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MEAT AND MEAT PRODUCT TECHNOLOGY

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CHAPTER-1

CHEMISTRY OF MEAT

Meat and meat products are concentrated sources of high quality protein and their amino acid composition usually compensates for shortcomings in the staple food. They supply easily absorbed iron and assist the absorption of iron from other foods as well as zinc, and are rich sources of some of the vitamins in the B group. By providing such nutrients, meat consumption can alleviate common nutritional deficiencies. The production of animals for meat can be integrated into the overall food system without competing directly with crops for human food; it enables utilization of land that is difficult to cultivate, and supplies valuable by-products as well as improving the fertility of the soil. The appropriate utilization or expansion of existing sources of meat calls for coherent development of a complex system of production, processing and marketing, including aspects of finance and expertise for construction and operation of meat plants, and means of storage, meat preservation, transport and marketing.

In many regions in developing countries meat production is carried out with efficiency, and slaughter and processing are based on many of recent scientific developments. However, even in industrialized countries there is often considerable room for improvement. In other regions methods are less advanced, with poor control of sanitation, leading to considerable loss of products as well as to the risk of meat borne diseases. Improvements of techniques of slaughter and processing, especially in hygiene, would result in greater yields and higher profits. These would also provide the incentive for increased production. While it is highly efficient in industrialized countries to specialise in single purpose animals it is often more efficient in some areas to raise dual-purpose animals. There is also scope for increased yields and efficiency by developing indigenous species for meat production, species that even without genetic selection thrive under local climatic conditions and withstand local diseases. Overall there is a great potential in the developing world to increase the production of meat and meat products to the benefit of the health of the consumer.

Muscle Compositions

Muscle Composition The largest constituent of muscle is water (Table 1.1; U.S. Department of Agriculture 2008).

Table1.1. Composition of Mammalian Muscle

Component	**% of Muscle Weight**
Water	75% (65 – 80%)
Protein	18.5% (16 – 22%)
Lipid	3% (1 – 13%)
Carbohydrate	1% (0.5 – 1.5%)
Non - Protein Nitrogenous Substances	1.7% (1 – 2%)

Numbers in parentheses indicate the average range of that component. (U.S. Department of Agriculture, 2008)

In living tissue, the average water content is 75% of the weight of the muscle; however, can vary, particularly in post-mortem muscle (range of 65 – 80%). Within the muscle, it is the primary component of extracellular fluid. Within the muscle cell, water is the primary component of sarcoplasmic (cytoplasmic) fluid. It is important in thermoregulation; as a medium for many cellular processes; and for transport of nutrients within the cell, between cells, and between the muscle and the vascular system. The second largest component of muscle is protein (U.S. Department of Agriculture 2008). Protein makes up an average of 18.5% of the weight of the muscle, though that figure can range from 16 to 22%. Proteins serve myriad functions and are the primary solid component in muscle. The functions of proteins are quite varied. Muscle proteins are involved in maintaining the structure and organization of the muscle and muscle cells (the role of highly insoluble stromal proteins). They are also important in the contractile process. These proteins primarily are associated with the contractile organelles, the myofibril, and are thus termed myofibrillarproteins. In general, the myofibrillar proteins are not soluble at low ionic strengths found in skeletal muscle (ionic strength ≤ 0.15), but can be solubilized at higher ionic strengths (≥ 0.3). This class of proteins includes both the proteins directly involved in movement (contractile proteins) and proteins that regulate the interactions between the contractile proteins (regulatory proteins). There are also many soluble proteins (sarcoplasmic proteins) that include proteins involved in cellular signaling processes and enzymes important in metabolism and protein degradation/cellular remodeling. The lipid content of the muscle can vary greatly due to many factors, including animal age, nutritional level of the animal, and muscle type. It is important to note that the lipid content varies inversely with the water content (Callow 1948). Some lipid is stored inside the muscle cell; however, within a muscle, the bulk of the lipid is found between muscle bundles (groupings of muscle cells). Average lipid content of skeletal muscle is about 3% of the muscle weight, but the range can be as much as 1 – 13% (U.S. Department of Agriculture 2008). In skeletal muscle, lipid plays roles in energy storage, membrane structure, and in various other processes in the organ, including immune responses and cellular recognition pathways. The two major types of lipid found in skeletal muscle are triglycerides and phospholipids. Triglycerides make up the greatest proportion of lipid associated with muscle. Triglycerides (triacylglycerides) consist of a glycerol molecule in which the hydroxyl groups are esterified with three fatty acids. The melting point and the iodine number of lipid that is associated with the muscle is determined by the chain length and the degree of saturation of the fatty acids. Phospholipids (phosphoglycerides) are another type ofcomplex lipid found in muscle. In this class of lipids, one of the hydroxyl groups of glycerol is esterified to a phosphate group, while the other constituents are fatty acids. The fatty acids associated with phospholipids are typically unsaturated. Phospholipids in skeletal muscle are commonly associated with membranes. The relative high degree of unsaturation of the fatty acids associated with the phospholipids is a contributing factor to the fluidity of the cell membranes. Carbohydrates make up a relatively small percentage of muscle tissue, making up about 1% of the total muscle weight (range of 0.5 – 1.5%). The carbohydrate that makes up the largest percentage is glycogen. Other carbohydrates include glucose, intermediates of glycogen metabolism, and other mono - and disaccharides. Glycosaminoglycan’s is found in muscle and are associated with the connective tissue. There are numerous non - protein nitrogenous compounds in skeletal muscle. They include substances such as creatine and creatine phosphate, nucleotides (ATP, ADP), free amino acids, peptides (anserine, carnosine), and other non - protein substances.

Muscle Structure

Meat muscle, which is what we eat, is made of **fibres**, bound together with connective tissue, that are mainly linked to other groups of muscles or directly to the animal's bone structure. Muscle contains 60% to 70% moisture, 10% to 20% protein, 2% to 22% fat, and 1% ash, depending on type and species.

On larger bones (such as the shanks of larger animals), it is easy to see the muscle groups in bundles (if cut on the cross-section) surrounded by **collagen** fibres and a much heavier connective tissue (**elastin**) that forms a thin covering (called **silverskin**) separating muscle groups or a **tendon** at the ends of the muscle group (Figure 1). The tendon is attached to the bone at or near a bone joint (Figure 2).

Figure 1. Crosscut of beef shank showing muscle fibres.

Figure 2. Bone with tendon attached (left) and muscle removed (right).

The muscle fibres are known as **myofibrils**, which are composed of thick and thin filaments arranged in a repeating pattern alongside the other myofibrils (Figure 3). One unit of a bundle is called a **sarcomere**, or little muscle. The thick filaments are the contractile protein **myosin**. The thin filaments, known as **actin**, contain two other proteins called **troponin** and **tropomyosin** that help regulate muscle contraction.

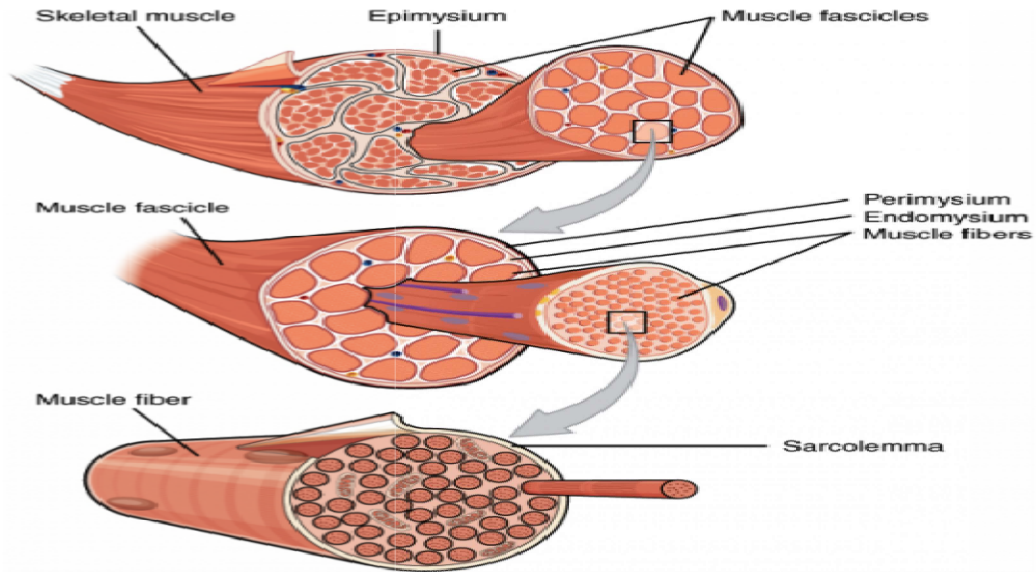

Figure 3. 1007 Muscle Fibres (large) by OpenStax College – Anatomy & Physiology, Connexions Website. June 19, 2013. Licensed under CC BY 3.0 via Wikimedia Commons

The amount of connective tissue in meats and its **solubility** (the degree to which it is dissolved during the cooking process) can directly influence the tenderness of meat muscle. For example, as an animal age, it has more connective tissue and therefore experiences **cross-linking**, an increase in connective tissue that becomes highly insoluble. This is why older animals are usually tougher and younger animals are tenderer.

