds and yeasts, which split the meat up into a number of chemical substances , many of which are gaseous and foul-smelling.
All forms of foods in their natural state remain in a fresh and edible state for only a comparatively short time. Foods are rapidly acquire bacteria , moulds or yeasts, which are the main causes of spoilage or decomposition. Before terminal

decomposition changes occur, however, other factors such as enzyme action (food and bacterial) and oxidation take place in some foods.

Present in all living cells are enzymes or ferments which catalyze the complicated chemical reactions taking place in the cells. The process of autolysis, self-destruction or self degradation is essentially brought about by enzymes, and at a rate which varies markedly in the different tissues. In general it is highest in those tissues in which protein is synthesized in large amounts and which have high water contents, e.g gastrointestinal mucosa, testes, pancreas and adrenals. Tissues such as liver, kidneys and endocrine glands have slower autolytic rates and the tissues with the lowest metabolic rates such as skin, muscles, bone, heart and blood vessels have the lowest autolytic rates of all tissues.

The various forms of food preservation are designed to prevent decomposition by limiting the activity of enzymes , the process of oxidation and bacterial spoilage.

All forms of food are subject to natural deterioration, their shelf-life being dependent on their structure, pH , composition, water content, presence or absence of bacteria and/or damage and conditions of storage. Bacteria, moulds and yeasts in turn are affected by factors such as temperature, moisture, availability of oxygen, nutrients, and the presence or absence of growth inhibitors. Control of one or more of these factors inhibits microbial growth and lengthens the shelf-life. Foods that have a high water content (e.g meat and offal) are liable to spoil rapidly unless steps are taken to control deterioration.
In addition to microbial spoilage , physical damage which occurs during handling , transportation and processing can be regarded as a form of spoilage , as can insects and other pests. Foods damaged in this way are more susceptible to change by microbial action.

The main types of bacteria involved in the spoilage of meat belong to the following genera;

Gram-positive organisms:

1. Micrococcus:

Cause spoilage of salted and chilled meats. Optimal growth temperature, 25-30C.

2. Staphylococcus:

S. albus is responsible for spoilage and S. aureus for food poisoning. Optimum temperature 37 C but can grow below this temperature.

3. Streptococcus:

Str. fecalis, Stre. durans, wide temperature range for growth 10-45C.

4. Lactobacillus

5. Leuconostoc:

Cocci which can produce slimes especially in high-sugar foods

6. Bacillus:

e.g B. subtilis , they are saccharolytic, proteolytic and lipolytic. Some forms can cause flat sours in canned meats.

7. Clostridium :

e.g C. botulinum, C. perfringens, C. sporogenes.

8. Corynebacterium

Fine, non-sporing rods, no growth below pH of 4.5.

9. Microbacterium

Able to spoil meat stored at chilling temperature with reduced relative humidity.

Gram-negative organisms:

1. Pseudomonas :

Widely distributed in soil, fresh and sea water and decomposing organic matter. Grows well in protein foods with the production of slime, pigments and odors. Temperature range is wide, 15-40C.

2. Flavobacterium:

Pigmented colonies (orange and yellow0 causing discoloration of meat and other foods such as eggs, butter and milk.

3. Acinobacter

4. Achromobacter
5. Alcaligenes:
An alkaline reaction is produced in some foods including meat.
6. Halobacterium
Spoiling meat high in salt content.
7. Moraxella
8. Escherichia
Abundant in the soil and intestines of man and animals. It is indicative of fecal or sewage pollution.
9. Klebsiella

These particular bacteria are found almost everywhere in nature and it is particularly impossible to avoid their contamination of carcasses during dressing procedures. The time taken for slime to develop on raw meats is directly related to initial number of organisms on the carcass surface. It is thus especially important to pay attention to efficient methods of hygiene at slaughter, during carcass dressing, refrigeration, storage and transportation, having first of all insisted on clean animals for slaughter.

Chilling procedures do not prevent the activity of spoilage organisms, which can grow at about -7C ; however, temperatures below 2C will delay the onset of slime formation.

Control of relative humidity in chill rooms, I,e reducing the amount of water activity can reduce bacterial spoilage, but results in a loss of carcass weight and liability to spoilage by psychrotropic bacteria (micrococcus, microbacterium, streptococcus, lactobacillus) and some moulds (Asperigillus, Botrytis, Cladosporium , others). A reduced partial oxygen pressure pCO2 which exists in the vicinity of stored meat is of value in curtailing spoilage, as is increased pCO2.

In recent years attempts have been made to counter the adverse action of spoilage bacteria by the use of irradiation , mainly with gamma rays.. using a dose of about 0.1 Mrad immediately before shipping , the storage life of carcasses under refrigeration has been prolonged and salmonellae eliminated.

