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MODULE 1

CONCEPTS AND CATEGORIES OF MEAT WITH THEIR CHILLING TEMPERATURES

UNIT 1 Definition, categories and chilling of meat

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1.1 Introduction

. Meat is food and food can be defined as the edible portion of animals, plants or sea foods that contains the six classes of nutrients (water, fat, protein, carbohydrate, vitamin and mineral). Production of animal from where meat is derived is expensive when compared to other sources of protein. The major nutrient in meat is protein and it is an expensive nutrient

1.2 learning outcomes

At the end of this unit, the student is expected to be able to: Define meat, understand the basic categories of meat, technique of chilling meat and how to handle raw meat

1.3 Concept and categories of meat

1.3.1 Definition of meat

Meat is the flesh of animals ingested as food. In the tropics, the bulk of the meat consumed is derived from sheep, cattle, goats, pigs, deer, antelope, rabbit, squirrel, rats, elephant, camel and other mammalian animals domesticated or wild; poultry, including chicken, turkey, ducks, guinea fowl, geese and meat from other avian and reptilian animals, crayfish, crabs, lobsters and other sea foods, snails and other molluscs and insects. Meat can also be defined as the edible portion of animal tissues. It includes all processed or manufactured products which might be prepared from these tissues.

Since the proportion of meat-derived food that one consumes is related to the general affluence of the society in which he lives, meat consumption in developed countries is more than in less developed countries is m. Obtaining food through animals tends to use up a greater amount of the available calories, proteins and other nutrients which might be available directly from plants. It is reported that it takes about 7-10 kg of plant food to produce 1kg of beef, 4-6 kg to produce 1kg of pork and 2-3 kg to produce 1kg of chicken. Thus meat production is not an efficient agricultural process in terms of conversion of animal feed to human food and in less affluent societies; populations are compelled to derive most of their nutrition from plant origin rather than from animal origin.

1.3.2 Categories of meat

The followings are the basic categories of meat:

1. Red Meat: This is the largest in terms of volume of consumption. It is so called because meat in this category is darkly pigmented. Beef, goat, lamb or mutton and pork are the most common red meats
2. White or lightly pigmented meat: This includes poultry meat which is the flesh of domestic birds such as chicken, turkeys, ducks, geese, guinea fowl etc.
3. Sea foods: Such as fish, lobsters, oysters, crabs and the flesh of other aquatic organism.
4. Flesh of non-domesticated (i.e. wild or game) animals and the flesh of the lesser known sources of meat protein and it includes tortoise, snails, grasshoppers, termites, beetles, insect larvae, cricket and low flying birds.

Self-assessment exercise 1

1. List five (5) different sources of meat
2. List two (2) categories of meat

1.4. **Recommended periods for chilling of different meat at 1°C**

1.4. 1 Chilling of meat

Chilled meat must be kept cold until it is sold or cooked. It the cold chain is broken, condensation forms and microbes grow rapidly. The same rules about not overloading, leaving space tor air circulation, opening doors as little as possible and observing the highest hygiene standards when handling the meat apply. An ideal storage temperature for fresh meat is just above its freezing point, which is about 1°C-3^{0}C for bacon because of the presence of salt. The expected storage life given by the International Institute of refrigeration of various types of meat held at these temperatures is as follows:

1.4 .2 Types of meat and their storage periods (at -1^{o}C)

Type of meat	**Expected storage life (at- 1°C)**
Beef	up to 3 weeks (4-5 with strict hygiene)
Veal	1-3 weeks
Lamb	10-15 days
Pork	1-2 weeks
Edible offal	7 days
Rabbit	5 days
Bacon 4weeks	(at-3^{0}C)

Under commercial conditions, meat temperatures are rarely kept at 1°C to 0°C, so actual storage times are less than expected. The times would also be reduced if RH were greater than 90 percent. Meat should be placed in the refrigerator immediately following receipt. Any parts which show signs of mould growth or bacterial slime should be trimmed off and destroyed. Hands must be thoroughly washed after handling such trimmings and knives must be sterilized in boiling water.

The refrigerator should be thoroughly cleaned after finding such meat and should also be cleaned on a regular basis. Carcasses, quarters and large animals should not be cut into smaller portions as this will expose a greater surface area for bacteria to grow. Freshly cut surfaces are moist and provide a better medium for bacterial growth than the desiccated outer surfaces of the cuts that have been stored for some time. An accurate thermometer should be placed in the refrigerator and checked regularly. The temperature should remain within a narrow range (0° to + 1°C)

Self-assessment exercise 2

1. State the maximum period for chilling of: beef, port and rabbit meat
2. Differentiate between chilling and refrigeration of meat

1.5. Guides for chilling and handling of meat

1.5.1 Guides for Chilling meat

Chilled meat is usually kept for the sale in refrigerated display cabinets, either unwrapped or portioned and packaged for self-service outlets. Refrigerated display cabinets may have fan-assisted convection and/or natural convection. Fan-assisted types are better able to maintain a lower temperature as they are less affected by draughts. Cabinets should be stacked to maintain a good air flow around all meat.

i. Do not store or display unwrapped cooked and raw meat together. Use separate refrigerators, display cabinets etc. to avoid cross-contamination. Kaw-meat exudate on to cooked meat gives an explosive bacterial growth. Simple packaging of fresh meat with plastic foil has become very popular with the availability of suitable and inexpensive film. The main objective of simple

ii. Packaging is to provide hygienically protected portioned meat for self-service retail outlets. But the meat portions must also satisfy the customer's preference for bright red fresh meat.

iii. This colour is due to the pigment myoglobin loosely binding oxygen to form oxymyoglobin. For this colour to develop and be maintained, the wrapping film must have high-oxygen permeability. To avoid desiccation of the cut surface, the film should have a low moisture permeability. After a time the cut surface becomes browner as a result of myoglobin binding the oxygen more tightly to form met myoglobin. This may take up to three days depending on the temperature, the number of bacteria and other conditions.

iv. Simple packaging for retail sale in self-service outlets usually involves placing the meat portion in plastic trays and overwrapping with a clear plastic film. Plastic trays are more hygienic than cardboard. The portions cut should be based on local demand and only a day's sales should cut at a time. The principal object of this type of simple packaging from a hygiene point of view is to reduce contamination from airborne micro-organisms.

v. High standards of hygiene are required in the cutting and packaging operations. On large pieces of meat the bacteria mainly colonize the outer surfaces. When meat is cut even with a clean knife they will be spread on to the freshly cut moist surface and multiply rapidly. This is not an argument for relaxing hygiene standards, rather it underlines the need not to add to the bacterial load by further contamination. All surfaces and tools in the cutting and packaging room must be kept thoroughly clean.

vi. Packaging materials should be stored in hygienic conditions protected from dust and attack from insects or vermin. It is most important that personnel involved in cutting and packaging pay particular attention to personal hygiene as they are the most likely source of food-poisoning pathogens which may survive better in the package environment than on unpackaged meat. This is in part due to the packaging preventing surface desiccation. The moist surface favours bacterial growth as does the high relative humidity that builds up within the pack.

vii. It is important to retard bacterial growth by maintaining a low temperature during the display life of the packs. Overwrapping actually increases the meat temperature as the layer of trapped air acts as an insulator. Heat generated by light warms the upper surface. Meat should be thoroughly cooled before packaging to maintain a low temperature during its display life.

viii. Mincing meat spreads bacteria on the surface all through the meat which therefore has a shorter shelf-life than cuts. Mince may be packaged and overwrapped but the mincer must be kept scrupulously clean and the packs kept well chilled. Only small quantities of mince should be prepared at a time. Cooked meats, which typically have much lower bacteria count than fresh, are more open to attack from airborne micro-organisms as these will be faced with little competition. Packaging is therefore particularly beneficial in preventing this type of contamination for cooked meats.

ix. Bacteria introduced during cutting and packaging face little competition and may be of the food-poisoning type if personal hygiene is poor. If very high standards of hygiene cannot be maintained then a pasteurizing treatment after packaging will be necessary. Even this, however, will not guarantee destroying Bacillus and Clostridium spp. if these have been introduced

Self-Assessment Exercise 3

x

1. Chilled meat is usually kept for the sale in ……. Cabinets?
2. The colour of meat is due to the pigment myoglobin loosely binding oxygen to form …..…….?

1.6 Summary

In this unit, students have been introduced to the basic definitions and categories of meat. In this unit we have learnt that meat is food and supplies mainly protein when consumed. There are various categories of meat such as red meat, white or lightly pigmented meat, sea food and domesticated animals. Meat can be stored for not more than three weeks if utmost hygiene is observed.

1.7 Glossary : *Pigmented* = colourful

1.8 References/Further Readings

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1.9 Answers to Self-Assessment Exercises

Answer for Exercise1 no 1.

1. The bulk of the meat consumed is derived from sheep, cattle, goats, pigs, deer, antelope, rabbit, squirrel, rats, elephant, camel and other mammalian

animals domesticated or wild; poultry, including chicken, turkey, ducks, guinea fowl, geese and meat from other avian and reptilian animals

Answer for Exercise 1 no.2.

1. Red Meat: This is largest in terms of volume of consumption. It is so called because meat in this category is darkly pigmented. Beef, goat, lamb or mutton and pork are the most common red meats
2. White or lightly pigmented meat: This includes poultry meat which is the flesh of domestic birds such as chicken, turkeys, ducks, geese, guinea fowl etc.
3. Sea foods: Such as fish, lobsters, oysters, crabs and the flesh of other aquatic organism.
4. Flesh of non-domesticated (i.e. wild or game) animals and the flesh of the lesser known sources of meat protein and it includes tortoise, snails, grasshoppers, termites, beetles, insect larvae, cricket and low fling birds.

Exercise 2

i. Beef up to 3 weeks (4-5 with strict hygiene)

ii. Pork = 1-2 weeks

iii. Rabbit = 5 days

Exercise 3

1. Chilled meat is usually kept for the sale in refrigerated display cabinets

2. The colour of meat is due to the pigment myoglobin loosely binding Oxygen to form oxymyoglobin

UNIT 2: ANATOMY, PHYSIOLOGY AND HISTOLOGY OF DOMESTIC ANIMALS

Unit structure

2.9 Answers to SAEs

2.1. Introduction

Meat consists primarily of muscular tissue with amounts of fatty tissue varying not only with the breed, age, sex and diet of the animal but also with the anatomical location

2.2 Learning outcome

At the end of this unit, the student is expected to be able to: Understand different compositions of meat, understand the process of livestock slaughtering, tenderization of meat, cold storage of meat and understand microorganisms associated with meat spoilage

2.3 Anatomy, Physiology and Histology of Domestic Animals

2.3.1 Primary composition of meat

Meat is primarily composed of muscle, plus variable as some epithelial of all the types of connective tissues. Skeletal muscle is the principle source of muscle tissue in meat. However, a small amount of smooth muscle (blood corpuscles) is also present in meat. Although all the connective tissue types are present in meat, adipose tissue (fat), bone, cartilage, and connective proper predominate. The muscle and the connective tissue are the gross components of the meat animal carcass, and they contribute almost exclusively to the qualitative and quantitative characteristics of characteristics of meat.

Chemical composition of meat

Meat consists primarily of muscular tissue with some amounts of fatty tissue varying not only with the bread, age, sex and diet of the animal but also with the anatomical location. As a guide the approximate composition of a typical mammalian muscle is 75% water, 19% protein 3.5% fat, 2.5% of soluble non-protein materials.

Meat structure and composition

Before considering the slaughter, post-mortem events, meat quality and meat preservation in the tropics, it is necessary to consider the fine structure and composition of mammalian tissue.

Muscle structure

Meat consists primarily of muscular tissue with amounts of fatty tissue varying not only with the breed, age, sex and diet of the animal but also with the anatomical location. As a guide, the approximate composition of a typical mammalian muscle is 75% water, 19% protein, 3.5% fat, 2.5% of soluble, non-protein materials. A crude relationship between moisture (M) and protein (P) contents given meat cut is P= M/4. The mineral content of deboned meat is low and the carbohydrate content is negligible. Variations result from differences in species, breed, sex, age, nutritional regimes, and muscle location within the animal.

Most skeletal muscles are attached directly to bone although a few are attached to ligaments, fascia, cartilage and skin. A muscle can be physically divided into successively smaller longitudinal units, each of which is surrounded by a sheath of connective tissue. Surrounding the muscle as a whole is a sheath of connective tissue known as epimysium. From the inner surface of the epimysium, septa of connective tissues penetrate into the muscles, separating the muscle fibre into bundles; these separating septa constitute the perimysium, which contains the larger blood vessels and nerves. From the perimysium a fine connective tissue framework passes further inwards to surround each individual fibre the essential structural unit of each muscle. The connective tissue surrounding each fibre is the endomysium and below it, the sarcolemma. Each muscle fibre is composed of several long thin, cylindrical rods known as myofibrils. These myofibrils are the essential contractile units of muscle and are separately enwrapped in the sacroplasmic reticulum, a highly specialized mesh of tubules concerned with calcium ion control and hence the initation and arrest of contraction. The myofibrils are bathed in an aqueous fluid, the sacroplasm, which is about 75-80% water and contain liquid droplets, glycogen granules, ribosomes, numerous proteins, non-protein nitrogen substances and a number of inorganic constituents.

When viewed under the microscope, cross-sections are seen. They arise from the orderly formations of two types of filament which, lying parallel to the axis of the fibre make up the myofibrils. The cross sectiotions are formed by alternate ranks of myosin and acting firmament.

The myosin filaments, being thicker, from the dark or A-bands with fine acting filaments extend into the dark bands overlapping the myosin filaments. The dark or A-band has a central clear area, the H-zone and the light or I-band has a central dark division, the Z-line is the functional unit of the myofibril and is known as sarcomere.

Muscle Tissue

The structural unit of muscle is a specialized cell, the muscle fibre, which constitutes 72-92 percent of the muscle volume. The membrane surrounding the muscle fibre is called the sarcolemma and the intracellular substance the sarcoplasm. The muscle fibre is composed of many myofibrils, which consist of thick and thin filaments (myofilaments). The special arrangement of these and the bands of myofibrils give the fibre a striated appearance under a microscope (Cross-striated muscle).

The filaments consist almost entirely of the myfibular proteins actin (thin 20-25 percent) and myosin (thick 50-55 percent). Although they make up only 7 % of muscle weight, they are mainly responsible for a very important property of meat, its ability to retain water and bind added water (water-holding capacity, WHC). The water-holding capacity is of particular importance in meat processing

Connective Tissue

Connective tissues are distributed throughout all body components -skeleton, skin, organs, fat, tendons and muscles. There are three kinds of connective tissue fibre: collagen, reticulum and elastin. Collagen constitutes 20-25 % of total protein, and has a major (negative) influence on meat tenderness. Skin (from pigs only) has excellent swelling and binding abilities owing to its high collagen content. It is therefore ideal for meat products such as emulsion-type cooked sausages provided it is properly scalded, completely de-haired, usually singed, scraped, washed and de fatted.

Fatty Tissues

The main fatty tissue deposits are in septa between muscle bundles (intramuscular fat), in spaces between muscles (intramuscular) and between skin and muscles (subcutaneous or back fat). Fat depots are also found around internal organs. The main depot is found around the kidneys (perirenal, leaf or kidney fat). Fatty tissues can be graded as "firm (back fat, jowl and brisket) and "soft fatty tissues (leaf perennial fat) are depending mainly on their connective tissue content.

Internal Organs

Depending on local regulations and eating habits, the following are commonly used in sausage manufacture:

- Heart after removing the pericardium is used as any other kind of meat.
- Liver is used for making various types of liver sausage and paste, because its proteins have high emulsifying capacity
- Tongue trimmed of all the hyoid bones, tonsils, and mucous membranes, can be cured and dried whole, used to make meat batter, or cured and canned (ox or pork tongues).
- Lungs. Beef lungs can be used to make cooked sausages. Pork lungs are frequently not fit for human consumption as they can be contaminated by scalding water.
- Kidneys are often contaminated to a certain extent with heavy metals or other residual substances and the consumption in higher quantities is not recommended in some countries,
- Tripe is the rumen and reticulum of ruminants, opened and rinsed. All the dark tissues (internal linings) must be removed by cooking (62- 65^{0}C).
- Stomach of pigs, properly cleaned, is used as a natural casing for cooked sausages.
- Intestines are mainly used as casings for various sausages.
- Blood is highly perishable and must be handled carefully to avoid contamination during collection. To prevent coagulation blood is either defibrinated or a solution of sodium citrate 1.6 percent or phosphate 1 percent is added. Blood plasma obtained by centrifuging should be cooled as quickly as possible to 0'C. Whole blood is used to make blood sausage, liver sausage, and blood pudding Blood plasma can be used for meat emulsions (batter).

All raw materials must be fit for human consumption. After inspection, final dressing removal of condemned and dirty parts and washing all meat and organs must be immediately hung on hooks and moved to a cooler to await processing. Carcasses may be fully or partially boned before chilling provided high hygienic standards are rigidly observed. A high degree of skill and special organisation of labour is required. If small-scale producers cannot chill the carcasses, they may use hot-boned meat for sausage production or meat batter. Hot boned meat has a high WHC so the use of phosphate is avoided. However, beet must be processed within four hours and pork within one hour of slaughter.

Pre-slaughter stress may result in abnormal undesirable muscle conditions called "pale, soft and exudative" (PSE), and "dark, firm and dry" (DFD). PSE meat is frequently found in pork caused by a sudden stress before slaughter. Glycogen levels are raised in response to the stress so that post-slaughter glycolysis is elevated leading to a build-up of lactic acid and a rapid fall in muscle pH to below 5.8 within one hour. This results in partial protein denaturation reducing WHC and increasing drip loss.

A prolonged period of stress prior to slaughter such as fighting during transport and lairage causes exhaustion and the depletion of glycogen reserves. Post-mortem glycolysis and lactic-acid production are therefore reduced, the pH falls slowly and protein degradation is reduced. The resulting DFD meat which is found in pork and beef has a high WHC but spoils vey quickly because the high pH and dry surface favour bacterial growth. Manufacturers must aim for uniform quality of their meat products. To attain this, raw materials must be standardized for different qualities. Good quality carcasses are usually divided into primal cuts (ham, shoulder, loin, neck, etc.)

The remainder of the carcass and trimmings from the primal cuts are standardized into different qualities of meat. Poorer-quality carcasses are used entirely for processing after being deboned and trimmed. Basic parameters for simple quality standards are size and shape of meat pieces, amount of visible fatty and connective tissues, and chemical composition. Meat must not contain sk in, lymphatic glands and particles of bones, bristles, large blood vessels or blood clots.

2.3.2. Process of livestock slaughtering

1. Lairage rest and care: The very first stage in a well-organized livestock slaughter is lairage rest and care. For convenience, the lairage should necessarily be close to, but screened from the slaughter slab or floor. An animal in the lairage should not be exposed to stressful sight of its comrades on slaughter till it is its turn-hence, the screening off of the lairage. There should, however, be an unobstructed access from the lairage to the killing floor. The entrance should be narrow, restraining only one to two animals at one time to the killing floor.
2. Stunning sticking and bleeding: Stunning minimizes the struggle of animals during sticking and bleeding and facilitates smooth operation of the slaughter line. Most common stunning methods include the use of hammer or pole axe, captive bolt, electric shock and O2 suffocation. Whatever the method of stunning accepted, it is essential that the animal is rendered unconscious without destroying the medulla oblongata which controls the action of the heart and lungs needed to pump out blood during exsanguinations. Stunning should be followed as quickly as possible by sticking/killing and bleeding to prevent the animal regaining consciousness. Sticking/killing of meat animals is commonly achieved by cutting the neck blood vessels. Bleeding should best be done on the hoist with the animal hanging head downwards to ensure rapid exsanguinations assisted by gravity, rapid blood collection from the killing floor and to ensure minimal contamination of the carcass by blood.
3. Evisceration: After bleeding the animal and while the carcass is still hanging from the chain shackled around the hind legs as practiced in organized operation, the head is skinned and removed

from the carcass. The legs or shanks are removing. After the hide is either skinned or pulled off, the carcass is opened and the abdominal viscera (e.g. intestine, stomach) are removed. This is case with cattle. Following bleeding, the animals like swine are placed in a scalding tank at the temperature of 57.2 to 71.1oc. The carcass is then opened by a cut down the belly from harn to breast, avoiding the cutting of the intestines. The bung is loosened and the intestinal tract removed.

4. Washing of the carcass: All blood should be washed off both the inside and outside of carcass
5. Cutting-up: In cutting-up the carcass, it is always necessary to always start by cutting through the lean meat and sawing through the bone in order to minimize contamination with bone which leads to early putrefaction or taint. It is necessary to cut along the natural seams forming the muscles so as to minimize injury to muscle and consequent drip loss of meat juice.

Self-assessment exercise 1

1. List the microorganisms that cause meat spoilage
2. State the approximate composition of a typical mammalian muscle
3. **State the Chemical composition of meat**
4. The mathematical relationship between the moisture and protein content of meat is .....

2.4 Different parts of the carcass muscle and tenderization

2.4.1 Muscular tissue

A muscle can be physically divided into successively smaller longitudinal units, each of which is surrounded by a sheath of connective tissue. Surrounding the muscle as a whole is a sheath of connective tissue known as the epimysim. From the inner surface of the epimysim, septa of connective tissue penetrate into the muscle, separating the muscle fibres into bundles. These separating septa constitute the perimysium which contains the larger blood vessels and nerves. From the perimysium, a fine connective tissue framework passes further inwards to surround each individual muscle fiber. These connective tissues are known as endomysium. The endomysium is the sarcolemme fiber membrane.

A muscle is made up of fibers which appear striated in the light microscope. A single muscle fiber is made up of myofibrils beside which lie cell nuclei and mitochondria. In a single myofibril, the striations are resolved into a repeating pattern of light and dark bands. A single unit of this pattern consists of a z-line, an i-band, an A-brand which is interrupted by an H-zone, then the next I-band and finally the next z-line Electron micrographs have shown that the repeating band pattern is due to the overlapping of thick and thin filaments. The myosin filaments, being thicker and form the dark or A-band while the fine action filaments form the light or I-bands. Action filaments extend into the dark bands overlapping

2.4.2. **Tenderization of meat**

Fresh meat is usually rather tough. After about 24-35 hour's chill, the meat becomes progressively tenderer. This is believed to result from alterations in the structure of the myofilaments and their cross-bridges. It is possible, although not certain, that these subtle but important structural changes are caused by the action of cathepsin enzymes. The structural alterations may either relate directly to the tenderization accompanying ageing (ripening or conditioning), or permit the shift of ions necessary for improved water holding capacity (WHC) or both. The action of proteolytic enzymes on the connective tissue in meat which reduces them to gelatinous consistency is the tenderizing action that transpires during ageing. Tenderization of meat can generally be achieved in two broad ways

2.4.2.1 Natural Tenderization

Natural ageing or ripening of the meat is achieved with the meat natural enzymes in the cold room/store. Here, the ageing or ripening of meat is generally done at 35^{o}F (2-3^{o}C) by hanging the carcass in a cold room. The best flavour and greatest tenderness develop with ageing at this temperature for 2-4 weeks. In this case, the humidity must be controlled and the meat wrapped to minimize drying and weight loss. New ageing process have also been developed using higher temperature for 2-4 weeks. In this case, the humidity must be controlled and the meat wrapped to minimize drying and weight loss. New ageing process have also been developed using higher temperatures for shorter time such as 68^{O}F (18-20^{O}C) for 48h. Tenderness is achieved but bacterial slime also develops quickly on the meat at this high temperature. In commercial practice where quick ageing at high temperatures is employed, ultraviolet light may be used to keep down bacterial surface growth

2.4.2.2 Artificial Tenderization

There are several artificial means of tenderizing meat to various degrees.

i. Mechanical means such as pounding, cutting, or separating and breaking meat fibers with ultrasonic vibration.

ii. By use of low level of salt, salt solubilizes meat protein and draws water to itself. Therefore, if salt is placed within the meat as in ground hamburger, it holds water within the mass. If it is placed on the surface of the meat, it draws moisture out of the mass to the surface. Phosphate salts may even be more effective than common table salt. In this respect, and either may be blended into ground meat or diffused into the flesh to help to retain juices and minimizes bleeding or dip losses.

iii. Tenderizing method involved the addition of enzymes to the meat such enzymes includes bromelin from pineapple, ficin from figs, trypsin from pancreas and papain from papaya. Enzymes may be applied to meat surfaces but the penetration is slow and so injection into the meat or into the bloodstream of the living animal before slaughter which is more effective for large cuts. With enzyme, ageing time is reduced markedly. The native practice in tropical countries of wrapping meat in pawpaw leaf results in this kind of tenderization.

Self-assessment exercise 2

1. Surrounding the muscle as a whole is a sheath of connective tissue known as the……….
2. Explain the term natural aging of meat:
3. Explain the term artificial tendering of meat

2.5 Cold storage of Meat

The meat under cold storage needs -15 ~-25 ^{o}C temperatures which can keep the meat from 6 to 12 months. And, the meat must be frozen from the blast freezer machine like blast freezer room, plate freezer. If your meat temperature is higher than 0^{o}C degrees (32 F), you should need a blast freezer room first understanding the correct meat cold room procedure whether frozen or chilled, is important if you want product that is as fresh, delicious and safe as possible.

Harmful bacteria begin to develop in raw meat from the moment an animal is slaughtered, making storage an incredibly time sensitive process. If you want or need to prolong the life of your meat for as long as possible, it’s crucial that you follow the correct safe storage procedures.

Usually the temperature dropped below -18 ℃, the food freezing rate was high, the microorganisms and enzymes basically stopped moving and growing, and the oxidation was also very slow. Therefore, the food can be stored for a longer period of time and has better frozen quality. In addition, frozen food also requires that the temperature in the storehouse be relatively stable. Excessive temperature fluctuations will cause spoilage of the food.

2.5.1 Pre-cooling room

Meat cold room is mainly used for the cold processing of meat carcasses such as pigs, cattle, and sheep. The freezing point of meat juice is -0.6 ~ -1.2 ℃. When the carcass temperature after slaughtering is about 35 ℃, it is sent to a cold room. The designed room temperature is about 0 ~ -2 ℃. The meat temperature is reduced to 4 ℃ in the cold room. Due to the small heat capacity and thermal conductivity of the air, increasing the air flow rate can increase the cooling rate. However, an excessively strong air flow rate cannot increase the cooling rate compared with the same period of the previous year, but it will greatly increase the dry shrinkage loss and power consumption of the meat surface. Therefore, in the cooling process, the wind speed in the cargo room of the cold room is suitable not to exceed 2m / s, and generally the above 0.5m / s is used. The air circulation times are 50 ~ 60 times / h, and the cooling time is 10 ~ 20 h. The average dry body consumption is about 1.3 %.

2.5.2 Cooling processing

A, The temperature is -10 ~ -15 ℃, the air velocity is 1.5 ~ 3m / s, and the cooling time is 1-4h. The average enthalpy value of the meat at this stage is about 40 kj / kg, which makes the surface of the meat form a layer of ice. Not only reduces the dry consumption, but also accelerates the cooling process (the thermal conductivity of ice is 4 times that of water).

B, The cold room temperature is about -1 ℃, the air velocity is 0.5 ~ 1.5m / s, and the cooling time is 10 ~ 15 h, so that the surface temperature gradually increases and the internal temperature gradually decreases, so that the temperature of the body is balanced until the thermal center temperature reaches 4 ℃. The meat cooled by this method has good color, aroma, taste and tenderness, which shortens the cooling time and reduces the dry consumption by 40 to 50 %. The following picture shows the process conditions for rapid cooling of meat.

Meat	Cooling stage	Air temperature/℃	Air velocity/(m/s)	Core temperature/℃	
				Beginning	Final
Beef	A	-10~-20	1~2	38	15~18
	B	-1~-1.5	0.1~0.2	15~18	4
Pork	A	-13~-15	1~2	38	18~22
	B	-1~-1.5	0.1~0.2a	18~22	4

The first thing to understand when considering storage options is that not all meats are equal and that their storage times reflect this. It’s important to remember that the fat and water content, as well as the size of the cut, will determine how long a piece of meat should be stored for in a blast freezer.

These timings are a good indication of how long regular cuts of meat will stay fresh at -18°C if storage procedures, up until this point, have been followed correctly.

2.5.3 Microorganisms associated with meat spoilage

Food poisoning may be due to infection or intoxication caused by microorganisms.

Infection is caused by the consumption of live bacteria which multiply in the human body producing characteristics symptoms.

Intoxication is due to toxins in food produced by bacteria before the food is eaten.

Toxins are chemical compounds which may linger in food with no microbes growing in it, and are therefore very dangerous.

2.5.4 *Salmonellae typhi*

Salmonellae are facultative anaerobes which cause food poisoning. Ten or 20 cells of *Salmonella typhi* are sufficient to cause typhoid but 10,000 to 100,000 cells of other species may be necessary to cause an infection. Some are host-specific affecting the animal from which the meat was produced but failing to cause infection when consumed by man.

Typical symptoms of salmonellosis include

- diarrhea,
- fever and
- vomiting
- The illness may last one to 14 days after a 12 to 24 hour incubation period.
- Victims may excrete the bacteria for weeks after the symptoms subside. Poor personal hygiene will cause contamination of meat.

2.5.5 *Staphylococcus aureus*

Staphylococcus aureus is a facultative aerobe that causes intoxication. It lives in the nose, throat, hair and skin and on animal hides. Meat is contaminated by handling and by sneezing or coughing. Minute amounts of the toxin will cause illness, which starts within one to eight hours of eating poisoned food.

- Nausea,
- Vomiting and
- Shock may last for one to two days.
- On rare occasions it is fatal.
- This bacterium does not produce off-odours or spoilage so it cannot be easily checked
- Refrigeration will control its growth.
- Cooking may destroy the bacteria but not the toxin as it is heat stable.
- It is particularly troublesome in cooked cured meats, normally as a result of recontamination after the curing process in subsequent handling, for instance during slicing.

2.5.6 *Clostridium botulinum*

Clostridium botulinum, an anaerobe, produces the toxin botulin, one of the most poisonous substances known. This attacks the central nervous system causing death by respiratory paralysis. The illness cause by this organism is called **botulism**. Dormant cells occur everywhere in the soil, fish, animals and plants. High-moisture, low-acid, low-salt conditions at above $3^{O}C$ will favour growth and toxin production. Control measures must destroy spores or prevent growth and toxin formation. Botulism is usually due to undercooking processed meats. Pressure-cooking will give commercial sterility. Pasteurization (heating to 70 ^{O}C and adding salt (NaCl) and sodium nitrite ($NaNO_2$) is used for canned ham. Refrigeration (0-10 ^{O}C) is essential for vacuum-packed meats. Frozen storage prevents growth.

2.5.7 *Clostridium perfringens*

Clostridium perfringens, an anaerobic bacterium, is a common cause of food poisoning but is rarely fatal. It grows well in warm meats so is usually found in left-over meats that have not been kept chilled and not been reheated to 70 ^{O}C to kill the bacteria present. The main symptoms are diarrhea and weakness which last for 12 to 24 hours after an incubation period of 8 to 20 hours.

Self-Assessment Exercise 3

1. The meat under cold storage (-15 ~-25 ^{o}C) temperatures can keep the meat from 6 to ………. months…… A. 7 B. 9 C. 10. D. 12
2. The following will determine how long a piece of meat should be stored for in a blast freezer except ………. A. Size of the cut. B. fat. C. water content. D. age of the animal
3. List the typical symptoms of Salmonellosis
4. The incubation period of *Clostridum perfringens* is ………..?
5. Botulism is an illness caused by organism called …..?

2.6 Summary:

i. Meat is primarily composed of muscle, plus variable as some epithelial of all the types of connective tissues. The muscle and the connective tissue are the gross components of the meat animal carcass. Meat consists primarily of muscular tissue with amounts of fatty tissue varying not only with the breed, age, sex and diet of the animal but also with the anatomical location. As a guide, the approximate composition of a typical mammalian muscle is 75% water, 19% protein, 3.5% fat, 2.5% of soluble, non-protein materials. A crude relationship between moisture (M) and protein (P) contents given meat is **P = M/4.** The mineral content of deboned meat is low and the carbohydrate content is negligible. Variations result from differences in species, breed, sex, age, nutritional regimes, and muscle location within the animal. Meat consists of connective tissues, fatty tissues and internal organs. An animal in the lairage should not be exposed to stressful sight of its comrades on slaughter till it is its turn-hence, the screening off of the lairage. A muscle can be physically divided into successively smaller longitudinal units, each of which is surrounded by a sheath of connective tissue. . Tenderization of meat can generally be achieved in two broad ways (natural and artificial ways). A clearly-defined system of frozen fish distribution is conducted through a chain of intermediaries who handle products at different levels. Food poisoning may be due to infection or intoxication. *Salmonella and Clostridum spp* are mostly implicated microorganisms in meat spoilage. It is difficult destroying *Bacillus and Clostridium spp*. if these have been introduced

2.7 Glosssary: *Carcass* = the dead body of animals used as meat

Salmonellosis = illness caused by Salmonella sp

Botulin = *Clostridium botulinum*, an anaerobe, produces the toxin botulin

2.8 References/Further Readings

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2.9 Possible Answers to the Self-assessment exercises (1-3).

Exercise1.

Answer to SAE 1, question 1:

1. ***Salmonellae typhi, Clostridium botulinum, Clostridium perfringens***
2. ***Answer to* Exercise 1. *question 2***

   As a guide the approximate composition of a typical mammalian muscle is 75% water, 19% protein 3.5% fat, 2.5% of soluble non-protein materials.

Answer to SAE 1 Question 3

Chemical composition of meat:

Meat consists primarily of muscular tissue with amounts of fatty tissue varying not only with the bread, age, sex and diet of the animal but also with the anatomical location. As a guide the approximate composition of a typical mammalian muscle is 75% water, 19% protein 3.5% fat, 2.5% of soluble non-protein materials.

Answer to Exercise 1 Question 4

The mathematical relationship between protein and moisture content of food is P = M/4

Answers to Self-assessment exercise 2

1. Surrounding the muscle as a whole is a sheath of connective tissue known as the epimysim
2. Natural aging: Here, the ageing or ripening of meat is generally done at 35 ^{o}F (2-3 ^{o}C)
3. Artificial tendering: addition of enzymes to the meat such enzymes includes bromelin from pineapple, ficin from figs, trypsin from pancreas and papain from papaya.

Answer to Self-Assessment Exercise 3:

(1) The meat under cold storage needs -15 ~-25 ^{o}C temperatures to keep the meat from 6 to 12 months.

(2). **D.** (i.e. **age of the animal)**

(3) Typical symptoms of salmonellosis include

- diarrhea,
- fever and
- vomiting
- The illness may last one to 14 days after a 12 to 24 hour incubation period.
- Victims may excrete the bacteria for weeks after the symptoms subside. Poor personal hygiene will cause contamination of meat

(4) The incubation period of *Clostridum perfringens* is 8 – 12 hours

(5) It is caused by an organism called: *Clostridium botulinum*

UNIT 3: ATTAINMENT OF OPTIMUM QUALITY AND BIOCHEMICAL CHANGES IN MEAT

Unit structure

3.1 Introduction

3.2 Learning outcome

3.3 Assessment of quality of meat

3.3.1. Factors that contribute to optimum quality of meat

3.3.2 Ways to achieve optimum quality in meat

3.4 Changes that occur during conversion of muscle to meat

3.4.1. Glycolysis

3.4.2. Other changes which accompany the conversion of muscle to meat

3.5 Effect of fat, storage and stress on meat quality

3.5.1 Fat as index of fresh meat quality

3.5.2 Storage conditions

3.5.3 Effect of stress on functional properties of meat

3.6 Summary

3.7 Glossary:

3.8 References/Further reading

3.9 Possible answers to the Self-assessment exercises

3.1 Introduction

The procedure of fresh meat production in the tropics is not standard. There should be a standard procedure in all meat processing operations. There are biochemical changes that occur during conversion of muscle to meat, and these phenomena should be well understood for adequate processing of meat to retain the desired qualities

3.2 Learning outcome

At the end of the lecture the students will be able to understand the factors that determine the optimum qualities of meat and changes that occur during conversion of muscle to meat

3.3 Assessment of quality of meat

3.3.1. Factors that contribute to optimum quality of meat

The procedure of fresh meat production in the tropics is not standard. After slaughter, usually by cutting the throat of the animal transversely or by decapitation, the animal is bled. Bleeding consists of skin incision along the jugular furrow and the carotid artery and jugular vein of one side severed. The knife is then passed through the skin incision towards the entrance of the chest, severing the anterior vena cava, but in some cases the skin is incised and the anterior aorta opened by a single cut at its junction with the two carotid arteries. Following bleeding, the animal is skinned as in the case of cattle, burned to remove the hairs for smaller animals, or scalded in pigs. It is then eviscerated by opening the median line of the belly, leaving the heart, liver and kidney in the carcass. At this point, health inspectors especially at the government controlled abattoirs must approve every carcass as suitable for human consumption. This is done by visual inspection of the viscera and certain other parts which would show any characteristic health-related malformations. This practice should be a standard procedure in all meat processing operations. In some parts of the world, there exist legal regulations concerning hygiene and conditions governing the processing of meat but in many rural areas of the tropics, perhaps due to certain economic constraints such as no provision of potable water and electricity, meat processing is traditionally carried out in an unhygienic condition.

Most of the abattoirs do not have lairages where animals can be rested before slaughter. Consequently the animals are low in muscle glycogen after the long tedious treks or lorry and rail-wagon journeys and produce high PH-meat. Where a lairage is available, it is simply an open fenced bare area of ground located opposite the abattoir such that live animals are made to watch their colleagues struggle to death. The fear and anxiety generated in animals are stressful and further result in poor quality meat.

The abattoirs themselves are commonly located in the market- a busy, dirty place where the air is stinking, polluted and heavily charged with both spoilage and micro-organisms. There, butchers literally wrestle with the best to restrain it for slaughter; this further exhausts the animals and its glycogen reserves. There is no stunning to reduce death shock and often no hoist to suspend the animal for thorough bleeding. Skinning, evisceration and cutting up of the carcass are often carried out on the filthy slaughter floor or on equally filthy platforms and tables. Usually many more hands than necessary are involved in these operations, each hand being a source of contamination.

In areas where there are no abattoirs, and this common practice with wild-life, processing takes place over leaves, especially banana or cocoyam leaves, spread on the ground. Water is generally lacking and sparingly used. As there are no chilling facilities, the meat is ever aged, rather the hot carcass are manually carried or transported in trucks or on bicycles direct from the slaughter slab to the retail table. The display requires no packaging, no counters or chambers or any other measures to reduce contamination and exposure to the intense sunshine; high temperature and high humidity which greatly accelerate microbial, chemical and physical deterioration of the meat. The meat is simply put on a table which is itself filthy as it is hardly washed thoroughly, not to talk of sanitizing.

As the meat is exposure to bright sunshine and high temperatures the surface tends to dry up and discololur. To avert this problem, the retailer often sprinkles water on the meat. Sometimes the meat is soaked in water as this also increases bulk. This water is far from being potable and is always heavily loaded with micro-organisms and flies.

Any unsold meat at the en of the day is stored at ambient temperatures overnight for sale the next day. The meat buyers are further sources of contamination, since butchering does not follow any standard pattern, the meat cuts are neither sorted nor graded and their prices are not fixed. For quality judgment and pricing buyers have to depend sensory evaluation by sight, smell and finger feel. The meat is sniffed and thoroughly fingered all over to judge its freshness and proportion of lean. In this way the buyer evaluates, or rather, contaminates several pieces before making a choice. The remainders of the meat pieces are repeatedly subjected to this ordeal by subsequent buyers. These habits are obvious deterrents to the maintenance of meat quality and storability.

But slaughtering methods and carcass handling in the tropics can be improved to minimize the risk to human health that may arise from eating contaminated meat.

3.3.2 Ways to achieve optimum quality in meat

There are technological principles that must be observed to ensure an optimum quality and stability of the end product. These are:

1. The animal should be well rested, calm and cool immediately prior to slaughter, for reasons outlined earlier
2. The animal should be clean, free from external soil and fecal material, both of which materials can introduce extremely heavy loads of microbial contamination onto the killing area. Cleaning may be achieved by footbaths and the use of overhead water sprays which also helps to cool the animals and so make the removal of blood much easier
3. The animal should be killed as quickly and as painless as possible in order to avoid stress and depletion of glycogen reserves, as well as for human reasons; and all processes applied should be designed to reduce to a minimum the number and types of contaminating micro-organisms that find their way onto the freshly exposed carcass.

The initial microbial contamination must be minimized in order to ensure a maximum storage life of meat that is to be distributed and marketed in the fresh condition. Sources of microbial contamination that must be monitored and controlled include:

4. The hides and skins of animals, which carry a heavy concentration of micro-organisms resembling those of the soil, preliminary washing can reduce this number, but is also most important to avoid contact of the hide or skin with the freshly exposed carcass surface during the skinning operation. The hide or wool of the skinning operation should be folded back as it is cut and not allowed to touch the carcass;
5. Soil itself, which can be a major source of contamination, should not enter the killing area;
6. The rumen and intestines, a very significant source of bacterial numbers, should not be ruptured to ensure the contents do not contaminate the meat surface;
7. Flies which must be excluded from the killing area; and
8. Equipment such as knives, hooks and benches which should be of stainless steel construction and should be subject to frequent cleansing by mans of boiling water or by use of hypochlorite solution. Wooden equipment and surfaces are impossible to maintain in a sanitary condition.

Self-assessment exercise 1

1. Explain two technological principles that must be observed to ensure an optimum quality and stability of the end product
2. A place where animals can be rested before slaughter is called……?

3.4 Changes that occur during conversion of muscle to meat

Conversion of the muscle of a living animal to meat or meat product may be viewed

as a simple mechanical disintegration of the carcass after the animal is slaughtered. The numerous biochemical reactions governing the actions of the muscle do not stop immediately after the animal is killed. At least cursory knowledge of most significant reactions occurring knowledge of most significant reactions occurring after slaughter is necessary to understand some of the basic steps in fresh and processed meat technology. In the living muscle, one of the important reactions, involving generation of energy needed for muscle contraction is glycolysis.

3.4.1. Glycolysis

The sugar, glycogen is used up to generate the needed energy in the presence of oxygen thus:

- When oxygen is not available, after the animal is killed, or under stress, the glycogen and the resulting glucose are broken down to lactic acid, which has a substantial effect on the pH drop in the muscle. In a living organism, the lactic acid can be utilized along another biochemical pathway, thus keeping the living muscle above pH 6.0. However, after death, this alternative pathway will not be utilized, and the pH of the meat will typically drop to about 5.4 or lower.

Advantage of glycolysis

This acidity generated gives the fresh meat some protection against microbial spoilage.

- Unless meat contains an appropriate amount of lactic acid it is sticky and flabby and bacteria are liable to multiply in it during storage. This is because a proper degree of acidity restricts bacterial growth, so acidity is required.
- Glycogen can be depleted in vivo in the muscular tissue by walking, running or fighting and it may take some time for the glycogen to be restored.