The tenders' cuts from a beef animal, such as tenderloin, strip loin, and top sirloin from the beef hind quarter, can be prepared using a **dry heat cooking method**. In contrast, tougher cuts from the front quarter of beef that have more collagen connective tissue, such as the blade, shoulder, and shank, require a **moist heat** or **combination cooking method**, which breaks down collagen into a **gelatin** form when cooked in water at temperatures of over 80°C (176°F). The collagen dissolves in the water, which is why stocks made from animal bones and connective tissue have body and thicken when cooled. (We discuss cooking potential and tenderness in more detail later in the book.)Heavy collagen, such as tendons at the ends of muscle groups and the protein elastin, does not break down under this cooking process and is therefore insoluble in water. In addition to silverskin and tendons, there is a specific piece of heavy collagen (also known as the **backstrap)** that is yellow in colour and located along the upper backbone from the base of the skull to the end of the rib cage in all meat animals (Figure 4).

Figure 4.Backstrap location on lamb rack.

Fats are deposited all over certain parts of the animal and contribute to the shelf life, flavour, and colour of dry aged meats. Fat in beef meat muscle is called **intramuscular fat** and appears as a pattern of wavy lines, commonly known as **marbling.**

Skeletal muscle has a very complex organization, in part to allow muscle to efficiently transmit force originating in the myofibrils to the entire muscle and ultimately, to the limb or structure that is moved. A relatively thick sheath of connective tissue, the epimysium, encloses the entire muscle. In most muscles, the epimysium is continuous, with tendons that link muscles to bones. The muscle is subdivided into bundles or groupings of muscle cells. These bundles (also known as fasciculi) are surrounded by another sheath of connective tissue, the perimysium. A thin layer of connective tissue, the endomysium, surrounds the muscle cells themselves. The endomysium lies above the muscle cell membrane (sarcolemma) and consists of a basement membrane that is associated with an outer layer (reticular layer) that is surrounded by a layer of fi ne collagen fibrils imbedded in a matrix

(Bailey and Light 1989). Skeletal muscles are highly diverse, in part because of the diversity of actions they are asked to perform. Much of this diversity occurs not only at the gross level, but also at the muscle cell (fiber) level. First, not only do muscles vary in size, they can also vary in the number of cells. For example, the muscle that is responsible for adjusting the tension of the eardrum (tensor tympani) has only a few hundred muscle cells, while the medial gastrocnemius (used in humans for walking) has over a million muscle cells (Feinstein et al. 1955). Not only does the number of cells influence muscle function and ultimately, meat quality, but also the structure of the muscle cells themselves has a profound effect on the function of living muscle and on the functionality of meat. Muscle cells are striated, meaning that when viewed under a polarized light microscope, distinct banding patterns or striations are observed.

Current trends indicate that by the end of the century 80% of the world's population will be living in the under-developed countries and a significant number of these will have large food deficits. An increased production of animal protein would make an important contribution towards filling this deficit (FAO 1984, FAO 1985, FAO 1990A).

On a world-wide basis cereals supply more than 50% of human requirements for energy and nearly 50% of the protein. Animal products, meat, milk, eggs and animal fats, supply 17% of the energy and 32% of the protein but there are vast regional differences between developed and under-developed countries. Table 1-1A shows world production 'of the various types of meat and illustrates these differences. In Oceania and North America, for example, the amounts of protein available per caput per day from meat are 31.5 and 38.3 g respectively, compared with 4.5 g in the developing countries of Africa and 4.8 g in the Far East (FAO Food Balance Sheets, 1990). The amounts of protein and fat from meat available per caput per day are shown in Table 1-1B. The ranges indicate considerable differences even between countries classed together as developed or developing. In most communities meat has long occupied a special place in the diet, for a variety of reasons including taste preference, prestige, tradition and availability, with the nutritional aspects being included more recently (Rogowski 1980).

Types of Meat

Meat is the flesh and organs of animals and fowls. There are various legal definitions of meat in different countries designed to control the composition of products made with meat.

The flesh of cattle, pigs and sheep is distinguished from that of poultry by the term red meat, while the flesh of poultry (chicken, turkey, duck, pigeon, guinea fowl) is termed white meat.

In addition to the common domestic animals a wide variety of wild animals are eaten - possum, deer, rabbit, moose, caribou, bear, polar bear, seals, walruses depending on availability and local custom, as well as horse, camel, buffalo, goat, dog and rodents. Meat from non-domesticated animals is sometimes termed game meat (de Janvry and Sadoulet 1986). Overall, as indicated in Table 1-1A, by far the greater part of meat supplies is from four sources but this may not be so in certain localities.

The relative importance of these various sources of meat in the diet varies from region to region and in different cultures; many that are rejected for various reasons in one culture are fully accepted in others. In the Indian sub-continent beef is socially and economically perceived as being second class compared with lamb, mutton and poultry, while the reverse is true in most industrialized countries; many western people abhor the thought of eating dog or horse meat which is relished elsewhere; the relative demand for organ meats compared with muscle meat varies in different regions.

Questions

1. What is meat? Explain the muscle structure and composition of meat
2. Write down about the types of meat?

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CHAPTER-2

PRODUCTION AND CONSUMPTION OF MEAT

Agricultural progress in most developing countries has mainly involved an increase in the production of staple crops and the introduction of industrial crops. New varieties, improved farming techniques, greater use of fertilisers, irrigation and chemical control of pests (a group of procedures collectively termed The Green Revolution) have resulted in considerable increases in production, sufficient, in the absence of climatic disasters, to meet domestic needs in many countries and even, in some instances, to provide a surplus for export.

On the other hand developments in livestock production have lagged far behind. Although there has been an increase over the years in the amount of meat available in developing countries the quantities are small. Between 1980 and 1990 world production of meat increased by 29%; 15.6% in developed countries and 56% in developing countries, but the latter was from a very low base. The daily per caput availability of protein from meat increased by 24% but this was an increase from only 4.9 g to 6.1 g in contrast these figures increased in developed countries by 8%, from 27.4 to 33.9 g per day (FAO Food Balance Sheets).

The mean annual output of milk and meat from cattle in the developing countries of Africa and the Far East is less than one tenth of that obtained in Europe (Blaxter 1975; FAO 1990A). This is a result of traditional subsistence farming practices which provide minimum feeding and management levels to livestock. Animals in developing countries are prized mainly for their draught power (Table 1-2 and Ramaswamy, 1980) and manure world-wide some 250-300 million buffalo make a major contribution to the supply of energy; so far as food is concerned they are prized more for their milk than for their meat. Yet as per capita income rises in Third World countries the demand for meat products is rising faster than that for cereals and outpaces supplies.

The problems of meat production are complex and include multiple biological, economic and social factors. The practices of the small-holder system of livestock production need to be gradually developed so as to fit local conditions and meet increasing demands. Modern scientific practices developed in industrialized countries are rarely directly transferable to developing countries and, if they are to be transferred usually need to be adapted to local conditions.

Promotion of Livestock Production

Three main reasons have been suggested for devoting scarce financial and technical assistance to livestock production in developing countries:

1. The possibility of moving into activities with higher added value per unit of product marketed and into products with higher income elasticity of demand.

2. The possibility of increasing supplies of grain products and of diversification of marginal lands into the production of feed grain, oilseed crops and fodder crops as a result of the Green Revolution.

3. The perception of livestock as a means of increasing rural incomes and increasing rural on-farm and off-farm employment (APO 1976, Bachman and Paulino 1979, De Boer 1982).

Animal versus Plant Production

Meat production from grazing animal calculated as energy or protein yield per hectare is very inefficient when compared with plant products. Yields, of course, vary enormously from one region to another and even from one farm to another in the same region but the figures in Table 1- 3 reveal the comparative inefficiency of animal production in those terms.

Animals are, moreover, poor converters of energy into foods for human consumption; if cereal grain is fed to livestock it requires on average 7 kcal input for every kcal generated - ranging from 16 for beef production to 3 kcal for broiler chickens. One argument that has been put forward against industrial systems of meat production is the competition between animal feed and food for direct consumption by human beings. However, certain animals like ruminants are valuable as converters of inedible agricultural and industrial by-products such as bagasse, molasses, sugar cane rinds, beet pulp, cotton seed hulls, poultry manure and urea, into products of high nutritional value, and they can graze on marginal land that is otherwise of little use (FAO 1976, APO 1990).

This can be illustrated by the considerable production of milk IA India largely using feed materials unsuitable for human food. It is estimated that in the hands of the smallholder some 60% of feed comes from farm by-products and 40% from natural vegetation (Groenwold and Crossing 1975). There have been several publications on this subject - "The Role of Animals in Meeting World Food Needs" (Rockefeller 1975), "The Contribution of Livestock on Small Farms. (FAO 1976), "The Potential for Livestock in Farm Diversification" (APO 1990) - but developments have been slow in most countries of the Third World.

Increasing Demand for Meat Products in Developing Countries

Increasing populations and increased demand per capita together with moderately rapid to rapid income growth lead not only to an increased demand for staple foods but also for preferred foods including, particularly, meat products (see income elasticities of demand Table 1-4). As a result meat consumption grew in the Third World between 1961-65 and 1973-77 at an average rate of 3.4%, and in the fast growth economies at more than 6% (Sarma and Young 1985). The expected average meat consumption by the year 2000 is 20 kg/head/year with a deficit in production of some 20-25 m tonnes. Meat consumption between countries varies from 4 kg per head per annum in low income groups to 35 kg in high income groups. In general there is a relation between income and the consumption of animal products but this does not always hold.