Decomposition of protein:

The putrefactive bacteria breaking up the protein molecule into proteoses , then peptones, peptides, amino acids, and finally indole, skatol, phenol, together with various gases including hydrogen sulphide, carbon dioxide, methane and ammonia: it is the   amino acids, non toxic in nature, which furnish bacteria with abundant and available nutritive material, and their breakdown products which give the typical appearance and odor of decomposed meat. The recognized signs of decomposition are marked changes of color to a grey , yellow or green, a softening in the consistency of the tissue, a pronounced repulsive odor and an alkaline reaction caused by the formation of ammonia.

After slaughter of a healthy animal , decomposition eventually develops in the parts exposed to the air, the time taken depending particularly on the degree of heat and moisture. The primary surface growth is initiated by aerobic bacteria , among these being Pseudomonas , Acromobacter and some coliforms. These organisms extract oxygen from the meat surface and produce conditions suitable for the growth of anaerobic bacteria , e.g Clostridium sporogenes which can also grow within the deeper tissues where there is no oxygen. After surface putrefaction of meat has commenced the process spreads gradually by way of the nerve and connective tissue sheats and along the surfaces of blood or lymph vessels. The rapidity of the extension of the putrefactive process throughout a carcass is greatly influenced by the condition of the animal before slaughter, in exhausted animals or in those that have suffered from fever (especially from a septic form) where the meat is alkaline , decomposition sets in very rapidly and quickly reaches the deeper parts.

In animals that have died and have not been eviscerated , both external and internal decomposition occur simultaneously , due partly to the high blood content of the meat and partly to the invasion of the abdominal veins by putrefactive bacteria from the intestines. The first bacterium to invade the carcass from the bowels is E.coli, which in warm weather may reach the joints within 24 hrs , these bacteria use up the oxygen in the carcass and pave the way for the pentration of anaerobic bacteria, e.g Cl. Perfringens, from the bowel. Presence of greenish hue , first apparent on the kidney fat and peritoneal wall , with the diaphragm soft and flaccid and lying close to the ribs , is a strong indication that evisceration of the animal has been delayed and calls for a severe judgment on the carcass. Lambs coming straight off grass and slaughtered in hot weather have been known to exhibit evidence of decomposition within 1 hr.

It is important to remember that while the spoilage organisms indicate their presence by off-colors, odors and tastes as well as changes in consistency, most food poisoning organisms give no indication of their presence in food.
Bacteria such as Bacillus cereus, E coli , Pseudomonas, Proteus and Citrobacter , as well as causing spoilage, can also on occasions cause food poisoning.
E coli is commonly found in foods of animal origin and is an indication of sewage pollution of water and unhygienic methods of preparation.

Decomposition of fat:
The problem of fat rancidity crops up in the storage of practically every foodstuff. An unpleasant odor or flavor in a fat may be due to : absorption of foreign odors, as in the tainting of meat stored in a chamber previously used for fruit, atmospheric oxidation; or the action of microorganisms, which may give rise to extensive hydrolysis of fat. It is more likely that the tainted flavor normally accompanying bacterial growth is mainly due to nitrogenous breakdown products of connective tissue.

Phosphorescence:

It is caused by a number of organisms, e.g Pseudomonas phosphorescens, which are widely distributed in nature, especially in sea water, and may infect a chilling room by the storage of fish therein. These organisms are resistant to chilling room temperatures.

At the commencement of phosphorescence ,the surface of the affected meat , when seen in the dark room, shows luminous areas scattered over its surface and appears as if it were studded with stars. If decomposition develops in the meat the phosphorescence disappears.

Salted or stored meat may show various changes in color due to bacterial action. Scattered areas, reddish in color are caused by Serratia marcescens , and a similar superficial change , but blue in color, is seen as a result of surface contamination by Pseudomonas cyanogenus, Pseudomonas cutirubra.

Moulds:

In contrast with yeast and bacteria, moulds are readily seen with the naked eye , appearing typically as fluffy growths on walls, rotting fruits, cheese, etc. they can occur in various colors, e.g white, black, green, blue. Unlike bacteria and yeasts, they are multi-cellular and consist of a mass of branched filaments or hyphae which bear reproductive bodies or spores. Along with yeasts, mildews, rusts, smuts and mushrooms they belong to the class Mycota or fungi.

Saprophytic moulds are largely concerned with the decomposition of organic matter and the decay of foodstuffs. The breakdown is due to the secretion of enzymes on to the surface and the mould absorbing the resultant fluid as food. Moulds can produce valuable antibiotics, e.g Penicil penicillium, one of which is P. notatum. A few moulds are pathogenic: Aspergillus flavus causes aflatoxicosis in cattle sheep, swine and poultry by the production of aflatoxins on groundnuts, soya beans and other cereals during storage

The growth of moulds can be prevented by low temperatures and attention to humidity, thus proper ventilation in refrigerating and storage works is necessary so that circulating air may dry the surface of food and containers.