- When a rested animal is killed the glycogen in its muscles breaks down to lactic acid. It, therefore, means than an animal should be killed when its meat may keep concentration of glycogen in order that its meat may keep satisfactorily. This implies that meat animals should be fully rested before slaughter. If they have to be driven to the slaughter house on foot, they must be kept quietly rested for some length of time

- .As well as the decrease in glycogen and increase in lactic acid concentrations, post-mortem glycolysis gives rise to many other changes in the muscle and the most important of these, from the view point of meat quality, is meat texture. For post-mortem glycolysis to occur, inorganic phosphate must be available to enable phosphorylase to convert glycogen to glucose-1-phosphate, the first product of glycolysis. The inorganic phosphate arises from the splitting of ATP, thus.

$$ATP \longrightarrow ADP + P$$

Thus, even in death, the muscle attempts to maintain its structural integrity and temperature by energy derived from this reaction. In many muscles there is a store of creatine phosphate (CP) which is used to resynthesise ATP via

$$ADP + CP \xrightarrow{\text{enzymes}} ATP + creatine$$

$$\text{glycogen} \xrightarrow{\text{enzymes}} \text{glucose} + O_2 + H_2O + \text{energy}$$

Thus, from the moment o death the CP level in muscle falls and ultimately there is a point at which it is no longer possible to re-synthesise ATP and the level of ATP itself begins to fall. As ATP disappears, the muscle cease to be elastic and tends to stiffen, i.e rigor mortis occurs. This change occurs because ATP, apart from being a plasticizer which prevents the myofibrillar proteins- acting and myosin- from cross linking to form the inextensible actomyosin.

Of all the various effects of rigor mortis, the most important one for the meat processor is the stiffening of the muscle fibres resulting in a temporary but sequential toughening of the meat. If the meat were cooked, or even frozen, during the rigor mortis, the eating quality of the final product would be very poor due to toughness.

After completion of the rigor mortis, the meat slowly returns to- and often exceeds- its pre rigor tenderness. This is due to the effect of various proteolytic enzymes that slowly degrade the muscle fibrous structure. This so called “aging” is a very important step in fresh meat technology. Industrially, aging is carried out at low temperatures and about 100% RH under strict microbiological control.

3.4.2. **Other changes which accompany the conversion of muscle to meat**

The other changes which accompany the conversion of muscle to meat and affect its quality are as follows:

1. The natural antibacterial defense mechanisms of the body are destroyed and thus growth of micro-organisms is encouraged
2. As the pH decreases, enzymes (cathepsins) may be released from the lysosomes and degrade the tissue
3. Some of the compounds formed may well modify the intrinsic flavour associated with the meat. For example the pattern of nucleotides change via

ATP ⟶ ADP ⟶ IMP ⟶ inosine ⟶ hypoxanthine
+ inosine +
P_i monophosphate P_i ↓
$+P_i + NH_3$ ribose

Most of the breakdown of IMP occurs during and after rigor mortis

Self-Assessment Exercise 2

1. State two changes which accompany the conversion of muscle to meat and affect its quality
2. State three advantages of glycolysis

3.5 Effect of fat, storage and stress on meat quality

3.**5.1 Fat as index of fresh meat quality**

The quality of meat has been related to the amount of fat which is distributed uniformly through the muscle. This effect is known as marbling. Quality is also related to the age of the animal. The younger animals have better the quality. Marbling tends to increase as the animal matures.

3.5.2 Storage conditions

When meat is stored unfrozen it should be stored in a temperature range of 1 to 3^0C. The relative humidity should be in the range of 85-90%. The high humidity will prevent excessive drying and shrinkage. In addition, the high humidity tends to preserve the white colour of the fat in meat.

With regard to texture it can be used rather generally that the lesser the amount of connective tissue in the meat, the more tender is the meat. When meat is heated in water as in boiling or in making of stew, the connective tissue is changed to sort of tender gelatin and it becomes more palatable. On the other hand, when the meat is heated without water, such as in oven dry heat, the connective tissues tend to become tougher.

3.5.3 Effect of stress on functional properties of meat

The stress associated with the conversion of living tissue to meat can lead to changes in the muscle metabolites and hence differences in the ultimate properties of the meat. Different animals have variable degrees of resistance to the stresses imposed by the pre-slaughter environment. Stress susceptible animals generally have higher post-mortem muscle temperatures and undergo very rapid post-mortem glycolysis and PH fall. The combination of high temperature and low pH encourages protein denaturation with concomitant loss of water-holding capacity (WHC) and colour so that, after rigor, the meat is PSE (pale, soft, exudative)

If an animal survives stress applied over a relatively long term, it may do at the expense of its glycogen reserves. Thus, some stress- susceptible animals and all stress-resistant ones which survive stress associated with fatigue, exercise, fasting, fighting etc, and are replenished, can only undergo limited post-mortem glycolysis .The resultant high pH gives rise to dark, firm meat, which as well being unpopular with the consumer on account of its appearance, is hygienically undesirable since the environment for bacterial growth is more favourable than in meat of normal pH on meat appearance (colour) can be explained thus: at high pH, the WHC of the muscle fibres is maximal, resulting in a dry, relatively compact structure which reflects little light; at normal pH values the decreased WHC of the muscle fibres lends to a more open structure, with which is associated some relatively free water, capable of reflecting more light. Also the surviving oxygen-utilizing enzymes in the tissue are more active at high than at low pH values so that oxygen cannot penetrate to any appreciable depth in tissue, causing the dark-purple colour of reduces myogloblin to be visible as opposed to the bright-red colour of oxymyoglobin see n at the surface of meat of normal pH.

The colour of red meat is determined by the chemical state of the purplish red muscle pigment myogloblin. In the presence of oxygen, the myogloblin is oxygenated (called oxymyogloblin) and the muscle is bright red in colour. When much of the oxygen is removed, the myogloblin will change to metmyogloblin with the resulting brownish colour developing in the muscle. The creation of metmyogloblin by vacuum packaging in improper semi-permeable plastic packaging materials may be serious problem since the brownish meat colour can be mistaken for an old product. Cooking of meat also denatures the meat pigment, as well as the various meat enzymes involved in colour reactions. This gives the cooked meat its characteristics grayish-brown colour.

The Chemistry of meat flavour is not fully understood. Cooking is necessary to develop meat flavour since raw meat has little odour and only a blood like taste. the Odour and taste of cooked meat arise from water or fat soluble precursors and by the liberation of volatile substances pre-existent in the meat. These precursors are distributed between the lean and fat. Over 100 compounds, of at least 10 chemical classes, have been identified. Although many of these have little or no odour, synergistic and antagonistic effects may prevail thus causing these apparently ineffective substances to become important flavour modifiers. The majority of flavour studies on meat have been concerned with the volatile aroma compounds; this may be misleading as the fulsome and satisfying sensation of juice in the mouth plays an important part in the appreciation of meat flavour. Certain reactions however, have been identified as being responsible for meat flavour and these can be summarized as follows here.

Amino acids may degrade to volatile products, e.g 3-methyl-and 2-methyl-butanol from leucine and isoleucine; 2-methyl-propanol from valine; benzene, toluene and ethyl-benzene from phenylalanine; hydrogen sulphide from cysteine; ammonia form lysine etc.

Carbohydrates may caramelize to highly odorifereous substances e.g. furan derivatives, carbonyl compounds and aromatic hydrocarbons.

Maillard browning reactions will occur between amino acids or protein material and carbohydrates. These types of reactions are probably of major importance in determining meat flavour since the above reactions only occur at relatively high temperatures.

Lipids will contribute to flavour when heated. Some non-acid compounds such as aldehydes, ketones, lactones, alcohols, esters, hydrocarbons and pyrazines have been identified in beef fat and may contribute to flavour.

5-ribonucleotides formed following slaughter may contribute to flavour but most recent studies have shown that inosine-5-monophosphate and other nucleotides modify existing flavours rather than contribute intristic notes.

Volatiles containing nitrogen, oxygen and sulphur will be formed or released during heating. Although their full relevance to flavour is not established, the nitrogen-containing pyrazines and several sulphur and oxygen containing volatiles found in cooked meat have such low-odour thresholds that they are believed to play a significant part in the formation of a meaty aroma.

The food ingested by the animal is sometimes responsible for undesirable odours and tastes in the flesh. There are noticeable differences in flavour beef fed on corn and that fed on grass.

Self-assessment exercise 3

1. Explain how age and fat affect meat quality
2. At what temperature and relative humidity should meat be stored?
3. Explain how stress affects meat quality?

3.6**. Summary**

To achieve high quality of the meat, the animal must be rested before slaughtering**;** the slaughter area must be clean. Flies which must be excluded from the killing area; and. Equipment such as knives, hooks and benches which should be of stainless steel. The other changes which accompany the conversion of muscle to meat and affect its quality are as follows: The natural antibacterial defense mechanisms of the body are destroyed and thus growth of micro-organisms is encouraged. As the pH decreases, enzymes (cathepsins) may be released from the lysosomes and degrade the tissue. Some of the compounds formed may well modify the intrinsic flavour associated with the meat.

3.7 Glossary: *Abattoirs* = A place where animals are slaughtered.

Lairage = A place where animals can be rested before slaughter

3.8 References/Further reading

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3.9. Possible answers to the Self-assessment exercise

Answers to Self- Assessment Exercises

Exercise 1:

Question 1

- The animal should be well rested, calm and cool immediately prior to slaughter, for reasons outlined earlier
- The animal should be clean, free from external soil and fecal material

Question 2

A lairage is where animals can be rested before it is slaughtered

Exercise 2

Answer to question 1.

Three changes which accompany the conversion of muscle to meat and affect its quality are as follows:

a. The natural antibacterial defense mechanisms of the body are destroyed and thus growth of micro-organisms is encouraged

b. As the pH decreases, enzymes (cathepsins) may be released from the lysosomes and degrade the tissue

c. Some of the compounds formed may well modify the intrinsic flavour associated with the meat

Answer for question 2

2. Advantage of glycolysis

1. This acidity generated gives the fresh meat some protection against microbial spoilage.

- Unless meat contains an appropriate amount of lactic acid it is sticky and flabby and bacteria are liable to multiply in it during storage. This is because a proper degree of acidity restricts bacterial growth, so acidity is required.
- Glycogen can be depleted in vivo in the muscular tissue by walking, running or fighting and it may take some time for the glycogen to be restored.
- When a rested animal is killed the glycogen in its muscles breaks down to lactic acid. It, therefore, means than an animal should be killed when its meat may keep concentration of glycogen in order that its meat may keep satisfactorily. This implies that meat animals should be fully rested before slaughter. If they have to be driven to the slaughter house on foot, they must be kept quietly rested for some length of time

Answer for Exercise 3

1. The quality of meat has been related to the amount of fat which is distributed uniformly through the muscle. This effect is known as marbling. Quality is also related to the age of the animal. The younger animals have better the quality. Marbling tends to increase as the animal matures.
2. When meat is stored unfrozen it should be stored in a temperature range of 1 to 3^0C. The relative humidity should be in the range of 85-90%. The high humidity will prevent excessive drying and shrinkage. In addition, the high humidity tends to preserve the white colour of the fat in meat.

No.3. Stress associated with the conversion of living tissue to meat can lead to changes in the muscle metabolites and hence differences in the ultimate properties of the meat

MODULE 2

SANITATION IN MEAT ESTABLISHMENTS AND PRESERVING TECHNIQUES

UNIT 1: SANITARY REQUIREMMENTS OF MEAT AND MEAT PRODUCTS

Unit structure

1.1 Introduction

1.2. Learning outcomes

1.3 Building specifications and equipment recommended in meat establishments

1.3.1. Building specifications

1.3.2. Meat Processing Equipment

1.4 Basic aspects of hygiene necessary in meat establishments

1.4.1 Personal hygiene

1.4.2 Cleaning

1.5 Regulations for stored meat

1.5.1 Regulation for Meat

1.5.2 Regulation on refrigeration of Carcass

1.6 Summary

1.7 Glossary

1.8 References/Further Readings

1.9. Answers to self-assessment exercises

1.1 Introduction

When meat-processing operations are carried out within a facility specifically built and maintained for meat processing, sources of contamination can be much more easily and adequately controlled. The following requirements are considered essential to good sanitary preparation of meat and meat products.

1.2. Learning outcomes

At the end of this unit, the student is expected to be able to: understand Facilities, Meat processing equipment **and** Personal hygiene, cleaning and freezing of meat as requirements considered as good sanitary preparation of meat and meat products

1.3 Building specifications and equipment recommended in meat establishments

1.3.1. Building specifications

Floors: Brick, tile, smooth concrete or other impervious, waterproof materials are suitable for floors. In some areas wooden floors will suffice if they are tight, smooth, in good repair and properly maintained. Wooden floors are not suitable in areas where slaughtering or curing takes p lace and meat juices and moisture collect.

Drains: To carry away waste liquids, there should be sufficient drains of the proper size that are correctly located, trapped and vented. All floors should be sloped toward the drains. Generally for adequate waste disposal, one drain is needed for each $18m^2$ of floor space in slaughtering areas, and one drain for each $46m^2$ in processing and other areas.

Walls: Glazed tile, smooth cement plaster, rustproof metal panels are all acceptable for walls in processing and refrigerated areas because they can all be effectively cleaned and sanitized. Other materials are also acceptable if they can be satisfactorily cleaned. In no instance should walls be made of materials that absorb moisture or other liquids.

Ceiling

Ceiling must be tight, smooth and free from any scaling that may fall into the meat products, and should also be of moisture-resistant materials.

Doors and doorways: All doorways, through which the product must pass, whether suspended on rails or lying on hand trucks, should be wide enough to ensure that the meats never touch the doorways risking contamination. Wooden doors and doorways should be covered with metal with tightly soldered seams.

Water supply: Whether from individually owned and controlled sources such as wells or streams or from a municipal system, the water supply must be potable and abundant cold and hot water must be distributed to all parts of the operation.

Lighting: In all areas where products are critically examined during sanitary control or for cleanliness, 50- foot candles of light should be provided. For adequate visibility 20-foot candles of light should be provided wherever any processing occurs. In all other areas, such as dry storage, there should be sufficient light to keep the area orderly and sanitary. All light bulbs should be covered with unbreakable material to prevent broken pieces from falling into the product.

Refrigeration: The main purpose of refrigeration is to cool the meat down after slaughter and to maintain it in a chilled state for shorter or longer storage periods and for cutting and further processing. If frozen storage is provided and utilized, it should be maintained at the lowest possible temperature for maximum shelf-life. Minus 18 ^{O}C to 12 ^{O}C is satisfactory freezer storage; however, large quantities of product must either be quick frozen prior to storage or thinly spread out to facilitate freezing.

It is also recommended that all rooms where meat is processed, except in the slaughter and cooler storage areas, should be maintained at a temperature of about 12 ^{O}C. In facilities where no refrigeration or cooling is furnished in processing areas, the handling of meat products is possible if all equipment contacting the products is thoroughly cleaned and sanitized from time to time (recommended every four hours). Frequent cleaning is necessary because in warmer temperatures bacteria multiply rapidly and the risk of product contamination increases.

1.3.2 Meat Processing Equipment

The equipment needed for converting livestock into meat products need not be elaborate and expensive. The amount of equipment will depend on the slaughtering and processing procedures employed. If possible, all equipment should be made of stainless steel or plastic, be rust resistant and easily cleaned and sanitized. All equipment should be constructed of stainless steel, galvanized steel, aluminum or approved plastic. Wooden tables are not acceptable because wood absorbs meat juices and fats and cannot be thoroughly cleaned.

Hardwood cutting-boards maintained smooth and free from checks and cracks may be used. Cutting tables covered with other than hard plastic are not acceptable for contact with meat. All other equipment should be of the type that can be taken apart and thoroughly cleaned. Any stationary equipment must be located far enough from walls to permit proper cleaning around and under it. In all areas there should be conveniently located foot-pedal or knee operated wash-basins with hot and cold water, soap and disposable towels.

In slaughtering areas, lavatories should be convenient to the dressing operations. Hot-water containers, either electric or steam-heated to 82 ^{O}C, should be available for sanitizing tools contaminated with diseased material or other filth during dressing. Rails must be located high enough to prevent meat from touching the floor. For beef carcasses, the minimum height for rail should be 3.4 meters, while 2.4 meters is sufficiently high for small livestock such as goats, hogs and sheep. Rails should also be far enough away from fixed objects and wall to avoid contact.

Self-assessment exercise 1

1. List the important areas of the building meant for meat processing
2. List the nature of materials for construction of meat processing equipment

1.4 Basic aspects of hygiene necessary in meat establishments

There are two basic aspects of hygiene necessary in meat establishment such as personal hygiene and general cleaning

1.4.1 Personal hygiene

Probably as important as anything in the production of clean, wholesome, unspoiled products is the attitude of the workers toward cleanliness. Personnel with clean hands, clothing and good hygienic practices are absolutely essential to the production of high-quality meat. All clothing should be clean, in good repair and made of washable material. Street clothing should be covered with coats or gowns while handling exposed product. White or light-coloured clothing is most desirable and garments that become soiled or contaminated should be changed when necessary.

All persons working with exposed meat products should have their hair covered, either completely covered with a clean cap or hat or confined by a hairnet to prevent hair falling into products. Safety devices such as aprons, wrist guards and mesh gloves and mesh gloves must be made of impervious material, clean and in good repair. At no time should leather aprons, wrist guards or other devices be worn unless clean, washable coverings are used over them. Light-coloured rubber or plastic gloves may be worn by product handlers only if clean and in good repair.

No person working with meat should wear any kind of jewelry, badges or buttons that may come loose and be accidentally included in the product. Shoes and boots should be worn at all times and should be appropriate for the operations being conducted. They should also be made of impervious materials. Any aprons, knives and footwear that become contaminated during operations should be routinely cleaned in areas or facilities provided for that purpose.

No cloth twine, belts or other similar materials should be used to cover implement handles or used in other places where they may harbor filth and serve as a ready source of product contamination. All unsanitary practices should be avoided by meat handlers. No one should smoke or use tobacco in area where edible products and ingredients are handled prepared or stored, or where equipment and utensils are cleaned.

When handling edible products, scratching the head, placing fingers in or around the nose or mouth, sneezing or coughing on the product should never occur. Workers must also guard against contaminating products from localized infections or sores. Workers can contaminate carcasses and meat through handling, coughing and sneezing. This may cause rapid spoilage of the meat or, more seriously, food poisoning. Coughs and sneezes are a particularly effective way of transmitting bacteria to meat.

Transfer of faecal matter either of animal or human origin to the meat is particularly hazardous. Most contamination on the hands of workers in slaughter floors with faecal matter comes from the hides and fleeces. Hands should be washed frequently to remove all visible soiling. Stainless-steel sinks without plugs should be conveniently accessible to all workers. Water should be supplied at approximately $43^{O}C$ to a simple tap which is foot- or knee- operated.

Liquid disinfectant soap and paper towels should be available. Particular attention should be paid to cleaning under the fingernails. Hands should also be thoroughly washed after using the toilet, smoking, coughing or sneezing, handling money, garbage or soiled or infected material. All precautions should be taken to prevent product contamination by visitors or other persons who are simply passing through the work area.

1.4.2 Cleaning

The floors should be kept clear of all debris, such as hooves and horns, in slaughter halls or other inedible parts or fat and meat particles in cutting, processing and by-product handling areas, and must be frequently washed down. At the end of each day a thorough cleaning programme should be followed. All matter should be removed from floors, platforms, gullies, etc. followed by a thorough hosing down of walls, floors and all surfaces to loosen dirt. Finally a strong cleaning solution should be applied and left for a while before being rinsed off.

A thorough inspection should be made afterwards and any areas remaining soiled should be cleaned again. In order to maintain the cleanest possible products a standard cleaning routine of the equipment should be established. Initially all large pieces of refuse material should be scraped or swept together and disposed of. Follow-up should include scrubbing of the equipment using brushes and a soap or detergent and a complete sanitizing with hot water at 82^{O}C and an approved chlorine or iodine rinse. Finally, a coating of light mineral oil can be applied to metal equipment, particularly which not fabricated of stainless steel, to prevent rust.

Self-assessment exercise 2

1. Describe how equipment and floor of meat establishment should be sanitized.
2. List the requirements for adequate personal hygiene

1.5 Regulations for meat and refrigeration of Carcass

1.5.1 Regulation for Meat

The aim of regulation for meat is to achieve quality assurance on the meat for the safety of consumers of the product

The Regulations imposed a prohibition on any person freezing ay carcass meat which was unfit for human consumption or specified offal in a slaughterhouse or any carcass meat or specified offal in a knacker's yard unless that meat had been sterilized or stained. There were two exemptions from this prohibition:

ii. In the case of any meat which was intended to be removed under the authority of a movement permit, from the slaughterhouse or knacker's yard to a destination referred to regulation of the country or local authority

iii. In the case of any meat from a carcass infested with *Cysticercus bovis* which was frozen in accordance with relevant meat inspection provisions.

2.5.2 Regulation on refrigeration of Carcass

Carcass should go into the cooler as soon as possible and should be as dry as possible. The object of refrigeration is to retard bacterial growth and extend the shelf-life. Chilling meat post-mortem from 4^0C down to 40°C and keeping it cold will give a shelf-life of up to three weeks, provided high standards of hygiene were observed during slaughter and dressing. Carcasses must be placed in the cooler immediately after weighing. They must hang on rails and never touch the floor. After several hours the outside of a carcass will feel cool to the touch, but the important temperature is that deep inside the carcass. This must be measured with a probe thermometer (not glass), and used as a guide to the efficiency of the cooling.

The rate of cooling at the deepest point will vary according to many factors including the efficiency of the cooler, the load, carcass size and fatness. As a general guide a deep muscle temperature of $6\text{-}7^0$ C should be achieved in 28 to 36 hours for beef, 12 to 16 hours for pigs and 24 to 30 hours for sheep carcasses. Failure to bring down the internal temperature quickly will result in rapid multiplication of bacteria deep in the meat resulting in off-odours and bone-taint.

High air speeds are needed tor rapid cooling but these will lead to increased eight losses due to evaporation unless the relative humidity (RH) is also high However, if the air is near to saturation point (100 percent RH) then condensation will occur on the carcass surface, favourin8 mould and bacteria growth. A compromise between the two problems seems to be an RH of about 90 percent with an air speed of about 0.5 m/second. Condensation will also occur it warm carcasses are put in a cooler partially filled with cold carcasses.

The cooler should not be overloaded beyond the maximum load specified by the manufacturers and spaces should be left between carcasses for the cold air to circulate. Otherwise cooling will be inefficient and the carcass surface will remain wet, favouring rapid bacterial growth forming slime. Once filled, a cooler should be closed and the door opened as little as possible to avoid sudden rises in temperature. When emptied, it should be thoroughly washed before refilling. Personnel handling carcasses during loading and unloading operations should follow the strictest rules regarding their personal hygiene and clothing and should handle carcasses as little as possible.

Self-assessment exercise 3

1. State the objective of refrigeration of carcass
2. State why it is not proper to store or display unwrapped cooked and raw meat together

1.6 Summary

Brick, tile, smooth concrete or other impervious, waterproof materials are suitable for floors. Wooden floors are not suitable in areas where slaughtering or curing takes p lace and meat juices and moisture collect. All floors should be sloped toward the drains. Walls, ceiling, light doors and doorway must follow specifications. It is also recommended that all rooms where meat is processed, except in the slaughter and cooler storage areas, should be maintained at a temperature of about 12 ^{O}C. If possible, all equipment should be made of stainless steel or plastic, be rust resistant and easily cleaned a. nd sanitized. All other equipment should be of the type that can be taken apart and thoroughly cleaned. Rails must be located high enough to prevent meat from touching the floor. Basic aspects of hygiene necessary in meat establishments include personal hygiene and cleaning generally**.** All persons working with exposed meat products should have their hair under control. The Regulations imposed a prohibition on any person freezing ay carcass meat which was unfit for human consumption or specified offal in a slaughterhouse or any carcass meat or specified offal in a knacker's yard unless that meat had been sterilized or stained. No person working with meat should wear any kind of jewelry, badges or buttons that may come loose and be accidentally included in the product

1.7 Glossary: *carcass* = slaughtered animal,

Regulations = Laws

1.8 References/Further Readings

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1.9. Answers to self-assessment exercises 1, 2 and 3

Exercise 1

- ✓ Things considered as facilities: floor, Drains, walls, watersupply, lighting and refrigeration
- ✓ Meat processing equipment: Stainless steel table, plastics, hard wood board for cutting

Exercise 2

- ✓ Sanitizing should be done with hot water at 82^{O}C and an approved chlorine or iodine rinse.
- ✓ Personnel with clean hands, clothing and good hygienic practices are absolutely essential to the production of high-quality foods

Exercise 3

1. The object of refrigeration is to retard bacterial growth and extend the shelf-life
2. Do not store or display unwrapped cooked and raw meat together

UNIT 2: PROHIBITIONS FOR MEAT ESTABLISHMENTS

Unit structure

2.1 Introduction

Persons involved in meat handling have to adhere to certain regulations to avoid meat contaminations and negative consequences of abnormal practices

2.2 Learning outcome

At the end of the unit, students are required to understand how the following factors are important in meat handling: Persons prohibited by regulations, Meat Storage, Destinations and Mode of transport

2.3 Meats prohibited by regulations

2.3.1. Meat prohibited by regulations for handling

The regulations prohibited any person from possessing for the purpose of sale or preparation for sale:

i. Any meat removed from a slaughterhouse, which was unfit for human consumption;

ii. Any meat removed from a knacker's yard; or

iii. Any meat unfit for human consumption from an animal which had died or had been slaughtered at a place other than a slaughterhouse or Knacker's yard, or had been brought to such a place after having died or been slaughtered; unless that meat had been sterilized.

There are exemptions from this prohibition in the case of any meat which is in the possession of a person:

i. While in transit under the authority of a movement permit to a destination referred to in Regulation

ii. Referred to in regulation at his premises; and, where required by the regulations, had been stained;

iii. While in transit under the authority of a movement permit to a destination referred to in Regulations and, where required by the Regulations, had been stained;

iv. At premises listed in Regulation for any purpose contemplated in the provisions or with a view to its removal from those premises in accordance for the provisions relating to closure, breakdown or trade dispute or while in transit from such premises in accordance for the provisions relating to closure, breakdown or trade dispute or while in transit from such premises in accordance with those provisions.

It was a defense for any person charged with a contravention of this provision to prove:

That he did not known, and could not with reasonable diligence have ascertained, that the meat was unfit for human consumption or removed from a knacker's yard; or

i. That any meat removed from a slaughterhouse became unfit only after its removal.

The Regulations imposed a prohibition on any person selling or offering or exposing for sale, by retail, any meat which was unfit for human consumption, or any knacker meat, unless that meat had been sterilized. For the purposes of this prohibition, a sale by retail did not include a sale of meat direct from a slaughterhouse or knacker's yard to a destination referred to in regulation

It was a defence for any person charged with a contravention of this provision to prove that he did not know, and could not with reasonable diligence have ascertained, that the meat to which this prohibition applied.

2.3.2 Prohibition on Meat intended for storage

No person was permitted to store any unsterilized meat which was unfit, or not intended, for human consumption in the same room as any meat which was fit for human consumption, unless that meat was stored according to an arrangement which ensured that it was adequately separated from the meat which was fit for human consumption and that the arrangement had been approved by the appropriate local authority; and unless any container, wrapper, or other packaging used to hold the meat bore a notice of adequate size which was conspicuously visible and contained a distinct, legible and unambiguous statement to the effect that the meat hel therein was not for human consumption, together with the name of the packer and the address at which the meat was packed. Meat unfit for human consumption and knacker meat could be removed unsterilized and unstained from a slaughterhouse or knacker's yard which was not equipped for the sterilization of meat provided that: All the destinations referred to in regulation 17(1) and to which it was reasonably practicable to deliver that meat were, by reason of permanent or temporary closure of the premises or breakdown of machinery or a trade dispute, unable to receive the meat. The meat was transported in a vehicle or impervious container which was locked or sealed at all times and which bore a notice of adequate size which was conspicuously visible and contained a distinct, legible and unambiguous statement that the meat contained therein was not for human consumption; and the meat was removed in accordance with an arrangement in writing with, and under the supervision of, an authorized officer of the local authority in whose district the slaughterhouse or knacker's yard was situated, to a place where it was buried or destroyed.

Further, carcass meat unfit for human consumption, or specified offal and knacker meat consisting of carcass meat or specified offal, could be removed unsterilized and unstained from a slaughterhouse or knacker's yard which had exhausted, and could not practicably replenish, its supplies of staining fluid, to a destination provided for such. This could be done if that meat was delivered in accordance with an arrangement in writing with, and supervised by, an authorized officer of the local authority. The removal of any meat in accordance with these provisions exempted the occupier of the slaughterhouse or knacker's yard from any requirement imposed by the regulations to sterilize or stain the meat.

Self-Assessment Exercise 1

1. State the types of prohibited any person from possessing for the purpose of sale or preparation for sale
2. State the two qualities of meat that is intended for storing

2.4 Destinations and Mode of Transport

2.4.1 Meat Transportation

The nature and destination of meat determines to a large extent the handling of such meat.

Vehicles for transporting meat and carcasses should be considered as an extension of the refrigerated storage. The object must be to maintain the meat temperature at or near 0^0C. Meat should be chilled to 0°C before loading. Meat should hang on rails, not on the floor. If stockinet is put on carcasses it must be clean. Meat trucks should not carry anything other than meat.

The refrigeration is usually produced by injecting liquid nitrogen or carbon dioxide (CO,) into the compartment or by blowing air over CO, chunks (dry ice). The temperature in these vans can be set and controlled to minimize the temperature rise and to avoid condensation on the meat surface. Insulated vans without refrigeration may be refrigerated by adding dry ice. While this is a reasonably good alternative to the refrigerated truck it does not allow the temperature to be controlled.

Un-insulated vans and open trucks should not be considered as suitable transport for meat, particularly in hot climates. In addition to the temperature abuse, condensation will occur when the meat goes back into refrigeration and in open trucks the meat is exposed to attack from insects. Loading and unloading should be done quickly. If there are any unavoidable delays then dry-ice blocks should be placed in the partly filled van.

The 1982 regulations imposed requirements on destinations and mode of transport, limiting what could be done at such destinations, and imposing (with exceptions) a scheme of movement permits.

Meat unfit, or not intended, for human consumption, or knacker meat, could be removed, in accordance with any movement permit required by the Regulations to be issued in respect of that movement, to one of the destinations identified in regulation which was kept closed and locked or sealed at all times except when necessary for the loading or unloading of the contents or their examination by an authorized officer; and bore a notice of adequate size which was conspicuously visible and contained a distinct legible and unambiguous statement to the effect that the meat carried therein was not for human consumption. Once meat unfit, or not intended, or human consumption, or knacker meat, had reached any of the premises referred to in Regulation it could not be further removed from those premises unless that meat:

i. Had been sterilized ; or
ii. Was removed from the premises referred to in regulation and was intended to be delivered to another destination listed in Regulation and its removal to that destination was authorized by a movement permit issued pursuant to the Regulations; or
iii. Could not be disposed of at those premises by reason of permanent or temporary closure of the premises or breakdown of machinery or a trade dispute, and was removed in accordance with an arrangement in writing with, and under the supervision of an authorized officer of the local authority in whose district those premises were situated, to another destination referred to in Regulation or a place where it was buried or destroyed.

Regulation 19 set out the procedure to be followed in those cases where the regulations required removal of meat from certain premises, the occupier of the premises or owner of the meat bad to apply to the local authority, giving the following information:

i. The intended removal date;
ii. The description of the meat
iii. The address and description of the premises to which the meat was to be delivered; and
iv. The expected date of arrival of the meat at those premises.

Upon receipt of an application, the local authority was required, without undue delay, to satisfy itself that the premises to which it was intended to deliver the unsterilized meat were of a kind referred to in Regulation and were capable of processing or otherwise disposing of the meat. If the premises were situated in the district of another local authority, the authority to which the application was made was required to notify that other authority which the application had been made, and was required to take into account any information obtained from that authority in reaching its decision on the nature of the premises.

When the occupier of any premises, or the owner of any meat, to which the regulation applied, regularly delivered unsterilized meat of a specific description to a particular destination, the authority in whose district the premises or meat were situated was required- on receiving an application stating the description of that meat and the address and description of its destination- to authorize in advance each such movement by issuing whatever quantity of movement permits it considered appropriate.

Movement permits were to be in the form specified in the schedule to the regulations. The permit was divided into part I to V. When satisfied of the matters referred to in regulation a local authority was required to complete part 1 of the permit and issue to the applicant an original and three copies of the permit.

The occupier of the premises from which the unsterilized meat was removed under the authority of a movement permit was required to complete Part II of the document delivered to him and to give the original and two copies to the driver of the vehicle by which the meat was removed and to keep the other copy for two years.

When the driver delivered the meat to the premises named in the movement permit, he will be required to give that permit to the occupier of those premises. The occupier was then required to complete Part III of the permit and to acknowledge receipt of the meat thus delivered to him by signing the original and two copies and was required, within seven days of receiving the meat, to send the original and one copy to the local authority in whose district his premises were situated.

The occupier was required to retain the other copy for two years from the date on which he received that meat.

If the driver was unable to deliver the meat to the premises named in the movement permit, he was required without delay to inform or cause to be informed either the local authority which had issued the permit, or the local authority in whose area the delivery premises were situated. That authority was required without delay to authorize the delivery of the meat to another destination referred to in regulation or, if no such alternative destination was available, require the meat to be returned to the premises, from which it had been removed, or to be buried or destroyed under its supervision.

The driver was required to hand the movement permit to the occupier of the premises to which the meat was delivered, or in the case of its burial or destruction, to the supervising authority. The occupier of the premises to which the meat was delivered was required to complete Part IV of the movement permit, acknowledge receipt of the meat to which the permit related by signing the original and its two copies and, within seven days of the receipt of the meat, to send the original and one copy to the local authority in whose district his premises were situated. The occupier was required to retain the other copy for two years from the date on which he received the meat to which it related.

Any local authority which was sent a movement permit was required to complete Part V of that permit and to send the original to the authority which had issued it and retain the copy for two years. Any person required to retain a document under Regulation 19 was required to make that document available for inspection by an authorized officer at any reasonable time.

Self-Assessment Exercise 2

1. Describe the process by which refrigeration is achieved in meat
2. State two properties of the vehicle or container that transport meat under regulation

2.5 Other means of meat handling

2.5.1. Meat Handling without Refrigeration

Apart from the procedures earlier described in 2.4, there are still other alternative methods of handling meat as described below. Where refrigeration is unavailable either owing to financial or technical reasons (e.g. no power supply), the shelf-life of meat is reduced to days or hours, not weeks. Slaughter and dressing must be near the point of sale and t must be quick and clean. If carcasses and meat are kept in well-insulated rooms, the temperature can be reduced with dry-ice blocks, if these are available. Since it is easier to chill boneless cuts rather than whole carcasses, hot boning should be considered.

Stock must be handled carefully to avoid producing high-pH meat which will spoil more quickly. Rooms used for slaughter and handling meat must be clean and ventilated, but out of direct sunlight, dust-free and vermin free (rodents and insects). Hot water (82°C) must be available to clean all equipment and surfaces and personnel must work very hygienically. Receive all blood into sealed containers and have separate skips on wheels for hooves, skins, green offal and trimmings.

Dressing on a vertical hoist will minimize contamination by floor or cradle contact. Let nothing drop on the floor, only into skips. Personal hygiene must be scrupulous. Any spills ot gut contents on to the meat should be cut off, but careful work will avoid this. The dressed carcass should be hung on rails. If beef is quartered to facilitate handling, the cut surface is at risk. Red offal should be hung on hooks. Any offal processing must be in rooms away from meat-handling facilities. Intestines for human consumption must be thoroughly cleaned and washed.

Meat should be put on sale within a day of slaughter. If it has to be held it should be hung in a clean, well-lit hall with good ventilation. Insects, rodents and birds must be kept out, dust must not blow in. Trays of offal should be on shelves, not on the floor. Barrows for wheeling carcasses and quarters are better than carrying on shoulders, as they can be cleaned frequently. All staff must wear clean clothing and observe strict personal hygiene. Transport of non-refrigerated meat is very hazardous. If meat is to be put in stockinettes and sacks these must be very clean. Meat should be on rails in the truck or wagon, and it is not advisable to carry it more than a day's journey before sale.

2.5.2 Meat Sterilization and Staining: Amendment regulation 1984

The 1982 Regulation were amended by the meat (Sterilization and Staining) (Amendment) Regulation 1984. The definition of 'specified offal' was amended to mean the hearts, kidneys, livers and lungs derived from an animal which, in the case of a carcass in a slaughterhouse, had been rejected by an authorized person as unfit for human consumption by reason of any disease or pathological condition other than:

i. Ascariais, fascioliasis, or telangiectasis; or
ii. Changes caused by the operations of stunning, slaughter or dressing of the animal.

A Regulation was introduced displaying the 1982 Regulation in respect of meat removed or intended to be removed from any place or premises by or under the authority of a veterinary surgeon for examination by him or on his behalf. A further prohibition was introduced against any person bringing or causing or permitting to be brought into England and Wales from Scotland or Northern Ireland any meat unfit for human consumption.

The exemptions from this prohibition were identical to those which existed in relation to the removal of unfit meat from a slaughterhouse, save for the fact that importation of meat from Scotland and Northern Ireland required the meat to be accompanied to the destination by a consignment note or permit rather than a movement permit. The driver of the vehicle in which the meat was delivered to any premises, accompanied by a consignment note or a permit, was required to give that note or copy of that permit to the occupier of those premises.

The occupier was required to retain that document for two years and within seven days to send a copy to the local authority in whose area his premises were located. The document was required to be available for inspection by an authorized officer at any reasonable time. Upon receipt of the copy, the local authority was required forthwith to notify in writing of the arrival of the consignment.

i. In the case of an importation from Scotland the local authority from whose district the meat was imported;
ii. In the case of an importation from Northern Ireland, the department of Agriculture Northern Ireland

This prohibition resulted in consequential amendments to the range of persons authorized to declare 'specified offal' as unfit and to the prohibition on possession for sale, the exemptions from that probation and the defences to it in Regulation 20 of the 1982 Regulations.

Regulation of the 1984 Regulations amended the list of destinations to which unfit meat could be delivered under the authority of a movement permit. The first destination was amended to include a 'pharmaceutical extract supplier' – i.e. a person whose business consisted, wholly or mainly, of the collection, storage and preparation of glands, liquid extracts and other materials derived from the carcasses of animals, price to their removal to a manufacturing chemist for the manufacture of pharmaceutical products.

The third destination was amended to prohibit the removal to a zoo, menagerie fur farm, maggot farm or greyhound kennels of carcass meat or offal rejected by an authorized person, as unfit for human consumption by reason of tuberculosis. The fifth destination was amended so as to make removal or storage prior to further removal permissible only where the subsequent removal was to a processor, further removal to a 'manufacturing chemist' was no longer permitted.

Finally, subsequent removal under Regulation 17(3) of the 1982 Regulations, from any of the listed destinations was now to be permitted in circumstances where the meat was removed from a hospital, medical or veterinary school, laboratory or similar institution in accordance with an arrangement in writing with and under the supervision of an authorized officer of the local authority in whose district the premises were situated to another destination listed in Regulation 17(1)(a) to (d) or to a place where it was buried or destroyed.

Self-Assessment Exercise 3

1. For how long should meat be put on sale after slaughter? 2. Which year was the regulation for meat instituted?

2.6 Summary

There are still other alternative methods of handling meat such as meat handling without refrigeration. Meat prohibited include: Any meat removed from a slaughterhouse, which was unfit for human consumption. Any meat removed from a knacker's yard; or any meat unfit for human consumption from an animal which had died or had been slaughtered at a place other than a slaughterhouse or Knacker's yard, or had been brought to such a place after having died or been slaughtered; unless that meat had been sterilized. But there are exemptions from this prohibition in the case of any meat which is in the possession of a person. Meat for human consumption should not be stored together with those not for human consumption unless adequate measures have been observes

2.7 Glossary

Specified offal' was amended to mean the hearts, kidneys, livers and lungs derived from an animal which, in the case of a carcass in a slaughterhouse, had been rejected by an authorized person as unfit for human consumption by reason of any disease or pathological condition other than

***Stockinett**e* = A soft stretch fabric used for cleaning, wrapping or bandaging

2.8 References/Further Readings

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2.9 Answers to the self-assessment exercise

Answers to Exercise 1

No. 1 The regulations prohibited any person from possessing for the purpose of sale or preparation for sale:

i. Any meat removed from a slaughterhouse, which was unfit for human consumption;

ii. Any meat removed from a knacker's yard; or

iii. Any meat unfit for human consumption from an animal which had died or had been slaughtered at a place other than a slaughterhouse or Knacker's yard, or had been brought to such a place after having died or been slaughtered; unless that meat had been sterilized.

No.2: a. The meat must be fit for consumption

b. The meat must be sterilized

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Answers to Exercise 2

No.1. The refrigeration is usually produced by injecting liquid nitrogen or carbon dioxide (CO,) into the compartment or by blowing air over CO, chunks (dry ice). The temperature in these vans can be set and controlled to minimize the temperature rise and to avoid condensation on the meat surface. Insulated vans without refrigeration may be refrigerated by adding dry ice

No.2. Meat removed to a destination referred to in regulation was required to be removed in a vehicle or impervious container which:

i. Was kept closed and locked or sealed at all times except when necessary for the loading or unloading of the contents or their examination by an authorized officer; and
ii. Bore a notice of adequate size which was conspicuously visible and contained a distinct legible and unambiguous statement to the effect that the meat carried therein was not for human consumption.

Exercise 3

No.1. Meat should be put on sale within a day of slaughter

No.2. It was instituted in 1982

UNIT 3: QUALITIES OF ESTABLISHMENT FOR MEAT PROCESSING

Unit structure

3.1 Introduction

Every operator must provide adequate facilities for the collection of inedible meat products. The registration of blueprints for plant facilities is for both edible and inedible areas of the registered establishment, all blueprints for registered establishments, including those for facilities, required for the collection, storage and disposal of inedible meat products must be registered by the Chief, Plants and Equipment of the Meat and Poultry Products Division

3.2 learning outcome

At the end of the unit, the students will be able to understand the requirements for meat establishment such as: Designing a slaughter house, Separation of Inedible Meat products, like the condemned products and Disposal of Inedible Meat Products

3.3.1 Designing a slaughter house

The following instructions should be adhered to while designing a slaughter house:

- ✓ A registered establishment should be designed in such a way that, starting from the slaughter of the animals and considering that the inedible waste products and inedible meat products are progressively removed from the carcass.
- ✓ As the carcass is being dressed, heavily contaminated portions such as hair, hide, feathers, etc are being removed and the carcass is moved to progressively cleaner areas.
- ✓ As they are being separated from the carcass, the inedible products shall be moved to the inedible section of the plant.
- ✓ There shall be no direction reversal of inedible meat products. Unless otherwise indicated separate receiving separate shipping, freezer, and cooler if necessary must be provided for inedible meat products

3.3.2 Sanitary conditions

- ✓ Sanitary conditions must be maintained at all times throughout the inedible section of the establishment.
- ✓ A daily clean up shall be carried out and immediate effective action shall be taken if unsanitary conditions develop.
- ✓ An effective insect and rodent control program shall be maintained in the inedible section of the registered establishment. This program should be similar to the program in effect in the edible section of the establishment.
- ✓ Plant employees working exclusively in the inedible section of the establishment shall have welfare facilities separate from employees working in the edible section of the registered establishment.
- ✓ If it is absolutely necessary that an employee working in the inedible section of the plant carries out work in the edible section, then that employee shall be required to completely change his protective clothing and thoroughly wash his hands before he commences work in the edible section of the establishment.
- ✓ Within the inedible section of the establishment, the raw material handling area shall be separate from the section where the sterilized inedible material is handled.
- ✓ Proper segregation must be maintained between the different categories of inedible meat products. When adequate segregation is not maintained between condemned meat products, all inedible meat products must be treated as condemned meat products requiring sterilization.
- ✓ Adequate facilities to render or denature the inedible meat product as applicable must be provided.