The growing demand for meat products that accompanies rising income has been paralleled by increasing interest in food quality, safety and nutritional aspects, which all give rise to appropriate legislation.

In some countries where economic growth has been rapid and sustained over a considerable period of time the contribution of the livestock subsector to agricultural gross domestic product has increased substantially. In Korea, for example, it increased from 5.4% of agricultural GDP in 1961 to 15.4% in 1973. In Taiwan (Chang 1981) it rose from 18% in the period 1952-57 to 29.5% in 1977. These figures can be viewed against an overall average increase of 1040% in developing countries and of 60% in the United States.

In most developing countries, however, the low level of meat supplies is due to the low return of resources devoted to animal production, which, in turn, depends on the low purchasing power of the vast majority of the population (FAO 1990A).

Constraints on Meat Production

Other constraints on meat production include inadequate feeding and poor management of animals, to which must be added animal health problems, lack of skilled manpower, problems arising from land tenure, lack of financial resources, and poor rural infrastructure - roads, power, health care, marketing organisation.

There is a great deal of illegal or poorly supervised slaughter which means that regulations are not being enforced, and conditions are unhygienic. Disease, parasites and poor management of all aspects of meat production impede progress. It is estimated that world-wide per year up to 50 million head of cattle and buffaloes and 100 million sheep and goats die from disease and parasites - mostly in the Third World. Even greater losses of production are estimated to arise from ailing and unthrifty animals and from poor handling before slaughter. In many regions of developing countries animals trek to market, often with inadequate feed and water and under considerable stress which lead to losses of both of weight and quality of meat. In parts of Africa, for example, it is estimated that there is often a 30% loss of weight and 10% mortality on the way to market.

In most areas animals are slaughtered on a simple slab, usually at night or in the early morning when the temperature is lower, and the meat is sold without refrigeration or further processing within a few hours.

The general disregard for grades and quality of meat both in buying and selling does not encourage investment to improve meat output. A more discerning market tends to develop with economic growth, and both producers and consumers would benefit by sale and purchase on grade and quality bases.

Increased Production and Productivity

Increases in meat production can be encouraged by stable profitable outlets in connection with improved processing and handling facilities and consequently large-scale investment. Loan institutions are usually not geared to make loans to small farmers because the administrative costs of small loans are relatively high and so some 70-80% of small farmers in most developing countries do not have access to institutional credit.

Shortage of trained personnel is another constraint on livestock production; there is a need for skilled producers, processors, distributors, extension advisers and technicians. Lack of qualified control personnel and veterinarians leads to enormous losses in quality and quantity of livestock products.

Lack of refrigeration and other preservation techniques results in considerable losses and can lead to public health problems. If animal production is to compete with crop production intended for direct consumption by human beings, then the efficiency of meat production and meat processing must be greatly increased (FAO 1990B). This is of particular importance for the supply of meat to growing populations.

Increasing Yields

There are many and continuing developments in the western world that increase productivity of animals ranging from artificial insemination of animals with synchronized oestrus and embryo transfer to recombinant DNA technology intended to improve growth and feed conversion. These are far from practicable in most parts of the developing world and, instead, there would seem to be considerable potential in making better use of indigenous animals and more immediate gains from better handling before and during slaughter and from closer control of processing.

The resources necessary for livestock production include water, feed, land, labour, capital and energy. Efficiency of output can be related to any of these and so what is perceived as efficiency will differ with the measure and local availability of these resources.

For example, it is common practice in intensive farming in the west to keep species separate and while this is efficient on managed pasture with a sward consisting of a few species of plants it may not be the most efficient method in developing regions since a mixture of types of animals can make better use of the wide variety of grazing species from grasses and legumes through creeping plants to tree-leaves. One of the biological constraints on the production of animal products is poor food conversion efficiency by the animals, in particular meat-producing animals. Scientific progress has been made in industrialized countries in selective breeding for strains with high feed conversion efficiency that could be adapted to meet the needs of developing countries (Blaxter 1975, De Boer 1982).

Age of Slaughter

One aspect of yield of meat is the age of slaughter in relation to maximum feed conversion efficiency, which applies to animals reared solely for meat. In the early stages when growth is rapid there is comparatively good return of meat for feed consumed. This declines with increasing maturity and at a later stage the weight gain is largely fat - which may or may not be wanted by the consumer but is, in any case, an inefficient procedure.

Thus efficiency of production of livestock products can be improved by appropriate livestock management to capitalise liveweight gain potential of young animals, adequate assessment of marketing premiums for carcass characteristics, together with genetic selection and the use of multi-purpose animals.

Multi-Purpose Animals

While maximum feed conversion efficiency can be achieved by specialising in the production of one product such as milk, eggs or flesh, it may be more efficient overall, despite a small loss of efficiency of production of any one product, to use animals for more than one purpose such as milk and meat or eggs and flesh (multi-purpose animals). It has been shown that dual-purpose beef-milk animals are more energy efficient for the same mix of final products than specialist systems - 44% compared with 34% (Preston 1977).

The choice between specialist and multi-purpose animals will depend on the socioeconomic aspects of the whole process and, to some extent, on the demands of the consumer. Slaughter of culled animals that have completed their life cycle as milk or egg producers results in tough meat typical of old animals, which may or may not suit the consumer. The extreme example comes from the Third World where draught animals are slaughtered when they cease to be economically useful for traction; however, tough meat is often acceptable locally where the meat is cut into small pieces and thoroughly cooked.

Fuller Use of Animal Tissues

The profitability of livestock production can be increased by making fuller use of the available animal tissues (Table 1-5). This requires special attention to separation of the organ meats and to the preparation of by-products. There is often considerable loss of these food materials from spoilage which can be reduced only by greatly improved hygiene and handling. In large-scale processing units with long distribution chains this invariably demands refrigeration. The small-scale sector can manage to market these products through short distribution chains without refrigeration which in any case is not available in most of these premises.

Unusual Species

There is potential in currently unexploited indigenous animals as sources of meat. Wild animals supplement domestic meat supplies in many parts of the world and there would appear to be considerable potential in developing these animals as managed meat producers. They are already adapted to local environments and so have advantages over imported stock and they appear to be resistant to many diseases that affect domestic livestock. Developments of this kind have already taken place in many countries illustrating this potential e.g. the farming of red deer in Scotland, hybrid deer in New Zealand (Ainger 1991), bison and water buffalo in other areas. Giraffe, elephant, hippopotamus, antelope, rhinoceros and possum can be added to the list; game reserves could be exploited as managed sources of meat.

These indigenous species are unselected and so there is considerable potential in selective breeding for improved growth rates, adequate production per unit of land and improved carcass composition where this is necessary to satisfy the consumer. One comparison between buffaloes and cattle showed that the former gained more weight than the cattle - 0.7 kg per day compared with 0.5 kg - but the dressing-out weight of the carcass was 47% compared with 50% (FAO 1976). The considerable improvements that have been achieved by breeding plans (originally by traditional but more recently by scientifically-based methods) and, above all, by improved overall management in the well-known domestic species indicate the potential achievement if such methods were applied to indigenous species.

It is not possible to arrive at "average" performance of animals since there are such large variations and so much depends on management but comparisons can be made through the "normal" levels of performance. Table 1-6 indicates "normal" levels of performance of some of the commoner domesticated and less common species (Spedding and Hoxey 1975). These animals, of course, may have differing potentials for improvement through feeding, management and disease control.

Inter Breeding

Some indigenous species will interbreed with conventional livestock and so provide important genetic reservoirs for maintaining and improving the quality of the stock.

Their use in meat production could also offer protection to some threatened or endangered species which might otherwise become extinct. Examples are species such as benteng in Indonesia, yak of Central Asia's high country and mithan of the border regions of India, Burma and Bangladesh.

Use is already being made of domestic bovine hybrids; the madura in Central Asia is a hybrid between benteng and cattle; domestic forms of at least two Asian pig species (the Indonesian wild boar and the Sulawesiwarty pig) are important husbandry animals. Other advantages of using unusual species are that some can subsist without encroaching on the feed requirements of others since they eat different species of plants or different parts of the same species, and feed at different times of the day and at different heights from the ground.

Buffalo as a Meat Source

In many countries - Italy, Egypt, Bulgaria, Australia, Venezuela - Buffalo has been developed as an animal resource to produce meat and has been shown to equal and surpass local cattle in growth, environmental tolerance, health and production of meat and calves. Popular misconception about the toughness of buffalo meat is largely due to its consumption after a life as a draught animal; however, when raised for meat and slaughtered at a young age the steaks are lean and appear to be as attractive as beef. Several trials have shown a preference for buffalo steaks over beef steaks; for example the demand for buffalo steaks in the northern territory of Australia exceeds supply and much of the meat in the Philippines is from buffalo. Another plus point is that buffalo meat is accepted by Hindus who forbid the slaughter of cows.

The buffalo is comfortable in a hot, humid environment, and is more resistant to ticks and other diseases. Raising buffalo not only as a draught animal but also as a meat producer could make a major contribution to meat supplies in many parts of the world. It is already exported from India and Pakistan to Thailand, South-east Asia and the Middle East.