The chief causes of mould on imported meat are: exposure to dust in between leaving the ship and sale, and variations in temperature causing condensation on the meat surface. Intermittent freezing or temperature fluctuations in a refrigerating chamber are common predisposing causes to mould growth.

Moulds are commonly encountered in imported carcasses of beef, mutton and lamb, but are much likely to attack chilled than frozen meat. The important forms of mould are black spot, white spot, whiskers, and the bluish green moulds, among which is Penicillium.

Black spot:
This is the most troublesome affection of imported meat and is caused by the mould Cladosporium herbarum, all grow well at around 0C. The spots are about 6-13 mm in diameter and occur on the surface of the meat.
Black spot which is not too extensive and which is unaccompanied by decomposition may be removed by trimming. Mould formation accompanied by bacterial spoilage requires more generous paring and, at times, condemnation of the whole affected area.

White spot:
This is caused by Sporotrichum carnis and is the most commonly encountered defect of imported meat. It is seen as small , flat, wooly spots, frequently accompanying black spot of similar size, but it is whitish in color and entirely superficial in nature. The spores can develop at -8C , grow more plentifully at -2.5 C , and become profuse when the temperature is above 0C.

Whiskers:
This fungoid growth belongs to the closely allied genera Thamnidium and Mucor. The presence of whiskers indicates the meat has been exposed during storage to a temperature at or above 0C.

Bluish-green moulds:
They belong to the genus Penicillium . they are superficial in character and can grow with difficulty at 0C.

The danger of decomposing meat to man:

Though decomposition is an index of bacterial growth , it is not an indication that the meat will necessarily be harmful; the question is simply one as to which bacteria and what conditions were concerned in the contamination. Clostridium botulinum produces specific symptoms, but in all other illnesses attributed to the eating of decomposed meat there are no specific symptoms and the affection is usually an acute afebrile gastrointestinal inflammation which is frequently of short duration but may prove fatal. The bacteria is capable of elaborating poisonous products when growing in food include Proteus, certain strains of staphylococci, streptococci, and coliform bacilli, but the nature and action of the toxins are not well known nor is it clear whether these toxins are direct secretions from the bacterial cell or whether they arise by decomposition of the meat protein. The presence of signs of decomposition is essentially an indication of bacterial growth and justifies the suspicion that harmful organisms may be present.
Another factor which dictates condemnation of decomposed meat is the aesthetic one. The appearance, odor and taste of decomposing meat is repugnant to most people, and in some individuals its consumption may be accompanied by marked psychological effects.

Assessment of decomposition:

Chemical, bacteriological and physical tests have been developed. The chemical methods include:
a. detection of free ammonia
b. determination of the total amount of volatile bases produced during spoilage
c. determination of free amino acids content as an indication of decomposition.
d. the production of indole, sulphur and others.
e. oxygen requirements of the meat or its power of reduction

bacteriological methods have been devised to relate bacterial plate counts to the quality of meat but these do not show any close agreement between the number of bacteria present and the degree of spoilage.

The experienced inspector can arrive at a sound conclusion by estimating the texture, , appearance, taste and odor of the food, with the use of boiling test where necessary. It is however, contented that in certain cases pH measurements may be of value.

pH estimation:

Meat from freshly killed cattle has an average pH of 6.4- 6.8 and sometimes up to 7.2, i,e slightly acid or slightly alkaline. The pH then falls rapidly , reaching its lowest level of 5.6-5.8 within 48 hrs after slaughter.
When a pH of 6.4 is reached there is a suspicion of the presence of incipient decomposition , while when muscle reaches a pH of 6.8 or over , the objective signs of decomposition, odor, color and texture become apparent. It is unfavorable indication if the pH does not fall to 6.1 or below within 24 hrs.
Estimation of the pH of meat is of value in the judgment of borderline cases, particularly of emergency slaughtered animals, for it indicates whether or not the meat will possess adequate durability. It is a routine procedure in many continental

abattoirs. In animals suffering from febrile disease or exhausted at the time of slaughter , the glycogen content of the muscles is low and the pH of the flesh will remain at a high level.
pH can be measured accurately with an electronic meter or, less accurately but more cheaply by methods employing color changes.

Chemiluminescence :

It is used for assessing the freshness of food. As food deteriorates, the unsaturated fats, oils and other lipids emit light.

Torrymeter:

The meter measures changes in the dielectric properties which occur as spoilage proceeds. These dielectric properties decrease rapidly as meats or fish pass through rigor and then more slowly during subsequent storage.