- ✓ The shipping containers for meat product destined for animal food or for medical purposes shall be labeled in accordance with subsection 94(2) of the meat Inspection Regulation 1990.
- ✓ The establishment ventilation shall be such that the air flow is, under no circumstance, directed from the inedible to the edible section.
- ✓ An effective system of odour control shall be provided in the inedible section of the registered establishment.
- ✓ Due to the high price of protein material, the destruction of condemned meat product by incineration is no longer of great importance.
- ✓ Operators wishing to incinerate condemned meat products may do so, on condition that the operator provides incineration facilities approved by the local authorities and by the Meat and Poultry Products Division.
- ✓ Registered establishments that receive inedible oils, fats, bones or meat scraps shipped directly from a retail store, restaurant or public institution, as provided for in subsection 44(2) of the Meat Inspection Regulations, 1990 shall provide receiving facilities directly to the inedible section of the establishment premises.
- ✓ Receipt of such products through edible receiving area is not acceptable. The receipt of dead animals for rendering in a registered establishment (other than those dying en route to a registered establishment) is only permitted with special permission from the Director, Meat and Poultry Products Division, under section 45 of the Meat Inspection Regulations, 1990. Such permission is only given when such receipt does not create any unsanitary condition on the establishment premises and when such a disposal is in the public interest.
- ✓ Dry or wet rendering methods may be employed. The destruction of viable pathogens is important in breaking the chain of infection.

- ✓ The heating process shall destroy all salmonella present in the raw material. It is also important that no recontamination of the sterilized rendered product takes place.
- ✓ All reasonable precautions must be taken to prevent reintroduction of salmonella and other pathogens through insects, rodents, birds and other animals. Inedible tallow and other inedible fats may be shipped appropriately identified for industrial use.
- ✓ Separate storage tanks, pumps and pipelines shall be used for the handling of inedible fats.
- ✓ Shipping areas for sterilized inedible meat products shall not be used for the receipt of raw materials for rendering. They shall be well protected to prevent recontamination.
- ✓ Sterilized and bagged inedible meat products shall be appropriately marked when shipped from the registered establishment.

Self-assessment exercise 1

1. State the instructions that should be adhered to while designing a slaughter house
2. State the goals of heating raw meat

3.4 Duties of Inspectors

The duties of the inspector are many as outlined in the separation of inedible meat products (Condemned Products) and in the control measures required for condensed products

3.4.1 Separation of Inedible Meat Products (Condemned Products)

Inspectors are responsible to ensure that the operator is carrying out his responsibility. On a general note, of all the inedible meat products in a registered establishment, condemned meat products require the closest supervision. The reason for this is obvious. Condemned meat products could be accidentally or fraudulently added to meat products approved for human consumption. Some condemned meat products could also spread disease to man and animals if they are not handled and disposed of in a sanitary manner. It is the operator's responsibility to dispose of condemned meat products as prescribed in section 54 of the Meat Inspection Regulations, 1990.

Condemned meat products include carcasses and portions of carcasses which upon inspection or re-inspection are found to be affected by disease or an abnormal condition that renders them unfit for human food. It further includes animals condemned on antemortem inspection, carcasses of animals that died enroute to the registered slaughter establishment and carcasses of animals that died in the yard or a livestock holding pen of the registered slaughter establishment.

Whenever applicable, a separate room or area shall be provided for the skinning of condemned carcasses and their preparation for rendering. Under no circumstance shall the skinning, evisceration and other preparation of animals condemned on ante mortem inspection, or found dead carcasses, be allowed on the killing floor. Such condemned food animals or found dead carcasses shall be directly conveyed from the livestock yards or pens to the inedible section of the registered slaughter establishment.

The collection and conveyance of condemned carcasses, organs and portions of carcasses or any other condemned meat product from the killing floor and processing area shall be done in a sanitary manner. Any contact of condemned meat products with carcasses being dressed or approved meat products shall be prevented. All equipment having been in contact with condemned meat products shall be cleaned and sanitised as required before reuse. Plant personnel and inspectors handling condemned meat products shall wash their hands and clean and sanitise their work clothing and equipment as required.

Containers used for Condemned meat products shall be distinctly marked “Condemned” and containers used for animal food products shall be marked "Animal Food". They should be preferably of a colour that distinguishes them from containers used for edible meat products. In addition to sanitary considerations, it is essential that condemned material be maintained under rigid inspection control until disposed as per section 54 of the Meat Inspection Regulations, 1990.

3.4.2 The control measures required for condensed products

The control measures will include one or several of the following:

- product is mixed with intestines or an accepted denaturing agent and crushed or ground in a continuous and non-reversible mechanical conveying system which empties directly to a melter or a conveyance acceptable to the inspector in charge for transportation to another registered establishment or authorized inedible rendering plant for sterilization;

- product is freely slashed, crushed or ground and mixed or sprayed with an accepted denaturant. The denaturant shall be reasonable well distributed to ensure that all condemned meat products are denatured. Product is shipped in containers marked with the words "Condemned" to another registered establishment or an authorized inedible rendering plant for sterilization;

- In the case of a carcass that has not been dressed, the denaturant may be applied by injecting it into portions of the carcass to the extent necessary to preclude its use for human or animal food purposes.

- Canned meat products may be disposed of by crushing and receives prior approval from the Regional Director, Meat Hygiene.

Operators may harvest or salvage certain condemned meat products for animal food with the consent of an official veterinarian. These products may be intended in the feeds for fish, pets, zoo animals and fur animals. Condemned meat products may be used for animal food provided:

i. they are derived from carcasses, portions or organs that are not affected with a disease transmittable to the above mentioned animals.

ii. they are derived from carcasses, portions or organs that are not affected with a disease that is a potential cause of zoonoses for handlers of this material;

iii. they are derived from carcasses, portions or organs where lesions or conditions mentioned in (ii) and (iii) are removed.

In the case of partial condemnation, i.e. condemnation of portions or organs, such consultation is not necessary provided the condemned meat products have been trimmed to make them free of transmittable pathogens.

Operators wishing to engage in the harvesting or salvaging of meat products for animal food must provide, adequate facilities for the separation, chilling, packing, marking, storage and denaturing of the product. Denaturing is required to clearly distinguish such meat products from those prepared and approved for human consumption.

In order to be considered as being properly denatured, charcoal or another accepted denaturing agent will have to be added to the meat product. Meat products shall be cut into pieces small enough to carry out effective denaturing. The denaturing shall be carried out in the inedible poultry carcasses, poultry intestines may be ground up with carcasses instead of charcoal or other accepted denaturing agents.

With the consent of an official veterinarian, operators may harvest or salvage certain condemned meat products for medicinal purposes. In situations where a specific need is identified to use such products for medicinal purposes, a request shall be made to the Chief. Epidemiology Agri-Food Safety Division.

The request shall include all the pertinent information (meat products to be salvaging, process use, salvaging process, etc.)

In the case of meat products that are judged by an official veterinarian to be unacceptable for rendering due to dangerous residues or for other reasons, may be disposed of in accordance with local environmental requirements.

Condemned meat products derived from a food animal affected with a reportable disease shall be destroyed pursuant to subsection 48(1) Health of Animal Act

Non Condemned Products

Operators wishing to engage in the harvesting or salvaging of meat products for animal food must provide adequate facilities for the separation, chilling, packing and marking, storage and denaturing of the product, as required. Denaturing is required to clearly distinguish such organs and portions approved for animal food from those prepared and approved for human consumption. The denaturing shall be carried out in the inedible products area of the establishment. Organs or portions shall be denatured with charcoal or another agent accepted by the Agri-Food Safety Division for that purpose. An exception to the use of an approved denaturant may be made in the case of spleens, lungs, udders, uncleaned gastro-intestinal tracts and poultry heads and feet. Animal food livers which are directly delivered from a registered establishment to a fish hatchery operated by the federal or by a provincial government may be shipped without being denatured.

Animal food products derived from non- condemned meat products in containers, fully marked, may be frozen and stored in a freezer used for freezing and storage of packaged, fully marked meat products for human consumption. Such meat products for animal food may also be shipped from the edible shipping area. The freezing, storage and shipment of these fully packaged and marked animal foods shall only be allowed if they are kept apart from meat products approved for human consumption and provided such handling does not create any lowering of the standards of sanitation.

Animal food products may be received from other registered establishments for freezing, storage and shipping in the frozen state provided they are packaged, identified for use as animal food, ad their handling does not pose any sanitary problems. All handling of inedible products harvested or salvaged for animal food shall be carried out away from edible product and as much as physically and operationally possible in a section of the establishment used only for that purpose.

Operators may harvest or salvage inedible meat products for medicinal purposes on their premises. Operators wishing to engage in the harvesting or salvaging of such meat products must provide adequate facilities for the separation, chilling, packing, marking and storage of the product. Inedible meat products destined for medicinal purposes in containers, fully may be frozen and stored in a freezer used for freezing and storage of packaged, fully marked meat products for human consumption. Such meat products may also be shipped from the edible shipping area.

The freezing, storage and shipment of these fully packaged and marked for medicinal purposes shall only be allowed if they are kept apart from meat products approved for human consumption and provided such handling does not create any lowering of the standards of sanitation.

Guidelines for the collection of bovine fetal blood for pharmaceutical or research purposes have been established. The collection of bovine fetal blood for the above usage is permitted in registered establishment where the process and handling are carried out in a manner which does not interfere with plant sanitation or unnecessarily create potential infection to employees. Adequate protection is to be provided to employees by management. All proposals are to be forwarded to the Chief, Plants and Equipment manager, with detailed plans, through the regional office has to ensure that facilities are satisfactory to carry out the operations in a satisfactory manner.

3.4.3 Requirement for facilities

The following requirements shall be met for the facilities:

- The access area to and fro the collection room should avoid backtracking and preclude cross-contamination.

- When a container is used, it must be water tight and properly identified.

- The feti are to be derived from carcasses in accordance with client specifications, but must exclude those derived from animals which reacted to the official test for Brucellosis. This is to reduce the health risk in regard to human contacts, during handling.

- Uteri containing the feti must be conveyed intact to a suitable room or area in the inedible section of the establishment.

- The collection room or area must have accepted room surface materials, satisfactory drainage and lighting. A rust-resistant metal table with drainage is required for bleeding with an adjacent knife sanitiser. A suitable hand washing station is to be provided along with soap, towels and disinfectant solution for personal hygiene. A hot and cold water outlet is required for room clean-up.

Inedible meat products that are treated by the operator as condemned meat products. The collection and disposal of all inedible meat products in thus category shall be carried out in a sanitary manner. Although inspectional control over this type of inedible meat product is not as critical as it is in the case of other condemned products, an orderly handling is still important. Such products can be a source of contamination if handled improperly.

This type or inedible meat product should be conveyed via the shortest possible route to the appropriate section of the inedible products area of the registered establishment to be disposed of in keeping with section 54 of the Meat Inspection Regulations, 1990.

An appropriate disposal effort should be made by plant management to prevent unnecessary accumulation of such products anywhere in the edible section of the establishment.

Products which are by their nature not edible: The collection and disposal of inedible products in this category shall be carried out in a sanitary manner. These products shall be taken forthwith to the appropriate section of inedible products area in a manner that prevents contamination of any edible meat product.

Self-assessment Exercise 2

1. Which categories of carcass are regarded as condemned products
2. State four (4) control measures for condemned products

3.5 Disposal of Inedible Meat Products

3.5.1 Conditions under which Condemned Meat Products to be Sterilized may be shipped from a Registered Establishment

Manure, paunch and viscera contents shall be disposed of in a manner which will not create a sanitary problem on the premises of the registered slaughter establishment. Storage of such wastes in the vicinity of the registered is not acceptable.

a) *Facilities for shipment:* General construction requirements for registered establishments apply also for condemned meat product holding rooms and shipping areas. Hot and cold water for clean-up purposes and for hand wash facilities must be available.

b) *Frequency of shipment*: Generally, it is understood that a daily pick-up service of condemned meat products is provided. Special permission for less frequent pick-up service may be given by the Regional Director, Meat Hygiene if refrigeration is provided in the room where the condemned meat products are stored.

c) *Containers for shipment*: Bulk containers or barrels used for shipment of denatured condemned meat products, from one registered establishment to another registered establishment or to an authorized inedible rendering plant, shall be impervious, in good repair, and shall be returned in a clean condition. They shall be marked with the word "Condemned".

d) *Sanitation:* A daily clean-up of the condemned product holding room shall be carried out. In addition, whenever unsanitary conditions develop due to a spill of product or for any other reason, management shall arrange for an immediate clean-up.

3.5.2. Conditions under which Condemned and other Inedible Meat Products may be received in a Registered Establishment for Sterilization

a) Receiving area**:** A separate receiving area for the inedible meat products must be set aside in the inedible section of the registered establishment. Structural facilities of the inedible section of the receiving registered establishment shall be such that the receipt of these additional inedible meat products originating in another registered establishment can be carried out.

b) Receipt of dead animals: The receipt, handling and disposal of dead animals other than those dead on arrival or those that died on the establishment premises requires special permission from the Director of the Meat and Poultry Products Division, as per section 45 of the Meat Inspection Regulations, 1990. Such permission is only given under extenuating circumstances.

c) **Sanitary requirements**: The receiving area for condemned and other inedible meat products must be separate from any area where edible meat products are prepared, stored, shipped or received. The receipt of the above described inedible meat products shall not interfere with sanitary standards in the registered establishment. Sanitary facilities for the cleaning and sanitising of containers and vehicles transporting inedible meat products must be available. Containers and vehicles returned to the other registered establishments must be clean and sanitary. Authorization Procedures should be observed.

Request for authorization of inedible rendering plants shall be made to the Regional Director, Meat Hygiene. Premises meeting requirements are listed as plants authorized to receive condemned meat products for sterilization. Authorized inedible rendering plants are not registered under the Meat Inspection Act and are therefore not considered registered establishments. After receipt of a request for authorization of an existing plant the following steps are followed:

a) The Regional Director requests a complete initial survey of the premises of the rendering plants to determine the acceptability of the layout of the premises.

b) A copy of the inspecting officer's report is forwarded to the management of the rendering plant. This report should describe construction details, equipment layout and operation of the existing plant. The report should further outline the improvements and changes required for authorization of the premises.

c) If management decides to make the required improvements then it shall submit three copies of the building blueprints and equipment layout, together with three copies of the plot plan. The blueprints shall be accompanied by specifications of construction of floors, walls and ceilings, details of drainage, water supply, welfare facilities, and all other relevant information. If the Regional Director is satisfied with the proposed changes, then he should forward the blueprints and relevant information together with his recommendation to the Chief, Plants and Equipment of the Meat and Poultry Products Division for evaluation and approval.

d) After review of the plans and completion of the renovations, the Regional Director, Meat Hygiene of the Region in which the inedible rendering plant is located will arrange for a final plant inspection. If renovations have been carried out satisfactorily, the Regional Director will recommend authorization of the inedible rendering plant to the Director of the Meat and Poultry Products Division.

e) In all instances, inedible rendering plants must comply with all federal provincial and municipal requirements before authorization is given by the Director of the Meat and Poultry Products Division.

Structural, equipment and operational requirements

a) An authorized inedible rendering plant shall be of solid construction, with interior finishes of smooth, hard and impervious materials capable of being cleaned.

b) The flow of product shall be such as to preclude any backtracking or intermingling or raw and cooked product.

c) The receiving dock area shall be hard surfaced, shall have suitable drainage and shall lead directly to the cooker charging area.

d) The cooker discharge, percolator, press, grinders and other equipment in the finished product area shall be entirely separate from the charging and other raw material handling areas.

e) Each melter and cooker shall be provided with an automatic temperature-recording device.

f) The shipping area for sterilised product shall be separate and apart from any raw product receiving area.

g) All floors shal1 be of concrete, tile or other approved construction, adequately sloped and drained.

h) Adequate facilities for the washing and sanitizing of vehicles and containers shall be provided. Containers and vehicles returned shall be clean.

i) Satisfactory employees welfare facilities shall be provided. Such facilities shall include washrooms, showers, toilets, cloakrooms and lunchrooms if employees consume food on the plant premises. The facilities shall be adequately ventilated, provided with potable water and artificial light.

j) Management is responsible for providing employees with protective clothing and having it laundered regularly. Employees shall frequently change their protective clothing.

k) Plant premises shall have adequate ventilation and be equipped with condensers to control odours.

l) An adequate program of insect and rodent control shall be carried out on the plant premises.

m) Any sterilized product not shipped in bulk containers shall be appropriately identified.

n) Hide storage room shall be separate and apart from the processing section of the plant.

o) A good janitor service shall be maintained throughout the plant and processing areas shall be regularly cleaned and sanitized. It is essential that a supply of cold and hot water be available.

p) Suitable disposal facilities for paunch contents shall be available.

q) Management shall be responsible for the provision of watertight bulk containers or other containers for the pick-up of condemned and other inedible meat products. Leaking containers presented for pick-up of condemned and other inedible meat products in registered establishments shall be rejected by Inspectors. Inspectors shall have unlimited access to the plant premises and shall have access to a telephone (for local or collect calls), washroom, toilet, and shall have permission to use a desk to write reports, as required. A filing cabinet or drawer which can be provided with a departmental lock shall be reserved for the use of the inspector.

r). Management hall keep records of condemned meat products received for sterilization from registered establishments. Those records shall be available for the inspector's review, as required.

3.5.3 Preparation of products at the authorized inedible rendering plant

a) Inedible protein residue such as meat meal, bone meal, blood meal, feather meal

b) Inedible tallow and other inedible fats.

c) Animal hides and skins.

d) Animal food.

It should be noted that the Meat and Poultry Products Division does permit the salvage of animal food from dead animals and other inedible meat products in authorized inedible rendering plants, provided such salvage is allowed under provincial legislation. Such salvage, however, should be carried out in separate rooms acceptable for that purpose. Under no circumstance shall it be permitted that any animal food products be salvaged from condemned, denatured carcasses or portions to be sterilized shipped from a registered establishment. These meat products shall be rendered sterile. Animal food salvaged in an authorized outside inedible rendering plant shall be denatured and labeled in the same manner as in registered establishments.

Self-assessment Exercise 3

1. State the requirement or specification for Bulk containers or barrels used for shipment of denatured condemned meat products
2. List the materials regarded as condemned products

3.6 Summary

The duties of the inspector are many as outlined in the Separation of Inedible Meat Products (Condemned Products) and in the control measures required for condensed products.

Separate rooms should be provided for different raw, intermediate and finished products. Sanitary conditions must be maintained at all times throughout the inedible section of the establishment. Control measures are required for condensed products. Condemned meat products may be used for animal food at certain conditions. Operators wishing to engage in the harvesting or salvaging of meat products for animal food must provide adequate facilities for the separation, chilling, packing and marking, storage and denaturing of the product, as required. In all instances, inedible rendering plants must comply with all federal provincial and municipal requirements before authorization is given by the Director of the

Meat and Poultry Products Division. An authorized inedible rendering plant shall be of solid construction, with interior finishes of smooth, hard and impervious materials capable of being cleaned. It should be noted that the Meat and Poultry Products Division does permit the salvage of animal food from dead animals and other inedible meat products

3.7 Glossary: ***Feti*** = Forensic experimental trauma

3.8 References/Further Readings

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3.9 Possible Answers to Self-Assessment Exercise (s)

Exercise 1

NO. 1. The following instructions should be adhered to while designing a slaughter house

- ✓ A registered establishment should be designed in such a way that, starting from the slaughter of the animals and considering that the inedible waste products and inedible meat products are progressively removed from the carcass.
- ✓ As the carcass is being dressed, heavily contaminated portions such as hair, hide, feathers, etc are being removed and the carcass is moved to progressively cleaner areas.
- ✓ As they are being separated from the carcass, the inedible products shall be moved to the inedible section of the plant.

✓ **NO. 2.** The heating process shall destroy all salmonella present in the raw material. It is also important that no recontamination of the sterilized rendered product takes place.

Exercise 2

2. The control measures will include one or several of the following:

- ➢ product is mixed with intestines or an accepted denaturing agent and crushed or ground in a continuous and non-reversible mechanical conveying system which empties directly to a melter or a conveyance acceptable to the inspector in charge for transportation to another registered establishment or authorized inedible rendering plant for sterilization;

- ➢ product is freely slashed, crushed or ground and mixed or sprayed with an accepted denaturant. The denaturant shall be reasonable well distributed to ensure that all condemned meat products are denatured. Product is shipped in containers marked with the words "Condemned" to another registered establishment or an authorized inedible rendering plant for sterilisation;

- In the case of a carcass that has not been dressed, the denaturant may be applied by injecting it into portions of the carcass to the extent necessary to preclude its use for human or animal food purposes.
- Canned meat products may be disposed of by crushing and receives prior approval from the Regional Director, Meat Hygiene.

Exercise 3

NO.1 *Containers for shipment*: Bulk containers or barrels used for shipment of denatured condemned meat products, from one registered establishment to another registered establishment or to an authorized inedible rendering plant, shall be impervious, in good repair, and shall be returned in a clean condition. They shall be marked with the word "Condemned".

NO.2. Materials regarded as condemned products

a) Inedible protein residue such as meat meal, bone meal, blood meal, feather meal

b) Inedible tallow and other inedible fats.

c) Animal hides and skins.

d) Animal food.

UNIT 4: DIFFERENT WAYS OF PRESERVING MEAT

Unit structure

4.1 Introduction

Meat is animal tissue which is used as food. Most often it refers to skeletal muscle and associated fat, but it may also refer to non-muscle organs, including lungs, livers, skin, brains, marrow, and kidneys. Other animal tissues used as food, and also to some extent in meat processing, are the internal organs including the blood.

4.2 Learning outcomes

At the end of the lecture, the students will understand different ways of curing meat using salts, common spices, natural smoke, and methods of meat sterilization

4.3. **Meat Curing Agents**

4.3.1 Nitrates

Sodium ($NaNO_3$) or potassium nitrate (saltpeter, KNO) allow cured meat colour to develop in products where drying is a long-term process. Nowadays, they are used less frequently because to be effective they have to be reduced to nitrites under the influence of bacterial enzymes, and this is a time-consuming process.

4.3.2 Nitrites

Nitrites are indispensable for meat curing, and no substitute has yet been found. Sodium nitrite ($NaNO_3$) is a toxic substance and can be fatal even in small doses. For this reason they are often mixed with common salt at a concentration of about 0.6 percent (so-called "nitrite salt") when used for curing. If excessive levels of nitrite are accidently reached the accompanying salty taste will be rejected by the consumer, thereby preventing nitrite poisoning. The maximum amount of nitrite permitted in finished meat products is usually 200 ppm (parts per million, or mg per kg), or may be less subject to the type of meat product or country legislation. Saltpeter can be added to the nitrite salt at a concentration of 1 percent and used for curing dry hams and dry sausages. Typical levels of nitrite and nitrate in meat products are shown in Table 1.

Table 5.1: Typical amount of nitrite and nitrate in cured products

Curing agents	Amount of nitrite or nitrate in cured-meat products
Nitrite salt (99.4% NaCI + 0.6% $NaNO_2$)	all-meat products, 100 ppm as nitrite dry hams, 150 ppm as nitrite
Saltpeter (KNO_3)	dry sausages, 100 Ppm as nitrate low-sodium products, 100 ppm as nitrate
Nitrite salt + saltpeter	dry hams, 600 ppm as nitrate

Three processes in meat curing are due to the effect of nitrites:

Cured-meat colour development is achieved when the muscle pigment (myoglobin) in an acid environment combines with nitric oxide (NO) (formed from nitrite) to form NO myoglobin. This reaction is affected by temperature, pH and oxygen-reducing agents. NO-myoglobin is relatively resistant to light and oxygen and, most importantly, it is heat stable. Thus, cured cooked meat and meat products maintain a bright red colour in contrast to uncured meat which turns grey after cooking. Nowadays it is considered that 3-50 ppm is sufficient to achieve colour in cooked sausages.

Cured-meat flavour development is based on various reactions between nitrite and the meat component. Typical flavour of cured-meat products is achieved with 20-40 ppm nitrite which also has preservative effect. Even in small doses (80-150 ppm), nitrite prevents the growth of numerous micro-organisms, and food-poisoning bacteria (*Clostridium botulinum, Salmonella spp*, *Staphylococci spp*, etc.). However, the effect of nitrite on shelf-life or prevention of food-poisoning bacterial growth must not be overestimated and decreases with increasing storage temperature.

4.3.3 Common Spices

Spices act on the salivary and gastric glands to promote secretion, stimulating appetite and improving digestibility of meat products. Their use varies from country to country depending on the climate, customs and eating habits. There are spices whose taste and smell remain unchanged even after exposure to high temperatures (chilies and sage). Less resistant are cardamom, clove, pepper, rosemary and thyme, and the least heat resistant are coriander, mace, marjoram, nutmeg, allspice and ginger.

Self-assessment Exercise 1

1. Why is sodium nitrite often mixed with common salt when used in curing meat?
2. Create a Table of typical amount of nitrite and nitrate in cured products

4.4 Other means of preserving meat

There are other alternative means of meat preservation which include: Use of chemical additives, Natural Smoke, heat treatment and drying

4.4.1 Use of chemical additives

- Phosphates are used to restore WHC to chilled meat, approximately to the same level as hot-boned meat. Certain countries forbid phosphates, whereas some allow their use only where there is a proven technological effect. Where permitted they should be restricted to 0.3-0.5 percent of the sausage mixture weight. Phosphates break down actomyosin into actin and myosin, which can be solubilized by salt to increase the WHC. This effect is retained even in cooked products, increasing the yield

- Ascorbic acid (vitamin C) and its salts (sodium ascorbate) contribute to the development of cured-meat colour. Sodium ascorbate is used in the manufacture of cooked sausages, made from uncooked or precooked raw materials. Ascorbic acid used is at a concentration of 0.03-0.05 percent, whereas sodium ascorbate is added at a concentration of 0.07 percent. Ascorbic acid is a strong reducing agent, enabling quicker formation of the NO myoglobin so that less nitrite is needed, and it inhibits the formation or an undesirable colour in cured-meat products.
- The curing of meat is a process depending upon the inhibition of microbial growth by the use of sodium chloride and control of water activity (a_w) together with the optional additional use of nitrite salts to stabilize meat colour, and smoking to give further microbial control, and a desirable cured meat flavour. Many traditional processes have been developed to give products of distinctive character.
- Pre-slaughter control design to achieve a low ultimate pH is an important aspect of all cured meat processes, since a pH of 5.8 or below is required.

1. to produce an open structure in the muscle which encourages the rapid and complete penetration of salt into the tissue
2. to aid in the control of microbial development on both the surface of the products and in the deep tissues where anaerobic spoilage bacteria have a slow growth only if the pH is below pH 5.6; and to aid in maintaining a desirable light red colour which is best achieved by having meat at pH 5.8 or lower

4.4.2 Natural Smoke

Natural smoke is a very complex mixture, consisting of a great number of compounds, and is obtained by controlled combustion of moist sawdust at low temperature. Sawdust from hardwoods is most commonly used to generate the smoke. Nowadays, it is considered that optimal smoke composition is obtained at temperatures of 300-500^{o}C. Smoke consists of gases (phenols, organic acids, carboniles and other compounds) and particles (pitch, tar, ash and soot). Gaseous components penetrate into a product through the casing to a certain level, and react with other components of meat products. Other components are deposited on to the surface. Smoke provides typical flavour and distinctive colour, and hardens the surface of the meat product.

All substances which are added to meat products must have food grade purity. They should not contain any food-poisoning bacteria, so must be treated according to the highest hygienic standards. It is important to keep them in properly closed containers or intact packages, away from any dampness and dust. They are usually kept in special, dry premises away from the workshop, in which they can be pre-weighed, blended and packed into plastic bags in the proportions required for sausage formulations. The nitrate must be kept under lock and key.

Dosage by hand of any non-meat ingredient is not allowed. The only correct way is with scales which must be checked occasionally for accuracy. One of the most serious consequences of failure to protect all non-meat substances is contamination with dirt, excreta from rodents, birds or other animals and infestation with insects

The optional smoking process may be carried out by the conventional process of hanging the product in a smokehouse in the presence of smoke for 4-8 hours at temperatures of 35-40^{0}C; or by holding for several hours in a room to which smoke is ducted from a smoke generator consisting of a grinding wheel and a length of wood. In both cases, the smoke should be generated from cured hardwood in order to avoid the gums associated with soft wood such as pine. The smoking process has a number of effects including a preservative effect brought about by the surface deposition of methanol, ethanol, dimethylpropanone, methanol, ethanol, phenols, methanoic and ethanoic acids, furfuraldehyde, resins, waxes, tars and doubtless, many other materials are all present in smoked products in levels ranging from parts per million to per billion.

4.4.3 Heat Treatment

During processing many meat products are subject to specific heat treatment. The first task of heat treatment is to:

- Reach satisfactory shelf-life by reduction of micro-organisms.
- The second task is to obtain desirable organoleptic characteristics, to preserve
- nutritive value and
- Improve digestibility of the product.

Reduction of Micro-organisms

Microorganisms are destroyed if exposed to sufficiently high temperatures for long enough. There is a direct relationship between bacteria survival and time of exposure to temperatures. As an example, if 10 000 000 bacteria (per ml) suspended in broth are exposed to heat (70^{O}C), after the first five minutes 1 000 000 will survive (90 percent are destroyed), after the next five minutes the number of surviving will be 100 000 (again 90 percent are destroyed), and so forth. This tenfold reduction in bacterial numbers between fixed time intervals is called decimal reduction. The time interval for decimal reduction varies between different bacteria and depends on the temperature applied. The number of bacteria present in a meat product just before the heat treatment (initial number) should be as low as possible so that a shorter time or lower tempera ture is needed to achieve a satisfactory shelf-life for the product. As sausage fillings as well as most other meat products represent a very good medium for bacterial growth, they should immediately be exposed to heat treatment in order to prevent bacterial growth. It is also important to perform all operations as quickly as possible, and to maintain the highest hygienic standards so that the initial bacterial count remains as low as possible. The manufacturer must always bear in mind that bacteria grow very fast. Their number may be doubled every 20 minutes.

4.4.4 Drying

A preservative effect is also induced by the surface drying that occurs to the extent of about 3% total weight loss in hot smoked products. An antioxidant effect is also produced by the deposition of phenolic compounds onto the surface, and these materials give rise in smoked products to a longer storage life free from rancidity development. Finally of course, smoking imparts a great deal of the characteristic flavour to traditional products

The practice of sun-drying of raw meat products has been practiced for thousands of years by pastoral and nomadic people seeking simple means to preserve meat in surplus supply. A variety of traditional products have been developed that rely upon the interaction of preservation techniques involving:

1. A restriction of water activity by drying
2. The use of salt and sugar to further control water activity and to act as selective inhibitors of microbial and enzymic actions; and
3. The use of spices to further limit microbial development and to impart characteristic flavours

Self –Assessment Exercise 2

1. List four other alternative means of meat preservation to use of curing agents
2. Explain the direct relationship between bacteria survival and time of exposure to temperatures

4.5. Cold storage and chilling processes

4.5.1 Cold storage

The familiar high perishable of meat is due to its nutritious composition, for both men and microbes, as well as to meat's invariable surface contamination by spoilage micro-organisms. Low temperatures have been used throughout history to slow down the rate at which surface contaminants increase their numbers from initial levels to final levels indicative of spoilage. The time taken for such microbial increase is a measure of the storage life. The term "cold storage" generally refers to the use of low temperatures within the range 1 to 3.5^{o}C, temperatures well in excess of the commencement of muscle freezing, but within the temperature optimum between -2^{o}C and 7^{o}C for growth of psychrophilic organisms. The essence of meat marketing through cold storage is thus to have as rapid turnover as possible based upon a storage life of not more than 3-5 days, ensuring maintenance of the cold conditions throughout wholesale storage, distribution, retail storage and sale. This procedure is very widely used throughout western cities, relying upon a large daily kill at a city-based abattoir together with a cold-chain distribution and refrigerated storage in the consumer's home. Spoilage of locally produced and consumed meat is avoided by using the meat promptly.

4.5.2 Chilling

Where a storage life in excess of about 5 days is required, as is the case for meat intended for export to other cities or countries, then the temperatures of 1^{o}C to 3.5^{o}C are no longer adequate and use must be made of lower temperature together with the use of other available methods of reducing the rate of onset of microbial spoilage. These factors include

1. a reduction of the initial contamination to the lowest possible levels by means of strict hygiene during slaughter and carcass dressing;
2. the choice of the lowest possible temperature that avoids freezing of the thin sections of the carcass, and its control to within the closest limits; which in practice means a temperature of -1.5 to 0.2 ^{o}C
3. in the case of carcass, the choice of storage 87-81% so the surface drying amounting to 2-4% of carcass weight occurs on the carcass surface, which is inhibitory to bacterial growth
4. the inclusion in the storage atmosphere of up 25 % carbon oxide in excess of 25% tend to promote the formation of the undesirable metmyogloblin and must be avoided;
5. the use of meat of low pH, preferably below pH 5.8; and a reduction of the carcass cooling process to the minimum time.

These principles find slightly different application dependent on whether the meat is in the form of a carcass or in the form of boned-out meat cuts.

4.5.3 Freezing process

By definition, the freezing and frozen storage of meat is carried out at temperatures where micro-organism will not grow, and at temperatures where the meat is hard enough to safely withstand bulk storage. In practice, this implies the use of temperature below -15^{0}C.

Meat, as the other biological materials has no precise freezing point but rather it has a freezing range in which the amount of water present as ice is determined by the lowness of the temperature. Thus, at 0^{o}C no ice is present, at -10^{0}C about 83% of the available water is frozen at -30^{0}C about 89% is frozen, and it is only at temperatures below -40^{0}C that all of the available water is frozen at the eutectic point. Once water has started to freeze, the rate of ice formation is determined by the rate of ice formation is determined by the rate of heat removal and the rate of diffusion of water from surrounding cell structures. At slow rates of freezing, few crystallization centres are formed, resulting in the growth of large ice crystals which can lead to cell rupture and excessive losses of fluid or drip when the meat is thawed. At fast rates of freezing, the number of ice crystals increase and the size of each crystals increase and the size of each crystal remains small to give a minimum fluid loss when the meat is thawed. Frozen meats undergo slow deteriorative changes during frozen storage due principally to the oxidation of fats, affecting the flavour particularly in those meats that contain a high proportion of unsaturated fats. Oxidation may be retarded by the use of oxygen impermeable films and low temperature storage.

Self –Assessment Exercise 3

1. Explain the term Cold storage
2. State the temperatures for Chilling and Freezing

4.6 Summary

5 Nitrites are indispensable for meat curing, and no substitute has yet been found. Sodium nitrite ($NaNO_3$) is a toxic substance and can be fatal even in small doses. The maximum amount of nitrite permitted in finished meat products is usually 200 ppm (parts per million, or mg per kg), or may be less subject to the type of meat product or country legislation. Cured-meat flavour development is based on various reactions between nitrite and the meat component. Spices act on the salivary and gastric glands to promote secretion, stimulating appetite and improving digestibility of meat

products. There are other alternative means of meat preservation which include: Use of chemical additives, Natural Smoke, heat treatment and drying.

6. Natural smoke is a very complex mixture, consisting of a great number of compounds, and is obtained by controlled combustion of moist sawdust at low temperature. Many other materials are all present in smoked products in levels ranging from parts per million to per billion.

7. During processing many meat products are subject to specific heat treatment. The first task of heat treatment is to: Reach satisfactory shelf-life by reduction of micro-organisms. The second task is to obtain desirable organoleptic characteristics, to preserve nutritive value and improve digestibility of the product. There is a direct relationship between bacteria survival and time of exposure to temperatures. Where a storage life in excess of about 5 days is required, as is the case for meat intended for export to other cities or countries, then the temperatures of $1^{o}C$ to $3.5^{o}C$ are no longer adequate and use must be made of lower temperature together with the use of other available methods of reducing the rate of onset of microbial spoilage. By definition, the freezing and frozen storage of meat is carried out at temperatures where micro-organism will not grow, and at temperatures where the meat is hard enough to safely withstand bulk storage. In practice, this implies the use of temperature below -15 ^{0}C

4.7. Glossary: ***ppm*** = parts per million, or mg per kg

Psychrophilic organisms = Organisms that can grow at very low temperature

4.8. References /Further Readings

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4.9 Possible answers to Self-assessment Exercises

Exercise 1

No.1. Sodium nitrite is poisonous salt, so it is often mixed with common salt at a concentration of about **0.6 percent** (so-called "nitrite salt") when used for curing meat

No. 2. **Typical amount of nitrite and nitrate in cured products**

Nitrite salt (99.4 % NaCl + 0.6 % $NaNO_2$. This can be added in all-meat products, 100 ppm as nitrite dry hams, 150 ppm as nitrite. Saltpeter (KNO_3), this can be added in dry sausages, 100 Ppm as nitrate low-sodium products, 100 ppm as nitrate. Nitrite + saltpeter. This can be added in dry hams, 600 ppm as nitrate

Exercise 2

No.1. There are other alternative means of meat preservation which include:

- Use of chemical additives,
- Natural Smoke,
- heat treatment
- and drying

No.2. **Relationship between bacteria survival and time of exposure to temperatures** Microorganisms are destroyed if exposed to sufficiently high temperatures for long enough. There is a direct relationship between bacteria survival and time of exposure to temperatures. As an example, if 10 000 000 bacteria (per ml) suspended in broth are exposed to heat ($70^{O}C$), after the first five minutes 1 000 000 will survive (90 percent are destroyed), after the next five minutes the number of surviving will be 100 000 (again 90 percent are destroyed), and so forth. This tenfold reduction in bacterial numbers between fixed time intervals is called decimal reduction. The time interval for decimal reduction varies between different bacteria and depends on the temperature applied. The number of bacteria present in a meat product just before the heat treatment (initial number) should be as low as possible so that a shorter time or lower tempera ture is needed to achieve a satisfactory shelf-life for the product. As sausage fillings as well as most other meat products represent a very good medium for bacterial growth, they should immediately be exposed to heat treatment in order to prevent bacterial growth. It is also important to perform all operations as quickly as possible, and to maintain the highest hygienic standards so that the initial bacterial count remains as low as possible. The manufacturer must always bear in mind that bacteria grow very fast. Their number may be doubled every 20 minutes.

Exercise 3

No. 1 The term “cold storage” generally refers to the use of low temperatures within the range **1 to 3.5^{0}C**

No.2. Temperatures for chilling and freezing:

Chilling = **-1.5 to 0.2 ^{0}C**

Freezing = **below -15 ^{0}C**

MODULE 3

DIFFERENCES BETWEEN VARIOUS MEATS AND THEIR PREPARATIONS

UNIT 1: COMPOSITION OF VARIOUS ASPECTS OF BEEF, PORK, LAMB AND MEAT STERILIZATION

Unit structure

1.1 Introduction

Throughout the world, countries have varied natural resources and capabilities for producing livestock and different methods must be used to utilize all meat products correctly and completely whether they are cut from cattle, goats, sheep, swine, deer or other animals and whether they come from the tender or less tender parts of those animals. In order to get the maximum eating satisfaction and also the maximum nutritional value, each cut must be matched with the correct cooking procedure. Loin cuts which are generally tender should be prepared by broiling or other dry-heat methods while cuts with considerable bone and connective tissue from the shanks should be either braised or simmered for slews and soups.

Generally, meat animals should be maintained in an environment that permits optimum growth and development. Animals gaining weight rapidly are usually in good condition and the meat derived from their carcasses will be fatter, juicier and richer in flavour. Additionally, the amount of meat in proportion to hid, bone and offal will be greater. The age to slaughter animal varies depending on many things. The highest quality beef comes from animals that are under 36 months of age. Old cows produce highly acceptable beef if properly fattened and processed.

Depending on the calf and the feeding regime, calves are best slaughtered between three and 16 weeks of age. Hogs may be killed any time after they reach six weeks of age, but tor the most profitable pork production may need to be fed for five to ten months. Sheep and goats may be killed any time after six weeks, but the more desirable age is from six to 12 months. All meat animal carcasses are composed of muscle, fat, bone and connective tissue. The chief edible and nutritive portion is the muscle or lean meat. The muscle is seldom consumed without some of the attached fat and connective tissue. The carcass composition of animals slaughtered after usual fattening periods is shown in Table 3. It can be noted that the carcass composition varies little between species and is somewhat dependent on the fatness of the animal at slaughter.

1.2. Learning outcomes

At the end of the unit, the students should understand the various compositional aspects of beef, pork and lamb. Students will also understand the colour variations of different meats, occurrence of rancidity in meat and meaning of Aseptic packaging of meat and Ohmic heating of meat

1.3 **Comparative differences in various compositional aspects of beef, pork and lamb**

1**.3.1 Differences in age, weight fat and bone of beef, pork and lamb used as meat**

Different animals vary in their compositions as shown in Table 1

Table 1: Comparative differences in various compositional aspects of beef, pork and lamb

	Beef	**Pork**	**Lamb**
Average live animal weight kg)	454-544	95-104	45
Age (months)	36	6	8-12
Dressing percentage	60	70	50
Carcass weight (Kg)	272-318	68-73	23
Carcass composition (%)			
Lean	52	50	55
Fat	32	32	28

Bone	16	18	17

The lean of each animal carcass consists of about 300 individual and different muscles of which only about 25 can be separated out and utilized as single muscle or muscle combinations. The separated muscles are not all the same. They vary widely in palatability (tenderness juiciness, flavour) depending on the maturity or age of the animal and the body location from which they were taken. Generally, muscles of locomotion found in the extremities or legs are less tender and more flavourful than muscles that simply support the animal such as those found along the back. The latter are usually tenderer and less flavourful. Other factors may influence palatability but maturity and body location are probably the most important. Colours of the lean and fat are important characteristics of a normal, wholesome, product

1.3.2. Colour of the muscle tissues from different animals

Most diseased or unnatural conditions will change the colour from what is considered normal for the species. Generally the colour of the fat will be from pure white to a creamy yellow for all animals. Pink or reddish fat probably means that the animal had a fever or was extremely excited prior to slaughter. The colour of the muscle tissues for normal product should be as shown in Table 2:

Table 2. Colour of the muscle tissues from different animals

Meat	Colour
Beef	Bright cherry red
Goat meat	Light pink to red
Lamb	Light pink to red
Pork	Greyish pink
Veal	Light pink to red

Venison	Dark red

Almost always tissues from older animals are darker in colour. At times the fat on some carcasses from young animals will be dark yellow because of the breed of the breed which lacks the ability to convert yellow carotene to colourless vitamin A and/or because the animals have consumed large amounts of green forage. It is not uncommon for aged ruminant animals to have carcasses with yellow fat. At times animals will suffer from stress prior to slaughter and signs of their reaction will be evident in the carcass. Stressed cattle often produce dark cutters in which the muscle is not the normal bright cherry red but rather is dark red and sticky. Hogs suffering from porcine stress syndrome (PSs) prior to slaughter may yield carcasses that are pale, soft and exudative (PSE) or dark, firm and dry (DFD). Exudative carcasses are watery and rapidly lose water. None of these conditions produced by ante-mortem stress renders the product inedible but both lower the palatability and eye appeal of the beef and pork and can be confused with other more serious disease conditions.