At the other end of the size scale is the rabbit, which has a high reproductive rate and yields a quick profit and is free from most social and religious taboos.

Questions

1. Write down the consumption pattern of meat in India?
2. Write down the present scenario of meat industry in India

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CHAPTER-3

REDUCTION OF LOSSES DURING SLAUGHTERING

In many developing countries the slaughter of animals is traditionally carried out in unsuitable buildings by untrained staff with little attention to sanitary principles. Preslaughter handling is poor and sometimes leads to spread of infection during transportation and in overcrowded lairages, as well as to loss of weight. The condition of the animal can deteriorate within a few days between selection for slaughter and actual slaughter: fatigue and lack of food will deplete muscles of glycogen which may result in quality deficiencies of the meat after slaughter. While walking animals to market is apparently the cheapest method of transport the loss of weight and the mortality may make this method expensive.

Traditional methods of processing and marketing also militate against quality. Even in larger towns abattoirs that have been specifically designed to supply meat to the expanding centres of urban population too often suffer from unsatisfactory hygiene. Sanitary regulations, where they do exist, may be disregarded and not enforced. Some of the traditional slaughter operations, developed when they served a small local population, are carried out in the open, on a slab, hanging under a tree or from a fixture in a walled area. There are no cooling facilities and to counter tropical temperatures slaughter is sometimes carried out at night, when it is cooler and the meat transported and sold before mid-day. In some areas in developing countries the retailer buys live animals from a livestock market or from farms and carries out the slaughter himself and carts the carcass to his retail outlet.

In smaller slaughterhouses this system has to be tolerated but supervision by veterinary authorities is essential. However, in larger operations slaughter should be carried out by a trained staff of abattoir workers in order to maintain the necessary standard of hygiene. Care must be taken in slaughter and handling since, for example, improper and insufficient bleeding does not allow the necessary degree of acidity to develop in the meat and shortens shelf-life; improper dehiding of the carcass leads to heavy contamination; improper evisceration through accidental opening of stomach and tripe's spreads contamination; contact with unclean materials during transport adds to contamination.

Refrigeration

The commonest method of prolonging the shelf life of meat is by cooling. Meat is first chilled after slaughter. It may be kept chilled if there is only a short period of time for distribution. For longer storage periods meat has to be frozen. The shelf life of all typs of unpackaged meat held at chilling temperature, 0°C to + PC or even better -1°C to +4°C, is only between a few days and one to two weeks - depending on the cut of meat, temperature, bacterial load and relative humidity. The shelf life is much longer at freezing temperatures and depends on circumstances such as whether or not it is packaged, type of packaging temperature, etc. Table 1-8 gives some indication of safe storage times at different freezing temperatures; under optimal conditions shelf life can be even longer than indicated.

Most processed meat products also need to be kept refrigerated from the time of processing until their consumption. However, the provision of refrigeration presents one of the biggest problems in many areas of developing countries since supplies of electricity are often inadequate. If meat has to be stored then greater use must be made of other methods of preservation.

Traditional Methods of Meat Preservation

Traditionally foods have been preserved by salting, drying and smoking, methods that have been improved by modern technology. The simplest and most commonly used method is drying in the open air under the influence of wind and sun. Under favourable climatic conditions a product of good quality can be obtained but otherwise losses from spoilage, infestation and contamination can be excessive; and meat is susceptible to natural predators.

Artificial drying plants which are used in advanced meat processing are energy capital- and technology-intensive, and require skilled labour. They are not suitable for the needs of small-scale producers in developing countries who manufacture small quantities for short periods throughout the year. An alternative is the type of fuelled mechanical dryer used in humid tropical regions to dry export commodities such as cocoa, coffee and copra. They use wood or charcoal as fuel so their use is restricted to areas where there are abundant supplies of wood. In other areas the most suitable solution may be to improve existing sun-dry methods or to introduce solar drying, a method by which sun drying is enhanced. The process is best carried out in an enclosed structure so the product is protected from rain, dust, insects and predators and reduces the risk of deterioration of quality and spoilage both during the drying process and during subsequent storage (FAO 1990c).

There are many traditional dried meat products in various regions around the world pastrami in Turkey, Egypt and Armenia, charque in South America, kilishi in Nigeria and West Africa, qwanta in Ethiopia and East Africa, biltong in South Africa. Local requirements, tastes and facilities will obviously influence decisions as to whether dried meat is acceptable and also the most useful process.

Questions

1. Explain the preservation process of meat and meat products
2. What is curing ?

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CHAPTER-4

MEAT CUTS AND PORTIONS OF MEAT

Meat animals are generally broken down from large carcasses into primal and sub-primal cuts. These are large parts of the animal that are then further broken down into retail or restaurant cuts. In some cases, primals and sub-primals are cooked whole, but for the most part they are broken down into a number of different types of smaller portion cuts or fabricated cuts.

These include:

Roasts – boneless or bone-in large cuts that are meant to be cooked whole and then sliced after cooking into portions

Racks – most common with lamb and pork, these are a special type of roast that contains the rib bones and has been trimmed to show the white portion of the bone. Bones which have been trimmed using this process are called frenched.

Steaks and chops – Boneless and individual portion cuts that are cooked and generally served whole or sliced. Chops always have a bone, while steaks can be bone-in (such as a beef T-bone or pork shoulder blade steak) or boneless (such as a tenderloin or sirloin).

Cutlets – thin slices of boneless meat, usually from the leg, which can be mechanically tenderized or pounded. Small round cutlets from the loin or tenderloin are also called medallions or noisettes.

Stew or cubed meat – cubes of meat used for stews and other similar dishes

Thinly sliced or emincé– used for stir-fry and similar dishes

Ground – usually made from trim, ground meat is a mixture of lean and fatty trim that has been passed through a grinder. It can be graded depending on fat content, and can be finely or coarsely ground.

Cured and smoked – most common with pork, meat cuts that are cured using a dry or wet cure (brine) and then may be smoked

Cuts of Meat

"Steak" is a catchall word that describes a cut of meat. Though some animals have different cuts based on their anatomy, beef is a good place to start with as found is just about every butcher counter, and has some complex muscle areas where meat is harvested from not found in other animals.

Taking a look at a butcher's diagram of cattle we can see there are many sections where steaks are cut from. The reason there are so many different regions that cuts of meat come from is related to the amount of use that part of the animal gets, how the fat is distributed, and the amount of meat to harvest in each region. Knowing this we can understand and explore why some steaks are more expensive than others:

Tenderness

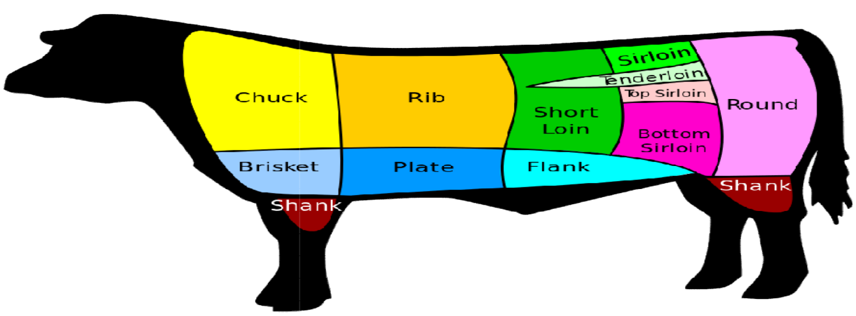
All animals have muscles that are more exercised than others, and the more a muscle is used the tougher the meat. Selections of meat come from a part of the animal that doesn't receive much exercise, typically high up and close to the rear.

Fat

When talking about meat the amount of fat that a cut has is important, since this is where the flavor come from. When looking at meat you will see fat in wide strips around or through the cut, or marbled throug

When looking at steaks these are the two most important things to consider. Unsurprisingly cuts with premium qualities represent a small percentage of all the meat on the animal, and are usually expensive.

Strip Steak



Strip steak (also called New York strip steak, or sirloin steak)

From the short loin section, an area where the muscle does little work, which means the meat is tender. A hallmark of the strip steak is the elongated shape and the pronounced fat cap running along most of the top.

Strip steaks are partially marbled, giving good flavor throughout, and the fat cap can be rendered during cooking to give even more flavor. This cut is great for grilling or the skillet where high heat can render the fat and produce good flavor, these steaks can usually be found in smaller portions.

Tenderloin

Cut from a very specific area near the kidneys, and has an oblong shape. This particular muscle area does very little work; making the meat quite tender (hence the name). Most tenderloin have minimal fat and very little marbling, making this cut tender and suitable for rare steaks, but lacking in big flavor when compared to other cuts. Due to its tenderness, this cut is also good for dishes like Stroganoff.

T-Bone

The "T" shape of the bone that comes with this cut and has meat on both sides. Cut from the short loin, this steak has good fat content and is also tender. The T-bone is actually 2 steaks in one: A strip steak with the identifiable fat cap along the top on one side of the bone, and a smaller section of tenderloin on the other. The anatomy of this steak makes it desirable because it has the fat benefits of the strip steak and the tenderness of the tenderloin. This cut is great for the grill or skillet.

Ribeye

High fat marbling throughout with large fat deposits, sometimes bought bone-in (called "cowboy cut"). In my opinion, this is the best cut of meat. With both tender and lots of fat, this cut produces great steaks any way you cook it.

Chuck

Cut from the area behind the head, chuck is an economical cut as the muscle area is heavily used making it a tougher cut of meat. While it usually has good marbling, chuck also has lots of connective tissue which needs to be rendered in order to be eaten. It is therefore typically used for slow cooking like pot roasts and braising - this is also the cut we'll use in the Smoker Lesson. Alternatively, chuck is commonly ground up and used in hamburger patties, since the grinding breaks the connective tissue and renders the meat very tender.

Questions

1. Explain the different portion of meat?
2. What is marbling

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CHAPTER-5

EFFECTS OF STRESS AND INJURY ON MEAT QUALITY

A. Meat quality

The energy required for muscle activity in the live animal is obtained from sugars (glycogen) in the muscle. In the healthy and well-rested animal, the glycogen content of the muscle is high. After the animal has been slaughtered, the glycogen in the muscle is converted into lactic acid, and the muscle and carcass becomes firm (rigor mortis). This lactic acid is necessary to produce meat, which is tasteful and tender, of good keeping quality and good colour. If the animal is stressed before and during slaughter, the glycogen is used up, and the lactic acid level that develops in the meat after slaughter is reduced. This will have serious adverse effects on meat quality.

Pale Soft Exudative (PSE)

PSE in pigs is caused by severe, short-term stress just prior to slaughter, for example during off-loading, handling, holding in pens and stunning. Here the animal is subjected to severe anxiety and fright caused by manhandling, fighting in the pens and bad stunning techniques. All this may result in biochemical processes in the muscle in particular in rapid breakdown of muscle glycogen and the meat becoming very pale with pronounced acidity (pH values of 5.4- 5.6 immediately after slaughter) and poor flavor. This type of meat is difficult to use or cannot be used at all by butchers or meat processors and is wasted in extreme cases. Allowing pigs to rest for one hour prior to slaughter and quiet handling will considerably reduce the risk of PSE

Dark Firm and Dry (DFD)

This condition can be found in carcasses of cattle or sheep and sometimes pigs and turkeys soon after slaughter. The carcass meat is darker and drier than normal and has a much firmer texture. The muscle glycogen has been used up during the period of handling, transport and pre-slaughter and as a result, after slaughter, there is little lactic acid production, which results in DFD meat. This meat is of inferior quality as the less pronounced taste and the dark colour is less acceptable to the consumer and has a shorter shelf life due to the abnormally high pH-value of the meat (6.4-6.8). DFD meat means that the carcass was from an animal that was stressed, injured or diseased before being slaughtered.

Bruising and injury

Bruising is the escape of blood from damaged blood vessels into the surrounding muscle tissue. This is caused by a physical blow by a stick or stone, animal horn, metal projection or animal fall and can happen anytime during handling, transport, penning or stunning. Bruises can vary in size from mild (approx. 10-cm diameter) and superficial, to large and severe involving whole limbs, carcass portions or even whole carcasses. Meat that is bruised is wasted as it is not suitable for use as food because:

- It is not acceptable to the consumer;
- It cannot be used for processing or manufacture;
- It decomposes and spoils rapidly, as the bloody meat is an ideal medium for growth of contaminating bacteria;
- It must be, for the above reasons, condemned at meat inspection.

Bruising is a common cause of meat wastage and can be significantly reduced by following the recommended correct techniques of handling, transport and slaughter. Injuries such as torn and hemorrhagic muscles and broken bones, caused during handling, transport and penning, considerably reduce the carcass value because the injured parts or in extreme cases the whole carcass cannot be used for food and are condemned. If secondary bacterial infection occurs in those wounds, this causes abscess formation and septicemia and the entire carcass may have to be condemned.

Hides and skins quality

Hides and skins should have the highest value of any product of slaughter animals, other than the carcass. This is particularly so of cattle hides and small ruminants and ostrich skins. In the case of pigs and poultry, the skin forms part of the edible meat. Useful leather can be made only from undamaged and properly treated skins. Proper handling of these items is important to produce a valuable commodity. Careless damage to hides and skins will cost the industry much loss. Hides and skins of slaughter livestock can be damaged by thoughtless handling and treatment of these animals in the following ways:

1. Before slaughter:-
    - Indiscriminate branding;
    - Injuries from thorns, whips, sticks, barbed wire and horns;
    - Unsuitable handling facilities;
    - Badly designed and constructed transport vehicles.
2. During slaughter:-
    - Causing the animals to become excited and injuring them;
    - Hitting or forcefully throwing the animal;
    - Dragging the carcass along the ground, alive or dead.

Muscle Color:

- Pork color can be described as pale (P), red (R) or dark (D).
- Color is important because it impacts consumers' first impressions of the meat. Most consumers prefer pork that is reddish-pink colored (R), as compared to pale (P) colored pork.
- Pale-colored pork is more likely to turn gray or green during display in a grocery store, making it even less appealing to consumers.

Muscle Firmness or Wetness:

- Muscle firmness or wetness can be described as soft and exudative (SE), firm and normal (FN), or firm and dry (FD).
- Soft and exudative means that the meat does not hold its shape and that moisture drips from the meat.
- Soft and exudative meat is often drier and tougher when cooked, so it is less desirable to consumers; it does not work very well for processing into sausage products.
- Soft and exudative meat is often associated with pale colored meat; this is known as PSE, or pale, soft and exudative meat.
- Both firm and normal and firm and dry meat are considered acceptable in the meat industry and to consumers.

Marbling:

- Marbling is the fat within the muscle, also called intramuscular fat.

- Marbling provides juiciness and flavor to meat.
- Meat with adequate marbling is less likely to be tough.

Other Factors that Affect Meat Quality

Stress Gene:

- Pigs that carry the stress gene often have carcasses that are leaner and heavier muscled. Because of this, many show pigs carry the stress gene.
- Negatively, over 95% of stress-positive pigs and 30-50% of carrier pigs produce meat that is PSE. Stress-positive pigs are those that inherit a copy of the stress gene from both parents. Carrier pigs inherit a copy of the stress gene from only one parent.

Extreme Leanness and Muscling:

- Overemphasis on carcass leanness and muscle may reduce meat quality.
- When backfat decreases, marbling also decreases.
- When loin-eye area increases, marbling often decreases.
- Decreased marbling can reduce flavor intensity, juiciness and tenderness of meat.

Inspection and Grading of meat

The objectives of meat inspection programme are twofold:

a. To ensure that only apparently healthy, physiologically normal animals are slaughtered for human consumption and that abnormal animals are separated and dealt with accordingly.
b. To ensure that meat from animals is free from disease, wholesome and of no risk to human health.

These objectives are achieved by ante-mortem and post-mortem inspection procedures and by hygienic dressing with minimum contamination. Whenever appropriate the Hazard Analysis Critical Control Point (HACCP) principles should be used: The inspection procedures should be appropriate to the spectrum and prevalence of diseases and defects present in the particular class of livestock being inspected using the principles of risk assessment.

Eating quality of meat: color, WHC, Juiciness, texture and tenderness, odor and aroma

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

Eating quality characteristics

Tenderness

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

Juiciness

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

Flavour

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

Colour

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

Texture

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

Question

1. What are PSE and DFD condition in meat during slaughtering?
2. Explain the eating quality of meat?

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CHAPTER-6

ANTEMORTEM AND POST MORTEM INSPECTION OF FOOD ANIMALS

GENERAL PRINCIPLES

Ante-mortem Inspection

Some of the *major objectives* of ante-mortem inspection are as follows:

- To screen all animals destined to slaughter.
- To ensure that animals are properly rested and that proper clinical information, which will assist in the disease diagnosis and judgement, is obtained.
- To reduce contamination on the killing floor by separating the dirty animals and condemning the diseased animals if required by regulation.
- To ensure that injured animals or those with pain and suffering receive emergency slaughter and that animals are treated humanely.
- To identify reportable animal diseases to prevent killing floor contamination.
- To identify sick animals and those treated with antibiotics, chemotherapeutic agents, insecticides and pesticides.
- To require and ensure the cleaning and disinfection of trucks used to transport livestock.

Both sides of an animal should be examined at rest and in motion. Ante-mortem examination should be done within 24 hours of slaughter and repeated if slaughter has been delayed over a day. Spread hogs and animals affected with extensive bruising or fractures require emergency slaughter. Animals showing clinical signs of disease should be held for veterinary examination and judgement. They are treated as “suspects” and should be segregated from the healthy animals. The disease and management history should be recorded and reported on an *A/M* inspection card. Other information should include:

1. Owner's name
2. The number of animals in the lot and arrival time
3. Species and sex of the animal
4. The time and date of ante-mortem inspection
5. Clinical signs and body temperature if relevant

6. Reason why the animal was held
7. Signature of inspector

Ante-mortem inspection should be carried out in adequate lighting where the animals can be observed both collectively and individually at rest and motion. The general behaviour of animals should be observed, as well as their nutritional status, cleanliness, signs of diseases and abnormalities. Some of the abnormalities which are checked on ante-mortem examination include:

1. Abnormalities in respiration
2. Abnormalities in behaviour
3. Abnormalities in gait
4. Abnormalities in posture
5. Abnormalities in structure and conformation
6. Abnormal discharges or protrusions from body openings
7. Abnormal colour
8. Abnormal odour

Abnormalities in respiration commonly refer to frequency of respiration. If the breathing pattern is different from normal the animal should be segregated as a suspect.