Self-assessment Exercise 1

1. All meat animal carcasses are composed of all except: A. muscle, B. fat, C. bone, D. fibre
2. The colour of beef is …………

1.4 Meaning and occurrence of rancidity

1.4.1 Meaning of rancidity in meat

Rancidity in meat products may result from the oxidation of lipid components or microbiological deterioration of the sample product. A variety of chemical compounds such as peroxides, aldehydes and free fatty acids are created as oil oxidizes.

1.4.2 Methods of measuring rancidity in meat

Rancidity is measured chiefly in the following ways:

- Thiobarbituric acid (TBA) value is widely applied in meat products. The amount of malonaldehyde is determined in a photometric way as rancidity starts at 0.4 – 0.6 mg of malonaldehyde per kilogram of the sample. Within this test, saturated aldehydes obtained during the termination phase of fat oxidation react with 2-thiobarbituric acid. TBA values generally correlate with the state of rancidity and increased values indicate an advanced state of rancidity
- Active Oxygen Method (AOM) is a measure of the ability of fat to resist oxidative rancidity during storage. Oil or fat is subjected to conditions known to accelerate degradation to help gauge the sample’s resistance to oxidation. Oxygen is bubbled into fat to cause oxidation of the fatty acids. The peroxide value test is used to monitor oxidation after the sample is stressed under controlled conditions for a long time or until a specific peroxide value is achieved.
- Analysis of the FFA content is based on measuring hydrolytic rancidity in fat or oil. This type of analysis is performed on fat only as hydrolytic rancidity originates from the hydrolysis of triglycerides in the presence of moisture. Enzymes such as lipase generally speed up this process and the hydrolysis results in FFA. The FFA values generally increase during storage of fat and fatty meats. FFA values in meat and meat products above 1.2 indicate rancidity
- Peroxide Value (PV) is the measure of the present state of rancidity of a sample. Fresh non-rancid fats have a low PV – usually less than 5. The PV of unstablised fat can change quickly. For this test, peroxides are indirectly measured under standardized conditions. The result is called the Peroxide Value, expressed as milliequivalents of peroxide per kilogram of fat. PVs from 0 to 6 are generally

seen when fat is not rancid whilst PVs from 7 to 10 are seen when fat is slightly rancid. PVs greater than 10 clearly indicate rancidity

Self-Assessment Exercise 2

1. List five methods used to determine rancidity in meat…
2. Explain the term rancidity...

3.5 Modern methods of sterilizing meat

3.5.1 Aseptic packaging

It is a **p**ackaging technique in which an aseptic product is placed into an aseptic container in an aseptic environment. The sealed container is designed to maintain aseptic conditions until the seal is broken. This practice enhances the shelf life of foods, e.g. **minced meat**. It has advantages over conventional **sterilization** technique which include high product quality, optimization of sterilization, minimum energy consumption and low production costs. Aseptic packaging is not suitable for use with products containing large particles, and shelf life stability is shorter than that of sterilized foods

3.5.2 Ohmic heating of meat

This is the thermal processing of foods using energy produced in the form of heat when a current passes through an electrical resistance. In this form of electric resistance heating, the food itself acts as a conductor between a ground and a charged electrode. The food may be immersed in a conducting liquid. Heating is accomplished according to Ohm's law, where conductivity of the food determines the current that will pass between the ground and electrode. Ohmic heating can be used as a cooking technique, and also for pasteurization and sterilization

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Self-assessment exercise 3

1. State the advantages of Aseptic packaging over conventional **sterilization** technique
2. Explain in one sentence the term Ohmic heating of food

1.6 Summary

- Some other factors may influence palatability but maturity and body location are probably the most important. Generally the colour of the fat will be from pure white to a creamy yellow for all animals. Pink or reddish fat probably means that the animal had a fever or was extremely excited prior to slaughter. Stressed cattle often produce dark cutters in which the muscle is not the normal bright cherry red but rather is dark red and sticky. There are four methods used to determine rancidity in meat: Thiobarbituric acid (TBA) value, Active Oxygen Method (AOM), Free fatty Acid (FFA) and Peroxide Value (PV). Aseptic packaging is not suitable for use with products containing large particles, and shelf life stability is shorter than that of sterilized foods. Ohmic heating is in the form of electric resistance heating where the food itself acts as a conductor between a ground and electrode which is charged. PVs from 0 to 6 are generally seen when fat is not rancid whilst PVs from 7 to 10 are seen when fat is slightly rancid. PVs greater than 10 clearly indicate rancidity.

1.7 Glossary: ***Aseptic packaging* =** It is a **p**ackaging technique in which an aseptic product is placed into an aseptic container in an aseptic environment.

1.8 References/Further Readings

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1.9 Answers to Self-Assessment Exercises

EXERCISE 1

No.1. All meat animal carcasses are composed of all except **Fibre**

No.2. Bright cherry red

EXERCISE 2

Answers to Self-Assessment Exercise 2

1. The five methods of determining rancidity in meat include: Thiobarbituric acid (TBA) value, Active Oxygen Method (AOM), Free fatty Acid (FFA) and Peroxide Value (PV)

2. Rancidity: Rancidity in meat products may result from the oxidation of lipid components or microbiological deterioration of the sample product

EXERCISE 3

Ohmic heating can be used as a cooking technique, and also for *pasteurizatio*n and *sterilization*

UNIT 2: MEAT PREPARATION

Unit structure

2.1 Introduction

Specific equipment are employed during the meat cutting operation. The pattern of cutting animal carcass depends on the animals being processed since the composition of animals differ

2.2 Learning outcomes

At the end of the lecture, the students will be able to list specific equipment in cutting meat, demonstrate how the meat can be cut using these equipment

2.3.1. Meat-cutting Equipment

The specifications for meat cutting equipment should be strictly adhered to in order to avoid problems in meat processing. The equipment are as follows:

- Solid cutting table, preferably made of non-corrosive material (stainless steel, aluminum or galvanised material) with hard plastic top. If wood has to be used instead of plastic only tight wooden tops/cutters should be used.
- Oil or water sharpening stone
- Sharpening steel
- Knives
- Boning 20 cm straight
- Steak 30 cm curved
- Meat saw hand or electric
- Totes, bins and meat trucks (plastic or other non-corrosive material)
- Wrapping table

  Paper or plastic foil/ bags for meat wrapping
- Tool holder
- Metal mask/safety gloves
- Boning aprons/safety aprons

- Hand wash-basin
- Knife sterilizer

2.3.2. Cutting of different meats

The pattern of cutting animal carcass depends on the animals being processed since the composition of animals differ

2.3.2.1. Beef Cutting

Four essential points when cutting beef or any other meat animal carcass are:

- Cut across the grain of meat when possible.
- Use sharp knives and saws for speed and good workmanship.
- Keep the cutting table orderly and have a place for everything
- Be clean and sanitary in all operations.

There are different ways to cut the fore- and hindquarters of beef depending on its use, the wishes of the consumers, and the quality of the carcass.

Poor quality meat is normally used for further processing, while higher-quality and thicker-fleshed carcasses are used as fresh meat in the form of steaks and roasts.

Halving

Halving is done immediately after the animal been dressed and every effort should be made to divide the carcass into equal sides through the center of the backbone.

Quartering

Quartering or ribbing down is the division of a side of between the twelfth and thirteenth ribs into fore- and hindquarters. One rib 1s usually left on the hindquarter to hold the shape of the loin and to make it easier to cut steaks. Dividing between the twelfth and thirteenth ribs splits the carcass almost in quarters, usually with slightly heavier forequarters. Make this cut straight and neat. Locate the exact place between the ribs on the inside of the carcass and make the cut about 5 cm from the midline at the flank.

The flank part should be left attached until the quarter is ready to be carried to the cutting table. Then saw the backbone, making the cut even with the knife to produce smooth and attractive appearances to the small end of the loin, Make this cut from the inside. The large muscle exposed when this cut is made is the "eye of beef" in which most of the quality characteristics of the meat can be seen including colour, marbling, firmness and texture. High-quality beef will have a bright cherry-red colour, some intramuscular fat or marbling, be firm to the touch and line in texture.

When the person carrying the meat has a firm grip on the forequarter, the small strip of flesh holding the quarters together should be cut. With some practice and experience, one can learn to carry a forequarter easily by holding below the shank so that the full weight of the quarter is on the carrier s shoulder when it is cut down. By taking a step forward as the cut is being made, it is easier to have the quarter drop with the right proportion of weight on the shoulder. The right forequarter should be carried on the left shoulder and the left forequarter on the right shoulder. When placing the forequarter on the cutting table, always have the inside up.

Bone-in method

By far the easiest way to merchandise meat is to have some basic information relative to the bone and muscle structure of the carcass and to utilize an electric saw to cut up the whole carcass. This is now being done to a large extent by meat packers who cut out what is commonly referred to as a wholesale or primal cut such as a whole chuck (shoulder), rib, loin or round of beef. The cut may or may not be trimmed of some bone and fat and then vacuum-packaged and shipped to a retail store.

The vacuum-packaging provides an anaerobic atmosphere and the refrigerated shelf-life of the product may be extended as much as two or three months. The store personnel need have only the slightest knowledge of meat cutting. The primal is positioned correctly and run across the saw in a prescribed fashion, the saw dust is scraped off, and the consumer-sized cut packaged for retail sale. Common wholesale or primal cuts of beef from the forequarter are the square-cut chuck, shank, brisket, plate and rib, and from the hindquarter the flank, loin and round. The kidney knob consisting of kidney and fat is removed from the loin. Since the hindquarter contains a higher proportion of tender cuts, it is usually in greater demand and returns higher prices.

Forequarter: The first cut to make is between the fifth and sixth ribs counting from the neck back. This cut is made parallel with the ribs and produces a cross-cut chuck consisting ot a square-cut chuck (also called chuck and blade), foreshank and brisket. Next the foreshank and brisket are removed by cutting through the first sternal cartilage (the first soft segment of the breastbone), and making the cut almost parallel with the backbone of the carcass.

Foreshank: The foreshank is separated from the brisket by following the natural connective tissue seam between the muscles with a knife. The foreshank can then be sawn into small pieces to be used for soup stock or the lean may be removed and used for ground meat.

Brisket: The brisket, boned and made into a roll, can be used either as a pot roast or can be cured (corned).

Square-cut chuck: This wholesale cut contains the first five ribs of the forequarter and may be sawn into steaks or roasts. Several cuts are usually made across the bottom or shank end of the chuck resulting in arm steaks or roasts. The chuck is then turned and cuts are made parallel with the ribs, resulting in blade steaks and roasts. If the carcass is of high quality and thickly fleshed, steaks cut from the rib end of the chuck or across the arm bone will be highly desirable. Blade cuts to be used as roasts should contain two or three ribs and should be trimmed as for standing rib roasts, although for convenience in carving all bones may be removed. The portions nearest the neck usually have more connective tissue and are recommended for Simmering rather than for steaks and roasts.

Only the neck remains to be processed. It is usually severed at a point where it enlarges to meet the shoulder. The neck contains a large amount of bone and connective tissue and is generally used for simmering corning or grinding. All bloody portions should be trimmed off before other cutting is done.

Short plate: The cut to divide the short plate from the rib is made 18-25 cm from the inside edge of and parallel with the chine or backbone. This division varies according to the thickness of the carcass. With a thick carcass, the cut may be made further down the ribs, and with a thin carcass nearer the spinal column. The plate may be used for different purposes, but it is commonly used for stews or further processing. Short ribs, which are suited for broiling, are also cut from the upper portion of the plate, usually about 5-8 cm in length.

If the plate is to be used for corning, all of the ribs should be removed. If used for stews, the ribs can be left in and the plate sawn crosswise into small pieces. The plate can also be boned and the meat used for ground meat or sausage products. Before cutting the plate in any way, remove the tough membrane lining the inner portion below where the ribs join the breastbone.

Rib: The rib cut is made up of the rear seven ribs in the forequarter. This is the most valuable piece of meat from the forequarter because it is the tenderest and has the least amount of bone. It has a large bundle of muscle fibre that runs parallel to the backbone. There are several different ways to prepare the rib cut for cooking as a roast. It may also be used for steaks. It may be prepared as a bone-in, folded or rolled roast. If prepared as a bone-in roast, the superior spinous processes of the vertebrae or featherbones are loosened from the meat and then cut off with a saw.

In making this cut, keep the knife as close to the bone as possible to avoid removing the thin lining that surrounds the bundle of muscle fibre next to the bone. With the saw, cut across the ribs at intervals of about 8cm, Just deep enough to cut through the ribs. Also remove the yellow connective tissue or ligament found between the outer covering and the layer of muscle. The only difference between bone-in and a folded rib roast is that a small 5-cm piece of rib is removed so that the thin end of the cut may be folded and skewered to the heavy portion. This simply makes a neater, more compact package.

Hindquarter: Place the hindquarter on the cutting table with the inside of the carcass up because the first cut made is to remove the kidney knob from the inside of the loin.

Kidney knob: Begin removing the kidney fat at the lower end and loosen it with a knife where it is attached to the loin, leaving a thin covering on the inside of the loin and being careful not to cut into the tender loin muscle.

Flank: Remove the flank next by cutting into the scrotum or udder, following the round muscle and cutting close enough so little of the lean meat is taken from in front of the stifle joint. Continue cutting along and below the outer portion of the line of the kidney fat, or in a straight line to leave 10 cm of the thirteenth rib in the flank. This cut may vary with the thickness of the carcass and is lowest in thick or heavy carcasses.

The tough membrane covering the inside of the flank must be removed by cutting off a thin strip on the lower side and then peeling off the membrane. A small piece of lean meat on the inside of the end portion of the flank, weighing 1.2-1.4 kg., is known as the flank steak. This heavy bundle of muscle fibres is dry and if used for steak is often scored on both sides, marinated or sliced thin to make it more tender and desirable as a steak. The entire defatted flank may be used for stew or ground beet or rolled around stuffing and pot-roasted.

Round: The round and loin are divided at about the fourth sacral joint in the spinal column to almost parallel with the back end of the round, or to about 5 cm in front of the stifle joint. The aim is to cut the tip of the ball-and socket bone in the hip joint, cutting off a piece about 2.5cm in diameter. The round includes the rump, round cushion (consisting of knuckle piece and inside round muscle or topside), outside round muscle (also called bottom round muscle or silverside) and hind shank.

Remove the rump by cutting just below the exposed pelvic or aitchbone. The rump usually has a large amount of bone. The most desirable piece of rump is cut from the upper portion and is composed of eye and bottom round muscles. The removal of bone and tying the rump means that it requires less oven space and is easier to carve. Round steak is cut in comparatively thin slices from the full round after removal of the rump. The choicest round steaks are cut from the centre section.

The remaining portion is made up of the hind shank and the piece called the heel of the round. The heel of round is used as a pot roast and is removed by cutting close to the bone and tearing away as much meat as possible from the backside. The shank can be sawn into pieces to be used for soup stock.

Loin: The loin is usually completely sawn into steaks beginning at the large end. Sirloin steaks are cut first and the first three or four are known as wedge or round bone sirloin steaks. These are the least desirable pieces of the sirloin. The last sirloin is cut where the hip-bone is separated from the spinal column and the steak cut there is known as the hip-or pin-bone sirloin steak.

The small portion of the loin known as the short loin is the source of T-bone steaks. This area contains the two most tender muscles in the whole carcass, namely, the loin eye muscle above the bone and the tenderloin muscle below the bone. T-bone steaks are cut to about 10 cm from the end of the short loin. This tip portion can either be used as a roast or be cut into rib steaks. Rib steak from ne short loin is identified by the piece of the thirteenth rib remaining on it.

When beef is to be cured and dried, piece should be taken from either the chuck or the round. If the round is used, remove the rump and follow the procedure for muscle boning. If taken from the chuck, use the heavy commonly known as shoulder clod

Muscle-boning method

One excellent approach to the cutting up of meat animal carcasses which is becoming more popular and utilized by large meat processors is the procedure commonly referred to as "muscle-boning". While this procedure is particularly adaptable to large carcasses such as beef, it can be successfully used on carcasses or cuts of any size. Muscle-boning is also popular among hunters who do not have meat saws but who want to cut up a whole carcass with a knife while removing the Done that would otherwise fill valuable freezer space. Any animal carcass with a complete and thick layer of subcutaneous or cover fat would have to have most of the fat removed in order to expose the muscles.

Once the fat is removed, a boning knife can be used to separate each large individual muscle or group of muscles. This is done along the seams of connective tissue that encases each muscle. Once separated the muscle mass is then cut from the bone, thus the term "muscle-boning". The advantages of this procedure are numerous; however, the principal reasons for using it are to obtain small-sized portions for sale or preparation; to permit each muscle or muscle combination to be treated or prepared according to its individual characteristics of size, tenderness, flavour or fibre orientation; and to remove much of the bone and fat that would otherwise take up packaging and storage space.

Directions for muscle-boning a side of beet are give here. Initially for muscle-boning, the side of beer is divided into fore-and hindquarters as described for the bone-in method. Also, both the fore-and hindquarters are placed on the cutting table with the inside up. One muscle-boning method is as follows:

Forequarter: The forequarter is sawn into square-cut chuck, foreshank, brisket, rib and plate as in the bone-in method.

Foreshank: The foreshank has attached to it, behind the elbow joint, a relatively large, thick piece of muscle. This is usually cut out by following the connective tissue seams and produces a fairly large triangular-shaped cut correctly identified as boneless arm roast. The remainder of the foreshank can be sawn into soup bones or can be separated into bone and soft tissue with a knife. The soft tissue is composed of muscle, fat and a large amount of connective tissue which is best utilised as ground meat.

Brisket: The ribs and sternum are lifted from the inside of the brisket and the excess tat is removed. The brisket can either be rolled or tied to be used as a pot roast or it can be cured.

Square-cut chuck: The neck is sawn from the chuck and trimmed of bone, fat and the large prescapular lymph gland. The boneless neck can be utilized as a pot roast; however, it is more often cut into cubes tor stew or ground meat.

From the large remaining portion of the chuck, the ribs and feather bones (superior spinous processes) are removed with a knife and the heavy, yellow connective tissue or elastin is removed from the top of the cut. With a knife the thick portion is then separated into outside and inside portions by following the inside or smooth side of the blade-bone which is then lifted from the outside piece along with what remains of the arm bone. The inside portion which contains some of the rib eye muscle is often rolled and tied to be used as a pot roast. There is a part of the outside chuck, a muscle that somewhat resembles the tenderloin muscle in size and shape but not in tenderness, which is often cut into steaks known as chuck fillets.

Rib: The rib is prepared by first sawing across the rib bones to facilitate the removal of both the backbone and the ribs with the knife. Another procedure often used to bone out a rib is carefully with a sharp knife to loosen the small strip of meat found between the ribs. The ribs are then loosened by cutting close to the bone and removed by striking with a blunt instrument. After removed all bones and the heavy yellow connective tissue, the meat may be rolled into a tight bundle with the thin portion on the outside and tied tightly. Preparing ribs in this way makes for convenient carving and requires less cooking and storage space. About 25 percent of the initial rib weight is lost when the bones are removed. The boneless rib may also be sliced into boneless rib steaks.

Plate: After the heavy connective tissue lining is peeled from the inside of the plate, the bones are removed and the lean meat cubed for stew or prepared for grinding in a way similar to the trimming of the brisket.

Hindquarter: As a first step, the kidney and accompanying fat are removed from the hindquarter carefully with a knife so as not to cut into the tenderloin muscle. The hindquarter is then separated into flank round and loin as described in the bone-in method.

Flank: Remove the flank by cutting into the scrotum or udder, following the round muscle and cutting close enough so that little lean meat is taken from the front of the stifle joint. Continue cutting along and below the outer portion of the line of the kidney fat in a straight line and saw through the thirteenth rib. Again the flank steak is removed as described in the bone-in method.

Round: The round and loin are separated with a saw as described in the bone-in method. The pelvic bone is removed from the round and the muscle sections of the round are exposed.

Muscle-boning the round means that the large muscle masses of the round are separated from each other by following the natural connective tissue seams. In front of the stifle joint, the tip or Knuckle piece is removed, then the topside or inside round muscle, and then the remaining silverside or bottom round muscles. The latter is often divided and the eye of the round removed separately. All of the separated muscles may then be used as roasts or sliced 1nto steaks. Muscle-boning is particularly useful when beef is prepared for roasting for large groups such as pit barbecuing.

Hind shank: The hind shank, somewhat like the fore shank, has a large muscle group attached to it that can be removed and utilized as a pot roast. This cut is sometimes referred to as the "duck" of beef.

Loin: The tenderloin muscle is carefully cut from the inside of the loin and usually cut into individual steaks. The remainder of the loin is then sawn just in front of the hip-bone into the short loin and sirloin sections. The bone is removed from the sirloin which is a somewhat complicated procedure because the pelvic bone is fused with the backbone. The short loin is boned and the muscle that is known as boneless top loin is usually cut into boneless top loin steaks.

On-the-rail Boning

This is a modification of the muscle-boning method. Typical for on-the-rail boning is the hanging position of the hindquarter or the entire beef side during boning procedure. The removal of the different meat cuts from the hanging carcass is considerably facilitated. Beef cuts can easily be pulled downwards under their own weight after them free along their natural connective tissue seams. Special hooks with handles used by the operators are an additional aid for the correct fixation of the cuts during boning.

On-the-rail boning 1s the most hygienic way of meat cutting contamination by hands of operators tools, cutting-boards, etc. is less than with other method. The technique is also suitable tor smaller operations. Final trimming of the meat cuts takes place on cutting tables as usual. When meat cuts are produced by muscle-boning it is often difficult to identify them, primarily because traditionally the size and shape of the accompanying bone has been used as the major means of identification.

Also, the traditional shape of muscle in a cut of meat is often determined because of its attachment to bone. Many conventional cuts of meat combine muscles because of their association, size and proximity to bone or general location. The basic principle of merchandising meat is to separate the tender from the less tender and to sell each according to its palatability characteristics and its possible method of preparation. Muscle-boning facilitates this type of merchandising.

Self-Assessment Exercise 1

1. List the meat cutting equipment
2. Explain the term Quartering or ribbing down

2.4 Cutting the carcass of pork and lamb

2.4.1. Pork Cutting

Halving is done immediately after the animal has been dressed and every effort should be made to saw the carcass into equal sides through the centre of the backbone. The side to be cut should be laid on the cutting table with the inside up. The primal cuts of pork are ham, fore-end or forequarter, loin and belly.

Hind foot: The hind foot is removed by sawing through the hock joint at a right angle to the long axis of the leg.

Ham**:** The ham may be removed in several ways to make either long-cut or short-cut hams. One procedure (short-cut) is to locate the division between the second and third (or the third and fourth) sacral vertebrae and saw perpendicularly to the long axis of the ham. After the bone has been severed with the saw, the knife is used to complete the removal of the ham. The ham is further trimmed by removal of the tail bone on one side and the flunk on the other side. Commonly a skinned ham is produced by removal of three-fourths of the skin and fat from the rump end. For the production of special cured dried hams the skin is left on.

In order to obtain a long-cut ham the division is made between the last two (fifth and sixth) lumbar vertebrae. The long cut is composed of a rump or chump portion and a leg portion comprising centre section and shank portion. Nowadays more processors are removing the bones thus fabricating a boneless rump (chump) and a boneless ham. The ham is commonly merchandised in smaller portions (topside, silverside, thick flank, shank) and the internal fat deposits before further preparation of the thick flank, e.g. for diced pork or steaks.

Forefoot: The forefoot is removed by sawing through the junction between the foreshank and the forefoot bone at a right angle to the length of the foot. This toot contains some muscle and is therefore more desirable than the hind foot for food.

Fore-end**:** Considerable variation exists as to where the fore-end is removed. Generally one to three ribs are left on the pork fore-end. Locate the division between the third and fourth ribs from the head end and saw perpendicularly to the length of the backbone. The fore-end is trimmed of the hock which is cut off about halfway up the leg and about two-thirds of the skin and fat is removed from the butt or top end. Additionally the neckbone (all cervical and three thoracic vertebrae) and the jowl or cheek meat are removed.

The jowl is removed by a straight cut parallel to the cut that separates the fore-end from the side just behind the site where the ear was removed. The fore-end may be divided into two cuts (spare-rib, also called blade Boston, and hand, also called arm picnic) by sawing just below the exposed lower end of the blade-bone parallel to the top of the shoulder. The spare-rib can be sliced into steaks or used as a roast. It can easily be made into a boneless cut by removing the corner of the blade-bone.

Besides this method some other ways of cutting and boning the pork fore end exist. In order to obtain boneless cuts (shoulder and neck-end) from the fore-end the following technique is recommended. Seam the shoulder carefully from the rest of the side, leaving the rind and associated fat behind. Release the under-blade steak and remove the blade-bone (scapula) and the shoulder-bone (humerus). Separate the main muscle block from the smaller group. The smaller group, after trimming the fat off, can be used for dicing.

The main shoulder block should be trimmed of excessive connective tissue. It can be separated further into the blade and feather muscles and the main shoulder muscle. These can then be sliced into a number of boneless steaks. The group of muscles on either side of the spinous processes of the neck bone and the two or three following segments of the backbone is called the neck-end. The neck-end is loosened from the backbone and after trimming of excessive rind, fat and any adhering ragged edges it can be cut into attractive steaks.

Lion**:** The middle or centre section of the pork side is divided into loin and belly by a straight cut from the edge of the tenderloin muscle on the ham end through a point on the front rib tight against the protruding edge of the split backbone. The fat back (skin and excess fat) is removed from the loin so that a complete fat cover about 0.5 cm thick remains. Starting along the backbone side at the shoulder end, cut and lift the fat over the curve of the loin muscles without cutting into the lean. The loin can be roasted whole, cut into smaller roasts or cut into chops. Shoulder, rib, loin and sirloin chops are made from the loin. Chops for broiling or frying should be cut 1.3-1.9 cm thick. Thicker chops may be made and a pocket cut into them for stuffing.

Belly: Separate the spare-ribs from the belly by cutting closely underneath the ribs beginning at the flank end. Prepare the bacon side from the belly by removing any thin or ragged pieces of lean. Turn the belly over and remove the lower edge with a straight cut just inside of the teat line. Trim the flank edge of the belly to square the whole piece to prepare it for curing.

2.4.2. Lamb Cutting

This procedure as described may also be followed for the processing of deer, goats, sheep or other animal carcasses of similar size. **Cooling**: All lamb carcasses should be promptly chilled and kept at a low temperature (-2^0 to 2^0C) until cut and utilized. Do not permit lamb carcasses to freeze within a day after slaughter or the meat may toughen. Lamb carcasses can be cut into retail cuts after they have been chilled for 24 to 48 hours. **Carcass:** Lamb carcasses are generally not split into halves after dressing because they are not thick enough in any location to create cooling problems. Begin cutting the lamb carcass by removing the thin cuts, i.e, flank, breast and foreleg. Lay the carcass on the cutting table and mark one side from the cod, or udder fat in front of the hind leg to the elbow joint. After removing the thin cuts from both sides, remove the kidneys, kidney fat and diaphragm. Next the carcass is turned over and the neck removed either in thin slices to be braised or in one piece to be added to stew or to be boned and ground.

The trimmed carcass can then be separated into four primal cuts, each with different characteristics. A cut between the fifth and sixth rib removes the shoulder. Another cut between the twelfth and thirteenth (last) rib separates the rib from the loin. The loin and legs are separated just in front of the hip bones by cutting through the back where the curve of the leg muscles blends into the loin.

Legs: Split the legs through the centre of the backbone. Trim off the flank and cod or udder fat. Utilise the saw and knife to remove the backbone from the leg. The leg may be further trimmed by cutting through the knee-joint which is located about halfway between where the muscles of the shank end and the muscles of the lower leg begin. Work the knife and cut through the joint. Several sirloin chops may be cut from the loin end of the leg. Legs may either be prepared with the bone in or the bones completely removed and the leg rolled and tied.

Loin**:** The loin is usually split through the middle of the backbone and chops are cut perpendicularly to the backbone. Lamb chops are cut about 2.5 cm thick. Double or English" chops are made from a loin that has not been split. Remove the fell or connective tissue covering before cooking chops.

Rib**:** The rib of lamb is prepared by sawing through the ribs on both sides of the backbone. The main portion of the backbone is then removed with a knife. Rib chops are easily made by cutting between the ribs. Remove the fell before cooking the chops. The breast portion may be barbecued in one piece or made into riblets by cutting between the ribs.

Shoulder: After splitting through the backbone, the shoulder may be roasted as 15, made into chops, or boned and rolled into a roast. Arm chops should be made first by cutting parallel to the surface where the foreleg and breast were removed. Blade chops are made by cutting between ribs and sawing through the blade- and backbones.

To prepare a boneless shoulder, first remove the ribs and backbone by cutting closely underneath the ribs, backbone and neck vertebrae. Next from the rear surface cut along the inside of the blade-bone to expose it and the arm bone. Cut along the edges of the bones and remove them. Roll the meat and tie it securely with clean twine. The boneless shoulder may also be made into a pocket roast and stuffed with ground lamb or other dressing. The edges of the pocket roast are stitched together.

Shanks: Both the fore- and hind shanks when removed can be barbecued, cut into pieces for stew or boned and the meat ground.

Lean trimmings: Lean trimmings of lamb in chunks are suitable for stews or to be marinated and used for special roasts. Other lean trimmings can be ground and used as one would prepare ground veal or beef.

Sheep

Sheep can carry large volumes of dirt into the slaughterhouse. It is impossible to avoid contamination of sheep and lamb carcasses when the fleece is heavily soiled. The fleece or hair must never touch the skinned surface; neither must the operator touch the skinned surface with the hand that was in contact with the fleece.

Combined horizontal/vertical method

The animal is turned on its back and cuts are made from the knuckles down the forelegs. The neck, cheeks and shoulders are skinned. The throat is opened up and the gullet (food-pipe) is tied off. The skin on the hind legs is cut from the knuckles down to the tail root. The legs are skinned and the sheep is hoisted by a gambrel inserted into the Achilles tendons. A rip is made down the midline and skinning proceeds over the flanks using special knives or the fists. The pelt is then pulled down over the backbone to the head. If the head is for human consumption it must be skinned or it will be contaminated with blood, dirt and hairs.

Moving cratch and rail system: The hanging carcass is lowered on to a horizontal conveyor made up of a series of horizontal steel plates, bowed slightly and divided into sets large enough to cradle a single animal. Two operators usually work together on each lamb performing the legging operations and opening the skin to the stage where it can be pulled off the back. When the gambrel is inserted into the hind legs it is hoisted on to a dressing rail.

Vertical method

At sticking the animal is shackled by one hind-leg and left to bleed. Dressing commences with the free leg which is skinned and the foot removed. A gambrel is inserted into this leg and hung on a runner on a dressing rail. The second leg is freed from the shackle, skinned and dressed, then hooked on to the other end of the gambrel. The skin is opened down the midline and cleared from the rump. A spreader frame (a bar U-shaped at each end) spreads the front legs to simplify work on the neck, breast and flanks.

The front toes are held in each end of the frame which is then slung up on to a separate travelling hook. The animal is therefore suspended by all four legs belly uppermost. Skinning continues as in the combined horizontal/vertical method. To clear the shoulders and flanks, the forelegs are freed from the spreader and the feet removed, the animal returning to a vertical position. The skin can now be completely pulled off, including the head if this is for consumption, though this takes some work with the knife. In both methods, after fleece removal the vent and food-pipe are cleaned and tied off.

Evisceration

With all species care must be taken in all operations not to puncture the viscera. All viscera must be identified with the carcass until the veterinary inspection has been passed. After inspection the viscera should be chilled on racks etc. for better air circulation.

Cattle

The brisket is sawn down the middle. In the combined horizontal/vertical system this is done with the animal resting on the cradle. The carcass is then raised to the half-hoist position and when hide removal is complete the abdominal cavity is cut carefully along the middle line. The carcass is then fully hoisted to hang clear of the floor so that the viscera fall out under their own weight. They are separated into thoracic viscera, paunch and intestines for inspection and cleaning. If any of the stomachs or intestines is to be saved for human consumption, ties are made at the esophagus/stomach, stomach/duodenum boundaries, the esophagus and rectum having been tied off during hide removal. This prevents cross-contamination between the paunch and the intestines.

Small Ruminants

A small cut is made in the abdominal cavity wall just above the brisket, and the fingers of the other hand are inserted to lift the body wall away from the viscera as the cut is continued to within about 5 cm of the cod fat or udder. The omentum is withdrawn, the rectum (tied off) loosened, and the viscera freed and taken out. The food-pipe (tied off) is pulled up through the diaphragm. The breastbone is split down the middle taking care not to puncture the thoracic organs which are then removed.

Loosen and tie off the rectum. Pigs are cut along the middle line through the skin and body wall from the crotch to the neck. Cut through the pelvis and remove the bladder and sexual organs. In males the foreskin must not be punctured as the contents are a serious source of contamination. All these organs are considered inedible. Remove the abdominal and thoracic viscera intact. Avoid contact with the floor or standing platform. The kidneys are usually removed after the carcass has been split down the backbone. The head is usually left on until after chilling. Pigs are suspended and are split down the backbone as for cattle, but the head is generally left intact.

Self-assessment exercise 2

1. Describe the preparation of the rib of lamb
2. Explain how to cut the belly of pork

2.5 Splitting and dressing the Carcass of cattle

2.5.1 Splitting of Cattle

The processor should work facing the back of the carcass; and splits the carcass down the backbone (chine) with a saw or cleaver from the pelvis to the neck. Sawing gives a better result but bone dust must be removed. If a cleaver is used, it may be necessary to saw through the rump and loin in older animals. The saw and cleaver should be sterilized in hot (82°C) water between carcasses. Power saws increase productivity. Sheep and lamb carcasses are generally sold entire. If necessary they can be split by saw or cleaver, but a saw will probably be necessary for older animals.

2.5.2. Carcass Dressing

The objective of carcass dressing is to remove all damaged or contaminated parts and to standardize the presentation of carcasses prior to weighing. The primary object of carcass washing is to remove visible soiling and blood stains and to improve appearance after chilling Washing is no substitute for good hygienic practices during slaughter and dressing since it is likely to spread bacteria rather than reduce total numbers. Stains of gut contents must be cut off. Wiping cloths must not be used. Carcass spraying will remove visible dirt and blood stains. Water must be clean. Soiled carcasses should be sprayed immediately after dressing before the soiling material dries, thus minimizing the time for bacterial growth. Under factory conditions bacteria will double in number every 20 or 30 minutes. In addition to removing stains from the skinned surface, particular attention should be paid to the internal surface, the sticking wound and the pelvic region.

A wet surface favours bacterial growth so only the minimum amount of water should be used and chilling should start immediately. If the cooler is well designed and operating efficiently the carcass surface will quickly dry out, inhibiting bacterial growth. Bubbling of the subcutaneous tat 1s caused by spraying with water at excessively high pressure, which may be due to the pressure in the system or a result of holding the spray nozzle too close to the carcassSpecifications will differ in detail for different authorities. Veterinary inspection of carcasses and offal can only be carried out by qualified personnel. Where signs of disease or damage are found the entire carcass and offal may be condemned and must not enter the food chain, but more often the veterinarian will require that certain parts, for instance those where abscesses are present, be removed and destroyed. Factory personnel must not remove any diseased parts until they have been seen by the inspector otherwise they may ask a general condition which should result in the whole carcass being condemned. Any instructions from the inspector to remove and destroy certain parts must be obeyed.

Self-easement exercise 3

1 Explain the splitting of pig and sheep

2. Explain the objective of carcass dressing

2.6 Summary: The specifications for meat cutting equipment should be strictly adhered to in order to avoid problems in meat processing. For cattle, they are separated into thoracic viscera, paunch and intestines for inspection and cleaning. The saw and cleaver should be sterilized in hot (82°C) water between carcasses. Power saws increase productivity. If a cleaver is used, it may be necessary to saw through the rump and loin in older animals.

2.7 Glossary

Viscera = internal organs like the intestine

2.8 References/Further Readings

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2.9 Answers to Self-Assessment Exercises

EXERCISE 1

No 1 The specifications for meat cutting equipment should be strictly adhered to in order to avoid problems in meat processing. The equipment are as follows:

- Solid cutting table, preferably made of non-corrosive material (stainless steel, aluminum or galvanised material) with hard plastic top. If wood has to be used instead of plastic only tight wooden tops/cutters should be used.

- Oil or water sharpening stone
- Sharpening steel
- Knives
- Boning 20 cm straight
- Steak 30 cm curved
- Meat saw hand or electric
- Totes, bins and meat trucks (plastic or other non-corrosive material)
- Wrapping table

  Ppaper or plastic foil/ bags for meat wrapping
- Tool holder
- Metal mask/safety gloves
- Boning aprons/safety aprons
- Hand wash-basin
- Knife sterilizer

No 2 Quartering

Quartering or ribbing down is the division of a side of between the twelfth and thirteenth ribs into fore- and hindquarters. One rib 1s usually left on the hindquarter to hold the shape of the loin and to make it easier to cut steaks. Dividing between the twelfth and thirteenth ribs splits the carcass almost in quarters, usually with slightly heavier forequarters. Make this cut straight and neat. Locate the exact place between the ribs on the inside of the carcass and make the cut about 5 cm from the midline at the flank.

EXERCISE 2

No.1 Rib: The rib of lamb is prepared by sawing through the ribs on both sides of the backbone. The main portion of the backbone is then removed with a knife. Rib chops are easily made by cutting between the ribs. Remove the fell before cooking the chops. The breast portion may be barbecued in one piece or made into riblets by cutting between the ribs.

No.2 To cut the Belly: Separate the spare-ribs from the belly by cutting closely underneath the ribs beginning at the flank end. Prepare the bacon side from the belly by removing any thin or ragged pieces of lean. Turn the belly over and remove the lower edge with a straight cut just inside of the teat line. Trim the flank edge of the belly to square the whole piece to prepare it for curing.

EXERCISE 3

No. 1: **Pigs**

These are suspended and are split down the backbone as for cattle, but the head is generally left intact.

Sheep

Sheep and lamb carcasses are generally sold entire. If necessary they can be split by saw or cleaver, but a saw will probably be necessary for older animals.

No.2. The objective of carcass dressing is to remove all damaged or contaminated parts and to standardize the presentation of carcasses prior to weighing. Specifications will differ in detail for different authorities

MODULE 4

SLAUGHTERING OF ANIMALS AND PRODUCTS DERIVED FROM THE CARCASSES

UNIT 1: SLAUGHTERING OF ANIMALS

Unit structure

1.1 Introduction

1.2. Learning outcomes

1.3 Appliances used in slaughtering and Principles of stunning

1.3.1 Slaughtering appliances

1.3.2. Types of stunning

1.4 Bleeding with and without stunning

1.4.1 Concept of Bleeding

1.4.2 Bleeding without Stunning

1.5 Procedures for removing of hair from animals

1.5.1 Scalding and De-hiring of Pigs

1.5.2 Skinning Cattle

1.6 Summary

1.7 Glossary

1.8 References/Further Readings

1.9. Answers to Self-Assessment Exercises

1.1 Introduction

Stress in its many forms, e.g. deprivation of water or food, rough handling, exhaustion due to transporting or trekking over long distances, mixing of animals reared separately resulting in fighting, is unacceptable from an animal welfare viewpoint and should also be avoided because of its deleterious effects on meat quality. The most serious consequence of stress is death which is not uncommon among pigs transported in poorly ventilated, overcrowded trucks in hot weather. From loading on the farm to the stunning pen, animals must be treated kindly, and the Lorries, lairages and equipment for livestock handling must be designed to facilitate humane treatment. Stress immediately prior to slaughter such as fighting or rough handling in the lairage cause stored glycogen (sugar) to be released into the bloodstream. After slaughter this is broken down in the muscles producing lactic acid. This high level of acidity causes a partial breakdown of the muscle structure causing the meat to be pale, soft and exudative (PSE). This condition is mostly found in pigs.

Long-term stress before slaughter such as a prolonged period of fighting during transport and/or lairage leads to exhaustion. The sugars are used up so that less is available to be broken down and less lactic acid is produced. The reduced acidity leads to an abnormal muscle condition known as dark, firm and dry (DFD) in pigs or dark cutting in beef. The condition is rarer in lamb. Such meat has a high pH (above 6.0) and spoils very quickly as the low acidity favours rapid bacterial growth.

To avoid stress, animals not reared together must not be mixed during transport and in the lairage. Load and unload using shallow stepped ramps to avoid stumbles. Trucks should be neither over- nor under loaded. Overloading causes stress and bruising due to crushing. Under loading results in animals being thrown around and falling more than necessary. Drivers should not corner at excessive speed and must accelerate and decelerate gently.

The lairage should have small pens. Corridors must curve and not bend sharply so that stock can see a way forward. Stock must not be slaughtered in sight of other stock. Plenty of clean water must be available. The lairage must be well lit and ventilated. Do not hold stock in lairage for more than a day. Only fit, healthy stock may be slaughtered for human consumption. Fasting before slaughter reduces the volume of gut contents and hence bacteria and therefore reduces the risk of contamination of the carcass during dressing.

It is usually sufficient for the animals to receive their last feed on the day before slaughter. Stock should have a rest after arrival at the slaughterhouse. However, long periods in the lairage can lead to DFD if the animals are restless and fighting or mounting. Animals should be as clean as possible at slaughter. Producers should wash their animals before leaving the farm. Trucks used for transport must be washed after each load and the lairage at the slaughterhouse should be kept clear of faecal matter and frequently washed

1.2. Learning outcomes

At the end of the lecture, the students will be able to explain the different slaughtering appliances and different ways of stunning, bleeding and scalding of carcass

1.3 Appliances used in slaughtering and Principles of stunning

1.3.1 Slaughtering appliances

Slaughtering appliances, particularly for smaller-scale operations, need not be elaborate and expensive. The amount of equipment will depend on the slaughtering procedures employed. If possible, all equipment should be made of stainless steel or plastic, be rust resistant and easily cleaned and sanitized. Equipment which does not get in contact with the meat (e.g. overhead rails, working platforms, knocking pen) is usually made of galvanized steel. Basic equipment needed for the slaughtering operation:

- stunning gun, electrical head tongs or simple stunning equipment for direct blow
- knives: sticking - 15 cm sharpened on both sides skinning 15 cm curved
- a sharpening steel
- oil or water sharpening stone
- scabbard and belt for holding knives
- meat saw hand or electric and cleaver
- block and tackle or chain hoist strong enough to hold the weight of the animal to be slaughtered
- pritch, chocks or skinning rack (dressing cradle)
- a strong beam, tripod or track 2.4 to 3.4 m from floor
- spreader gambrel or metal pipe
- several buckets
- working platforms
- scalding barrel or tank
- pot, barrel or system for boiling water
- bell scrapers
- solid scraping table or platform
- thermometer registering up to 70°C
- hog or hay hook
- torch or flame for singeing

The last seven items indicate additional equipment required when hogs are scalded and scraped rather than skinned. Useful additional equipment:

- knocking pen
- bleeding hooks (for vertical bleeding)

- blood-catching trough
- wash trough (tripe) Sanitation of hands and tools:
- hand wash-basin
- implement sterilizers

Means should be available to clean thoroughly all equipment coming into contact with carcasses or meat. Implement sterilizers are stainless-steel boxes holding hot (82 ^{0}C) water, shaped to suit particular equipment knives, cleavers, saws, etc. Knife sterilizers should be placed in positions where every operator who uses a knife has immediate access. Handles as well as blades must be sterilized. Each operator should have at least two knives etc., one to use while the other sterilizes. Failure to sterilize all knives and equipment regularly will result in carcass contamination. Bacteria will be transferred from the hide to the carcass and from carcass to carcass.

1.3.2. Types of stunning

Most countries have legislation requiring that animals are rendered unconscious (stunned) by humane methods prior to bleeding. Exceptions are made for religions which require that ritual slaughter without prior stunning is practiced, provided the slaughter method is humane. Stunning also makes sticking (throat-slitting) less hazardous for the operator. The animal must be unconscious long enough for sticking to be carried out, and for brain death to result from the lack of blood supply

Direct blow to skull using a club or poleaxe: The blow must be dealt with precision and force, so that the skull is immediately smashed, causing instantaneous unconsciousness. ln cattle the aiming point is in the middle of the forehead in line with the ears, where the skull is thinnest. Horses have thinner skulls and are therefore easier to stun by this method. In sheep and goats the brain is more easily reached from the back of the neck. Pigs have a well-developed frontal cavity so the blow should be aimed slightly above the eyes.

Slaughtering mask: A bolt held in the correct position by the mask is driven into the animal's brain by a hammer blow. The device is usually fitted with a spring which returns the bolt to its original position.

Free bullet fired from a pistol into the skull is effective but unsafe: This method has been used on horses and cattle. Captive-bolt pistols fitted with a blank cartridge are effective on cattle and sheep but not pigs whose skulls are thicker. After firing, the bolt returns to its original position in the pistol. The bolt may or may not be designed to penetrate the skull. With penetrating types the brain becomes contaminated with hair, dirt and bone fragment. If brains are to be saved as edible tissue then the non-penetrating type with a mushroom-shaped head should be used.

Electrical stunning: An electric current of high frequency but, in the case of manually operated equipment, of relatively low voltage (60-80 V) is passed through the brain of an animal tor a few seconds to produced unconsciousness. If applied correctly a deep state of unconsciousness is invariably achieved. Strict safety rules must be observed. Head tongs are suitable for pigs and sheep but not for cattle. The electrodes carried on the ends of the tongs must be accurately placed. Places where the skull is thick must be avoided. Electrical contact is impeded by hair and caked mud. Water or brine will improve contact but the head must not be completely wet otherwise the current will have a short-circuit path avoiding the brain. The electrodes must be applied with strong pressure.

Carbon dioxide stunning: Carbon dioxide stunning is used only in large pig abattoirs. Pigs are induced into a chamber and exposed to a concentration of 85 percent CO_2 for about 45 seconds. Although effective for anaesthetizing sheep, it is impractical because of large amounts of CO_2 collecting in the wool and affecting operators on the killing line.

Self-assessment exercise1

1. Which of these is not in the list of basic slaughtering equipment:
A. sharpening steel
B. oil or water sharpening stone
C. scabbard and belt for holding knives
D. stone mill
2. Where is **Carbon dioxide stunning used**

1.4 Bleeding with and without stunning

1.4.1 Concept of Bleeding

Bleeding usually comes after stunning. The objectives of bleeding are to kill the animal with minimal damage to the carcass and to remove quickly as much blood as possible as blood is deal medium for the growth of bacteria.

Sticking, severing the major arteries of the neck should immediately follow stunning. Care must be taken not to puncture the chest cavity or it will fill with blood.

Cattle: Insert the sticking knife carefully just above the breastbone at 45^0 pointed toward the head. Ensure that the carotid arteries and jugular veins are severed in one movement.

Sheep: Draw the knife across the jugular furrow close to the head severing both carotid arteries. Alternatively, the knife may be inserted through the side of the neck, though this requires more skill.

Pigs: As for cattle but do not 8O m too far or a pocket of blood will collect at the shoulder. To reduce contamination by the Scalding tank water the cut should be as small as possible.

Bleeding on a Rail

The most hygienic system of bleeding and dressing is to shackle the animal immediately after stunning, then hoist it on to a moving rail. The animal is stuck while being hoisted to minimize the delay after stunning. Bleeding continues until the blood flow is negligible when carcass dressing should begin without further delay. Blood for human use must be collected with special equipment to avoid contamination from the wound, the gullet of the knife.

A hollow knife directs blood away from the wound into a covered stainless-steel container without touching the skin or hide. The knife may be connected to a hose to reduce the risk of contamination. The hose may even be connected to a pump to speed the blood flow. Between 40 and 60 percent of the total blood volume will be removed through this will be reduced if sticking is delayed. To prevent coagulation, citric acid solution made up with one part citric acid to two parts water is added at a rate up to 0.2 percent of the blood volume.

The main sources of contamination during sticking and bleeding include the knife, the wound and the food-pipe. The knife should be changed after each operation and returned to a steriliser. Cutting the hide of sheep and cattle and opening out to make a clean entry for the sticking knife reduces contamination from the wound. If the food-pipe is pierced semi-digested food may be regurgitated contaminating the blood and neck wound

Horizontal Bleeding

Horizontal bleeding is claimed to give faster bleeding rates and a greater recovery of blood. This may be due to certain organs and blood vessels being put under pressure when animals are hoisted, thus trapping blood and restricting the flow. Bleeding on the floor is very unhygienic. The operation should take place on a specially designed, easily cleaned stainless-steel table which should be cleaned frequently. If blood is to be saved it must not come in contact with the table before reaching the collecting vessel.

1.4.2 Bleeding without Stunning

The Jewish and Muslim religions forbid the consumption of meat which was killed by any method other than bleeding. Since it is difficult to guarantee that all animals will recover consciousness after being stunned by any particular method, stunning is not generally allowed.

There are exceptions, however. Some communities do accept low-voltage electrical stunning. Because animals are fully conscious at the time of sticking, ritual slaughter may be less humane than sticking after stunning.

To reduce the suffering operators must be highly skilled so that a successful gash cut severing all the veins and arteries is made quickly at the first attempt. Different communities have different regulations as to the orientation of the animal at sticking some favouring a position lying on its side, others insisting it lie on its back. The animal should not be hoisted until unconsciousness due to lack of blood supply to the brain is complete.

Self-Assessment Exercise 2

1. State the objectives of bleeding
2. When should bleeding stop?

1.5 Procedures for removing of hair from animals

1.5.1 Scalding and De-hiring of Pigs

Scalding in water at around 60^0C for about six minutes loosens the hair in the follicle. Too low a temperature and the hair will not be loosened and too high a temperature and the skin will be cooked and the hair difficult to remove. The simplest equipment consists of a tank into which the pig is lowered by a hoist. The water is heated by oil, gas, electricity or an open steam-pipe. To check the effectiveness of the scald, rub the skin with the thumb to see if hair comes away easily. Some machines have the thermostatic controls and timers.

To reduce contamination, scalding water should be changed frequently, pigs should be as clean as possible at sticking, and bleeding should be fully completed before immersion. In large factories pigs are transported through scalding tanks with rotating bars or through long scalding tanks stretching from the sticking point to the dehairing point in the time required for an effective scald.

De-haring is done with a specially formed scraper (bell scraper or knife). If the scald is effective all the hair can be removed by this manual method. Another simple method is to dip the pig in a bath containing a hot resin adhesive. The pig is removed from the bath and the resin allowed to set partially when it is peeled off pulling the hair with it from the root. This is less labour-intensive than scraping and produces a very clean skin. After use the adhesive is melted again, strained to remove the hair and returned to the tank.

Another method of removing dirt and hair in one operation is to skin the carcass though this is only done when the skin 1s required for leather goods. With the simple scalding tank, dehairing and scalding may be combined in one operation. Inside the tank are rotating rubber-tipped paddles which are started after closing the lid. As the hair is loosened by the scalding water it is removed by the rubbing effect of the paddles against the skin.

Singeing removes any remaining hairs, shrinks and sets the skin, decreases the number of adhering micro-organisms and leaves an attractive clean appearance. It may be done with a hand-held gas torch. Automated systems transport the pig into a furnace and leave it long enough for an effective singe.

After singeing, black deposits and singed hairs are scraped of and the carcass is thoroughly cleaned before evisceration begins.

1.5.2 Skinning Cattle

The outer side of the hide must never touch the skinned surface of the carcass. Operators must not touch the skinned surface with the hand that was in contact with the skin.

Combined horizontal/vertical methods

Head**:** After bleeding, while the animal is still hanging from the shackling chain, the horns are removed and the head is skinned. The head is detached by cutting through the neck muscles and the occipital joint. Hang the head on a hook. Lower the carcass on its back into the dressing cradle.

Legs: Skin and remove the legs at the carpal (foreleg) and tarsal (hind leg) joints. The forelegs should not be skinned or removed before the carcass is lowered on to the dressing cradle or the cut surfaces will be contaminated. The hooves may be left attached to the hide.

Flaying: Cut the skin along the middle line from the sticking wound to the tail. Using long firm strokes and keeping the knife up to prevent knife cuts on the carcass skin the brisket and flanks, working backwards toward the round. Skin udders without puncturing the glandular tissue and removed, leaving the super mammary glands intact and attached to the carcass. At this point raise the carcass to the half-hoist position, the shoulders resting on the cradle and the rump at a good working height.

Clear the skin carefully from around the vent (anus) avoiding puncturing it and cut the abdominal wall carefully around the rectum. Tie off with twine to seal it. Skin the tail avoiding contamination of the skinned surface with the hide. Raise the carcass free of the floor and finish flaying.

Vertical methods

High-throughput plants have overhead rails which convey the carcass from the sticking point to the chills. Hide removal is carried out on the hanging carcass. The operations are as in the combined horizontal/vertical method, but as it is not possible to reach the hide from ground level more than one operator is needed. A single operator may work with a hydraulic platform which is raised and lowered as required. Automatic hide pullers are used in high-throughput slaughterhouses. Some types pull the hide down from the hind, others from the shoulders upwards toward the rump.

Automation of hide removal reduces contamination since there is less handling of the carcass and less use of knives. Moving overhead rails also improve hygiene by reducing carcass contact with operators, equipment such as dressing cradles and with each other since carcasses are evenly spaced.

Self-assessment exercise 3

1. Why shouldn’t too high temperature be used to scald pig
2. Why shouldn’t the forelegs be skinned or removed before the carcass is lowered on to the dressing cradle.

1.6 Summary

Stress in its many forms, e.g. deprivation of water or food, rough handling, exhaustion due to transporting or trekking over long distances, mixing of animals reared separately resulting in fighting Stress in its many forms, e.g. deprivation of water or food, rough handling, exhaustion due to transporting or trekking over long distances, mixing of animals reared separately resulting in fighting. Slaughtering appliances, particularly for smaller-scale operations, need not be elaborate and expensive. The amount of equipment will depend on the slaughtering procedures employed. If possible, all equipment should be made of stainless steel or plastic, be rust resistant and easily cleaned and sanitised. Types of stunning includes: Slaughtering mask and Carbon dioxide stunning. Bleeding usually comes after stunning. The objectives of bleeding are to kill the animal with minimal damage to the carcass and to remove quickly as much blood as possible as blood is deal medium for the growth of bacteria. Sticking, severing the major arteries of the neck should immediately follow stunning. Care must be taken not to puncture the chest cavity or it will fill with blood. Scalding in water at around 60^{0}C for about six minutes loosens the hair in the follicle. Too low a temperature and the hair will not be loosened and too high a temperature and the skin will be cooked and the hair difficult to remove.

1.7 Glossary: ***Stunning*** **=** To render animal unconscious

1.8 References/Further Readings

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1.9 Answers to Self-Assessment Exercises

Self-assessment exercise1

1. Which of these is not in the list of basic slaughtering equipment

   D. **stone mill**

2. Carbon dioxide stunning is used only in large pig abattoirs

Self-Assessment Exercise 2

1. The objectives of bleeding are to kill the animal with minimal damage to the carcass and to remove quickly as much blood as possible as blood is deal medium for the growth of bacteria.
2. Bleeding continues until the blood flow is negligible

Self-assessment exercise 3

1. Too high a temperature, the skin will be cooked and the hair difficult to remove.
2. The forelegs should not be skinned or removed before the carcass is lowered on to the dressing cradle or the cut surfaces will be contaminated.

UNIT 2 METHODS OF PREPARING MEAT

Unit structure

2.1 Introduction

Depending on the desire of the meat processor and because of natural tenderness or lack of tenderness, different cooking procedures are utilized to correctly prepare the various cuts of meat Pan-broiling is recommended for tender cuts suitable for broiling. Broiling is recommended for all tender cuts and for best results

2.2 Learning outcomes

At the end of the lecture, the students will be able to understand the effect of cooking on meat quality, different cooking procedures, Pan-broiling, roasting, pan frying, braising and simmering of meat.

, with knowledge of braising and simmering of meat

2.3 Effect of cooking and broiling of meat

2.3.1. Effect of cooking on meat quality

Meat is cooked in order to increase palatability and tenderness. Also thorough cooking kills most, if not all, food poisoning organisms that might be present. Various changes occur in meat during cooking.

1. Muscle fibre proteins and the meat shrinks
2. Shrinkage results in a loss of juices from the meat. The juices or extractives contain water, water soluble salts and vitamins and peptides (short chains of amino acids) meat extractives, together with fat, are largely responsible for the flavour of meat
3. Collagen in the connective tissue is converted into gelatin. This makes

   meat more tender. Moist cooking ,methods, e.g. stewing and braising result in a greater breakdown of connective tissue than dry methods, such as roasting, and therefore more suitable for cheaper cuts which contain greater quantities of connective tissue
4. Certain nutrients are lost or destroyed during the cooking of meat. B vitamins, being water soluble, are lost in the juices. Thiamin is destroyed by heat and losses during cooking vary from 30% to 50%. Riboflavin and nicotinic acid are more heat stable and losses are smaller.

Offal: Certain organs of animals, such as the liver, kidney and heart, are eaten and are known collectively as offal. Other types of offal include tripe (the tissues of the stomach) and sweetbreads (the –pancreas). Most offal has a high nutritional value. Liver, for example is a very good source of iron, riboflavin, nicotinic acid and vitamin A. Although it is eaten relatively infrequently it provides one-third of the vitamin A in the average diet. Liver is also a good source of protein, thiamin and vitamin D.

Primarily because of natural tenderness or lack of tenderness, different cooking procedures are utilized to correctly prepare the various cuts of meat. Tender cuts are best cooked with dry heat, as by broiling or pan broiling. Less tender cuts are tenderized by cooking with moist heat. Connective tissue is softened and made tender by cooking slowly in moisture.

Temperature control is important in meat cookery. Meat loses moisture, fat and other substances such as soluble proteins during cooking. Cooking losses can be minimized by controlling the cooking temperature and the final internal temperature of the meat. Higher oven and higher internal temperatures increase shrinkage. Whenever possible a meat thermometer should be used to determine accurately the degree of doneness of meat. Time and temperature guides can be used to ascertain doneness, but cooking time is affected by fat, bone and moisture content and the shape and size of the cut.

The method chosen to cook a certain cut of meat should relate directly to the inherent tenderness of that cut. Tenderness is determined by where on the animal the meat comes from the degree of marbling the age of the animal how the meat was stored how the meat was prepared for market In general, cuts from the loin section are the most tender; the farther away from this section the less tender the meat will be. The basic types of meat cookery follow

2.3.2. Broiling

Broiling is cooking by direct heat from a flame, electric unit, or glowing coals. Meat is cooked one side at a time. Choose tender beef steaks, lamb chops, cured ham slices, and bacon for broiling. Use steaks or chops cut 1 to 2 inches thick. If steaks or chops are less than 1 inch thick, pan broil them. Consult the manufacturer’s instructions for broiling since equipment varies.

Usually the door is left open when broiling in an electric range and closed when broiling in a gas range.

Broiling is recommended for all tender cuts and for best results:

- Set the oven for broiling
- Place thin cuts of meat on a rack at a distance from the heat equal to two times the thickness of the cut plus 2.5 cm
- Broil steaks, chops or patties for approximately one-half the desired cooking time before turning
- Season and serve at once.

Pan-broiling of meat

Pan-broiling. Pan-broiling is cooking in an uncovered pan over direct heat. Fat that cooks out of the meat is drained off.

Pan-broiling is recommended for tender cuts suitable for broiling. For best results:

- Place meat in a hot frying-pan or on a griddle
- Do not add fat or water
- Cook slowly over moderate heat, turning occasionally
- Pour off or remove fat as it accumulates
- Brown meat on both sides
- Avoid overcooking
- Self-Assessment Exercise 1

1. Explain how B vitamin and Thiamin are differently lost during cooking of meat
2. State six conditions to achieve pan-broiling of meat

2.4 Roasting and pan frying of meat

2.4.1 Roasting of meat

Roasting is recommended for large, tender cuts. Some beef cuts suitable for roasting are rib and top sirloin roasts. Dry Heat cooking method is roasting. Roasting is a cooking method in which meat is surrounded and cooked by heated air, usually in an oven. Meat is not covered and no water is added For best results:

- Season with salt and pepper as desired
- Place the meat, fat side up, on a rack in an open shallow roasting-pan
- Insert a meat thermometer so that the bulb is in the centre of the largest muscle without touching bone.
- Add no water and do not cover
- Roast at oven temperature of 176°C to desired internal temperature.

Meats are usually cooked to degrees of doneness as follows:

- Rare 60°C
- Medium 71°C
- Well done 77°C

2.4.2 Grilling

The technique we call grilling is thought to have originated in the Caribbean, where natives smoke-dried meat over hot coals on wood-frame “grills? Early Spanish explorers called this the “barbacoa” which evolved into the modern-day word “barbecue.” Due to the method of heating, grilling is actually a method of broiling. Meat can be grilled on a grid or rack over coals, heated ceramic briquettes or an open fire. While it is usually done outdoors, grilling can be done in the kitchen with special types of range tops or small,appliances.

2.4.3 Pan-frying of meat

Pan-frying is similar to pan-broiling, except that meat is cooked in a small amount of fat. The easiest way to tell when steaks and small pieces of meat are done when you broil, pan-broil, or pan-fry is to make a small cut in the meat near the bone and check the interior color.

Pan-frying is usually recommended for tender cuts 2.3 cm thick or less. For best results:

- Place meat in a hot frying-pan or on a griddle
- Fat may be added
- Cook slowly over moderate heat, turning occasionally
- Allow fat to accumulate
- Brown meat on both sides
- Avoid overcooking.

Stir-frying

Stir-frying is similar to panfrying except that the food is stirred almost continuously Cooking is done with high heat, using small or thin pieces of meat.

Deep-fat-frying

When meat is cooked immersed in fat, the process is called deep-fat frying. This method is only used with very tender meat. Usually, meat to be deep-fat fried is coated with egg and crumbs or a batter, or it is dredged in flour or corn meal (breaded). This method of cooking is sometimes used for brains, sweetbreads, liver and croquettes; however, a number of other meat products are suitable for deep-fat frying

Braising is cooking in steam trapped and held in a covered container or foil wrap. The source of the steam may be water or other liquid added to the meat, or it may be meat juices. Large, less tender cuts, such as chuck, round, and rump, are braised as pot roasts.

Cooking in liquid

This method involves covering a less tender cut of meat with liquid and simmering in a covered kettle until tender and well-done. Care should be taken not to let the temperature of the liquid exceed 195°F, because boiling (212°F) toughens meat protein. When the liquid is used as a base for soup it is called meat stock (also called broth or bouillon). Meat that is partially cooked in liquid before cooking by another method is called “parboiled.”

The three ways to cook in liquid are simmering, stewing and poaching. Simmering and stewing are used for less tender cuts of meat while poaching is used for tender cuts. Also, poaching is only appropriate for beef while any type of meat (beef, veal, pork or lamb) can be simmered. The difference between simmering and stewing is that simmering is used with whole cuts of meat while stewing is used with small pieces of meat.

Poaching has been a traditional way of cooking poultry and fish. However, beef roasts can also be successfully poached if they come from tender cuts. Appropriate roasts for poaching are beef eye round, rib eye and tenderloin.

Self-Assessment Exercise 2

1. At what temperature should meat be roasted to desired internal temperature?
2. State the conditions to achieved best result during pan frying

2.5 Braising and simmering of meat

2.5.1 Braising of meat

Braising method is best used for less tender cuts such as beef round or chuck steak, Pot roast, stew or short ribs. For best results:

- Use a heavy pan
- If desired, brown meat slowly on all sides with sufficient fat to keep meat from sticking
- Season with salt, pepper, herbs or spices
- Add a small amount of liquid
- Cover tightly
- Cook slowly over low heat on a stove burner or in a moderate oven until meat is tender.

Braising with large cuts is often called pot-roasting and with thin cuts may be known as Wising.

2.5.2 Simmering

Simmering method consists of cooking a small amount of meat with a large amount of water. For best results the container should be tightly covered and the meat cooked slowly below the boiling point until tender. This method is used for the production of soups to which vegetables, grains or pasta products may be added

Self-Assessment Exercise 3

1. Braising with large cuts is often called **……**and with thin cuts may be known as **…….?**

2. Explain the term simmering used meat science

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2.6 Summary

Different cooking procedures are utilized to correctly prepare the various cuts of meat. Pan-broiling is recommended for tender cuts suitable for broiling, while broiling is recommended for all tender cuts and for best results. Roasting is recommended for large, tender cuts. Some beef cuts suitable for roasting are rib and top sirloin roasts. Braising method is best used for less tender cuts such as beef round or chuck steak, Pot roast, stew or short ribs. Braising with large cuts is often called pot-roasting and with thin cuts may be known as Wising. Simmering method consists of cooking a small amount of meat with a large amount of water. For best results the container should be tightly covered and the meat cooked slowly below the boiling point until tender. This method is used for the production of soups to which vegetables, grains or pasta products may be added. Meat is cooked in order to increase palatability and tenderness. Also thorough cooking kills most, if not all the food poisoning organisms that might be present. Various changes occur in meat during cooking but desirable and undesirable changes. However, efforts should be made towards controlling the undesirable changes.

2.5 Glossary

Wising = Braising with large cuts is often called pot-roasting and with thin cuts may be known as

2.8 References/Further Readings

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2.9 Answers to Self-Assessment Exercises

Exercise 1

No.1 . B vitamins, being water soluble, are lost in the juices.

Thiamin is destroyed by heat and losses during cooking vary from 30% to 50%.

No 2 For best results to be achieved during pan-broiling of meat:

- Place meat in a hot frying-pan or on a griddle
- Do not add fat or water
- Cook slowly over moderate heat, turning occasionally
- Pour off or remove fat as it accumulates

- Brown meat on both sides
- Avoid overcooking

Exercise 2

No.1. Roast meat at oven temperature of **176°C** to desired internal temperature

No.2 The conditions to achieve best results during pan frying include:

- Place meat in a hot frying-pan or on a griddle
- Fat may be added
- Cook slowly over moderate heat, turning occasionally
- Allow fat to accumulate

Exercise 3

No1. Braising with large cuts is often called **pot-roasting** and with thin cuts may be known as wising**.**

No.2 Simmering consists of cooking a small amount of meat with a large amount of water

UNIT 3: PRODUCTS DERIVED FROM MEAT

Unit structure

3.1 Introduction

There are numerous products derived from processing of meat. These meat products varies from country to country and from locations to locations within a country

3.2 Learning outcome

At the end of the lecture, the students will be able to understand production of different products derived from meat such as comminuted meat products, kilish,

3.2 Learning outcomes

At the end of the lecture, the students will be able to describe how to produce the following meat products: Comminuted meat products, "kilishi" gelatin from bone, canned meat and meat sausages

3.3 Production of comminuted meat and kilishi

3.3.1. Comminuted meat products

Finely chopped or blended meat products constitute a groups of food denoted as comminuted meat products. These comminuted products are mostly made from meat cuts, lower grade carcasses, meat by-products, and filler or a binder. Some of the typical fillers are processed wheat flour, baker products, milk or whey powder and starch; the mixture of filler with a carbohydrate source, salt, spices, egg white or other gelling agents, and a preservative such as sodium nitrite, is defined as binder. Numerous calculations are performed to determine the amount of each constituent of the product that must be utilized. The so-called least-cost formulation takes form of a series linear equations. Successful formulation depends upon the availability of accurate information about the properties and composition of the potential raw materials that may be included in the product. The process of formulation must determine to what extent substitutions that can be made, and when extent substitutions can be made and when it would be best, in terms of economics, to do so

3.3.2. Production of Kilishi

Product Description

Kilishi is a special, sun-dried beef snack. it will keep for up to six months at ambient be used. The meat should be prepared quickly to prevent bacterial growth. As the product is not cooked it should be processed hygienically to prevent the risk of food poisoning.

Equipment

Drying racks, Pestle and mortar.

The process

The meat is cut into thin slices, spiced and sun dried. Preservation is mainly due to the low moisture content but the spices also have an antimicrobial effect. The meat is pounded with the spice mixture into thin sheets. The sheets are dried in sun on drying racks for two to three days to about 5% moisture. It is sold wrapped in paper.

Process Notes

Meat ↓	Meat from any of healthy cattle can be used.
Separate ↓	Cut off the fat using a sharp knife.
Cut ↓	Cut the meat into thin slices, 1-2 cm thick.
Wash ↓	Wash in clean water.

Mix Add mixed spiced to the strips**.**

↓

Pound Pound the meat-spiced mixture with a pestle into thin sheets.

↓

Dry Dry in the sun on drying racks for 2-3 days (to about 5% moisture)

↓

Packaging Kilishi is stored in jute bags. It is sold from bowls, wrapped in paper

The meat is not packaged, but is sold from bowls. It is cut into different-sized pieces depending on the price paid

Self-assessment exercise 1

1. Comminuted products are mostly made from?
2. Explain the process of kilishi production starting from raw meat

3.4 Production of gelatin and canned meat

3.4.1 Production of gelatin from bone

Gelatin is a cream/brown powder which can be used as a thickening or gelling agent for table jelly and a wide range of confectionery. It is also used to clarify wines; the shelf-life is several months depending on the packaging and storage conditions.

Raw material

The yield of gelatin is determined by the amount of cartilage and the collagen in the bones. Bones should be fresh and without gross contamination by soil or bacteria. Leg bones and joints are usually selected because of their high collagen content.

Equipment

Filter bags, grinding mill, Heat sealer.

The process

The process involves a hot water extraction of gelatin after it has been dissolved out of the collagen in bones and tendons. After separation of the fat and meat, the gelatin is concentrated and dried and then ground to a fine powder.

Process Notes

Bones Use fresh meat bones and tendons as they contain more cartilaginous tissue

↓

Clean Remove all meat from the bones by scraping. Retain cartilage tissues.

↓

Chop Break bones into manageable pieces using choppers.

↓

Heat Boil gently for 5-6 hours.

↓

Cool Cool to room temperature.

Separate fat Remove floating soli, fried fat.

Filter solids Decant clear liquid to separate from layer of solids at the base.

Concentrate Gently simmer to boil off water until the liquid is thick and viscous

Dry

Sun-dry in thin layers on metal sheets until dried and crisp

Grind Pound using a mortar and pestle or a manually operated

Pack Package in sealed polythene bags.

Store Store in a cool, dry place.

Process control

Hot water not only extracts the gelatin but also sterilizes the product. The time and temperature of heating determines the yield of gelatin.

Evaporation and drying should be done quickly to prevent microbial growth on the gelatin before it is fully dried. The thickness of the gelatin layer and the drying conditions mostly determine the drying time. The extent of grinding and sieving determines the fineness of the final product.

Packaging and storage

The product is hygroscopic and should be quickly packaged in moisture-proof clean containers. It should be stored in a cool, dry place.

3.4.2 Canned meat

Canning is one of the three (Canning, freezing and Dehydration) major methods of modern food preservation. Out of the three, canning was the first to be carried out on an industrial scale. It is still the most certain method so far as it is the only one which completely destroys enzymes and micro-organisms. Sterilization is the most accurate description of this method since glass jars, bottles and similar containers may take the place of cans, for example in the preservation of meat and fish pastes and in bottling of beverages. Practically every kind of food can be preserved by this method – meats, fish, vegetables, fruit and drinks.

History of canning

Present day canning stems from the work of Nicholas Appart, who in the 1870’s discovered that food hermetically sealed in glass jars and subsequently heated for an adequate time remained wholesome. Knowing nothing of bacterial activity, Apart incorrectly assumed that his success depended on the complete exclusion of air from the food.

The real impetus to the development of a large-scale canning industry came in America during the civil war and in England during the World War 1; in both cases because of the need to feed troops. Discovery of the modern sanitary can is the most important single historical event in canning.

Principles

The general principles of canning are:

To put the food into a sealed container so that further bacteria and other micro-organisms cannot get in.

To heat the container sufficiently to destroy any micro-organisms present

As mentioned previously, it is very important to heat strongly enough to get rid of all spore-formers since many of those are extremely heat-resistant.

Manufacturing Process

The canning process is outlined diagrammatically in Figure 1.

1. **Preparation:** Involves sorting grading, and washing of raw food to be canned.

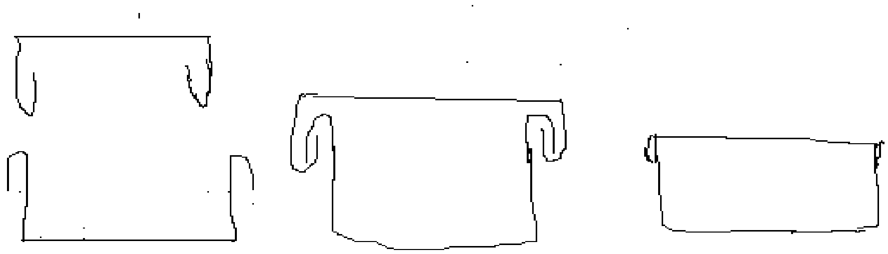
2. **Blanching:** is common to most schemes of fruit and vegetable preservation. It consists of a heat treatment in hot water or steam at 90 - 100 ^{o}C for a short period of 1-5 minutes. It is performed to:

   - Destroy or inactivate enzymes
   - Reduce initial microbial load
   - Remove gas from tissues of plants, then relaxing the tissues
   - Facilitates filling.

3. **Filling:** Food pieces are put into cans along with a liquid (brine, oil or syrup) which aids heat transmission from the outside to the centre of the can during sterilization. Lacquered cans are often used to package processed fruits and vegetables except for products like carrots which develop off flavour in lacquered cans. Lacquers are non-toxic organic coating that is applied to

tin plates before tin plates are made into cans. The external surface of the can may also be sprayed with corrosion resistance lacquers

Processing of vegetables are commonly at very high temperatures since they are low acid foods. The type of lacquer applied therefore should be the one to withstand very high temperature processes such as epoxy resins and phenolic resins.



4. **Exhausting:** After filling, the can is passed through exhausting line to remove air, forming a vacuum in the head space which if not, the O_2 will encourage microbial growth and oxidative rancidity.

5. **Sealing:** The container is sealed hermetically with a specially fitting lid which drops just over the edge. It is spun in the sealing machine until the edges of the lid and the can curl together and are rolled flat. The two terms hermetic and non-hermetic sealing (closure) are very important in packaging. A container is said to be hermetically sealed if it is absolutely impermeable to gasses and water vapour throughout the body of the pack including its seams. Such a container, so long as it remains intact, will automatically be impervious to bacteria, yeasts, molds and dirt from

dust and other sources since all these agents are considerably larger than gas or water vapor molecules.

For a container to be considered as being hermetically closed, it has to be able to protect the product from moisture gain or loss, and from oxygen pick-up from the atmosphere; and it should be good enough for strict vacuum and pressure packaging.

The most common hermetic containers are rigid metal cans and glass bottles, however faulty closures can make them non-hermetic. In other words, glass bottles or containers are hermetic as far as the lids are tight. But one must have to know that bottles fail more often than cans in becoming non-hermetic.

6. **Sterilization:** The product is now ready for sterilization immediately after sealing. **Sterilization** (or **sterilization**) is a term referring to any process that eliminates (removes) or kills all forms of life, including transmissible agents (such as **fungi**, **bacteria**, **viruses**, **spore forms**, **etc**.) present on a surface, contained in a fluid, in medication, or in a compound such as biological culture media Sterilization can be achieved by applying heat, chemicals, irradiation, high pressure, and filtration or combinations thereof. The aim of sterilization is the reduction of initially present microorganisms or other potential pathogens. The degree of sterilization is commonly expressed by multiples of the decimal reduction time denoting the time needed to reduce the initial number to one tenth of its original value. A widely used method for heat sterilization is the **autoclave**, sometimes called a converter. Autoclaves commonly use steam heated to 121–134 °C (250–273 °F). To achieve sterility, a holding time of at least 15 minutes at 121 °C (250 °F) at 100 kPa (15 psi), or 3 minutes at 134 °C (273 °F) at 100 kPa (15 psi) is required. Additional sterilizing time is usually required for liquids and instruments packed in layers of

cloth, as they may take longer to reach the required temperature (unnecessary in machines that grind the contents prior to sterilization). Following sterilization, liquids in a pressurized autoclave must be cooled slowly to avoid boiling over when the pressure is released. Modern converters operate around this problem by gradually depressing the sterilization chamber and allowing liquids to evaporate under a negative pressure, while cooling the contents. **Dry heat** can be used to sterilize items, but as the heat takes much longer to be transferred to the organism, both the time and the temperature must usually be increased, unless forced ventilation of the hot air is used. The standard setting for a hot air oven is at least two hours at 160 °C (320 °F). A rapid method heats air to 190 °C (374 °F) for 6 minutes for unwrapped objects and 12 minutes for wrapped objects. Dry heat has the advantage that it can be used on powders and other heat-stable items that are adversely affected by steam (for instance, it does not cause rusting of steel object

This may be carried out by batch process in retorts, but various types of continuous cookers have now been developed. The sterilization efficiency of steam depends on the transfer of its heat of condensation to the contents of the can as the steam condenses.

Batch steam retorts may be configured in a number of geometries, the most common being vertical steam retort.

During operation, baskets containing the product to be processed are loaded into the vessel and the lid is secured. At the start of the process, the vent valve is opened and a high flow of steam enters the vessel through a distribution spreader located at the bottom of the retort. This condition is maintained for a minimum time interval and until the retort reaches a minimum temperature; these factors are determined by experimental data to ensure that air present in the retort has been purged. At that point the vent is closed and the retort is brought to the desired processing temperature.

During sterilization, heat is transferred by conduction from the steam to the can. The contents of the can will heat either by convection where a large proportion of liquid is present for example in soups or by conduction where the contents are mainly solid, for example meat products. Sometimes food will heat partly by one method and partly by another.

At the end of the heating period, cooling water floods the retort. The cans are finally cooled under water. They are labeled, packaged and warehoused.

Advantages of canning

Apart from its effectiveness in destroying bacteria, one of the main advantages of canning is that no special storage conditions are required for the finished product.

Disadvantages of canning

The disadvantages are weight, involving heavy transport costs, and the limitations imposed by strong heat treatment, making it applicable only to foods which are eaten in a cooked form.

Self-assessment Exercise 2

1. Explain the process control in gelatin production
2. State the advantages and disadvantages of canning foods

3.5 Advances in meat processing

3.5.1 Different types of Meat Sausages

Cured meats especially, and uncured meat to a lesser extent find their way into enormous quantities of sausage products. There are over 200 kinds of sausage products. Its classification is confusing but generally broken down into

1. Fresh sausage
2. Uncooked smoked sausage
3. Cooked smoked sausage and
4. Dry sausage.

To produce sausage, meat chunks of variable size and shape and with variable fat contents are ground to form uniform cylinders of fat and lean which are then tumbled in a mixer to give a uniform distribution of fat and lean particles. It is then subjected to emulsifier which combines the principle of grinding and chopping to emulsify the meat product. The sausage emulsion, also known in the trade as mix, sausage dough or batter, is transferred to suffer for extrusion into casing. Three types of stuffers are used (1) piston and pump in a single unit. The encased mass is tied with tread or fastened with metal clips. In the case of small sausages, such as frankfurters stuffed casing is twisted or drawn together to produce links either by hand or with mechanical devices. At this stage (i) Fresh sausages: The links are separated and the product chilled prior to packaging

(ii) Cooked and smoked sausages: The links are hung on sticks either manually or automatically and placed on smoke house racks or sent on through the continuous processing system. Cooking smoking schedule vary considerably. The temperature of the heating medium and the time taken for cooking should be efficient to bring the temperature of the entire product to at least 68 ^{O}C.

Examples of sausage include Frankfurter, Bologna, Braunschwj, Gneoa, Gothenborg, Lyons and Arles. It should be noted that these names came about in Europe during middle ages when sausages acquired the name of the area or city in which they were prepared

1. Fresh Sausage

This is made from selected cuts of fresh meats principally pork but sometimes also beef that have not previously been cured. This type of sausage must always be kept under refrigeration and must be cooked thoroughly before serving. Examples are fresh pork sausage and fresh country style pork sausage.

2. Uncooked Smoked Sausage

This is similar to fresh pork sausage except that the meat is subjected to mild cure, then placed in natural hog casing or collagen casings and smoked. All such products should be kept under refrigeration and cooked before marketing unless it is made from trichina free pork E.g. Polish sausage (kielbasa)

3. Cooked Smoked Sausage

This is the most popular type of sausage in many countries representing about 30% of all sausages. They are usually cured, flavoured and spiced. The link Is hung on sticks either manually or automatically and placed on smoke house racks or sent on through the continuous processing system. Cooking should be sufficient to bring the temperature of the entire product to at least 68 ^{O}C. Examples are ham style bologna, german-type mortadela, liver sausage, etc.

4. **Dry Sausage**

This may be classified into two general types –dry and semi-dry sausages. A semi-dry sausage will have lost between 8 and 15 % of its original weight through processing and drying while a true dry sausage will lose 25 to 40 %. All dry and semi dry sausages are fermented by the lactic acid bacteria and manufacturers now usually employ the starter cultures. Chemical sources of lactic acid can also be used. Drying is accomplished by the use of a carefully controlled air-conditioning system which removes water from the products.

3.5.2 **Spoilage of meat sausages**

One of the earliest signs of meat spoilage is a potently rancid odor. This comes off of any spoiled meat, and that includes seafood, which starts to smell "fishy" when it spoils.

No meat, whether it is seafood, poultry, or red, should have a detectable foul smell. If yours does, then it is not safe for eating. Quick removal from storage is advised to prevent the pungent odor from spreading.

When the meat starts to rot, microbial activity may begin to become noticeable in the form of molds and an unusual texture. For spoiled red and poultry meat, molds and a mucus-like coating are usually apparent, giving it a sticky or slimy texture.

A discoloration of meat is yet another vital sign of spoilage. Fresh meat should have a pinkish-red color or be colorless, at least. If you spot a grayish, greenish, or black color on any part of the flesh, it is not safe for eating.

If the meat is packaged, the expiration date is a quick and easy way to detect if it has spoiled. Averagely, the shelf life for red meat is approximately 1-3 days if it is raw and 7-10 days if it is cooked.

Figure 1: Meat sausage

3.5.3 How to Store Sausage

1. An excellent way to prolong the lifespan of meat is by freezing it; a freezer is your best pal when it comes to conserving the taste and freshness of meat. Refrigerate. Refrigerate sausages in original packaging until ready to use.
2. Seal. Once opened, seal sausages in a Food Storage Zipper Bag.
3. Seal. Or, seal sausages in a food protection container.
4. Refrigerate cooked sausages in shallow airtight containers or wrap tightly with heavy-duty aluminum foil or plastic wrap.

3.5.4 Period of storage of sausages

Properly stored, cooked sausages will last for 3 to 4 days in the refrigerator.

Properly stored, they will maintain best quality for about **1 to 2 months**, but will remain safe beyond that time. The sausages that have been kept constantly frozen at 0°F will keep safe indefinitely.

Self-Assessment Exercise 3

1. List four different types of meat sausage
2. A semi-dry sausage will have lost between ….. and ……. % of its original weight through processing

3.6 Summary

There are numerous products derived from processing of meat. These products include: Comminuted meat products,“kilishi” gelatin from bone, and canned meat These meat products varies from country to country and from locations to locations within a country. There are over 200 kinds of sausage products. Sausage classification is confusing but generally broken down into Fresh sausage, Uncooked smoked sausage, cooked smoked sausage and dry sausage. Kilishi is a special, sun-dried beef snack. it will keep for up to six months at ambient be used. The meat should be prepared quickly to prevent bacterial growth. As the product is not cooked it should be processed hygienically to prevent the risk of food poisoning. Gelatin is a cream/brown powder which can be used as a thickening or gelling agent for table jelly and a wide range of confectionery. It is also used to clarify wines; the shelf-life is several months depending on the packaging and storage conditions. Canning is one of the three (Canning, freezing and Dehydration) major methods of modern food preservation. Out of the three, canning was the first to be carried out on an industrial scale. It is still the most certain method so far as it is the only one which completely destroys enzymes and micro-organisms. The general principles of canning are: To put the food into a sealed container so that further bacteria and other micro-organisms cannot get in and to heat the container sufficiently to destroy any micro-organisms present. Apart from its effectiveness in destroying bacteria, one of the main advantages of canning is that no special storage conditions are required for the finished product. The disadvantages are weight, involving heavy transport costs, and the limitations imposed by strong heat treatment, making it applicable only to foods which are eaten in a cooked form.