Abnormalities in behaviour are manifested by one or more of the following signs:

The animal may be:

a. walking in circles or show an abnormal gait or posture
b. pushing its head against a wall
c. charging at various objects and acting aggressively
d. showing a dull and anxious expression in the eyes

An *abnormal gait* in an animal is associated with pain in the legs, chest or abdomen or is an indication of nervous disease.

Abnormal posture in an animal is observed as tucked up abdomen or the animal may stand with an extended head and stretched out feet. The animal may also be laying and have its head turned along its side. When it is unable to rise, it is often called a “downer”. Downer animals should be handled with caution in order to prevent further suffering.

Abnormalities in structure (conformation) are manifested by:

a. swellings (abscesses) seen commonly in swine
b. enlarged joints
c. umbilical swelling (hernia or omphalophlebitis)
d. enlarged sensitive udder indicative of mastitis
e. enlarged jaw (“lumpy jaw”)
f. bloated abdomen

Some examples of *abnormal discharges* or protrusions from the body are:

a. discharges from the nose, excessive saliva from the mouth, afterbirth
b. protruding from the vulva, intestine
c. protruding from the rectum (prolapsed rectum) or uterus
d. protruding from the vagina (prolapsed uterus)
e. growths on the eye and bloody diarrhoea

Abnormal colour such as black areas on horses and swine, red areas on light coloured skin (inflammation), dark blue areas on the skin or udder (gangrene).

An *abnormal odour* is difficult to detect on routine A/M examination. The odour of an abscess, a medicinal odour, stinkweed odour or an acetone odour of ketosis may be observed.

Since many abattoirs in developing countries have not accommodation station or yards for animals, Inspector's antemortem judgement must be performed at the admission of slaughter animals.

Post-mortem inspection

Routine post-mortem examination of a carcass should be carried out as soon as possible after the completion of dressing in order to detect any abnormalities so that products only conditionally fit for human consumption are not passed as food. All organs and carcass portions should be kept together and correlated for inspection before they are removed from the slaughter floor.

Post-mortem inspection should provide necessary information for the scientific evaluation of pathological lesions pertinent to the wholesomeness of meat. Professional and technical knowledge must be fully utilized by:

1. *viewing, incision, palpation* and *olfaction techniques*.
2. *classifying the lesions* into one of two major categories - *acute or chronic*.
3. establishing whether the *condition is localized or generalized*, and the extent of systemic changes in other organs or tissues.
4. *determing the significance of primary and systemic pathological lesions* and their relevance to major organs and systems, particularly the liver, kidneys, heart, spleen and lymphatic system.
5. *coordinating all the components of ante-mortem and post-mortem findings* to make a final diagnosis.
6. *submitting the samples to the laboratory for diagnostic support*, if abattoir has holding and refrigeration facilities for carcasses under detention.

Carcass judgement

Trimming or condemnation may involve:

1. Any portion of a carcass or a carcass that is *abnormal* or *diseased*.
2. Any portion of a carcass or a carcass affected with a condition that may present a *hazard to human health*.
3. Any portion of a carcass or a carcass that may be *repulsive to the consumer*.

Localized versus generalized conditions

It is important to differentiate between a localized or a generalized condition in the judgement of an animal carcass. In a *localized* condition, a lesion is restricted by the animal defense mechanisms to a certain area or organ. Systemic changes associated with a localized condition may also occur. Example: jaundice caused by liver infection or toxaemia following pyometra (abscess in the uterus).

In a *generalized* condition, the animal's defense mechanisms are unable to stop the spread of the disease process by way of the circulatory or lymphatic systems. The lymph nodes of the carcass should be examined if pathological lesions are generalized. Some of the signs of a generalized disease are:

1. Generalized inflammation of lymph nodes including the lymph nodes of the head, viscera and/or the lymph nodes of the carcass
2. Inflammation of joints
3. Lesions in different organs including liver, spleen kidneys and heart
4. The presence of multiple abscesses in different portions of the carcass including the spine of ruminants

Generalized lesions usually require more severe judgement than localized lesions.

Acute versus chronic conditions

Acute conditions

An acute condition implies that a lesion has developed over a period of some days, whereas a chronic condition implies the development of lesions over a period of some weeks, months or years. A sub-acute condition refers to a time period between an acute and chronic condition.

The acute stage is manifested by inflammation of different organs or tissues, enlarged haemorrhagic lymph nodes and often by petechial haemorrhage of the mucosal and serous membranes and different organs such as heart, kidney and liver. An acute stage parallels with the generalized disease complex, when an acute infection tends to overcome the animal's immune system and becomes generalized.

Each case showing systemic lesions should be assessed individually taking into account the significance that these lesions have towards major organ systems, especially the liver, kidneys, heart, spleen and lymphatic system as well as the general condition of the carcass.

Chronic conditions

In a chronic condition, inflammation associated with congestion is replaced by adhesions, necrotic and fibrotic tissue or abscesses. The judgement in the chronic stage is less severe and frequently the removal of affected portions is required without the condemnation of the carcass. However, judgement on the animal or carcass judgement tends to be more complicated in sub chronic and sometimes in peracute stages. If generalized necrotic tissue is associated with previous infection, carcass must be condemned.

Question

1. Write down about ante-mortem inspection
2. Explain the post-mortem inspection of meat

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CHAPTER-7

POSTMORTEM CHANGES IN MUSCLE

There are two major aspects of meat quality, nutritional quality which is objective and "eating" quality as perceived by the consumer - flavour, juiciness, tenderness and colour - which is highly subjective. There are considerable differences between the preferences of individuals including preferences for different cuts of meat, lean or fatty, muscle or organ meats, methods of cooking, etc.

In the industrialised countries the demand for what is perceived as eating quality and also the demand for particular qualities for a range of products from the meat processing industry dictate the breed, feed and management of the animals with intensive rearing and specially formulated dietary supplements and a tendency to slaughter earlier.

On the other hand the demand in most developing regions of the world is for more animal products of almost any kind. The animals live under variable conditions often of rough grazing and grow more slowly, yielding older animals for slaughter; when animals are primarily used for draught they are very old at the time of slaughter. Old animals yield meat that is less juicy and of a quality that differs considerably from that demanded in the industrialised countries.

Post-Mortem Changes

The post-mortem changes that take place when muscle is converted into meat have a marked effect on the quality of the meat. After slaughter the glycogen in the muscle is converted into lactic acid causing a fall in pH from an initial value of pH 6.8 - 7.3 to about 5.4 - 5.8 at rigor mortis. If animals are stressed immediately prior to slaughter as when they are roughly handled or fight one another the muscle glycogen is released into the blood stream and, after slaughter, is rapidly broken down to lactic acid while the carcass is still warm. This high level of acidity causes a partial breakdown of muscle structure which results in pale, soft and exudative meat (termed PSE) - a condition mostly occurring in pigs. The meat losses some of its water-binding capacity which is so important in certain types of meat processing.

Long-term stress before slaughter or starvation uses up the glycogen so that less lactic acid is formed after slaughter resulting in an abnormal muscle condition in which it remains dark purplish-red on exposure to air instead of a bright red colour. This is termed dark, firm and dry (DFD) in the case of pigs and "dark cutting" in beef. The condition is rarer in lambs. Such meat and products made with it have a pH above 6.0 and spoil quickly since the low acidity favours rapid bacterial growth.

PSE and DFD meat are perfectly safe to eat but limited in their processing capacity. PSE meat has higher drip and cooking losses due to the reduced water-binding capacity (WBC). As well as the pale colour the meat has less flavour than usual.

DFD meat has normal or increased WBC and so is suitable for scalded/boiled sausages and other cooked products but it has poor meat flavour. While there is no remedy for these defects in the meat, DFD and PSE meats can be blended with normal meat for the preparation of products of good quality.

After slaughter as the glycogen in the tissues is exhausted rigor mortis sets in and the whole carcass become stiff. This is due to the contraction of the muscle fibres when the actin filaments of the muscle fibres slide inwards between the myosin filaments so shortening the myofibrils.

If the meat is cooked when the muscles are still in rigor it is extremely tough. This condition is prevented by "aging" or "ripening" after slaughter which is achieved by storing the meat until the muscles gradually recovers their extensibility and become tenderer through partial enzymatic breakdown of the muscles fibres. At this stage rigor mortis is said to be resolved.

Rigor is completed in cattle after 12-24 hours and is resolved by periods that depend on the temperature:- 10-13 days at 0°C, 4-5 days at 10°C, 30-40 hours at 20°C and 10-11 hours at 30°C The process is twice as fast in pork as beef or lamb: it is faster in young animals and slower in "red muscles. That function slowly and continuously in the living animal. "Aging" also leads to improvement of flavour.

Obviously if meat has to be sold within a few hours of slaughter it is still in pre-rigor or rigor, and the tough meat has to be cooked longer with some loss of nutrients.