3.7 Glossary: ***Kilishi*** is a special, sun-dried beef snack. it will keep for up to six months at ambient be used.

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3.9 Answers to Self-assessment Exercises

Exercise 1

Question 1   Comminuted products

These comminuted products are mostly made from meat cuts, lower grade carcasses, meat by-products, and filler or a binder

Question 2 The process of kilishi production is follows:

The meat is cut into thin slices, spiced and sun dried. Preservation is mainly due to the low moisture content but the spices also have an antimicrobial effect. The meat is pounded with the spice mixture into thin sheets. The sheets are dried in sun on drying racks for two to three days to about 5% moisture. It is sold wrapped in paper.

Answers to Self – Assessment Exercise 2

Question 1: **Process control during gelatin production**

Hot water not only extracts the gelatin but also sterilizes the product. The time and temperature of heating determines the yield of gelatin.

Evaporation and drying should be done quickly to prevent microbial growth on the gelatin before it is fully dried. The thickness of the gelatin layer and the drying conditions mostly determine the drying time. The extent of grinding and sieving determines the fineness of the final product.

Packaging and storage

The product is hygroscopic and should be quickly packaged in moisture-proof clean containers. It should be stored in a cool, dry place.

Question 2

Advantages of canning

Apart from its effectiveness in destroying bacteria, one of the main advantages of canning is that no special storage conditions are required for the finished product.

Disadvantages of canning

The disadvantages are weight, involving heavy transport costs, and the limitations imposed by strong heat treatment, making it applicable only to foods which are eaten in a cooked form.

Self-Assessment Exercise 3

1. Four different types of meat sausage. Sausage classification is confusing but generally broken down into Fresh sausage, Uncooked smoked sausage, cooked smoked sausage and dry sausage
2. A semi-dry sausage will have lost between **8** and **15 %** of its original weight through process

MODULE 5

PROCESSING AND PRESERVATION OF FISH AND FISH PRODUCTS

UNIT 1: Characteristic of fish

Unit structure

1.1 Introduction

The word **fish** is commonly used to describe all forms of edible finfish, mollusks (e.g., clams and oysters), and crustaceans (e.g., crabs and lobsters) that inhabit an aquatic environment. Fish from the marine and freshwater bodies have been a major source of food for mankind since before recorded history. Harvesting wild fish from fresh and marine waters and raising cultured fish in ponds were practices of ancient Egyptians, Greeks, and other Mediterranean peoples. Rudimentary processing techniques such as sun-drying, salting, and smoking were used by these ancient groups to stabilize the fish supply. Modern methods of processing and preservation have encouraged the consumption of many species of fish that are popular throughout the world.

1.2. Learning outcomes: At the end of the lecture, the students will be able to explain the Characteristic of fish based on the structure of skeletal muscles, nutrient, and pattern of spoilage.

1.3 Characteristic of fish

1.3.1 Structure of skeletal muscles

The majority of edible fish products are derived from the skeletal muscles (flesh), which represents more than 50 percent of the total body mass of the fish.

The skeletal muscles of fish differ from those of mammals and birds in that they are largely composed of stacks of short bundles of muscle fibres called myomeres. The myomeres are separated by thin horizontal (myosepta) and vertical (myocommata) layers of connective tissue.

The unique structure and thin connective tissue sheaths of fish muscle give the meat its characteristic soft, flaky texture.

The skeletal muscles of fish are composed mostly of white, fast-twitch fibres. The high percentage of white fibres allows fish to swim with sudden, rapid movements and gives the meat its white colour. These fibres primarily metabolize glucose, a simple sugar released from muscle glycogen stores, for energy production through anaerobic (i.e., in the absence of oxygen) glycolysis. Therefore, white fibres **contain relatively little myoglobin**, which is the oxygen-binding protein that provides the red colour of muscles in other animals

1.3.2 Nutrient composition

The composition of fish may vary considerably especially in their fat content—during certain growth periods and annual spawning or migration periods. In addition, the composition of fish bred in captivity (i.e., aquaculture fish) may vary according to their artificial diet. The table shows the nutrient composition of several types of fish. Fish provide a number of important vitamins and minerals to the diet. They are a good source of the fat-soluble vitamins A, D, E, and K and the B vitamins riboflavin, niacin, and thiamine. The mineral content includes calcium, magnesium, phosphorus, and iron.

Nutrient composition of raw edible portion of fish species (per 100 g)

Species	energy (kcal)	water (g)	protein (g)	fat (g)	cholesterol (mg)	calcium (mg)	iron (mg)	riboflavin (mg)	niacin (mg)
Source: U.S. Department of Agriculture, Composition of Foods, Agriculture Handbook no. 8–11.									
catfish, channel (farmed)	135	75.38	15.55	7.59	47	9	0.50	0.075	2.304
cod, Atlantic	82	81.22	17.81	0.67	43	16	0.38	0.065	2.063
grouper, mixed species	92	79.22	19.38	1.02	37	27	0.89	0.005	0.313
Haddock	87	79.92	18.91	0.72	57	33	1.05	0.037	3.803

Species	energy (kcal)	water (g)	protein (g)	fat (g)	cholesterol (mg)	calcium (mg)	iron (mg)	riboflavin (mg)	niacin (mg)
halibut, Atlantic or Pacific	110	77.92	20.81	2.29	32	47	0.84	0.075	5.848
herring, Atlantic	158	72.05	17.96	9.04	60	57	1.10	0.233	3.217
mackerel, Atlantic	205	63.55	18.60	13.89	70	12	1.63	0.312	9.080
salmon, Atlantic	142	68.50	19.84	6.34	55	12	0.80	0.380	7.860
salmon, pink	116	76.35	19.94	3.45	52	—	0.77	—	—
trout, rainbow (wild)	119	71.87	20.48	3.46	59	67	0.70	0.105	5.384
tuna, Bluefin	144	68.09	23.33	4.90	38	—	1.02	0.251	8.654
clam,	74	81.82	12.77	0.97	34	46	13.98	0.213	1.765

Species	energy (kcal)	water (g)	protein (g)	fat (g)	cholesterol (mg)	calcium (mg)	iron (mg)	riboflavin (mg)	niacin (mg)
mixed species									
crab, blue	87	79.02	18.06	1.08	78	89	0.74	—	—
lobster, northern	90	76.76	18.80	0.90	95	—	—	0.048	1.455
oyster, Pacific	81	82.06	9.45	2.30	—	8	5.11	0.233	2.010
scallop, mixed species	88	78.57	16.78	0.76	33	24	0.29	0.065	1.150
shrimp, mixed species	106	75.86	20.31	1.73	152	52	2.41	0.034	2.552

Self-assessment exercise 1

1. ….. is the oxygen-binding protein that provides the red colour of muscles in other animals
2. The fish that contains the highest amount of fat is ……..

1.4. Proximate composition of fish

The term proximate composition comprises five (5) parameters: Protein, Fat moisture, carbohydrate and ash content of the food sample. However, the protein and fat contents of fish is most important

1.4.1 Explanation of protein and fat content of fish

Protein: Fish are an excellent source of high-quality protein. Mollusks are generally low in protein compared with fin fish and crustaceans because of their high water content. The proteins found in fish are essentially the same as those found in the meat derived from other animals—that is, the sarcoplasmic proteins (e.g., enzymes and myoglobin), the contractile or myofibrillar proteins (e.g., actin and myosin), and the connective tissue proteins (i.e., collagen).

Fat: The fat in fish is mostly liquid (i.e., fish oil), because it contains a relatively low percentage of saturated fatty acids. Omeg-3 fatty acid present in fish is known as acardio-protective compound. This is because when ingested, it aids the body in the production of high density lipoprotein cholesterol (HDL). This HDL cholesterol is the good form of cholesterol that scavenges the bad one known as Low

Density Lipoprotein cholesterol (LDL) Fish belongs in a special nutritional class because they contain the omega-3 polyunsaturated fatty acids [eicosapentaenoic acid (EPA)] and docosahexaenoic acid (DHA)—which have been shown to protect against several diseases, including heart disease. Unlike land plants, the marine and freshwater plants on which fish feed are rich in EPA and DHA .

Self-assessment exercise 2

1. ….. is an example of connective tissue protein in fish
2. A cardio-protective oil fish is called ……… fatty acid
3. (a) Omega-3, (b) Omega-1, (c) beta-3, (d) Alpha -6

1.5 Causes of fish spoilage and detection of spoiled fish

1.5.1 Microbiology of fish

Because of their soft tissues and aquatic environment, fish are extremely susceptible to microbial contamination. At the time of harvest, fish carry a high microbial load on the surface of their skin, in their intestinal tract, and in their gills.

The type and number of microorganisms that live in fish vary according to the season, the species, and the natural habitat. Additional contamination may occur during the harvesting, handling, or processing of the fish. Common spoilage microorganisms of fish include species of *Pseudomonas, Moraxella*, and *Acinetobacter*, found mainly in marine fish, and *Bacillus* and *Micrococcus*, found in freshwater fish. Fish may also contain pathogenic (disease-causing) microorganisms such as *Salmonella* and *Escherichia coli*. Pathogenic contamination is of special concern with mollusks because they are often eaten raw and as whole animals.

1.5.2 Factors that cause spoilage of fish

Spoilage and freshness are the two qualities that have to be clearly defined.. A fresh product is defined as the one whose original characters remain unchanged. Spoilage therefore is the indicative of post-harvest change. This change may be graded as the change from absolute freshness to limits of acceptability to unacceptability.

- Spoilage is usually accompanied by change in physical characteristics. Change in colour, odour, texture, colour of eyes, color of gills and softness of the muscle are some of the characteristics observed in spoiled fish. Spoilage is caused by the action of enzymes, bacteria and chemicals present in the fish. In addition, the following factors contribute to spoilage of fish.

- High moisture content
- High fat content
- High protein content
- Weak muscle tissue
- Ambient temperature
- Unhygienic handling

1.5.3 Detection of spoiled fish

Some common traits of bad fish are a slimy, milky flesh (a thick, slippery coating) and a fishy smell than normal smell This is hard because fish is smelly and slimy by nature, but these traits become much more pronounced when fish has gone badly. Fresh fillets should glister like they came out of water.

To tell if your fish has gone wrong, touch it to see if it is slimy or has a strong odor. If it smells fishy, it is spoiled. It also has a bluish tint and an increasingly awful taste

Spoiled fish have yellow or grey gills that can be covered in a slimy film. Fresh should look as healthy as it did when it was harvested.

Raw fish doesn't last very long in a fridge. And it starts to spoil soon after the sell-by date

Self- Assessment Exercise 3

1. List the common spoilage microorganisms of fish
2. State the signs of spoiled fish

1.6 Summary

Processing techniques such as sun-drying, salting, and heating (smoking) were used by these ancient groups to stabilize the fish supply. The unique structure and thin connective tissue sheaths of fish muscle give the meat its characteristic soft, flaky texture. Therefore, white fibres contain relatively little myoglobin, which is the oxygen-binding protein that provides the red colour of muscles in other animals. fish are extremely susceptible to microbial contamination. At the time of harvest, fish carry a high microbial load on the surface of their skin, in their intestinal tract, and in their gills. The type and number of microorganisms that live in fish vary according to the season, the species, and the natural habitat. Additional contamination may occur during the harvesting, handling, or processing of the fish. Common spoilage microorganisms of fish include species of *Pseudomonas*, *Moraxella*, and *Acinetobacter*, found mainly in marine fish, and *Bacillus* and *Micrococcus*, found in freshwater fish. Fish may also contain pathogenic (disease-causing) microorganisms such as *Salmonella* and *Escherichia coli*.

1.7 **Glossary:** ***EPA*** = eicosapentaenoic acid which is present in sea plants that fish feeds on

1. 8 References/Further Readings

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1.9 Answers to Self-Assessment Exercises

Exercise 1, Question 1 Myoglobin, which is the oxygen-binding protein that provides the red colour of muscles in other animals

Exercise 1 , Question 2 Mackerel-Atlantic

Exercise 2, Question 1 Collagen

Exercise 2, Question 2 (a) Omega-3

Exercise 3, Question 1 Common spoilage microorganisms of fish include species of *Pseudomonas*, *Moraxella*, and *Acinetobacter*, found mainly in marine fish, and *Bacillus* and *Micrococcus*, found in freshwater fish. Fish may also contain pathogenic (disease-causing) microorganisms such as *Salmonella* and *Escherichia coli*. Pathogenic contamination is of special concern with mollusks because they are often eaten raw and as whole

Exercise 3, Question 2 Some common traits of spoiled fish are:

A slimy, milky flesh (a thick, slippery coating) and a fishy smell than normal smell

UNIT 2: Handling of harvested fish

Unit structure

2.1 Introduction

2.2 Learning outcomes

2.3. Assessing the freshness of fish

2.3.1. Chilling and butchering of fish

2.3.2 Butchering of fish

2.4 Final processing of fish

2.4.1. Heating.

2.4.2 Freezing

2.4.3 Controlling water activity.

2.4.4 Curing of fish

2.4.5 Smoking

2.5 Preservation of fish

2.5.1 Salting

2.5.2 Semi-preserves

2.5.3 Canning

2.6 Summary

2.7 Glossary

2.8 References/Further Readings

2.9 Answers to Self-assessment Exercises

2.1 Introduction

Handling of fish is all about preprocessing of fish. This operation prepares the raw material for final processing. It is often performed on shipboard or in a shore-based plant.

The retention of nutritional properties and product quality of fish is dependent on proper handling of the catch after it has been harvested from its aquatic environment.

2.2 Learning outcomes

At the end of the lecture, the students will be able to explain different handling operations on harvested fish. The handling of fish includes such operations as inspection, washing, sorting, grading, chilling and butchering of the harvested fish including the four basic procedures used in the final processing of fish products are heating, freezing, controlling water activity (by drying or adding chemicals), and irradiating

2.3 Assessing the freshness, chilling and butchering of fish

Freshness of fish is usually judged in the trade entirely by appearance, odour and texture of the raw fish. Since assessment depends upon the senses, these factors are known as sensory or organoleptic. The most important things to look for the freshness of fish are:

1. The general appearance of the fish including that of the eyes, gills, surface slime and scales and the firmness or softness of the flesh.

2. The odour of the gills and belly cavity;

3. The appearance, particularly the presence and absence of discoloration along the underside, of the backbone.

4. The presence or absence of rigor mortis or death stiffening;

5. The appearance of the belly walls.

2.3.1. **Chilling of fish:** Chilling and butchering: Chilling and butchering are the most technical aspects of handling practices of fish. Harvested fish must be immediately stored in a low-temperature environment such as ice or refrigerated seawater. This chilling process slows the growth of microorganisms that live in fish and inhibits the activity of enzymes. Because fish have a lower body temperature, softer texture, and less connective tissue than land animals, they are much more susceptible to microbial contamination and structural degradation. If immediate chilling is not possible, then the fish must generally be sold and eaten on the day of the harvest.

Ice cooling and holding normally requires a one-to-one or one-to-two weight ratio of ice to fish, depending on the specific geographic location and the time it takes to transport the fish to the processing plant.

Refrigerated sea-water as cooling technique causes less bruising and other structural damages to the fish than using ice cooling. However, fish cooled in refrigerated seawater absorbs salt from the water. For this reason fish that is destined for sale on the fresh or frozen market may be held in refrigerated seawater for only a limited amount of time. The addition of salt during canning or smoking processes is adjusted in order to compensate for any absorbed salt

2.3.2 Butchering of fish

The butchering of fish involves the removal of nonedible portions such as the viscera, head, tail, and fins. Depending on the butchering process, as much as 30 to 70 percent of the fish may be discarded as waste or reduced to cheap animal feed. The lower figure applies when the fish is canned or sold as "whole." The higher figure applies when the fish is filleted or made into other pure meat products; in these cases the skeleton is discarded with as much as 50 percent of the edible flesh attached. Efforts to utilize this discarded fraction for the production of alternative food products have begun in the fish industry.

Self- assessment exercise 1

1. Refrigerated sea-water as cooling technique ……..
2. The butchering of fish involves the removal of ………….

2.4 Final processing of fish

The four basic procedures used in the final processing of fish products are heating, freezing, controlling water activity (by drying or adding chemicals), and irradiating. All these procedures increase the shelf life of the fish by inhibiting the mechanisms that promote spoilage and degradation. Each of these procedures also has an effect on the nutritional properties of the final product.

2.4.1. Heating.

This comprises the following treatments: cooking, canning**.** Heat treatment can significantly alter the quality and nutritional value of fish. Fish is exposed to heat during both the cooking process and the canning process. **Cooking**: Fish is cooked in order to produce changes in the texture and flavour of the product and to kill pathogenic microorganisms. Heating fish to an internal temperature above 66 °C or 150 °F (i.e., pasteurization conditions) is sufficient to kill the most resistant microorganisms. The cooking time must be closely regulated in order to prevent excessive loss of nutrients by heat degradation, oxidation, or leaching (the loss of water-soluble nutrients into the cooking liquid). **Canning of fish:** The canning process is a sterilization technique that kills microorganisms already present on the fish, prevents further microbial contamination, and inactivates degradative enzymes. In this process fish are hermetically sealed in containers and then heated to high temperatures for a given amount of time. Canned fish can be stored for several years. However, sterilization does not kill all microorganisms, and bacterial growth and gas production may occur if the products are stored at very high temperatures.

Because the severe thermal conditions of canning cause the disintegration and discoloration of the flesh of many species of fish, only a few types of fish are available as canned products. The most common types are tuna, salmon, herring, sardines, and shrimp. The thermal processing does not have a detrimental effect on the high-quality protein of the fish. In addition, these species are often canned with their bones left intact. The bones become soft and edible, significantly increasing the level of calcium present in the fish product. Tuna is an exception; because of special handling considerations, the bones of tuna are removed prior to canning. Tuna is normally caught far offshore and must be frozen and held for some period of time prior to canning. During this freezing and holding period unsaturated fatty acids are oxidized, causing the tuna to become rancid. The rancidity is removed by precooking, and the bones are removed at this time in order to facilitate the cutting and preparation of the meat for canning.

2.4.3 Freezing

This comprises immediate cooling and rapid freezing**.** Of the many processing methods used to preserve fish, only freezing can maintain the flavour and quality of fresh fish. Freezing greatly reduces or halts the biochemical reactions in fish flesh. For instance, in the absence of free water, enzymes cannot react to soften and degrade the flesh. The three steps for freezing fish include immediate cooling and holding, rapid freezing, and cold storage. If fish is frozen improperly, structural integrity may be compromised because of enzymatic degradation, texture changes, and dehydration.Once fish is frozen, it must be stored at a constant temperature of −23 °C (−10 °F) or below in order to maintain a long shelf life and ensure quality. A large portion of fresh fish is water (e.g., oysters are more than 80 percent water). Because the water in fish contains many dissolved substances, it does not uniformly freeze at the freezing point of pure water. Instead, the free water in fish freezes over a wide range, beginning at approximately −2 °C (28 °F). The amount of remaining free water decreases until the product reaches a temperature of approximately −40 °C (−40 °F). Fish held below that temperature and packaged so as not to allow water loss through sublimation can be stored for an indefinite period. Unfortunately, there are relatively few commercial freezers capable of storing fish at -40° because of the tremendous variation in energy costs. Fish are therefore normally stored at −18 to −29 °C (0 to −20 °F), resulting in a variable shelf life ranging from a few weeks to almost one year.

: The rapid cooling and holding of fish at temperatures between 2 and −2 °C (36 and 28 °F) takes place immediately after the fish have been harvested, and this is called **immediate cooling**

The key to freezing is rapid reduction of the temperature to between −2 and −7 °C (28 and 20 °F). This temperature range represents the zone of maximum ice crystal formation in the cells of the flesh. If water in the cells freezes quickly, then the ice crystals will remain small and cause minimal damage to the cells. However, slow freezing results in the formation of large ice crystals and the rupturing of the cell membranes. When slow-frozen flesh is thawed, the ruptured cells release water (called drip) and many compounds that provide certain flavour characteristics of fish, resulting in a dry, tasteless product. Fish that passes through the zone of maximum ice crystal formation in less than one hour will generally have minimum drip loss upon thawing.

The Nigerian frozen fish industry and channel of marketing of the fish

The Nigerian frozen fish industry is based on the industrial fishery and chartered vessel landings. Shrimps by-catches occupy a potentially important position. Because the species are usually from different distant water fishing grounds, they often represent a mixture of local and exotic fish species. Marketing of fishes begins as soon as the vessels land and so, the post-handling operations constitute essential components of the marketing system. Factors influencing the intensity and efficiency of these operations include the location of cold stores and markets to be supplied in relation to the quay. While, for instance, some companies have direct access to docking facilities, many others discharge their catch in rented wharf. There has been an upsurge in the degree of mechanization in catch off-loading. Off-loaded fish in boxes are either arranged in cold rooms immediately after landing or loaded into trucks to be transported to the companies' main cold stores somewhere inland of the quays.

A clearly-defined system of frozen fish distribution is conducted through a chain of intermediaries who handle products at different levels. Cartooned fish are marketed either directly after off-loading from the vessel or after a period of storage in the cold-rooms. As soon as the product enters the distribution channel, it exchanges hands a number of times until the retail stage, when it is sold to the ultimate consumer. The frequency at which the product changes hands varies from company to company and from place to place. The sole distributors at the retail level are the women. They monopolize the marketing of frozen fish through a particularly powerful organization

Self-assessment exercise 2

1. Explain what is meant by **immediate cooling**
2. Explain clearly the defined system of frozen fish distribution in Nigeria

2.4.3 Controlling water activity (a_w)

Water activity is represented by the symbol $a_{w.}$ It is that amount of water present in a food that supports the growth of microorganism in that food. Its value is used to predict the type of microorganism that causes the spoilage of that food; because different microorganisms grow at different water activity values. Treatments involved in controlling water activity include: drying, curing and smolking

Reducing the water activity of fish inhibits the growth of microorganisms and slows the chemical reactions that may be detrimental to the quality of the fish product. The control of water activity in fish is accomplished by drying, adding chemicals, or a combination of both methods. **Drying:**

Fish drying carried out under ambient conditions and fish dehydration carried out artificially enhance the storage life of fish by decreasing its water content. In a drying process moisture content is reduced from about 80% to about 10% and may take several months. In cold climates, dried fish may last for several years with control of spoilage being due to control of microbial growth and enzyme activity by the low moisture content. The principal methods of drying, or dehydrating, fish are by forced-air drying, vacuum drying, or vacuum freeze-drying. Each of these methods involves adding heat to aid in the removal of water from the fish product. During the initial stages of drying, known as the constant-rate period, water is evaporated from the surface of the product and the temperature of the product remains constant. The final stages of drying, is known as the falling-rate period, the temperature of the product increases, causing water to move from the interior to the surface for evaporation. **Sun-drying:** In the Northern part of Nigeria, sun-drying as a means of preservation is the most important method. It takes advantage of the high ambient temperature and low humidity. In the lake Chad area, where a lot of fishes are sun-dried in the open, split fish is often dipped in approximately 8% Grammalin 20 solution before being exposed to the sun it is erroneously believed that this dip prevents insect infestation of the finished product. It must be stressed that this use of insecticide is dangerous and must be discouraged. The water content of the dried fishes ranged between 14-30% and no salt is used. *Clarius sp*. are often gutted, haphazardly cleaned, and then bent into a horse shoe manner, the shape being retained by means of a sharp stick that pierces through the caudal region and the head. This practice is presumably designed to prevent the crumbling of a well-dried product. the product is heavily smoked and attains a shining black luster. Bony fishes like *Tilapia sp*. are split asymmetrically in the longitude plain and sun dried. Big fishes such as *Gymorachus sp* . and *lates sp.* are chopped into lumps, smoked for a short time and then sun dries. This products is the traditional “banda” fish and is in great demand among fish eating communities. In the Kainji Lake area of Nigeria, *physalia sp.* and *Clupeids* are also sun dried. As for the latter, the fish is spread out on mats or polythene sheets in the open. They are then allowed to dry over a period of about 1 week with regular turning. Smoking is the commonest method of fish processing in the southern part of Nigeria, and they employ kilns of all forms and shapes. Among certain fishing communities where this technology, firing is usually aided by means of bellows. There is no general agreement about gutting. For instance, very big fishes are cut into chunks before smoking in certain parts; and within the same locality, they are not. Members if the catfish family are known to be smoked ungutted in some fishing villages.

The fish processors believe that gutting of fish is an economic waste. In Bendel state, small fishes are sometimes tied to neatly-woven frames and smoked as such. This prevents crumbling of the fish and improves drying pattern.

2.4.4 **Curing**

Curing reduces water activity through the addition of chemicals, such as salt, sugars, or acids. There are two main types of salt-curing used in the fish industry: dry salting and pickle-curing. In dry salting the butchered fish is split along the backbone and buried in salt (called a wet stack). Brine is drained off until the water content of the flesh is reduced to approximately 50 percent (the typical water content of fresh fish is 75 to 80 percent) and the salt content approaches 25 percent. In heavy or hard-cure salting, an additional step is taken in which warm air is forced over the surface of the fish until the water content is reduced to about 20 percent and the salt content is increased to approximately 30 percent. Most dry-salted fish products are consumed in warm, humid countries or in areas that have few means of holding products in refrigeration or cold storage. In pickle-curing, fish are preserved in airtight barrels in a strong pickle solution formed by the dissolving of salt in the body fluids. This curing method is used for fatty fish such as herring.

2.4.5 **Smoking**

Traditionally, smoking was a combination of drying and adding chemicals from the smoke to the fish, therefore preserving and adding flavour to the final product. However, much of the fish smoked today is exposed to smoke just long enough to provide the desired flavour with little, if any, drying. These products, called kippered fish, have short shelf lives, even under refrigeration, since the water activity remains high enough for spoilage organisms to grow.

The smoking process consists of soaking butchered fish in a 70 to 80 percent brine solution for a few hours to overnight, resulting in a 2 to 3 percent salt content in the fish. The fish are then partially dried on racks. As the brine on the surface dries, dissolved proteins produce a glossy appearance, which is one of the commercial criteria for quality. Smoking is carried out in kilns or forced-air smokehouses that expose the fish to smoke from smoldering wood or sawdust. In cold-smoking the temperature does not exceed 29 °C (85 °F), and the fish is not cooked during the process. Hot-smoking is more common and is designed to cook the fish as well as to smoke it. Two separate stages are involved in the smoking of fish. The fish is split and eviscerated and steeped in brine composed of 70-80% saturated salt solution. This reduces the water content of the fish and causes also the water surface layer proteins to coagulate. After treatment with brine, the fish si hung on racks in a kiln and exposed to smoke from burning wood. The tar and phenols from the smoke produces a desirable colour, flavour and odour while methanol provides a preservative effect.

(vi). Irradiating

Irradiation offers a means of pasteurizing or sterilizing a variety of food products. However, the use of this process has not been universally accepted throughout the food industry. Food irradiators utilize radioisotopes, such as cobalt-60 (^{60}Co) or cesium-137 (^{137}Cs), or electron beam generators to provide a source of ionizing radiation. The irradiation of seafood has been extensively studied since the 1950s. The pasteurization of fresh fish using low-level dosages of ionizing radiation may extend the shelf life of the product up to several weeks. The sensory and nutritional characteristics of the fish are unaffected at these low levels of radiation. Minced fish flesh is used in a wide variety of products. The largest volumes are extruded into formed patties for main dishes and sandwiches. The forming process involves combining the minced flesh with condiments and extruding the mix under pressure to produce the desired product, much like the formation of hamburger patties and sausages. The formed product may be battered and breaded in a final processing step. Other minced flesh products include nuggets and items used as hors d'oeuvres, fish chowders, and smoked fish sticks.

Self-Assessment Exercise 3

1. Why is it that kippered fish have short shelf lives, even under refrigeration?

2. The two treatments that make up heating of fish are ….. and …….

2.5 Preservation of fish

The preservation and processing of fresh water and marine fishes are largely dependent on the technology developed in any particular area. Once fishes has been preserved, further processing is less sophisticated than the various red meats industry process and its limited mainly to fresh frozen products, as well as smoked, salted, dried and some canned products. The principals involved in preservation include: scrupulous cleanliness and hygiene in handling the fish caught; immediate freezing to at least-10^0C; the freezing time not to exceed two hours; glazing to prevent drying; and storage of the frozen fish well below -16^0C

2.5.1 Salting

Salting reduces the moisture content and discourages the growth of micro-organisms which otherwise would cause decay. The process of salting involves interspersing salt between layers of piled, split fish. The pile of fish and salt is left for up to a month. The high concentration of salt outside the fish causes the liquor inside the fish to be drawn out by plasmolysis and when it does so, it drains away. This extracted fluid is called green cured a "pickle". This fish at this stage is called *green cured* and its water content has been reduced from 82% to about 54%. The green cured fish is next exposed on racks to dry in the sun and wind. It may also be hung up and dried over a coal fire.

2.5.2 Semi-preserves

The semi-preserves involve the treatment of raw fish with ethanoic acid or acid brine. The texture of the flesh becomes less elastic and the storage life is fairly limited since the concentration of ethanoic acid necessary to prevent microbial growth would make the product unpalatable. The European product roll mops is an example of a semi preserve. These products may be given a pasteurization to enhance their storage life. The acid conditions in these products contribute to their storage stability.

2.5.3 Canning

Canning softens the bones and renders them edible so they become a useful source of calcium. Fish is a good source of protein and iodine but the proteins are limited by the sulphur amino acids and contain relative surplus of lysine. The vitamin of greatest importance of fish is vitamin D in fatty tissues and this is stable to canning and subsequent storage cause negligible damage but there can be considerable extraction into the canning brine of source of fat, fat-soluble vitamins and bone minerals. These, are of course lost if the liquor is discarded

Self-assessment Exercise 4

1 State the major reason for salting fish

2 State the what canning does to the bones of fish

2.6 Summary

Handling of fish is all about preprocessing of fish. This operation prepares the raw material for final processing. It is often performed on shipboard or in a shore-based plant.

The retention of nutritional properties and product quality of fish is dependent on proper handling of the catch after it has been harvested from its aquatic environment.The students will be able to explain different handling operations on harvested fish. The handling of fish includes such operations as inspection, washing, sorting, grading, chilling and butchering of the harvested fish including the four basic procedures used in the final processing of fish products are heating, freezing, controlling water activity (by drying or adding chemicals), and irradiating. Ice cooling and holding normally requires a one-to-one or one-to-two weight ratio of ice to fish, depending on the specific geographic location and the time it takes to transport the fish to the processing plant. The thermal processing does not have a detrimental effect on the high-quality protein of the fish. Fish held below that temperature and packaged so as not to allow water loss through sublimation can be stored for an indefinite period. Unfortunately, there are relatively few commercial freezers capable of storing fish at -40° because of the tremendous variation in energy costs. Fish are therefore normally stored at −18 to −29 °C (0 to −20 °F), resulting in a variable shelf life ranging from a few weeks to almost one year. Marketing of fishes begins as soon as the vessels land and so, the post-handling operations constitute essential components of the marketing system. Factors influencing the intensity and efficiency of these operations include the location of cold stores and markets to be supplied in relation to the quay. Reducing the water activity of fish inhibits the growth of microorganisms and slows the chemical reactions that may be detrimental to the quality of the fish product. The control of water activity in fish is accomplished by drying, adding chemicals, or a combination of both methods. The smoking process consists of soaking butchered fish in a 70 to 80 percent brine solution for a few hours to overnight, resulting in a 2 to 3 percent salt content in the fish. The fish are then partially dried on racks. As the brine on the surface dries, dissolved proteins produce a glossy appearance, which is one of the commercial criteria for quality. Salting reduces the moisture content and discourages the growth of micro-organisms which otherwise would cause decay. Canning softens the bones and renders them edible so they become a useful source of calcium

2.7 Glossary

2.8 References/Further Readings

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2.9 Answers to Self-assessment Exercises

Answer to Self- assessment exercise 1

1. Refrigerated sea-water as cooling technique causes less bruising and other structural damages to the fish than using ice cooling

2. The butchering of fish involves the removal of nonedible portions such as the viscera, head, tail, and fins.

Answer to Exercise 2

1. : The rapid cooling and holding of fish at temperatures between 2 and −2 °C (36 and 28 °F) takes place immediately after the fish have been harvested, and this is called **immediate cooling**
2. A clearly-defined system of frozen fish distribution is conducted through a chain of inter-mediaries who handle products at different levels. Cartooned fish are marketed either directly after off-loading from the vessel or after a period of storage in the cold-rooms. As soon as the product enters the distribution channel, it exchanges hands a number of times until the retail stage, when it is sold to the ultimate consumer. The frequency at which the product changes hands varies from company to company and from place to place. The sole distributors at the retail level are the women. They monopolize the marketing of frozen fish through a particularly powerful organization

3. **Answer to Exercise 3.**

1. Kippered fish have short shelf lives, even under refrigeration, since the water activity remains high enough for spoilage organisms to grow.

2 Smoking and irradiation

Answer to Exercise 4.

1 **Salting** reduces the moisture content and discourages the growth of micro-organisms

2 **Canning** softens the bones and renders them edible so they become a useful source of calcium

UNIT 3 Fish products used as ingredients

Unit structure

3.1 Introduction

The processing of fresh water and marine fishes into various intermediate products are largely dependent on the technology developed in any particular area. Once fisheshas been preserved, further processing is less sophisticated than the various red meats industry process.

3.2 Learning outcomes

At the end of the lecture, the students will be able to understand the various food ingredients or intermediate products derived from processing fish

3.3 Products obtained from whole fish

3.3.1 Minced fish flesh

The success of *surimi*-based products has stimulated the development of other products made from minced flesh. Minced fish products do not undergo the repeated washing cycles necessary for the production of *surimi*. Because of the presence of residual oils and sarcoplasmic enzymes (both oil and sarcoplasmic proteins are removed during the washing of *surimi*), cryoprotectants must also be added to the minced flesh prior to freezing in order to protect the product from oil oxidation and enzyme degradation. Surimi was developed in Japan several centuries ago when it was discovered that washing minced fish flesh, followed by heating, resulted in a natural gelling of the flesh. When the *surimi* was combined with other ingredients, mixed or kneaded, and steamed, various fish gel products called *kamaboko* (fish cakes) were produced and sold as *neriseihin* (kneaded seafood).

Modern *surimi* production consists of continuous operating lines with automated machinery for heading, gutting, and deboning of the fish; mincing, washing, and pressing (to remove water); and heating of the flesh. The *surimi* is then mixed with cryoprotectants and frozen for cold storage. Frozen *surimi* blocks are shipped to processing plants that produce various *kamaboko* products such as original *kamaboko* (*itatsuki*), broiled *kamaboko* (*chikuwa*), fried *kamaboko* (*satsumage*), and analog products, including imitation crab, scallops, and shrimp.

The chemistry of the *surimi* process involves the differential extraction of muscle proteins. The water-soluble sarcoplasmic proteins are removed during the washing of the minced flesh. These proteins inhibit the gelling properties of the minced flesh. The flesh is then comminuted with salt, which solubilizes the myofibrillar proteins actin and myosin. Upon heating, the myofibrillar proteins form a network structure that takes on a gellike consistency. Cryoprotectants are necessary to stabilize the myofibrillar protein network during frozen storage.

3.3.2 **Fermented fish products**

A number of fermented fish products are prepared in regions of the world. In general the fish is mixed with a certain amount of salt and allowed to ferment. The Vietnamese product nuoc mam is one such product. A range of fish sauces are prepared in a number of countries.

Fermented fish products in Asia are generally salt-fermented products: fish sauce, fish paste, and cured fish. When the salt concentration is higher than 20% of the total weight, growth of pathogenic and putrefactive microorganisms can be prevented. In this case, the products do not need other preservative means. The first criterion for classification in this group is the degree of hydrolysis, which is influenced by fermentation time and temperature, added enzyme sources, and the water content. The fully hydrolyzed liquid is defined as fish sauce. The cured fish is confined to represent the partially hydrolyzed fish products that retain the original shape of fish in the exuded liquid, and this form is frequently used as a side dish for rice meals. Fish paste is characterized by partially dried salted fish, which restricts the degree of hydrolysis and produces a homogeneous and solid condiment. Each type can be further subdivided by the type of raw materials, such as fish species, portion of fish, etc.; accordingly, numerous products can be named. In Korea, more than 30 products are included in the category of cured fish.

When the salt concentration is lower than 20%, the salted fish undergoes rapid spoilage, and other means of preservation is needed. Lactic fermentation by the addition of carbohydrate is an old method for fish preservation in low-salt processes. Rice, millet, flour, and even syrup (or sugar) are used as the carbohydrate source. The amount of added carbohydrate and the salt concentration primarily control the extent of acid fermentation and maintain quality. An alternative method keeps the low-salt fermented fish with vinegar at low temperatures. This method is practiced widely in the Scandinavian countries. Many Asian countries produce salt-cured and dried-fish products, for example, *Plakem* in Thailand, *Jambalroti* in Indonesia, *Maldive fish* in Sri Lanka, and *Gulbi* in Korea, but the role of fermentation in these products is not fully understood.

Fermented fish products can be divided on the basis of the enzyme hydrolyzed versus the microbial fermented. The products are subdivided into four groups depending on the enzymatic hydrolysis: (1) hydrolysis in >20% salt, (2) hydrolysis in salt+drying, (3) hydrolysis at low temperature, and (4) hydrolysis at low pH. The products preserved by microbial fermentation are subdivided into two groups: (1) fermented with added carbohydrate and (2) fermented without added carbohydrate.

The major potential hazard associated with proteinaceous foods, such as fermented fish, is from the growth of pathogenic bacteria such as *Vibrio* spp., presence of parasitic worms, and the production of physiologically active amines. Of particular concern for unheated foods in anaerobic conditions is the possible growth of *Clostridium botulinum* and its toxin production.

It is evident that neither the high-salt nor the low-salt lactic fermented fish products will cause the growth of any pathogenic bacteria once they are prepared with the appropriate salt content and/or low pH. However, the improper storage of raw fish before salting and insufficient acid production in a very low-salt fermentation can cause an outbreak of botulism. The botulinum toxin is destroyed relatively easily by cooking, but it is very stable in salty and acidic environments. The fermented fish products most frequently incriminated in *C. botulinum* type E poisonings are *Sushi* (a type of *Narezushi*) and *Kirikomi* (a type of Shiokara) in Japan, and salmon egg cheese (fermented crushed salmon roe) among British Columbia First Nation Peoples and Alaska Indians.

The physiologically active amines, such as histamine formed by the bacterial decarboxylation of histidine, may be produced in amounts sufficient to cause poisoning in certain fishes. *Jeot-gal* is the generic name of high-salt fermented fish products, which are used not only for side dishes but also for additives in making *Kimchi*. *Jeot-gal* contains large amounts of precursor amino acids of biogenic amines because it is made from the muscles and viscera of seafood and salts. It is therefore important to reduce the biogenic amine content. Several studies suggested that the addition of garlic and glycine can inhibit amino acid decarboxylase activity in *Myoelchi-jeot* (made of anchovies). In fact, the cadaverine and tyramine contents were reduced by up to 18.4% and 30.9%, respectively, in the culture treated with garlic extract. Glycine has the greatest inhibitory activities on biogenic amine production. The contents of putrescine, cadaverine, histamine, tyramine, and spermidine were reduced by 32.6%, 78.4%, 93.2%, 100%, and 100%, respectively, compared with the control. Therefore, there is no doubt that these findings can help improve safety. Nowadays, many people are trying to reduce sodium intake because they are paying attention to their health and well-being. Keeping this in mind, companies are investing in cooling systems to produce refrigerated products with less salt. Following the HACCP, plan for liquid fermented anchovy is based on products that are produced not in a cooling system but in a traditional way (Figure 4). The possibility of pathogen growth results in a CCP at the pasteurization step (CCP-1B). Sufficient bottle washing is required to eliminate debris inside the bottle (CCP-2P). Proper filling and a packaging system (CCP-3B) are essential to prevent decomposition and microbial contamination due to poor sealing.

3.3.3 Fish Protein Hydrolysate

Fish Protein Hydrolysate is similar to FPC except that the oil and water has not been removed. To achieve this, fish protein is sometimes enzymatically hydrolyzed using a combination of enzyme and acid so that the bone can be more easily removed.

3.3.4 Fish Silage

Fish silage is conserved fish waste made up of reads, spines (franics), trimmings and offal, which has been finely chopped and dosed with a small amount of formic acid followed by thorough mixing. The acid is used to create an environment in which spoilage bacteria cannot function, allowing the enzymes in the offal to digest the tissue of the fish. After a period of five to ten days, depending on the temperature of the silages the protein will have fully liquefied, making a product with a considerably long shelf life. The advantage of conserving fish waste in this way is that it enables smaller fish producers to store their waste until they have sufficient volume to make transporting it to a central processing plant economical. Fish silage in reprocessed by heating and subjecting the silage to high velocity separation and centrifuging. This splits out into ‘slick’ water, oil and protein liquor. Further processing polishes the oil to produce a high quality material for further processing into finished products. The ‘slick’ water and protein are put through an evaporation process to drive off more water, ending up at about 35% protein, 4% oil concentration called marine protein concentrate (MPC) or fish protein concentrate (FPC).

3.3.5 Fish Fillet

Fish fillets consist of flesh cut away from the backbone of skinned and gutted fish. They are fully edible products of the highest quality being almost or entirely free of bones. To fillet a fish is simply to cut the flesh away from the bones and the skin. It is a popular method of preparing fish for meals. With practice and proper knife, filleting is really easy. The end product is a boneless and skinless piece of fish ready to be cooked. The production of fish fillet involves a number of steps: pretreatment, filleting, grading, packaging and storage: Pretreatment involves trimming of loose scales, fins, etc; de-heading; and grading according to the required sizes. After pretreatment, the fish is filleted. This is usually done by mechanical filleting machines but in some processing industries, fish are hand filleted. The machines used for production of fillet consist of cutting knives which cut the flesh from the backbone and cut the collarbone; skinning of the flesh is done at a stage. White fish such as hake cod and haddock has soft white flesh and thus make it easy to fillet. After the above processes, the fish fillet is processed into different types of end products. This is done as per customer’s requirements. The fish fillet coins, fish fillet tail, etc. it is then packed individually in blocks and kept in cold stones.

Self-assessment exercise 1

1. *kamaboko* in Japan is referred to **……….**

2. Growth of pathogenic and putrefactive microorganisms can be prevented when the salt conc. is above …..%

3. What is the difference between Fish Protein hydrolysate and Fish protein concentrate?

4. ………consist of flesh cut away from the backbone of skinned and gutted fish

3.4 Products obtained from defatted fish

After the removal of fat from fish, the defated raw material canbe utilized in the production of protein rich flours majorly fish protein concentrate and fish meal

3.4.1 Fish protein concentrate (FPC)

Fish protein concentrate, or fish flour, is accepted as human food and not animal food. Fish meal is not accepted as human food. Fish meal is not accepted as human food because of its comparatively for flavour stability, in general requiring antioxidants for flavour maintenance, its odour and also the fact that many countries will not permit the sale of foods made from “unwholesome” raw materials, e.g. fish guts. In addition the use of formalin makes fish meal unacceptable as a human food.