If lamb, and to a lesser extent beef, are chilled too rapidly after slaughter the muscles may undergo extreme contraction or "cold shortening" which results in very tough meat when cooked. Pork is almost unaffected in this way. Cold shortening does not take place when the carcass is cooled more slowly - the temperature must not fall below 10°C before the onset of the rigor. To achieve this carcass is kept at ambient temperature for some hours to accelerate rigor and then rapidly chilled or frozen - a process called "conditioning".

Old animals, especially old draught animals, have a high content of tough connective tissue in the muscle and prolonged cooking at a low temperature is needed to soften the meat by hydrolysis of the connective tissue - a fact not always known to consumers. So it is clear that in many areas conditions militate against good quality meat long transport of animals and poor lair-age facilities prior to slaughter reduce the glycogen in the muscles, poor hygiene, high ambient temperature and lack of refrigeration during and after slaughter lead to heavy contamination and growth of microorganisms and considerable losses from spoilage together with dangers of food poisoning. All this can be aggravated by inadequate care of the meat during transport and in the market. Obviously there is room for improvement in conditions of meat production even for purely local consumption to reduce losses and improve efficiency but if shipment of meat to distant parts is to be considered then it is essential to adopt the sophisticated techniques and methods of refrigeration that are now expected in national and international trade.

Question

1. What is rigor mortis and explain it
2. Write down about post- mortem changes in muscle

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CHAPTER-8

MICROBIOLOGY OF MEAT

The microbiological profile of meat products presented to the consumers is the sum total of the slaughtered animal health, conditions under which it was reared, quality of slaughtering, processing, packaging and conditions under which the meat was stored. Meat pathogens can cause self-limiting human enteric diseases or systemic and fatal infections of the immune compromised the elderly and the young. Meat can act as an ideal substrate for microbial proliferation. Major meat associated pathogenic bacteria include *Clostridium perfringens, Staphylococcus aureus*, *Salmonella spp*, pathogenic strains *of Escherichia coli, Campylobacter spp, Yersinia enterocolitica, Listeria monocytogenes* and *Aeromonashydrophila*

Microorganisms Associated with Meat during Processing

Meat spoilages indicate (a) color changes (b) textural changes and (c) development of off-flavour or off-odor or slime as a result of microbial growth. *Salmonella* is the primary microbial challenge for poultry. The primary microbial to the beef industry is *Escherichia coli* O157: H7. *Listeria*, which is an adulterant with zero tolerance, is the major problem for ready to eat meat products. Treatment with organic acids, hot water steam carcass pasteurization and steam carcass vacuuming, trisodium phosphate, acidified sodium chlorite, chlorine dioxide, lactoferrins, peroxyacetic acid, sodium lactate, sodium acetate and sodium diacetate, ozone and radiation have been used as microbial decontaminants during meat processing operations. Carcass washing with hot water of 80°C for 10 seconds can reduce microbial loads by 2 logs. Current regulatory policies and inspection in the meat industry include the HACCP (Hazard Analysis Critical Control Point) food safety system with an objective to provide safe food for consumption and prevent chemical, physical and biological hazards.

Gram-negative bacteria (Aerobes)

- *Neisseriaceae*: *Psychrobacterimmobilis, P. phenylpyruvica, Acinetobacter* spp*., A. twoffii, A. Johnsonii,*
- Pseudomonadaceae: *Pseudomonas fluorescens*, *P. lundensis, P. fragi, P. putida*

- **Gram-positive bacteria:** *Brochothrixthermosphacta, Kurthiazophii, Staphylococcus spp., Clostridium estertheticum, Clostridium frigidicarnis, Clostridium casigenes, Clostridium algidixylanolyticum* sp. *nov.*

Spoilage

Fresh Meat

In contrast to fruits and vegetables, meats are composed mainly of protein and fats rather than carbohydrates. Water content is 71–76% and therefore moisture is not an issue except for spoilage microbes on cured meats. Muscles of healthy animals do not contain any bacteria or fungi but as soon as animals are slaughtered, meat is exposed to contaminants and good sanitation practices are essential to produce high quality meats. The number of spoilage organisms on meat just after slaughter is a critical factor in determining shelf life. The surface of beef carcasses may contain anywhere from 10^1 to 10^7 cfu/cm2, most of which are psychrotrophic bacteria. Chopping and grinding of meats can increase the microbial load as more surface area is exposed and more water and nutrients become available. A large variety of microbes are commonly found on fresh meat, but different microbes become dominant during spoilage of different meats depending on pH, composition and texture of processed meats, temperature and packaging atmosphere. *Pseudomonas* spp. is the predominant spoilage bacteria in aerobically stored raw meat and poultry. Once the initial low levels of glucose are depleted by various microbes, *Pseudomonas* has an advantage because it can catabolize gluconates and amino acids more readily than other microbes. Break down of these compounds results in production of malodorous sulfides, ammonia, and amines, including the biogenic amines putrescine and cadaverine. Dark, firm and dry meat with a relatively high pH of 6.0 spoils more rapidly because deamination of amino acids starts earlier. *Shewanellaputrefaciens* does not grow on meat at pH<6.0 but can produce sulfides and ammonia even when glucose is still available. These sulfides not only smell bad but also cause color changes in meat, and therefore Shewanella has a high spoilage potential on fresh, high pH meats stored aerobically even when it is not a dominant microbe. *Brochothrixthermosphacta* is often a significant spoilage organism on fresh meat stored aerobically at refrigeration temperatures. *Enterobacteriaceae*, particularly species of *Serratia*, *Enterobacter*, and *Hafnia*, are major causes of spoilage in vacuum-packed, high pH fresh meats. These organisms are facultative anaerobes that produce organic acids, hydrogen sulfide and greening of meats.

Lactic acid bacteria (LAB) grow on meat and poultry packaged under vacuum and modified atmospheres, producing organic acids from glucose by fermentation. This gives rise to aciduric off-odors which may be accompanied by gas and slime formation and greening of meat. However, LAB are weakly proteolytic and so do not produce large amounts of amines or sulfides, and spoilage of meat by LAB is not as offensive. Psychrophilic, anaerobic *Clostridium* spp. are associated with spoilage of vacuum-packaged meats. "Blown pack" meat spoilage is characterized by excessive gas formation with off odors due to formation of butyric acid, butanol and sulfurous compounds. Yeasts and molds grow relatively slowly on fresh meat and do not compete well with bacteria. Therefore, they are a minor component of spoilage flora.

Processed Meat

Addition of sodium chloride, nitrites and/or nitrates, along with various other seasonings, emulsifiers and preservatives to ground or whole muscle meats changes the environment significantly and also the spoilage flora of processed meats. Dried and dry-fermented meats generally do not support microbial growth although process deviations may allow growth of some organisms. Spoilage organisms can grow on fresh and cooked cured meats, so they are best stored chilled, under a vacuum or modified atmosphere. *Pseudomonas* spp. are not usually important causes of spoilage in processed meats because of their sensitivity to curing salts and heat pasteurization and their inability to grow well in meats packed with a vacuum or high carbon dioxide atmosphere. However, when packages have been opened and there has been insufficient curing, these bacteria may spoil refrigerated processed meats. Some cold- and salt tolerant *Enterobacteriaceae* have been found to cause spoilage in some specific processed meats, such as ham or bacon.

Lactic acid bacteria (LAB) is the group of bacteria primarily associated with spoilage of processed meats. They produce sour off-flavors, gas, slime, and greening, and this spoilage may be more severe than in fresh meat because of the presence of added carbohydrates. Competitive ability of different LAB strains is related to pH and water activity of the meat, cooking and storage temperatures and oxygen and carbon dioxide levels. Sporeformers (*Clostridium* and *Bacillus*) are usually not a spoilage problem in processed meats because of the presence of nitrite and other curing salts. However, faulty cooking/cooling procedures, including long cooling periods and temperature abuse, has allowed growth of these organisms in some cases. Spores of these organisms may be introduced with spices or other ingredients.

Yeasts cause some spoilage in processed meats but are generally only important when sulfite is used as a preservative or when meats have been irradiated or are stored aerobically in the cold. Slime may be produced along with vinegary or malty off-odors in some sausages.

Spoilage under aerobic condition

1.) Surface slime, caused by *Pseudomonas acinetobacter, Moraxella alcaligenes Streptococcus, Leuconostuoc, Bacillus* and *Micrococcus.*

2.) Change in colour of meat pigment. The red colour of meat may be changed to shades of green, brown or grey by *Lactobacillus* and *Leconostocs* spp.

3.) Changes in fat. The unsaturated fat in meat gets oxidized by lypolitic bacteria which produce off odours due to hydrolysis of fats and production of aldehydes and acids. This type of spoilage is caused by lypolitic *Pseudomonas*, Achromobacter and yeast.

4.) Surface color change. The red pigment producing bacteria, *Serratiamarcescens*, caused red spots on meat. Blue color surface is caused by *Pseudomonas syncyanea* and yellow color is caused by *Micrococcus* species.

5.) Off odor and off taste. Volatile acid like formic, acetic, butyric and propionic acid produce sour odor and *Actinomycetes* produce musty or earthy flavor. Yeast also cause sliminess discoloration and off odor and taste defects.

6.) Aerobic mold also cause spoilage in meat. These are stickiness, whiskers, black-spot, white-spot, green patches off odor and off taste.