One way of supplementing the nutritional deficiency of a cereal diet leis in eating meat, fish, eggs and dairy products which supply high quality protein. However 60% of the World population cannot afford these products, nor could the world supply enough of these to feed its entire population. Thus the problem resolves itself into finding an inexpensive way of fortifying such products as bread and other cereal good with cheap, high quality protein, preserved and stabilized to retain its nutritive quality. Fish protein concentrate meets the desired requirements whereas, with the possible exception of non-fat milk powder, no other dry animal protein in commercial sue can achieve its low and high nutritive value.

3.4.2 Fish Protein Concentrate (FPC)

Fish protein concentrate is any stable fish preparation, intended for human consumption, in which the protein is more concentrated than in the original fish. The Food and Agriculture Organization (FAO) of the United Nations defines three types:

Types A: Virtually colourless and tasteless powder having a maximum total fat content of 0.75%

Types B: a powder having no specific limits as to odour or flavour, but definitely having fishy flavour and a maximum fat content of 3%

Type C: normal fish meal produced under satisfactorily hygienic conditions.

In a sense, these three types resemble fish meal but there are other fish protein concentrations (FPC) which are totally unlike fish meal. These are typically made by hydrolyzing fish protein by means of enzymes or other chemicals and then concentrating the product into a paste or extract.

The fat content is specified when defining types of FPC because fat, when oxidized, can produce a strong, often rancid, taste in the product. The protein content of FPC depends on the raw material used and the extent to which water has been removed, but the products normally contain at least 65% protein, and in products normally contain at least 65% protein, and in type A, up to 80% protein.

The raw material for FPC can be fresh fish of almost any kind or size or fish meal. The care taken of the fish o the fishing vessel should be at least equal that given to fish for ordinary consumption. It should normally be stored in ice immediately after capture, and the factory should start processing it within at the most 48 hours and preferably within 12 hours of landing. Storage of the raw fish in ice for up to 8 days after capture does not affect the nutritive value of the FPC.

In some areas of the world's ocean, there are large stocks of unexploited fish, and these might well be used to make FPC. In any large-scale operation, FPC would be in direct competition with the fish meal industry for its raw material. Also, FPC can be prepared from any type of fish or fishes waste. It is prepared from fish by extracting out the oil, screening or settling out the bones and drying so that the resulting product (FPC) is higher in protein (85-95%) and lower in ash content than fish meal. The particle size of the FPC is smaller and also uniform in colour and texture than that of fish meal. Due to the processing lost associated with producing this product, it is more expensive than fish meal and is usually only used in human application or for very specialized applications primarily in bent ik, replace since its oil content is low, the problem of fishery loss occurring in the edible portion is less.

3.4.3 Fish meal

Fish meal can be defined as a solid product obtained by removing most of the water and some or all of the oil from fish or fish waste. In the UK, the fish meal means a product obtained by drying and grinding or otherwise treating fish or fish waste to which no other matter has been added.

Virtually any fish or shellfish in the sea can be used to make fish meal, although there may be a few rare unexpected species which would produce poisonous meal. Based on the type of raw material, Fish meal can be classified into two basic types.

1. Fish meal from fishery waste that are associated with the processing of various edible human fishery products and by-products associated with fish or production.
2. Fish meal from industrial fishery, i.e. where fish catches are solely for the fish meal industry. Heron specific fish (herring, menhaden, Pollack, etc) are harvested just for the purpose of

producing fish meal. Most of the world's fish meal is made from whole fish; the pelagic species are used most of this purpose.

The following points are important when selecting species for an industrial fishery:

a. The species must be in large concentration to give a high catching rate, this is essential because the value of industrial fish in less than that for direct human consumption.

b. The fishery should preferably be based on than one species in order to reduce the effect of fluctuation in supply of any one species.

c. The total abundance of long lived species varies less from year to year.

d. Species with a high fat content are more profitable because the fat in fish is held at the expense of water and not at the expense of protein.

There are several ways of manufacturing/producing fish meals from raw fish:

(i) Sun drying method which is the simplest and which is still used in some parts of the world where processing plant are not available. However, the product is poor in comparism with ones made by modern methods.

(ii) The most well known heat transfer method (HTM) developed in USA, in which oil added to slurry of the raw material acts as a heat transfer medium.

(iii) The presses method in which water and oil removed by use of screw press. The use of this method is increasingly favoured and there are main reasons:

(iv) Centrifugation method in which presses are replaced by centrifuges.

(v) Solvent extraction method in which oil is removed by solvent extraction.

Almost all fish meal is made by cooking, pressing drying and grinding the fish in machinery designed for the purpose. Although the process is simple in principle, considerable skill and experience are necessary to obtain a high yield of high quality product, and to make the plant efficient.

Cooking: When fish are cooked and the protein is coagulated, much of the water and oil runs off, or can be removed by pressing, whereas raw fish lose very little liquor even under very high mechanical pressure. A commercial cooker consists essentially of a long steam jacketed cylinder through which the fish are moved by a screw conveyor. Some cookers also have the facility for injecting steam into the cooking material.

The cooking operation is critical if the fish are incompletely cooked, the liquor cannot be pressed out satisfactorily, and if overcooked the material becomes too soft for pressing.

Pressing: This stage of the process removes some of the oil and water. The fish are conveyed through a perforated tube whilst being subjected to increasing pressure. A mixture of water and oil is squeezed out through the perforations and the solid, known as press cake, emerges from the end of the press. During the pressing process, the water content may be reduced from about 70% to about 50%, and the oil content reduce to about 4%.

In the UK, where white fish offal are the main raw materials, the pressing is not essential since material contains only small amount of oil. While fish meal can be produced by a simple process of cooking and drying only,

Drying: There are two main types of dryers, direct and indirect dryers. In the direct dryer, very hot air at a temperature of up to 500^0c is passed over the material as is tumbled rapidly in a cylindrical drum. This is a quicker method but heat damage is very much likely, the process is not carefully controlled. The meal does not reach the temperature of the hot air because rapid evaporation of water from the surface of each particle of fish causes cooling. Normally, the product temperature remains at 100^0C.

The most usual type of indirect dryer consists either of a steam jacketed cylinder or a cylinder containing steam heated disc which also tumble the meal.

Although basically a simple operation, considerable skill is required to get the drying conditions just right if the meal is under dried, moulds or bacteria may be able to grow; if it is over-dried, scorching may occur and the nutritional value of the meal will reduce much of the unpleasant odour from fish meal originate from the dryers. Indirect dryers, which are normal, used in UK, cause fewer nuisances because they use less.

Grinding and Packing: The final operation of grinding to break down lumps and particles of bone, and packing the meat into bags or storing it in sales for bulk delivery. The importance of fish meal can best be judged by the fact that some 30% of the world catch of fish ends up ad fish meal. Peru, U.S.A. and Japan are the major producers of fish meal.

3.4.4 Differences between Fish meal and Fish protein concentrate

Fish meal is a fish protein concentrate (FPC), but the term FPC usually means a material suitable for human consumption. Fish meal prepared under hy gienic conditions can be FPC in this sense, and small amounts made from white fish meal have been sold for incorporation in other foods. The specification for some types of FPC demands a very low fat content and in some plants it is possible to treat the press cake or the fish meal with a solvent to extract the fat from the raw material rather than from the finished meal when making FPC of law fat content.

Fish meal as produced throughout the world, therefore, is a very cheap potential FPC but not intended for human consumption. It is used for making pig and poultry feeds. Ordinary fish meal is unsuitable for human consumption for three reasons:

1. It is not normally made under sufficiently hygienic conditions to rule out the risk of occasional contamination by disease-causing bacteria

2. It usually contains rancid fat which destroys certain vitamins and may lower the nutritive value of the protein. A fish meat diet may precipitate vitamin deficiency in poorly nourished people. Moreover, the flavour of the rancid fat is unacceptable in many societies, though not all.
3. There is a slight risk that the rancid fat may have a cumulative toxic effect if consumed over a long period.

   The first of these reasons is the most important. Thus, fish meal made under hygienic conditions is called FPC type C.

Uses of Fish Meal

Fish meal in the UK was used as a fertilizer but its high nutritional value has been far better utilized in animal feeding. Hence, in some parts of the world, it is often the primary supplemental protein source that is fed to livestock because plant derived sources are either unavailable or are too expensive. It has been widely used for many years as supplemental protein source for monogastric animals (eg. Poultry, etc) but more recently it is being used more for ruminant animals.

A very small amounts of specially processed meals have been used in prepared foods for humans, and fish meal is also used in the preparation of certain antibiotic for the pharmaceutical industry

Quality expected of fish meal

Freshness of fish being processed into fish meal in highly correlated with the quality of the resulting fish meal. if fish has been allowed to degrade prior to processing, the fish meal will be of lower quality. fish meal prepared from materials that have been allowed to degrade prior to processing can contain high level of histamine and can be toxic. Elevated histamine. (1000 ppm) can cause gizzard erosion and black vomit in poultry.

The crude protein, ash, either extract, etc of fish meal can vary depending on the raw material or substrate and the method used to prepare the meat fish meal made from whole fish, but a high portion of small whole fish in the raw material can have the same effect.

The value of protein from vertebrate fish differs little from one specie to another, whole shellfish would, however, give a nutritionally poorer meal because of the lower protein content of the shell. Amino acid quality of fish is excellent but excessive heating during the drying process can reduce digestible of the protein fraction whereas some amino acids from complex so that they are not available.

The oils associated with fish meal are highly unsaturated and are oxidized easily. Hence, fish meal made from fatty fish shows gradual decrease in fat content unless antioxidants are present. this is because the fats slowly oxidize during storage and become relatively in soluble in common organic solvents. oxidized fat is less valuable nutritionally because the animal cannot utilize it for its energy needs. moreover, the heat generated as fish oil reacts with atmospheric oxygen (during oxidation)may damage the meal nutritionally and on occasion, cause the meal to catch fire . This is now a rather rare occurrence, due to widespread use of antioxidant. The most commonly used antioxidant is ethoxyguin; the amount used varies but is normally in the range of 200-1000 mg/kg

3.4.5 Fish meal production

Fish meal is produced from a number of raw materials which include: skeletal remains of filleted fish, fish cannery waster, fish offal, whole fish generally regarded as inedible, some varieties of herring, pilchards and many very small fish. Shark may also be used, and such large fish are cut into small pieces before processing. Fish meal finds its main, almost exclusive, use as an animal feed supplement with particular application to poultry and pigs, or as a soil fertilizer.

The levels of usage of fish meal in the feed vary, but 2%-10% is the range normally encountered. In general, higher levels of the meal are fed when starting the animals, with reduced levels when finishing. This is done because consumption of high levels of fish meal just prior to slaughter can cause “fishy” flavours in the animals flesh. Also the use of high levels of fish meal in poultry diets has caused fish flavours in eggs.

Fish meals is of particular value because of its high content of essential amino acids, especially lysine. This makes fish meal of special value in combination with cereal feeds which are low in lysine content. In addition fish meal provides vitamins and minerals not provided by cereal grains or plant protein supplements

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Grinding and Packing: The final operation of grinding to break down lumps and particles of bone, and packing the meat into bags or storing it in sales for bulk delivery.

Fish Meal by- Products

The liquor from the presses is screened to remove coarse pieces of solid material, and centrifuged to remove the oil. The oil is sometimes further refined in a final centrifuge, a process known as polishing, to storage tanks. The refined oil in valuable and is used in the manufacture of edible oils and fats such as margarine.

The water or aqueous portion of the liquor, known as ‘stick’ water, contains dissolved material and fine solids in suspension which may amount to about 90 % by weight. The solids are mostly protein and stick water can contain as much as 20% of total solids in the fish so that it is normally well worth recovering. The material is recovered by evaporating the stick water to thick syrup containing 30-50% solids, and sometimes marketed separately and known as condensed fish soluble. However, the concentrated product is added back to the press cake and dried along with it to make what is known as whole meal.

In Nigerian, fish processing is basically in the hands of the artisanal fisherman. In response to an increased demand for "ready-to-eat" fish products, along with a growing awareness of the limited supply of natural fish stocks, the fish industry has developed procedures for more efficient utilization of available raw materials. Because as much as 70 percent of harvested fish has traditionally been discarded or converted into cheap animal feeds, initial efforts to conserve fishery resources have focused on the development of edible products from underutilized species.

Self-assessment exercise 2

1 State the differences between categories A, B and C of fish protein concentrates 2 List the materials from which fish meal can be produced from …..

3.5 Spiced fish products

3.5.1 Production of salted-smoked Fish

Product Description: Fish salting, drying and smoking are the choice of fish processing technologies particularly suited for small-scale producers.

The product is usually a dry, brown, leathery fish that has a salty taste and a characteristic flavor.

It has a shelf-life of several weeks or months when stored correctly. It is a valuable product which has a high domestic demand.

Raw Material

The most important factors which affect the suitability of fish for salt-smoking process are oil content and flesh texture. Very small fish may be dried whole; larger fish must always be cut or filtered so as to increase the surface area available for salt penetration and/or moisture loss. However fish for processing must be fresh and devoid of putrid odors.

Preliminary processing

Preliminary process of fish usually consists of the following steps or unit operations: evisceration, beheading (optional) scaling cutting of fine and belly flaps, slicing of whole fish into steak, filleting, and different combination of these. As a result of the preprocessed fish are obtained.

- Whole fish
- Gutted fish without head
- Gutted fish without head fins
- Sliced whole fish after beheading and evisceration
- Fillet without ribs, with or without the skin
- Fillet without ribs

Any of these could form the raw material for production of salted, smoked fish.

Equipment

- Smoking kiln
- table with smooth surface,
- cutting knife,
- plastic buckets and
- basins.

The Process

Saturation of raw materials with wood smoking is the main principle of the smoking process. During this process, some water is removed from the tissue and changes of proteins occur. The smoked fish is ready for consumption without further culinary treatment.

There are two methods of fish smoking; hot and cold, which give very different products. The difference lies in stability and sensory properties which in turn depend on degree of fish dryness and saturation with smoke components.

Smoke is produced by partial burning of some type of hard wood and is a mixture of more than a hundred chemical components.

During the smoking process sensory features such as color of properly smoked fish depends on the quantity and composition of the smoke components absorbed through the darker the color of the fish. The presence of antioxidants in smoke renders smoked products resistant to rancidity.

The hot-smoking process includes the preliminary processing of raw material, brining, drying to a certain loss of water content, the actual smoking process and thermal treatment at temperatures usually 70-80^{o}C.

The cold-smoking process involves no thermal treatment, and the entire process is carried out at temperatures below 30^{o}c.

Bringing is carried out to ensure penetration of about 2% salt into the fish tissue; the salt gives the desired taste to the product.

Brining or salting

During hot-smoking, brining is carried out to ensure penetration of about 3% salt into the fish tissue. It is recommended to dip the intended for about 30 min. This results in a salt uptake of only 2-3% and produces a good gloss on the surface. For longer storage life, the use of more salt is required and levels of 8-10% salt or more in the finished product is not uncommon.

A fully saturated brine contains about 360g of salt to each liter of water, Full strength or saturated brine is called a 100o brine. A 10o brine with 9 parts of water is sometimes used to soak fish before salting.

- Prepare an 80% saturated brine add spices e.g. onion extract, garlic extract and pepper (optional).
- Place fish in brine. Let it stand for 30-40min.
- Drain and dry on perforated trays.
- Hot smoke in 3 stages: Lower heat 25-55^{o}C for 30-60 min. Medium heat 80-110^{o}C for 40-50 min. For a kiln without temperature control, smoke for at least 5 hours.
- Cool and package.

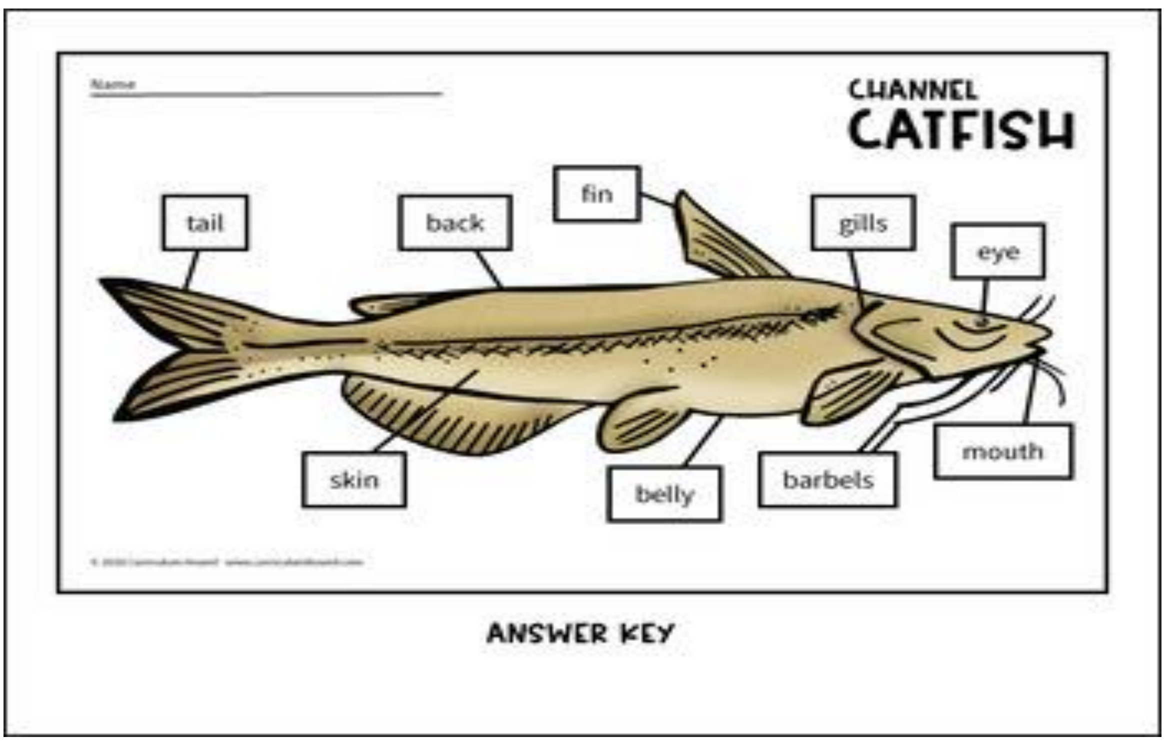

Fig. 3.4: Catfish

Process Notes

Raw Fresh fish

↓

Clean and fillet Cut the fish from tail to head through the stomach using a sharp knife. Wash with clean water.

↓

Mix salt and spices prepare 80% saturated brine solution. Mix with spice extracts.

↓

Cure Dry fillets in brine for 30-40 min.

↓

Smoke Place the salted-fish on the smoking racks in kiln in an orderly fashion. Smoke for at least 5 h.

↓

Cool At room temp

↓

Pack Package in polythene bags and seal

Process control

Adequate cleaning and preparation of the fish is to prevent contamination of the final product.

Correct smoking temperature and time: overheating causes excessive browning and under heating/inadequate time may result in incomplete drying and mould growth.

The main quality characteristics of the product are color, texting and flavor. These are each determined by the type of wood used to smoke the fish and the time and temperature of smoking. Packaging is needed to prevent contamination by dust and insects. Sealed polythene bags are suitable. The product should be stored in cool dry place.

All true fish and some crustacean and Mollusca muscle is typical striated muscle although, in each case, the cells are inserted into sheets of connective tissue, arranged in a complicated pattern which, on heating, break down and give rise to the characteristic flaky appearance of coagulated blocks (myotomes) of cells. Two main types of muscle exist- red or dark, and white, the former being disposed literally along the body in discrete strips or blocks between the skin and backbone. Different species of fish contain different proportions of red and white muscle, the latter generally predominating. In crustacean the blocks of striated cells are somewhat similarly segmented whilst in mollusks, the cells, which are predominantly of a specialized smooth type, run in a complex patter for much of the length of the muscle.

The major feature of the proximate composition of fish and shellfish is the great variability in lip content. Lean species contain typically 0.3-1.0% lipid, most of which is phospholipid and the remainder triglyceride, whereas the total amount in fatty species can be as much as 30%. In fatty species, the amount of lipid varies seasonally within a species and may fall to as low as 1%; these changes are accounted for entirely by changes in the proportion of triglycerides. As the amount of lipid increases, the amount of water falls in almost linear proportion, while the amount of protein remains fairly constant. In lean fish and crustacean, the amount of water is generally slightly greater than that in meat or chicken; in fatty fish of high lipid content it is often less. Several mollusks have a high water content. The proportion of protein, as in meat and chicken, is in most cases in the range of 15-18%, the remaining content of nitrogenous substances (1-3%) being made up of a multiplicity of low molecular-weight compounds.

The lipids of fish are amongst the most un-saturated of animal-muscle lipids. Whether phospholipids or triglycerides, they contain high proportion of polyunsaturated fatty acids which in most fish are very susceptible to oxidation by atmospheric oxygen during handling and processing. In some species, the presence of natural antioxidants retards this tendency. The immediate products of oxidation are hydroperoxides which readily break down to a series of carbonyls, several of which have rancid odours and flavours. Such reactions are among the reasons why fish is so perishable.

Fish and crustacean contain the normal types of muscle proteins. Some mollusk muscles contain a special form of myofibrillar protein known as paramyosin. The proportion of connective tissue proteins is lower than in meat, being 3-5% of the total proteins in many species and 8-10% In stock-fish. This is likely to be one of the reasons why fish is much more tender than meat. To the food scientist and technologist, the special feature of the main fish-muscle proteins, including enzymes, is their instability vis-à-vis their meat counter parst. Thus, fish myosins, either when isolated or when in the intact tissue, denature much more rapidly than beef or chicken myosins kept under the same conditions. Also the thermal shrinkage or denaturation temperatures of fish connective tissue collagen are not richly insulated and therefore the concentration of blood chromo proteins is lower than that, the concentrations of myoglobin are very low and moderate, respectively.

The array of low molecular-weight compounds in fish and shellfish is, in general, typical of any muscle. of particular note are the high concentration of triumethyamineoxide (TMAO). This compound is of considerable significance as an odour precursor in that it is reducdes by spoilage bacteria or otherwise degraded during processing to trimethylamine (TMA), dimethylamine (DMA) and monomethylamine (MMA). TMA is a prominent contributor to the odour of stale fish.

3.5.3 Fish Spoilage

Freshness and spoilage are two qualities that have to be clearly defined. A fresh product is defined as the product whose original characteristics remain unchanged. Freshness is the property of fish that has a considerable influence on its quality. It is the most important single criterion for judging the quality of the majority of fish product. Loss of freshness followed by spoilage is a complex combination of microbiological , chemical and physical processes.

Spoilage is the degradation of food such that the food becomes unfit for human consumption. Food can be spoiled by a number of means including physical, chemical, enzymatical and microbiological. However, the most prevalent cause of food spoilage is microbial growth and residence in the food. Spoilage, therefore, is an indicative of postharvest change. This change may be graded as the change from absolute freshness to limits of acceptability and unacceptability.

Fish spoilage is usually accompanied by change in the following physical characteristics: change in colour, odour, texture, colour of the eyes, colour of the gills and softeness of the muscle. With regard to smell or odour, spoiled fish will generally have a fishy, sour or ammonia-like stench. Appearance-loose, spoiled fish may appear to be dry or mushy in certain areas and the grills may have slime. Typically, spoiled fish will also have a green or yellowish discolouration which arises not from the spoilage metabolites but rather oxidation of the oxygen transporter in the fish-myoglobin and metamyoglobin- during frozen storage from prolonged or unnecessary exposure of fish to any spoiled fish will also have flesh that is soft, or does not spring back when pressed upon. The spoilage process of fish starts immediately after the death of fish. The process involves three stages:

1. Rigor Mortis
2. Autolysis

3. Bacterial invasion an putrefaction

Spoilage factors of fish

Through the action of enzymes, bacteria, chemicals present in fish, and physical phenomenon, the following factors contribute to spoilage of fish:

- High mixture content
- High fat content
- High protein content
- Weak muscle tissue
- Unhygienic handling

Enzyme Action

The rigor mortis is a physical effect on the muscle tissue of fish caused by chemical changes following the death. In live fish, the glycogen present in the muscle is converted to CO_2 and H_2O after supply of O_2 to the cells. After the death of fish, the blood circulation stops and the supply of O_2 ceases. The enzymes present in the muscle convert glycogen into lactic acid. The pH of fish muscle falls. The formation of lactic acid continues until glycogen is completely depleted. The process is known as rigor mortis.

After the completion of rigor mortis, muscle stiffness gradually decreases accompanied by increase in pH, leading to softening of muscle. This is followed by breakdown of proteins by enzymes. This is called autolysis. Thus, autolysis can be described as an internal breakdown of the structure of the protein and fat due to a complex series of reactions by enzymes. Autolysis of protein starts immediately after rigor and creates favourable conditions for the growth of bacteria.

Another important action of the enzyme is that it affects the flavour of fish. The component responsible for the taste and flavour of fish are changed by the enzymatic action such as the progressive degradation of ATP to AMP and hypoxanthine. Hypoxanthine is produced by the breakdown of ATP which is the main component of fish muscle nucleotide. The accumulation of hypoxanthine imparts bitter taste in the fish muscle accompanied by loss of fresh fish flavour. Thus, the estimation of hypoxanthine indicates the degree of freshness.

Enzymatic action also causes decomposition in the fish known as belly bursting, This is caused by the action of digestive enzymes present in the gut of the fish. The black spot formation in shrimps is also caused by the action of the enzymes on the amino acid. The black colour is due to the formation of melanin (black pigment) by the action of tyrosinase on tyrosin present in the shrimps. Black spots present a poor appearance which is not acceptable.

Bacteria Action

The freshly caught fish is almost free from bacteria but the surface slime, gills and intestine may contain considerable load of bacteria when the fish is dead, these bacteria start attacking the flesh causing spoilage and produce undesirable compounds. The nature and type of bacteria present in flesh depend upon the water from where it is caught and methods used in handling the fish after catch. Compared to after foods, fish is unique as a substrate for microbial growth. This uniqueness stem from several important factors:

- The poikilotherm nature of fish
- A high post mortem pH in the flesh (typically greater than 6.0)
- The presence of non-protein nitrogen (NPN) in large quantities

- The presence of trimethylamine oxide (TMAD)

The poikilotherm nature of fish selects for bacteria that can thieve in a wide range of temperatures. For example, the microflora of temperate water fish is dominated by psychrotrophic gramnegative rod-shaped bacteria such as those found in genera pseudomonas and moraxella with only a varying proportions of Gram-positive organisms such as Bacillus.

High post mortem pH of fish flesh is caused by the fact that fish flesh is low in carbohydrate (less than 0.5%)in the muscle tissue and that only small amount of lactic acid are produced after death. This allows pH sensitive organisms such as *Shewanella prutrefacien* in seafood but not in other meat.

The NPN fraction of the fish flesh consists of low-molecular-weight, water-soluble nitrogen compounds particularly free amino acids and nucleotides that are readily available bacterial growth substrate. The spoilage of fish is influenced most by the presence of TMAO in conditions where oxygen is not present. Some anaerobic bacteria are able to utilize TMAO as the terminal electron acceptor in an anaerobic respiration process with TMA as the primary products.

The important changes brought about by the action of bacteria in fish are as follows:

i. Reduction of TMAO to TMA: The odourless TMAO, found in small percentage in marine fish is reduced to offensive smelling TMA. This contributes to the characteristics ammonia-like and fishery off- flavour in spoiled fish.

ii. The breakdown of amino acids and formation of amines: This is responsible for many off-flavour and off-odour typically found in spoiled fish. Examples include breakdown of cystein and methionine by certain microorganisms leading to the formation of hydrogen sulphide and methlymerceptone, respectively, from both sulphur containing amino acids; the formation of primary amines such as histamine from histridine, arginime from glutamic acid, etc. May cause food poisoning in extreme cases.

iii. Breakdown of Urea, found in high concentrations in flesh of some fish, to ammonia by the microorganisms is accompanied by an offensive odour.

Chemical Action

The chemicals present in living things are able to change due to their either splitting up or joining together. In both cases, new chemicals are formed. These changes are called chemical reaction. The most common chemical action which causes spoilage is the oxidative rancidity in fatty fishes. This is due to unsaturated fatty acids which are reactive with oxygen and then to the autoxidation. The primary oxidation product, **the peroxide,** is odourless and flavourless. The secondary oxidation products which comprise the aldehydes, ketones, short chain fatty acids, etc. have very unpleasant odours and flavours. These chemicals in combination yields the fishy and rancid character associated with oxidized fish lipid.

Self-Assessment Exercise 3

1 The most important factors which affect the suitability of fish for salt-smoking process are ….. And ……….

2 List the factors that contribute to spoilage of

3 Name the three spoilage processes of fish

3.6 Summary

Minced fish (Surimi) was developed in Japan several centuries ago when it was discovered that washing minced fish flesh, followed by heating, resulted in a natural gelling of the flesh. When the *surimi* was combined with other ingredients, mixed or kneaded, and steamed, various fish gel products called *kamaboko* (fish cakes) Fish meal is produced from a number of raw materials which include: skeletal remains of filleted fish, fish cannery waster, fish offal, whole fish generally regarded as inedible, some varieties of herring, pilchards and many very small fish. During hot-smoking, brining is carried out to ensure penetration of about 3% salt into the fish tissue. It is recommended to dip the intended for about 30 min. This results in a salt uptake of only 2-3% and produces a good gloss on the surface. For longer storage life, the use of more salt is required and levels of 8-10% salt or more in the finished product is not uncommon. The following factors contribute to spoilage of fish: High mixture content, High fat content, High protein content, Weak muscle tissue and Unhygienic handling. The spoilage process of fish starts immediately after the death of fish. The process involves three stages: Rigor Mortis, Autolysis and Bacterial invasion an putrefaction

3.7 Glossary

Minced fish = Surimi

kamaboko = fish cakes

3.8 References/Further Readings

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3.9 Answers to self-assessment exercises

Exercise 1

Question 1. *kamaboko* in Japan is referred to **………. Fishcake**

Question 2 Growth of pathogenic and putrefactive microorganisms can be prevented when the salt concentration is above **…..% 20%**

Question 3 Fish Protein Hydrolysate is similar to FPC except that the oil and water has not been removed.

Question 4 Fish fillets consist of flesh cut away from the backbone of skinned and gutted fish

Exercise 2

Question 1. **Types A**: Virtually colourless and tasteless powder having a maximum total fat content of 0.75%

Types B: a powder having no specific limits as to odour or flavour, but definitely having fishy flavour and a maximum fat content of 3%

Type C: normal fish meal produced under satisfactorily hygienic conditions.

In a sense, these three types resemble fish meal but there are other fish protein concentrations (FPC) which are totally unlike fish meal.

Question 2. Fish meal is produced from a number of raw materials which include: skeletal remains of filleted fish, fish cannery waster, fish offal, whole fish generally regarded as inedible

Exercise 3

Question 1. The most important factors which affect the suitability of fish for salt-smoking process are **oil content** and **flesh texture**

Question 2. Through the action of enzymes, bacteria, chemicals present in fish, and physical phenomenon, the following factors contribute to spoilage of fish:

- High mixture content
- High fat content
- High protein content
- Weak muscle tissue

- Unhygienic handling

Question 3 The spoilage process of fish starts immediately after the death of fish. The process involves three stages:

1. Rigor Mortis
2. Autolysis
3. Bacterial invasion and putrefaction

MODULE 6

PROCESSING AND PRESERVATION OF POULTRY AND POULTRY PRODUCTS

UNIT 1 PROCESSING OF POULTRY MEAT

Unit structure

1.1 Introduction

1.2 Learning

1.3 Basic steps for processing poultry

1.3.1 Killing/Slaughtering (Removing the blood)

1.3.2 Removing the feather (scaling)

1.4 Taking the organs out or Evisceration

1.4.1 Steps for evisceration

1.5. Chilling, microbiology and preservation of poultry meat

1,5.1 Second washing

1.5.2 Preparing the ice water bath and technique for chilling

1.5.3 Microbiology of poultry meat

1.5.4 Preservation of poultry meat

1.6. Summary:

1.7. Glossary

1.8.. References/Further readings

1.9, Answers to Self-assessment exercises

1.1 Introduction

Chickens, turkeys, ducks, bush fowl, geese, guinea fowl or pigeons are all classified as poultry.

Edible meat varies from 34.4-39.1% for roast turkey, of which approximately 60% is light meal and 40% is dark. The yield of edible meat may be as low as 28.4% from chicken wings and as high as 62.3% from breast and thigh. Edible yield of poultry is influenced by age, size, and strain, processing techniques phosphate treatment and cooking methods. Other components of poultry which influence yield are moisture, protein and fat. On a raw basis over all classes, protein content averages 18.1% for chicken and 20.1% for turkey. The lipids of both turkey and chicken are relatively rich in unsaturated fats and are influenced by diet; age and sex of birds. Cholesterol content is low in raw turkey with the least amount in the breast meat. The four basic steps of processing birds include: Removing the blood, removing the feathers, taking the organs out and chilling the carcass

1.2 Learning outcomes : At the end of the lecture, the students will be able to explain of poultry

Removing the blood, Removing the feathers, Taking the organs out, Chilling the carcass

1.3 Basic steps for processing poultry

1.3.1 Killing/Slaughtering (Removing the blood)

Before processing your chickens, you will want to remove feed no less than four hours prior to processing. This will help empty the intestine and reduce the risk of breaking the intestines during step three. You will also want to keep water in front of the birds until about an hour before processing. The only exception to this rule would be during periods of extreme heat where the birds may become uncomfortable without fresh, cool, and clean water. Whenever possible, broilers are caught at night for loading. At that time they are easier to catch, struggle less, struggle less and settle down in the coops faster. Turkeys and fowl are caught and handled whenever they are needed for processing. Slaughtering and de-feathering consists of hanging, sometimes stunning, bleeding, scalding, picking and washing, slaughtering involves stunning and bleeding. In those cases where carcasses are stunned, the method of stunning should be such that the heart action is not destroyed.

Stunning with an electric shocker is frequently used when slaughtering turkeys and occasionally with other types of poultry to prevent struggling. Stunning also relaxes the muscle which holds the feathers. It has been demonstrated that shocking reduces the rate of bleeding with turkeys, but that the total amount of blood lost is the same as other methods of slaughter if the bird is given sufficient time for complete bleeding.

This is the first step in processing the bird. The head can be removed, but it is will be nice restraining the bird so it doesn't jump around after head removal so that you don't bruise the meat.

If you hang the bird upside down and just nick the carotid artery by cutting the neck just behind the ear, then the bird's heart does the work of pumping the blood out of the body. You want to avoid leaving blood in the body because the meat will be left with a strong metallic or iron taste. Use a short, sharp knife for this step.

As the bird is being bled out, you can pith the bird. Pithing is when you take a sharp knife and plunge it into the bird's brain through the roof of its mouth. This is done by inserting the knife into one of the slits in the roof of the mouth and aiming toward the angle of the eye. Once the blade is in the brain, give the blade a twist to hopefully contact with the hypothalamus. If done well, sometimes the hypothalamus is hit and the bird may release all of its feathers, making the next step easier.

To take this to the next level, consider making or investing in a killing cone. This holds the bird upside down for bleed out while restricting the movement. Again, this relates to preventing any opportunities for bruising the meat after you spent so much time and energy raising your flock. If you are really serious about doing a lot of birds, then you may wish to invest in a stun knife which renders the bird unconscious before bleed-out. The blood can be collected and disposed of in a compost pile, or washed down the drain.

There are several ways of cutting poultry so that they can bleed.

(a) "Modified Kosher" killed birds are those where the juglar vein is severed just below the jowls so that the wind-pipe and esophagus remain uncut.

(b) Decapitation

(c) Severing the veins in the roof of the mouth. This is usually used when carcasses are pierced through the brain. Between the three methods, "modified kosher" slaughter is the most widely used in modern processing operations because it is easier to obtain good bleeding and leave the head and neck intact for use in suspecting the carcass for the later eviscerating operations. Birds which are decapitated lose less blood that those slaughtered by "kosher" killing or those stuck and then pierced through the brain.

1.3.2 Removing the feather (scalding)

Poultry immersed in water heated over 160-180F for 30 to 60 sec is considered to be hard scalded. It is easier to remove the feathers from carcasses scalded at this temperature than those scalded at lower temperature but the flesh of such poultry is "doughy" and lifeless and the skin becomes discoloured soon after processing. Hard scalding is used mostly for waterfowl because it is the only satisfactory way, to release feathers and the skin of the waterfowl does not discolour as readily as do species of poultry. Carcasses scalded in water of 138-140^{O}F for 30 to 75^{O}C are generally considered as subscalded. Such carcasses have the outer layer of skin broken down but the flesh is not affected as in hard-scalding. The main advantage of subscalding is easy removal of feathers and a uniform skin colour. However, the skin surface is semi scalding, often called sort of slack-scalding, is carried out at 123-130^{O}F for 90-180 sec. The chief advantage of this method is that it leaves the skin intact and so permits more adverse methods of chilling and packaging. Its disadvantage is that it is harder to remove feathers and more hand pinning is required or additional pickers must be installed on the processing line. To overcome some of the disadvantages of semi-scalding, the hocks and necks are sometimes scalded separately, at a higher temperature after the rest of the carcass has been picked, As a result the neck and hock feathers can be removed by pickers and the skin is removed only on the neck and hocks. Generally, scalding carcasses in the range between 130 and 138^{O}F should be avoided because the temperature is too hot to keep all the skin intact and too low to remove the entire epidermal layer of skin. As a result, blotches and unsightly patches are formed if the skin dehydrates. Recently, a new “semi-scald” system was developed. With this process, the carcasses are showered with hot water and then conveyed through humidity cabinets where they are sprayed with steam at 140^{O}F.

The term scalding in poultry is the process of treating carcasses with hot water or steam to loosen the feather from the follicle to aid their removal. Usually scalding is done by the process of immersing the birds in warm water.

To scald a turkey, plunge it into the hot water (145-155 degrees F) and let it sit for 3-4 minutes. Swirl it around a bit to give the water a chance to permeate all the surfaces and feathers. You'll know it's ready to pluck when you pull on the tail feathers and they come off easily

The water temperature needs to be between 130 to 170 degrees Fahrenheit. For best results, use a thermometer to monitor the water temperature. Chickens will need to be scalded between 30 seconds to two minutes. To scald a chicken: Chicken is scalded by dunking it up and down in hot water. Such action serves to loosen the feathers so the bird plucks easily. Proper scalding of your chickens is critically important for plucking success and satisfaction.

Nobody wants to eat the feathers, much less see them left on the bird. We are spoiled here in the U.S. because we don't see grocery store chickens with feathers on the carcass. To do a good job of removing the feathers, you will first need to scald the bird. Scalding in hot water loosens the feathers and makes plucking easier.

Over-scalding is when you begin cooking the skin. This happens when you use water that is too hot or you scald the bird for too long.

Scalding can be done with a big pot of water. Immerse the whole bird, feet included, and then use a spoon to agitate the bird. You'll need a thermometer that can read a temperature of between 125°F to 130°F for 90 to 120 seconds, which is considered a "soft" scald.

Pull a leg out and test the scald by pinching the scales on the toe to see if they release. If so, then pull the birds out and start plucking. Work by pulling the feather backwards from their natural direction. Many home-processors eventually invest in a mechanical chicken plucker to cut down on the amount of time plucking takes.

Don't forget to remove the scales and to remove the enails on the legs too. If you have a propane or butane torch, then you can briefly singe the tiny hair-like feathers that remain after plucking the whole bird. White feathers, if they accidentally remain on the carcass, are less visible than colored feathers. Feathers can be added to your compost pile or disposed of in your regular trash. After fowl carcasses have been scalded and rough picked they are usually dipped in wax to remove pin feathers, generally the carcasses are dropped into a tank of hot wax while suspended on the shackles by the head and feet, removed, and dipped a second time. Then they are immersed in cold water to harden the wax. When the wax is properly hardened, it peels off in large pieces pulling out small feathers with it thus leaving a clean carcass. Because of better processing methods and equipment, picking has been replaced by other methods. In processing plants, carcasses are carried by a conveyor line through rubber-fingered pickers which beat and rub off the feathers from the carcass. A steady stream of water washes the feathers away.

After picking and pinning, carcasses are singed over a flame to remove hair-like appendages called filopumes. This process is called **Singeing**

1.3.3 Washing

Finally the carcasses are washed with a stream of water and scrubbed with rubber fingers at the same time. Scrubbing not only loosens and removes soiled areas but also reduces the number of microorganisms found on carcasses

Self-assessment exercise 1

1. Why must sharp knife be used to kill birds
2. What is pithing
3. At what temperature and time is considered soft scald?
4. Why is mechanical chicken plucker employed

1.4 Taking the organs out or Evisceration

1.4.1 The steps for eviscerating poultry

The methods of eviscerating poultry vary considerably not only among different areas and for different species of poultry, but also among different plants. Among the normal removal of the belly content, evisceration includes inspection of the viscera by a veterinarian or someone under his supervision.

If you do not remove the organs, and leave the head and feet attached, then you have what is called a "New York" dressed chicken, commonly found in Asian markets. However, most folks in the U.S. prefer to remove the intestinal tract and related organs. Keep in mind that a bird, freshly killed, will still be warm inside.

First, you will want to carefully cut the skin in a circle around the vent using the side of a sharp knife. Using the point of the knife at this step increases the risk of nicking the intestines and spilling intestinal contents all over the inside and outside of the bird. If you should accidentally break or nick the intestines, then you will need to clean the bird so that no feces are visible before the carcass goes into the chiller. You will also need to clean the workspace and knives.

Once the vent has been released from the rest of the skin, then widen the opening with your fingers. Turn the bird around and work on the head end of the bird. Remove the head using a pair of sharp chicken shears. Run the knife up through the skin along the back of the neck to avoid hitting the esophagus and larynx. Pull back the skin and locate the esophagus. It is the soft tube along the front of the neck, whereas the hard tube is the larynx. Grab the esophagus and work it loose from all of the surrounding tissues. Then work toward the crop and carefully loosen it from the skin and all surrounding tissues.

This is the hardest part—most people don't realize how strongly the crop is attached to the other tissues. Work carefully, but use a firm touch. Reach into the neck cavity and loosen all the tissues inside so that the crop will be pulled smoothly into the body cavity when you pull on the intestines from the vent. Once loosened, you will be pulling from the vent. The crop and esophagus, as well as all other attached organs, need to slide out with almost no resistance. Remove the larynx and lungs as well as the reproductive organs. The lungs are bright pink and are wedged in between the ribs. Use your fingers to gently remove and discard them.

Flip the bird back to the vent end and reach inside along the breast plate to grasp the heart. This is considered a giblet and can be set aside for later. Pull out the intestines and separate the liver as it is also a giblet. Make sure that you do not nick or break open the gall bladder which is the small green sack attached to the liver. The bile within the gall bladder will stain your hands, your clothing, the carcass making it taste bitter, as well as your work surface. You can also cut the gizzard out of the intestines as it is also a giblet. Discard the remaining sections of the intestine. This process is called eviscerating

Using the poultry shears, the neck is cut off from the carcass as close to the shoulders of the bird as possible. Keep it for use in soup stock. Cut the top part of the heart off where the veins and arteries enter and exit. Squeeze out any blood that may have coagulated within the heart. Cut open the gizzard and wash out any remaining feed or other contests. You will notice a thick leathery yellow lining which is called koi lin. This will need to be peeled free from the rest of the gizzard and discarded. Wash the gizzard thoroughly. Remove and discard any excess ducts as well as the gall bladder from the liver. Save all of your giblets and the neck separately in a small plastic bag or other container as they are great for adding to soup stock or gravy.

Flip the carcass onto the breast and look at the tail of the bird. The preen gland will need to be removed or it can impart a strong flavor to the carcass. At the head end of the gland, use a knife to cut straight down the bone and then scoop the gland out by sweeping the blade back towards the tail. Discard the gland. Remove the feet, otherwise known as paws, at the hock joint, which is the joint where the skin and scales meet. These can also be used to make a wonderful soup stock as long as there are no lesions caused by ammonia anywhere on the foot pad or toes. Wing tips can also be used in soup stock.

Self-study exercise 2

1. ………. Makes the carcass taste bitter
2. ………. Is used to make soup stock

1.5. Chilling, microbiology and preservation of the poultry carcass

1.5.1 Second washing of the carcass

Before adding the carcass to a chill bath, you will need to vigorously wash it out on both the inside and outside with clean water. You should not see any visible fecal material on either the inside or the outside of the carcass. The carcass is again washed and rapidly chilled from about 90^{O}F to 35^{O}F to prevent bacterial spoilage and to preserve quality, Chilling from the slush which makes them more succulent after packaging. The poultry is graded and packaged as fresh poultry.

1.5.2. Preparing the ice water bath and technique of chilling

Before chilling your chicken, you will need to prepare an ice water bath. Use a bucket, bin, or ice chest large enough to immerse a whole bird or multiple birds. The chicken will need to remain immersed in the chill bath for up to four hours. This helps the muscle fibers complete rigor mortis in a timely manner and you will end up with tender muscles rather tough ones. However, since the meat chickens are typically younger, the meat will be automatically tenderer than an old hen. During these four hours, you will want to continue adding more ice as needed to ensure that the thickest part of the meat (usually the breast) drops below 40°F. Use a thermometer to make this measurement directly into the breast muscle of the bird.

Once chilled, let the chill water drain and place the carcass in a reseal able plastic bag. Keep the carcass refrigerated or place it in the freezer until it is time to prepare it for the table. It is proper that you now understand the method of processing a chicken for your home consumption. Ask your local poultry extension specialist for help the first time or consider going to a poultry processing class so that you can gain experience. From there, it is up to your imagination to create a wonderful chicken dinner for all to enjoy.

1.5.3 Microbiology of poultry Meat

Salmonella is probably the most important group of bacteria found in poultry which can cause human illness.

Salmonella orangienburg, S. typhimurium, S. newport, S. enteritidis, S. anatum, S. nentevideo, and under certain conditions S. *gallinarium and S. pullorum* may cause gastrointestinal disturbances in human beings. A considerable number of other *Salmonella* organisms have also been found to cause disease in humans. Other bacterial diseases transmissible to humans from poultry are paracolon infections, erysipelas, staphylococcal infections, tuberculosis, brucellosis, listerosis, tularemia, pasteurellosis, pseudotuberculosis, diphtheria, anthrax, botulism and leptospirosis. In general, organisms cause spoilage by bringing about chemical changes in one or more of the three major nutrients –carbohydrates, fats and proteins. In other cases they bring about desirable change such as fermentation. Live poultry generally had from 600 to 8100 organisms per square centimeter of skin area. After processing and evisceration, careasses had from 11,000 to 93,000 organisms/cm^2. Live turkey generally had from 750 to 41000 organisms/cm^2. The bacterial population also influences the point at which spoilages is observed organoleptically. In a review of microbiological standards for foods, it was reported that off-odours appeared from poultry carcasses when the log of the number of bacteria reached from 6.5 to 8.0 per cm^2. Slime formation occurred when the number of organisms reached a log concentration of 7.5 to 9.0/ cm^2. Pseudomonas and *Alcaligenes* were found to be the principal organisms found on slime spoiled carcasses.

The genera of microorganisms identified on eviscerated cutup poultry are Pseudomonas, Micrococcus, Achromobacter, Sarcina Streptococcus, Eberthella, Salmonella Escherichia, Streptomyces, Penicillum, Oospora, Cryptococcus, and Rhodotorula. Immediately after processing, chromogenic bacteria represented about 50-60% of the microflora on the carcass; *Pseudomonas*, colourless cocci, and closely related form, and the remaining 20-25% of the organisms consisted of miscellaneous bacteria. After storage chromogens and miscellaneous components accounted for less than 1% of total organisms present

1.5.4 Preservation of poultry meat

In the tropics, quality changes in poultry carcass meat occur so fast as to preclude safe handling without refrigeration for more than a few hours after slaughter. For this reason, poultry is purchased by the consumer as live birds. Whether or not poultry is held alive until purchased by the consumer, quality is greatly affected by the method employed in transporting them from the farm. Serious death losses, broken wings and legs, and bruises result if the birds are handled roughly.

After slaughter, the only desirable change in poultry is increased tenderness which requires only a few hours. The time needed for this carcass to become tender is generally shorter than that which will lead to deterioration or spoilage. The rate of quality deterioration and more particularly of spoilage depends very much on the form in which the carcass is sold. Dressed poultry with only the blood and feathers removed spoil much more slowly than eviscerated or cut-up or boned carcasses because there is little contamination of the meat. In Nigeria, poultry are not sold for good storage life is sanitary processing, rapid chilling, low storage temperatures and moisture-vapour-proof packaging. Prompt chilling to less than 1.7^{O}C (35^{O}F) and storage or transport at temperature close to 0^{O}C (32^{O}F) is preferable. With good sanitation, a storage life of 2-3 weeks at 0^{O}C (32^{O}F) may be expected. Dipping the poultry in water to which an antibiotic, chlortetracycline or oxytetracycline, has been added or in corn citric acid-potassium sorbate solution may extend storage life at refrigeration storage if sanitation has been adequate. At freezing condition below -9^{O}C (15^{O}F), microbial activity ceases, sliming and souring no longer occur and poultry meat can be kept for months or even years. Once the temperature is below 9^{O}C, the greatest quality threat is dehydration. This protein is more serious with eviscerated and especially cut-up and boned carcasses because of the large amount of exposed muscle surface. To avoid this, moisture vapour proof packaging materials are used.

Self-study exercise 3

1. How long is chicken carcass chilled?
2. What is the benefit of chilling the carcass
3. Explain the term Singeing
4. Mention eight *Salmonella spp* that causes human illnesses from poultry meat
5. Microbial activity ceases at what freezing temperature…..

1.6. Summary

In summary, poultry should be sold as live birds or placed in the consumers 'hand within a few hours of slaughter and cooked promptly or else be preserved by refrigeration or curing and smoking

1.7 C***hilling*** i.e. cooling with ice in a chill bath

Scalding in poultry is the process of treating carcasses with hot water or steam to loosen the feather from the follicle to aid their removal.

Singeing: After picking and pinning, carcasses are singed over a flame to remove hair-like appendages called filopumes

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1.9, Answers to Self-assessment exercises

Self-assessment exercise 1

1. Why must sharp knife be used to kill birds
2. What is pithing
3. At what temperature and time is considered soft scald?
4. Why is mechanical chicken plucking machine employed

Answers: 1. Use a short, sharp knife for this step if you want to avoid leaving blood in the body because the meat will be left with a strong metallic or iron taste.

3 Pithing is when you take a sharp knife and plunge it into the bird's brain through the roof of its mouth.

4 Between 125°F to 130°F for 90 to 120 seconds is considered a "soft" scald.

5 Mechanical chicken plucker to cut down on the amount of time plucking takes.

Self-study exercise 2

1. ………. Makes the carcass taste bitter
2. ………. Is used to make soup stock

   Answers

   1. Bile
   2. Wing tips can also be used in soup stock

Self-study exercise 3

1. How long is chicken carcass chilled?
2. What is the benefit of chilling the carcass

Answers

1. 4 hours

2. Chilling helps the muscle fibers complete rigor mortis in a timely manner and you will end up with tender muscles rather tough one
3. . Singeing

After picking and pinning, carcasses are singed over a flame to remove hair-like appendages called filopumes

4. Salmonella is probably the most important group of bacteria found in poultry which can cause human illness. *Salmonella orangienburg, S. typhimurium, S. newport, S. enteritidis, S. anatum, S. nentevideo*, and under certain conditions S. *gallinarium and S. pullorum* may cause gastrointestinal disturbances in human beings

5. At freezing condition below **-9** ^{O}C (15^{O}F), microbial activity ceases

UNIT 2 FACTORS AFFECTING QUALITY OF POULTRY MEAT PRODUCTS AND PRODUCTS DERIVED FROM POULTRY MEAT

Unit structure

2.1 Introduction
2.2 Learning outcome

2.3 Factors affecting the quality of poultry meat

2.3.1 Appearance

1.3.2 Texture
2.3.3 Flavour

2.4 Products derived from poultry meat

2.4.1 Sausages

2. 4.2 Chicken suya and kilishi

2.4.3 2.4.3 Marinated Poultry

2.5 Storage period, cooking temperature and nutritive value of poultry meat

2.5.1 Storage period of poultry meat

2.5.2 Cooking temperature of poultry meat

2.5.3 The nutritive values of poultry

2.6 Summary

2.7 Glossary

2.8 References/further reading

2.9. Answers to Self- assessment exercises

2.1 Introduction

The term quality relates to poultry. This is a difficult task because quality is 'in the eye of the beholder'. For example, someone trying to sell a product might view its quality in terms of how well it sells and how much people are willing to pay for it. However, this definition is incomplete because it does not consider the product's character. Since people only buy what they like, the consumer's perspective of quality is more appropriate. When consumers buy a poultry product, cook and serve it to their families, they expect it to look, taste and feel good in their mouth. If these characteristics do not meet the consumer's expectation, the product is considered to be of lower quality.

2.1 Learning outcome: At the end of the lecture, the students will be able to explain:

- The factors affecting the quality of poultry meat
- Products derived from poultry meat
- Storage period, cooking temperature and nutritive value of poultry meat

2.3 Factors affecting the quality of poultry meat

2.3.1 Appearance

At times, it is difficult to separate appearance from colour. However, the two can be interwoven for the purpose of this discussion. Colour of cooked or raw poultry meat is important because consumers associate it with the product's freshness, and they decide whether or not to buy the product based on their opinion of its attractiveness.

Poultry is unique because it is sold with and without its skin. In addition, it is the only species know to have muscles that are dramatic extremes in colour (white and dark meat). Breast meat is expected to have a pale pink colour when it is raw, while thigh and leg meat are expected to be dark red when raw. There are times when poultry meat does not have the expected colour, and this has created some special problems for the poultry industry. Poultry meat colour is affected by factors such as bird age, sex, strain, diet, intramuscular fat, meat moisture content, pre-slaughter conditions and processing variables. Colour of meat depends upon the presence of the muscle pigments myoglobin and haemoglobin. Discoloration of poultry can be related to the amount of these pigments that are present in the meat, the chemical state of the pigments, or the way in which light is reflected off of the meat. The discoloration can occur in an entire muscle, or it can be limited to a specific area, such as a bruise or a broken blood vessel. When an entire muscle is discolored, it is frequently the breast muscle. This occurs because breast muscle accounts for a large portion of the live weight (about 5 per cent), it is more sensitive to factors that contribute to discoloration, and the already light appearance makes small changes in colour more noticeable. Extreme environmental temperatures or stress due to live handling before processing can cause broiler and turkey breast meat to be discolored. The extent of the discoloration is related to each bird's individual response to the conditions. The colour of the bruise, the amount of 'blood' present, and the extent of the 'blood clot' formation in the affected area are good indicators of the age of the injury and may give some clues as to its origin. A bruise will vary in appearance from a fresh, 'bloody' red colour with no clotting minutes after the injury to a normal flesh colour 120 hours later. The amount of 'blood' present and the extent of clot formation are useful in distinguishing if the injury occurred during catching/transportation or during processing. Injuries that occur in the field are usually magnified by processing plant equipment or handling conditions in the plant.

2.3.2 **Texture (Tenderness)**

After consumers buy a poultry product, they relate the quality of that product to its texture and flavour when they are eating it. Whether or not poultry meat is tender depends upon the rate and extent of the chemical and physical changes occurring in the muscle as it becomes meat. When an animal dies, blood stops circulating, and there is no new supply of oxygen or nutrients to the muscles. Without oxygen and nutrients, muscles run out of energy, and they contract and become stiff. This stiffening is called rigor mortis. Eventually, muscles become soft again, which means that they are tender when cooked. Anything that interferes with the formation of rigor mortis, or the softening process that follows it, will affect meat tenderness. For example, birds that struggle before or during slaughter cause their muscles to run out of energy quicker and rigor mortis forms much faster than normal. The texture of these muscles tends to be tough because energy was reduced in the live bird. A similar pattern occurs when birds are exposed to environmental stress (hot or cold temperatures) before slaughter. High pre-slaughter stunning, high scalding temperatures, longer scalding times and machine picking can also cause poultry meat to be tough.

Tenderness of portioned or boneless cuts of poultry is influenced by the time post-mortem of the deboning. Muscles that are deboned during early postmortem still have energy available for contraction. When these muscles are removed from the carcass, they contract and become tough.

To avoid this toughening, meat is usually 'aged' for 6 to 24 hours before deboning. However, this is Costly for the processor. When poultry is deboned early (0 to 2 hours post-mortem), 50 to 80 per cent of the meat will be tough. On the other hand, if the processor waits 6 hours before deboning, 70 to 80 per cent of the poultry meat will be tender. The poultry industry has recently started using post-slaughter electrical stimulation immediately after death to hasten rigor development of carcasses and reduce 'aging' time before deboning. This is different from energy depletion in the live bird, which causes meat to be tough. When electricity is applied to the dead bird, the treatment acts like a nerve impulse, and causes the muscle to contract, use up energy and enter rigor mortis at a faster rate. In the live bird, the same treatment causes meat to be tough but after death, the treatment causes tender deboned poultry meat within two hours post-mortem instead of the four to six hours required with normal aging.Although electrical stimulation is still in the developmental stages, it seems that processors using it can debone carcasses right out of the chiller and save on their equipment costs, time, space and energy requirements.

2.3.3 Flavour

Flavour is another quality attribute that consumers use to determine the acceptability of poultry meat. Both taste and odour contribute to the flavour of poultry, and it is generally difficult to distinguish between the two during consumption. When poultry is cooked, flavour develops from sugar and amino acid interactions, lipid and thermal oxidation and thiamin degradation. These chemical changes are not unique to poultry but the lipids and fats in poultry are unique and combine with odour to account for the characteristic 'poultry' flavour. Few factors during production and processing affect poultry meat flavour. This means that it is not only difficult to produce a flavour defect but it is difficult to enhance flavour during production and processing.
The chicks take three to four months to reach a good size, and can be butchered as late as 8 months old. After that, they tend to get tough. Many people choose Cornish Cross Hybrids for their meat birds. Age of the bird at slaughter (young or mature birds) affect the flavour of the meat. Minor effects on meat flavour are related to bird strain, diet, environmental conditions (litter, ventilation, etc.), scalding temperatures, chilling, product packaging and storage. However, these effects are too small for consumers to notice.

Self-assessment exercise 1

1. Explain the term rigormotis
2. What can be done to avoid toughening of meat

2.4 Products derived from poultry meat

2.4.1 Chicken Sausages

Sausages are usually defined as minced seasoned meats, stuffed into casings; they may be smoked, cured, fermented and heated. They are made from any edible part of the slaughtered, veterinary-inspected animal, and a series of non-meat ingredients.

Sausages are meat products that are salted & usually seasoned or spiced and are examples of comminuted meet products that are generally recognized as emulsified, stuffed, linked, smoked, and cooked meat products. Based on the product characteristics and processing methods, they are broadly divided into three categories: fresh sausages cured sausages and fermented sausages

Selection of ingredients
↓
Grinding
↓
Mixing
↓
Chopping and emulsifying
↓
Stuffing
↓
Linking or tie
↓
Hanging
↓
Smoking
↓
Cooking
↓
Showering with chilling
↓
Peeling or slicing
↓
Packaging

Fig. 1: Sausage production

2.4.2 Chicken "suya" and kilishi

Suya (Hausa word for "to fry"" or "fried meat") is an intermediate moisture meat product that is easy to prepare and is highly relished . Suya is a popular, traditionally processed ready to eat Nigerian meat product, originally produced from beef and later extended to other ruminant animals. However, in recent years, non-ruminant animals are being utilised in suya making

'Suya'and 'kilishi' are made by roasting the spiced, salted slices/strips of meat (usually beef). 'Kilishi' differs from 'suya' because; 'kilishi' has lower moisture content (6-14%) than 'suya' (25-35%) and it is not roasted

Dambu-nama is a Nigerian traditionally spiced, cooked, pounded, shredded and dried meat product which is commonly obtained using beef, goat meat, mutton, or camel meat and is popularly consumed in the Northern parts of Nigeria. The product appears to have developed as a means of preserving meat, in the absence of facilities for refrigerated storage by the early Hausa and Fulani herdsmen.

Chicken Suya

2.4.3 Marinated Poultry

Most recipes for marinating meat and poultry recommend six hours up to 24 hours. It is safe to keep the food in the marinade longer, but after two days it is possible that the marinade can start to break down the fibers of the meat, causing it to become mushy. Always marinate meat and poultry in the refrigerator, and boil the used marinade if you want to brush it on the meat or poultry while it's grilling. It is advised not to save the used marinade.

Self-Assessment Exercise 2

1. Sausages are broadly divided into three categories: fresh sausages cured sausages and ……. sausages
2. 'kilishi' has lower moisture content ………..
3. Most recipes for marinating meat and poultry recommend six hours up to ……. hours

2.5 Storage period, cooking temperature and nutritive value of poultry meat

2.5.1 Storage period of poultry meat

If kept frozen continuously, chicken will be safe indefinitely, so after freezing, it's not important if any package dates expire. For best quality, taste and texture, keep whole raw chicken in the freezer up to one year; parts, 9 months; and giblets or ground chicken, 3 to 4 months. Cooked chicken will taste best if kept frozen up to 4 months; poultry casseroles or pieces covered with broth or gravy, 6 months; and chicken nuggets or patties, 1 to 3 months cooked. For more information about the safe handling of chicken

2.5.2 Cooking temperature of poultry meat

The minimum oven temperature to use when cooking chicken is 325 °F (162.8° C). Using a food thermometer is the only sure way of knowing if your food has reached a high enough temperature to destroy foodborne bacteria. All poultry should reach a safe minimum internal temperature of 165 °F (73.9 °C) as measured with a food thermometer. A whole chicken must reach this temperature throughout the bird. Check the internal temperature in the innermost part of the thigh and wing and the thickest part of the breast. For reasons of personal preference, consumers may choose to cook poultry to higher temperatures.

2.5.3 The nutritive values of poultry

Poultry provides the body with protein, vitamin B, including thiamin, riboflavin, niacin and pyridoxine, vitamin E, zinc, iron and magnesium. Protein is essential for the human body because it helps build healthy bones, muscles, skin, cartilage and blood cells.

Besides being rich in protein, poultry meat is good source of phosphorus and other minerals, and of B-complex vitamins. It contains less fat than most cuts of beef and pork. Poultry meat is low in harmful trans fats, but high in beneficial monounsaturated fats – which make up about half of the total.

Chicken is rich in a variety of important nutrients, including protein, niacin, selenium, and phosphorus. One 3-ounce (85-gram) serving of chicken breast contains (1): Calories: 122. Protein: 24 grams.

Self-Assessment Exercise 3

1. Cooked chicken will taste best if kept frozen up to ….. months
2. The minimum oven temperature to use when cooking chicken is …….
3. Besides being rich in protein, poultry meat is good source of phosphorus and other minerals, and …….. vitamins

2.6 Summary

- The most important aspect of poultry meat is its eating quality – the state of the animal at slaughter. Poultry processing affects meat quality
- The producer, processor, retailer and consumer all have specific expectations for the quality attributes of poultry but the ultimate authority will always be the consumer.
- Sausages are broadly divided into three categories: fresh sausages cured sausages and fermented sausages
- 'kilishi' has lower moisture content of 6-14%
- Most recipes for marinating meat and poultry recommend six hours up to 24 hours
- Cooked chicken will taste best if kept frozen up to 4 months
- The minimum oven temperature to use when cooking chicken is 325 °F (162.8° C)
- Besides being rich in protein, poultry meat is good source of phosphorus and other minerals, and of B-complex vitamins

2.7 Glossary

rigormotis **---** Without oxygen and nutrients, muscles run out of energy, and they contract and become stiff. This stiffening is of the carcass muscle

fastidious **……..** Difficult or hard to satisfy

Marinate ….. This is to put meat in a sauce for a period of time to add flavor or to make the meat tenderer

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2.9. Answers to Self- assessment exercises

SAE 1

No. 1.Rigormotis: This happens when an animal dies, blood stops circulating, and there is no new supply of oxygen or nutrients to the muscles; without oxygen and nutrients, muscles run out of energy, and they contract and become stiff. This stiffening of the muscle is called rigor mortis

No.2. In order to avoid this toughening, meat is usually 'aged' for 6 to 24 hours before deboning

SAE 2

1. Fermented sausages
2. 'kilishi' has lower moisture content of between 6-14%
3. 24 hours

SAE 3

1. 4 months
2. 325 °F (162.8° C)
3. B-complex vitamins

UNIT 3 EGG TECHNOLOGY

Unit structure

3.9 Answers to Self-Assessment Exercises

3.1 Introduction

Egg is an organic vessel in which an energy embryo first begins to develop. In most birds, an egg in the zygote, resulting from fertilization of the ovum, which is expelled from the body and permitted to develop outside the body until the developing embryo can survive on its own. The term egg in restricted to animal Kingdom, Similar reproductive structures in other kingdoms are called spores

3. 2. Learning outcomes

At the end of the lecture, the students will be able to understand:

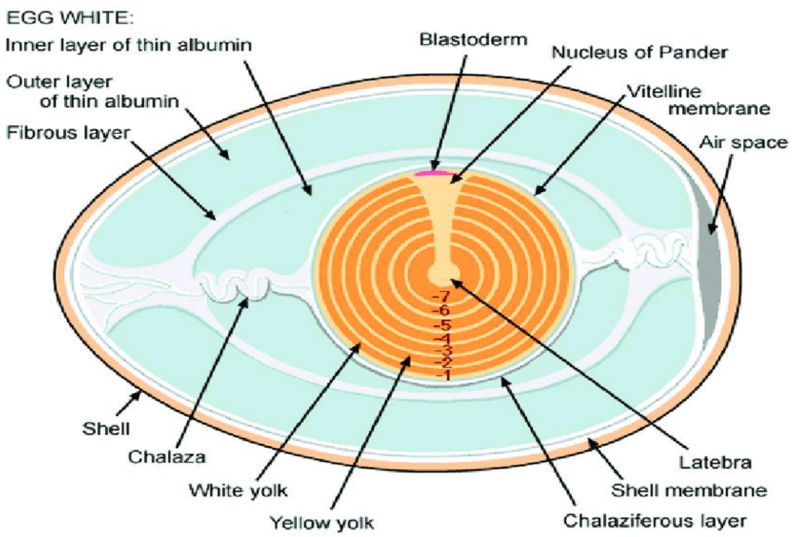
- The composition of the egg,
- The importance of egg in human nutrition and functional Properties of Egg
- Products derived from egg

3. 3. Composition of egg

3.3.1. Structure and composition of Egg

Egg consists of three major parts- the shell, the white or albumen and the yolk.

Most poultry eggs are oval in shape, with one end rounded (the aerus) and others more pointed (the taglion). The shape results from the egg being forced through the oviduct. Muscle contracts the oviduct behind the egg, pushing it forward. The egg wall is still shapeable, and poultry end develops at the back. Structurally, eggs are divided into district parts the shell, the white (albumen) and the vitellus (egg yolk, contained within various thin membranes). They shall form the outer protective layer composed mainly of calcium carbonated the porous nature of the shell allows a developing embryo to obtain a supply of oxygen. The colour of the shell may vary from white to brown. The colour difference gives no indication as to the quality of the content of the egg. Inside the shell in a viscous a colourless liquid called egg white which in fresh egg is divided into region of thick and thin white which accounts for about 60% of the total egg weight. In the center of the egg in the yolk which is thick yellow or orange o/w emulsion stabilized by egg is not a complete food lacks carbohydrate and vitclecithin. It is suspended in the white, being held in position by the chalazae; the larger end of the egg contains the air or space that forms when the content of the egg cool down and contract after it is laid.



Shell

The shell is the outermost covering of an egg. It consists of 94 to 97% calcium carbonate. The other 3-6% are organic matters and shell pigments (blue or brown pigments) which is seen as the shell colour

Quality changes and Evaluation of shell Egg

3.3.2 Factors that cause Changes in quality of egg shell during storage

(i) Chemical reactions

(ii) Microbiological reaction

(iii) Physical phenomena like absorption of unwanted odour under adverse condition.

Changes which occur during storage of shell eggs include

- Loss of weight due chiefly to loss of moisture from the albumen but also partly due to loss of CO_2, NH_4, N_2 and H_2S gases
- Increase in air cell size. As moisture is lost, the volume of the air cell increases.
- Decrease in specific gravity due to increase in air cell size
- Mottling on the surface of the shell due to aneyen moisture distribution.
- Decrease in the amount of chick white due to breakdown of the fibrous glycoprotein ovomucin
- Increase in size of the yolk because of the movement of water from the albumen to the yolk as a result of osmotic pressure differences
- Change in flavours
- Increase in pH particularly in the albumen which increases from approximately 7 to 10 or 11 as a result of loss of CO_2.

As the egg ages, the firmness of the white decreases and when broken the yolk flattens and the content decreases. The quality of eggs in the intact state is assess by candling which consists of holding the egg in the path of a strong light which permits examination, of the interior of the egg By candling eggs, it is possible to detect cracks in the shells, the size and mobility of the yolk, the size of the air cell, blood spots, meat spots, microbiological defects and germination. However, only obvious defects are detectable by candling.

Grades of shell eggs

Quality has been defines as the sum of the characteristics of a given food item which influence the acceptability

White (or albumen)

The white or albumen is the watery, gelatinous material around the yolk. It is made up of four layers which from the outer to the inner portion are arranged in the following order – the outer thin, the outer thick, the inner thin and the inner thick layers. The yolk consists of the concentric layers of light and dark yolks.

The gross composition of edible portion of egg has 60 parts by weight of white to 40 parts of the yolk. Whole egg is the mixture of white and yolk in natural proportion. The egg white is made up of mostly proteins which have rather unusual properties. The important proteins of egg white are ovomucin, globulin,lysozymes ovalbumin, ovomucoid and coalbumin

White are which is albumin with phosphate and carbohydrate as non-protein component part; conalbumin which is purely albumin lysozyme, which is purely globulin and ovomuen and ovomuzoid which are globulin conjugated with carbohydrate but only differ in molecular weight. It also contains small amount of avidin. The main proteins of the yolk are phosphor proteins Lipovitellin and Lipovitellenin- which comprise about 30% of the total egg yolk solids. The phosphorus content of these proteins is in the form of phosphoric acid esterified with the hydroxyl groups of hydroxyl amino acid.

Fats constitute $^{2}/_{3}$ of the solids in the yolk and comprise of triglycerides, phospholipids and cholesterol. The main phospholipid is lecithin (phosphatidyl choline) the small amounts of P ethanolamine and P serin. Most of the lipids are in the low-density lipoprotein fraction which, in unaltered egg yolk liquid is in a finely dispersed state. It has been postulated that the triglycerides make up the inner core of the highly emulsified low-density lipoproteins. This inner core is surrounded by a phospholipid shell and then protein molecules are wrapped around this shell.

Yolk

Egg yolk is a very complex mixture of essentially lipids and proteins. It is further complicated by the inclusion of the whites. Most of the lipids are in the low density Lipoprete in fraction which in unaltered egg yolk liquid is in a finely dispersed state. It has been postulated that the triglycerices make up the inner core of the highly emulsified lipoproteins. This inner core is surrounded by a phospholipid shell and then protein molecules are wrapped around this shell. All the lipids of unaltered egg yolk are associated with lipoproteins.

Self-study exercise 1.

1. Egg consists of three major parts which are (i) …,(ii)…. and (iii)….
2. Three changes in shell eggs during storage could be caused by…. and ….
3. List the important proteins of egg

3.4. Importance of Egg in human nutrition

3.4.1 The value of egg as food

Eggs possess two important characteristics that make them valuable as food.

i. It is one of the most nutritious foods we consume and can be prepared in many different ways. Hence, it is an essential part of many baked goods, candies, and other foods.

ii. Egg functions in many different ways to give certain desirable characteristics to food products in which it is used. It leavens, binds, thickens, emulsifies, tenderizes, retains moisture, adds flavour and colour, and improves nutrition

A whole liquid egg constitutes about 73.7% water, 12.9% protein, 11.5% fat, 1.4% carbohydrate. Hence egg is high in water, protein and fat. It is also rich in B-complex vitamins provide a fair amount of minerals and contain traces of carbohydrate

The protein in eggs is the highest quality protein found in any food. The proteins are of high nutritional value and because of the quantity present, about 12% of the edible part eggs must be considered as a valuable protein food. They contain all the essential amino acids required by the body. Egg protein has a high biological value.

Egg supplies the diet with valuable amount of iron, phosphorus and useful amount of fat, vitamin A and calcium. It also supplies D, riboflavin, thiamine and biotin.

Egg; however is not a complete food as it lacks sugar and vitamin C, through rich in other valuables.

Avadin is of some nutritional importance as it combines with the vitamin, biotin, rendering it unavailable to the body.

A large egg yolk contains more than $^{2}/_{3}$ of the recommended daily intake of 300 mg cholesterol.

The Nutrient in egg can play a role in weight management and muscle strength.

The protein in eggs is the highest quality protein found in any food. The proteins are of high nutritional value and because of the quantity present, about 12% of the edible part eggs must be considered as a

valuable protein food. They contain all the essential amino acids required by the body. Egg protein has a high biological value of.

Egg supplies the diet with valuable amount of iron, phosphorus and useful amount of fat, vitamin A and calcium. It also supplies D, riboflavin, thiamine and biotin.

However, egg is not a complete food as it lacks sugar and vitamin C, through rich in other valuables.

Avalin is of some nutritional importance as it combines with the vitamin, biotin, rendering it unavailable to the body.

A large egg yolk contains more than $^{2}/_{3}$ of the recommended daily intake of 300 mg cholesterol.

Table 1: The Nutrient in egg can play a role in weight management and muscle strength.

Nutrient Components (%)	Whole Liquid	White	Yolk
Water	73.7	87.6	51.1
Protein	12.9	10.9	16.0
Fat	11.5	Trace	30.5
Carbohydrate	1.1	1.1	1.0
Free carbohydrate	0.3	0.4	0.2

3.4.2 Functional Properties of Egg

1. Leavening power: This is sometimes called the aerating, foaming, or whipping properties of eggs. It means the ability to incorporate air by itself or in a mixture with other ingredient and to hold the aerated structure long enough so that it can be set by heart, drying or other means. This foam formation in as a result of surface denaturation of protein. It involves unfolding and spreading of protein as a monomolecular layer over the surfaces
2. Binding and thickening: Proteins of egg coagulate during heating and thus give to eggs the ability to bind pieces of foods together or to thicken foods such as custard. This ability to coagulate in on of the most important properties of eggs. Coagulate is sometimes referred to as denaturation or gelation Eggs go through the following stages during heat coagulation, denaturation, flocculation and insolubility
3. Emulsifying power: Egg yolk, whole egg and egg white are all good emulsifiers, and they contain some natural emulsifiers in the form of lecithin and phosphor lipids and are therefore important ingredients in the preparation of permanent food emulsions like myonaise, salad creams, spreads and dips
4. Antimicrobial action: Freshly laid eggs are coaten with mucin which prevents bacterial invasion. When this seal is broken by washing, the egg becomes vulnerable to entry by microbes and moistures. The natural antimicrobial and ovalbumin. The lysozym dissolves the cell membranes of some bacteria, and is an effective germicidal agent. The lower the pll the greater in its effectiveness, which in an added reason for prevention of Co_2 Loss from eggs. The avidin acts by binding biotin, a nutrient needed by some microorganisms and thus inhibit their growth ovalbumin units with iron and makes it unavailable for the growth of microbes

5. Tenderizing: Eggs contribute to smoothness, moistness, and a desirable texture in baked products. One reason for this is that they are known to retard crystallization of sugar. The property of adding softness and crispness to foods is called shortening. The texture is achieved because of the high content of the fat in the yolk
6. Moisture retention: in baked good. Eggs help to retain moisture during baking and also during storage. Eggs bind the ingredients together and offer a barrier through which it is difficult for moisture to escape
7. Flavour: Eggs are of course, good eating by themselves. They have a distinct flavor which affects baked products. They also help flavor by imparting better mouth feel to these products
8. Color: eggs add colour (browning) to products in which they are used

Self- study exercise 2

1. State the two important characteristics that eggs possess that make them valuable as food.
2. Egg is not considered a complete food as it lacks …. and ….
3. State the contents (%) of egg in terms of water, protein, fat, and carbohydrate.

3.5. Products derived from egg

There are now several different types of dried egg products available that can be summarized under four major headings:

- ✓ Dried egg white,
- ✓ Dried plain whole egg and yolk,
- ✓ Dried blends of whole egg and yolk with carbohydrates,

- ✓ Special types of dried egg products.

3.5.1 Manufacture of egg white powder

The production of dried egg products is a sophisticated process. Spray drying is now the most common method for producing egg powder. However, some egg white is pan-dried and some whole egg is freeze-dried. Spray drying is the most commonly used method for drying whole eggs, egg yolks, or egg whites. The eggs are preheated to 60°C, and then sprayed into a drying chamber through which air between 121 and 149°C is passing. The powder separates from the air and is continuously removed from the drying chamber. Prior to drying, egg white usually is subjected to a controlled bacterial fermentation process. Although dried egg products usually are not available to consumers at the retail level, they are widely used in mixes and in quantity food production. Removal of water lowers *a*w and therefore retards chemical reactions that affect quality and inhibits the growth of microorganisms.

Spray-dried egg white is commonly used as a food ingredient for its foaming and gelling properties. Additionally the removal of water to a low enough level stops the growth of microorganisms and slows chemical reactions. Thus, dehydration is a successful way of preserving egg white. There are a number of different types of dried egg white products available. The most important types of commercial dried egg white products are spray-dried and pan-dried products; the spray-dried egg white is also available in an instant-dissolving form. Agglomerated instant egg white provides good dispersing characteristics and rapid dissolving properties when added to water. Most dried egg white products are available in a whipping or non-whipping type, depending on the functional properties required. For example, there is demand for an excellent whipping of dried egg white for use in biscuit, cakes and meringues. On the other hand, there are several uses where the whipping properties are not necessary but the demand for excellent gelling properties dominates. It has to be mentioned that most commercially available whipping egg white powders have a whipping aid, such as sodium laryl sulfate, triethyl citrate, xanthan gum or sodium oleate. These additives are used at about 0.1% based on the egg white solids and depending on the type of additives. Depending on the regulatory status of each country, it is necessary to declare the addition of such additives in the final product. Pan-dried egg white represents only a small branch and is mostly used for the production of aerated confectioneries. Pan drying produces flake type material to a moisture level of about 14%. Due to the heat sensitivity of egg white proteins the temperature control of all drying methods is very important. It is necessary to preserve the native characteristics of egg white proteins, which includes the ability to gel with heat and the production of stable foams.

The authors concluded that the most critical step was the spray drying that strongly damaged foaming properties. During this step, heat transfers and the air–product interface are more responsible than shear rates for the negative changes occurred in egg white foaming properties. In most cases of industrial processing, the air inlet temperature is set higher than 140 °C. Because of heat sensitivity of egg white proteins, it was observed that a moderate drying conditions with low air inlet temperature < 120 °C and short residence time in the dryer. Their results showed that spray drying under moderate scale led to egg products with good foaming, gelling and emulsifying properties.

3.5.2 Advantages of dried egg products

Dried egg products have a number of advantages, which are listed as:

(1) They can be handled and stored with ease and at low cost.

(2) They are ready to use immediately with no thawing.

(3) They are easy to handle in a hygienic way.

(4) They are easy to remove from the container without scraping.

(5) No bacterial growth can occur in powder at room temperature, provided it is kept dry.

(6) There is good uniformity.

(7) There is precise control over the amount of water used in formulation.

(8) There is no loss when used because the dried egg is usually added directly to the batch.

(9) No special transfer or storage equipment is needed.

(10) Because the moisture content is reduced from around 74% to 2–4% by weight, there is a reduction in weight and volume and a concentration of food value.

(11) Dried eggs are a nonperishable commodity while fresh or liquid eggs are perishable foods. Additionally the removal of water to a low enough level stops the growth of microorganisms and slows chemical reactions

(12) Powdered eggs have a storage life of 5–10 years depending on the environment. The shelf life can further be extended by placing eggs powdered in air tight containers under anaerobic conditions or placed in a cool storage place. There is no need for any refrigeration or cold chain as in case of liquid eggs. In the absence of cold storage, the shelf life ranges from 6 to 12 months.

(13) The second advantage of powdered over the fresh eggs is that there is no chance of contamination from the breakage of shells. The third advantage of dried eggs is less space required for storage. Furthermore, storage of fresh eggs requires special instruction regarding handling and stacking in the warehouses.

3.5.3 Disadvantage of dried egg products

A possible disadvantage of powder compared with liquid egg is a loss of 'fresh flavor' and a loss of certain functional properties such as aerating power, unless treated with a sugar that is not a reducing sugar prior to heating. This, however, limits its use because of the sweetened nature of the powder.

3.5.4 Storage of dried egg products

One of the real advantages of dried egg products is their ease of storage. Most are relatively stable when stored at room temperature. Dried egg whites can be held under almost any storage condition for an indefinite period of time. Dried products containing whole egg and yolk should be under refrigeration if held for long periods of time. Some of these are relatively stable at room temperature, particularly those where the natural glucose has been removed prior to

3.5.5 Factors that Affect Quality of Dried Egg Products

The quality of dried egg or dried egg products can be affected by a number of factors. Important are the quality of the eggs broken out to make the original product, handling methods, sanitation practices, conditions during processing, pasteurization procedures, drying, and conditions under which the products are held in storage. Glucose (0.3–0.5%) is removed from the liquid egg white prior to drying by fermentation using a yeast or bacterial culture or by oxidation to gluconic acid using a glucose oxidase–catalase enzyme system. With glucose removed, dried egg whites are completely stable. If glucose is not removed, the product would be unstable because reducing groups from the glucose would combine with amino acids in the protein, leading to a condensation reaction that would be followed by browning and the development of insoluble proteins. There could also be the development of off-odors and the loss of some functional properties during storage. Plain whole egg and yolk can be pasteurized and dried without removal of the glucose, and consequently, these are the least stable of the egg products.

The physical properties important in relation to dried egg products are bulk density, dispersibility, solubility, and reconstituted viscosity.

3.5.6 Factors for an equal content in dry solids for the reconstitution of dried egg products into fluid

13 g of whole egg powder plus 39 g of water is equivalent to 1 shell egg

For separate rehydration pre-blend a small quantity of other powders (sugar, starch, flour) from the recipe into the whole egg powder prior to adding water in order to avoid lumpiness

Otherwise the pre-blending of all powder ingredients of a recipe is recommended before water addition for preventing lumps

Egg white powder

4 g of whole egg powder plus 29 g of water is equivalent to 1 shell egg white

For separate rehydration pre-blend a small quantity of other powders (sugar, starch) from the recipe into the whole egg powder prior to adding water in order to avoid lumping

Otherwise the preblending of all powder ingredients of a recipe is recommended before water addition for preventing lumps

Egg yolk powder

9 g of egg yolk powder plus 11 g of water is equivalent to 1 shell egg yolk

For separate rehydration pre-blend a small quantity of other powders (sugar, starch, flour) from the recipe into the whole egg powder prior to adding water in order to avoid lumping

Otherwise the pre-blending of all powder ingredients of a recipe is recommended before water addition for preventing lumps

Self-study exercise 3

1. List four products derived from egg
2. State how dried products containing whole egg and yolk should be stored

3.6 Summary

Egg is an organic vessel in which an energy embryo first begins to develop. In most birds, an egg in the zygote, resulting from fertilization of the ovum, which is expelled from the body and permitted to develop outside the body until the developing embryo can survive on its own. The term egg in restricted to animal Kingdom, Similar reproductive structures in other kingdoms are called spores. Most poultry eggs are oval in shape, with one end rounded (the aerus) and others more pointed (the taglion). The shape results from the egg being forced through the oviduct. Muscle contracts the oviduct behind the egg, pushing it forward. The shell is the outermost covering of an egg. It consists of 94 to 97% calcium carbonate. The other 3-6% are organic matters and shell pigments (blue or brown pigments) which is seen as the shell colour. Quality has been defines as the sum of the characteristics of a given food item which influence the acceptability. Egg white and yolk are majorly used to determine egg quality

3.7 Glossary

Emulsifier: Substance the prevents the separation of oil from water layer in emulsion products

3.8. References/Further Readings

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3.9. Answers to Self-Assessment Exercises

Self-study exercise 1.

1. Egg consists of three major parts- the shell, the white or albumen and the yolk.

2. Three changes in quality of shell eggs during storage could be caused by
   i. Chemical reactions
   ii. Microbiological reaction
   iii. Physical phenomena like absorption of unwanted odour under adverse condition.

3. Ovomucin, globulin, lysozymes ovalbumin, ovomucoid and coalbu min are the important proteins of **egg white**

Answers to Self-study exercise 2

Exercise 2

1. The two important characteristics that make them valuable as food are:

i. It is one of the most nutritious foods we consume and can be prepared in many different ways. Hence, it is an essential part of many baked goods, candies, and other foods.

ii. Egg functions in many different ways to give certain desirable characteristics to food products in which it is used. It leavens, binds, thickens, emulsifies, tenderizes, retains moisture, adds flavour and colour, and improves nutrition

1. Egg is not a complete food as it lacks **sugar** and **vitamin C**
2. A whole liquid egg constitutes about: 73.7% water, 12.9% protein, 11.5% fat, 1.4% carbohydrate.

Self-study exercise 3

1. Products derived from egg include:

- ✓ Dried egg white,
- ✓ Dried plain whole egg and yolk,
- ✓ Dried blends of whole egg and yolk with carbohydrates,
- ✓ Special types of dried egg products.

No. 2 Dried products containing whole egg and yolk should be under refrigeration if held for long periods of time