7.) Spoialage under anerobic condition.

i) Souring is caused by production of formic, acetic, butyric, lactic, succinic and propionic acid.

ii) Putrefaction. It is caused by decomposition of proteins under anaerobic condition by *Clostridium* species. The foul smell is due to production of hydrogen sulphide, mercaptans, indol, scatol, ammonia and amines.

Egg

Freshly laid eggs are generally sterile particularly the inner contents. However the shells get contaminated from the environmental sources such as fecal matter of the bird, beddings, by the handlers and wash water and also the packaging materials in which the eggs are packed. There are several extrinsic and intrinsic mechanisms through which the egg protects itself from the microbial invasion. Waxy shell membrane retards the entry of microorganisms. Further, the shell also prevents the entry of microorganisms. The membranes inside the shell behave as mechanical barriers to the entry of microorganisms. Further lysozymes present in the egg white is effective against Gram positive bacteria and avidin in the egg white forms a complex with biotin, thus making it unavailable for the microorganisms. Also high pH (pH 9-10) of albumin inhibits the microbial growth. Binding of riboflavin by the apo protein and chelation of iron by conalbumin further helps in hindering the growth of microorganisms that might have gained entry inside the egg.

Spoilage of egg

Breaks or cracks in egg shell taking place due to transportation or mechanical damage may allow microorganisms to enter in to the egg yolk and cause spoilage on storage. Eggs on storage may lose moisture and, therefore, weight. The white of the egg becomes thinner and more watery on storage. The major changes in the egg take place due to spoilage organisms. In general the spoilage of eggs is caused by bacteria as compared to molds and can be described as green rot due to the growth of *Pseudomonas fluorescens,* colourless rot due to the growth of *Pseudomonas, Acinetobacter* and other species; black rots due to *P roteus, Pseudomonas;* red rots due to *Serratia* spp. and custrad rots due to *Proteus vulgaris* and Pseudomonas *intermedium.* Growth of *Aeromonas* in the egg yolk turns it to black colour and also there is strong putrid odour due to the formation of hydrogen sulphide (H_2S). Storage of eggs in high humid atmosphere may help in growth of several molds on the surface of the egg shell. Molds causing spoilage of eggs include species *of Pencillium*, *Mmucor, Alterneria* , etc.

Poultry Meat

Poultry meat like meat of other animals is also susceptible to contamination by various sources. Contamination of skin and lining of the body cavity take place during various processing operations. The organisms of great importance in poultry are *Salmonella* spp.

and *Campylobacter jejuni.* Several Gram negative psychrotropic bacteria *viz*., *Pseudomonas*, *Acenitobacter* and *Flavobacterium* have also been isolated from poultry carasses. Ground turkey also may carry fecalstreptococci. It is important to freeze the poultry fast in order to keep it in good condition for several months. Freezing further reduces the number of microorganisms in the poultry meat provided the temperature is maintained quite low (-18 ° C or below).

Fish Spoilage

Fish is a very perishable, high-protein food that typically contains a high level of free amino acids. The lipid content of the fish is up to 25%. It has very low content of connective tissue, i.e. approximately 3% of the total weight as compared with around 15% in meat. Fish flesh generally contains 15-20% protein and less than 1% carbohydrate. Non-fatty fish such as teleosts cod, haddock and whiting, the fat levels are only about 0.5%, while in fatty fish such as mackerel and herring, levels can vary between 3 and 25%.

Composition of a fish

- Water 65 – 80 %
- Fat 1 – 20 %
- Protein 14 – 20 %

Microbes metabolize these amino acids, producing ammonia, biogenic amines such as putrescine, histamine, and cadaverine, organic acids, ketones, and sulfur compounds. Degradation of lipids in fatty fish produces rancid odors . In addition, marine fish and some freshwater fish contain trimethylamine oxide that is degraded by several spoilage bacteria to trimethylamine (TMA), the compound responsible for fishy off odors. Iron is a limiting nutrient in fish, and this favors growth of bacteria such as *pseudomonas* that produce siderophores that bind iron. Spoilage bacteria differ somewhat for freshwater and marine fish and for temperate and tropical water fish. Storage and processing conditions also affect microbial growth. *Pseudomonas* and *Shewanella* are the predominant species on chilled fresh fish under aerobic conditions. Packing under carbon dioxide and addition of low concentrations of sodium chloride favor growth of lactic acid bacteria and *Photobacteriumphosphoreum*. Heavily wet-salted fish support growth of yeasts while dried and salted fish are spoiled by molds. Addition of organic acid select for lactic acid bacteria and yeasts. Pasteurization kills vegetative bacteria but spores of Clostridium and Bacillus survive and may grow, particularly in unsalted fish.

Spoilage of fish and sea foods :Halophilic bacteria like *Serratia*, *Micrococcus, Bacillus, Alcaligenes* and *Pseudomonas* cause spoilage of salt fish. Shell fish are spoiled by *Acenetobacter, Moraxella* and *Vibrio*. Crab meat is spoiled by *PseudomonasAcinetobacter* and *Moraxella* at low temperature and by *Proteus* at high temperature.

Microbial loads in shrimps, oysters, and clams depend on the quality of the water from which they are harvested. If the sewage is drained to water bodies, the microbial quality deteriorates. During handling, fecal coliforms, fecal streptococci, and *S. aureus* may be incorporated into the product. *Salmonella* also is found in oysters possibly due to contaminated water. Seafood also is the source for *Pseudomonas* spp., *C. perfringens, L. monocytogenes, Vibrio parahemolyticus, Salmonella enterica* serovar *enteritidis* and *typhimurium*, *Campylobacter jejuni, Yersinia enterocolitica*, and Enteroviruses (Hepatitis A). Smoked salmon and shrimps also are found to carry pathogenic *L. monocytogenes*.

Meat Borne Diseaeses

Food borne microbial hazards have a devastating impact on human suffering. Microbial pathogens of current concern that need to be controlled in the fresh meat include *Salmonella, Campylobacter*, enterohaemorrhagic *Escherichia colli* including serotype O157:H7 and other enteric pathogens. Infection due to *Listeria monocytogenes* following consumption of ready to eat meat and poultry products is a major problem in the recent years. Also there are food borne infections caused by *Yersinia enterocolitica*, *Staphylococcus aureus, Clostridium botulinum, Clostridium perfringens* and *Bacillus cereus*. Prevalence of some food borne pathogens recognized since 1970's include *Vibrio cholerae, Vibrio vulnificus*, Noro virus,,*Enterobactersakazakii*, prions and resistant bacteria. In recent years the food borne pathogens associate with animal health pandemics include Avian Influenza (AI) and Foot and Mouth Disease (FMD) viruses. Avian influenza is not of concern to poultry meat safety, because it is inactivated by proper cooking with a temperature of 70°C and more. Also the oral route of transmission is less important than the non-food borne route. Presently there is continuous adaptation and development of resistance by pathogenic microorganisms to antibiotics and potentially to traditional food preservation barriers, like low pH, heat, cold temperatures, dryness, low water activity and chemical additives. Development of antibiotic resistance in food borne pathogens is very important from public health view point in present days and in the future.

Control of meat borne pathogens

Effective control of meat borne pathogens and enhancement of meat safety can be achieved by control of latent infections among livestock, animal welfare and humane treatment, application of antimicrobial interventions at the farm, during harvesting, dressing and product processing, improvement in process food hygiene and potential application of new or novel processing and preservation technologies. Animal stress can damage meat quality and lead to more contamination and increased pathogen shedding. Antimicrobial intervention technologies can be used effectively to improve the microbiological quality of meats. These technologies include reduction of contamination on the raw product, minimization of microbial access to the products, reduction of contamination that has gained access to the product, inactivation of the microbes on the product without cross contamination and prevention and control of the growth of non-inactivated microbes, which have gained access to the meat. An effective pathogen control at pre-harvest, postharvest, processing, storage, distribution, merchandizing, preparation, food-service and consumption of meat include activities employed during pre-harvest or in the field, during post-harvest or processing in the plant, at retail and food service and at home. Pre-harvest pathogen control interventions include diet manipulation, use of food additives, antibiotic, bacteriophage therapy, and immunization of the animals, complete exclusion, probiotics and proper animal management practices like pen management, clean feed, clean and chlorinated water, and clean and unstressful transportation. Antimicrobial intervention activities during harvest and post harvesting should be designed to minimize introduction of microbial contaminants and reduce existing contaminant levels through implementation of decontamination and sanitization interventions, processing treatments for partial or complete destruction of contaminants and antimicrobial procedures for inhibition or retardation of microbial growth. Certain inspection regulations should be followed in meat and poultry plants, such as establishment of sanitation standard operating system, operations under the HACCP system and performing HACCP verifications to meet microbiological standards, establishment of good manufacturing practices (GMP) and good hygiene practices (GHP). Antimicrobial interventions used to control pathogens in further processed meat products include physical hurdles (low and high temperature, non-thermal process like irradiation and high pressure and packaging treatments), physiochemical interventions (low pH, reduced water activity, modification of oxidation reduction potential through packaging and application of antimicrobial additives), and biological interventions (microbial competitors, such as lactic acid bacteria and antimicrobial products, such as bacteriocins). Events of the most food borne illness happen due to mishandling of foods in various ways. So, there should be provisions to educate the food handlers and consumers particularly on culinary tips.

Question

1. Write down about the associated microorganisms in meat
2. Explain the spoilage of meat

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