

LECTURE NOTES

For Environmental Health Students

Food Hygiene Part II



**Ethiopia Public Health
Training Initiative**

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DEFINITIONS

Adulteration of milk: This is the adding of water or extracting the fat by removing the cream.

Milk fat: This refers to the pure fat which consists of glycerol and fatty acids.

PH: This is the hydrogen ion concentration of milk.

Raw Milk: This is a secretion produced by all mammals before it has been altered to into any other form.

Cholesterol: This is an alcoholic compound of complex structure that, in milk, is mostly found in the fat globules.

Lactation: This is the giving of milk by mammals.

Lobster: This is a hard shelled animal that lives on the bottom of the ocean near the shore.

Specific gravity of milk: This is related to its density. It is found by dividing the density of the substance by the density of water at either 4°C (39 °F) or 20 °c (68 OF).

Mammary glands: These are special glands found in all mammals. In female mammals the mammary glands produce milk.

PREFACE

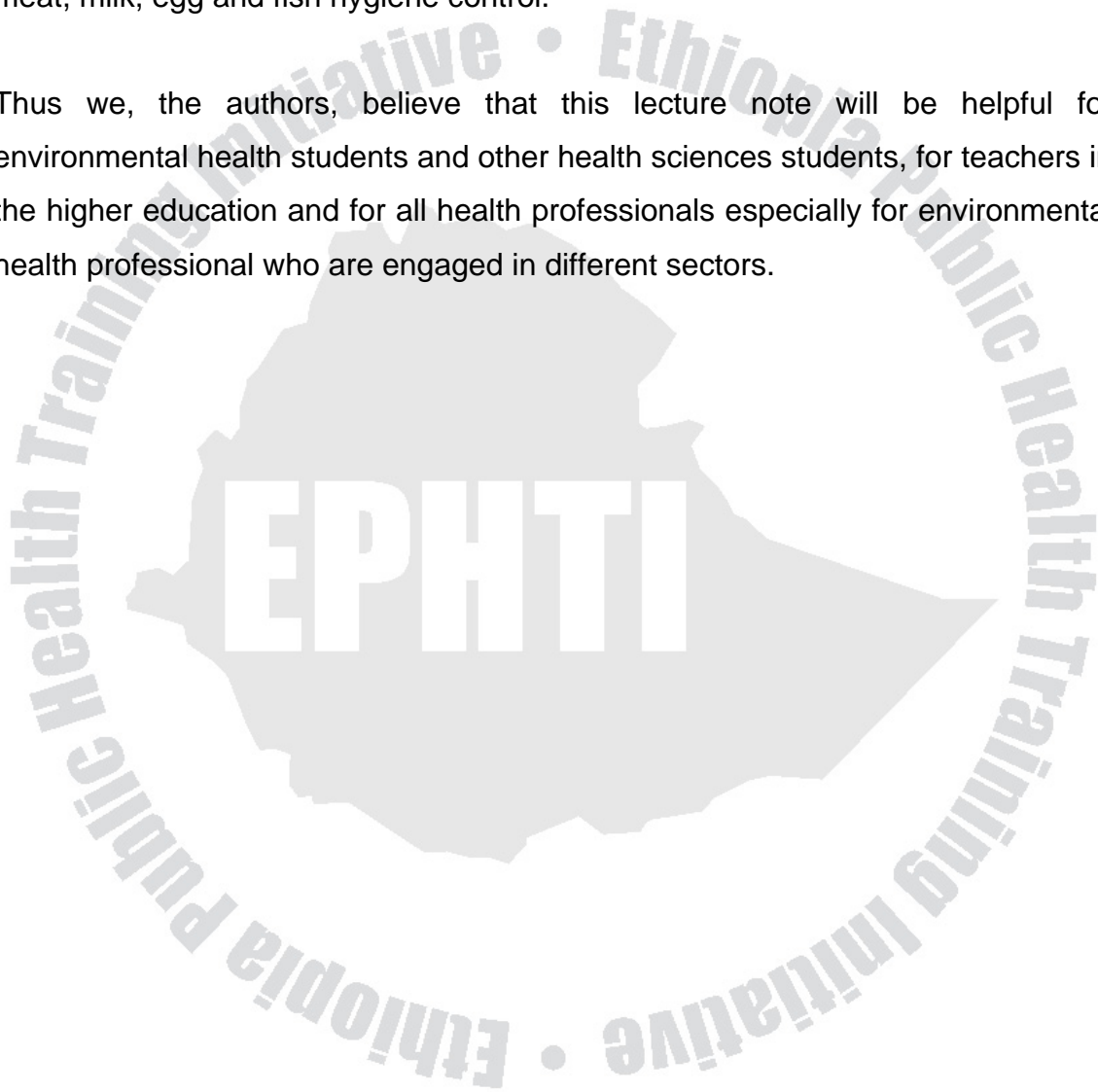
Food hygiene is a subject of wide scope. It aims to study methods for the production, preparation and presentation of foods that are safe and that are of good keeping quality. It covers not only the proper handling of many varieties of foodstuff and drink but also all the utensils and apparatus used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

Food should be nourishing and attractive. It must be visibly clean and it must also be free from noxious materials. These harmful substances may be poisonous chemicals and even chemicals that can be harmless in small amounts but damaging in large quantities. They may enter the food accidentally during growth, cultivation or preparation, or they may accumulate in the food during storage in metal containers. Harmful substances may also form in the food through the interaction of chemical components, or, accumulate in the food during storage in metal, chemical, components. They may also be concentrated from the natural components of the food. Micro-organisms (germs) may be introduced directly from infected food animals or, during food preparation, from workers, other foods or the environment. Poisonous substances may be produced by the growth of bacteria and moulds in food.

Towards the end of the Nineteenth century the danger of infection from milk was recognized and in cities such as London the heat treatment of milk by pasteurization began. Pasteurization kills many bacteria in the milk, including those that are harmful. Incidents of tuberculosis infection from raw milk are no longer seen in the UK because of pasteurization and also because the infection of cows has been eliminated. The eradication of brucellosis in cattle has similarly reduced the incidence of undulant fever. Food poisoning or food borne infection from organisms such as the salmonellae and campylobacter still occur from “untreated” milk and from imperfectly heat-treated milk.

This lecture has been written for those environmental health professionals engaged in food handling or quality and safety inspection. It has been written, with the propose of simply explaining the nature of these various dangers, how they arise and how some of them can be prevented, specifically in relation to meat, milk, egg and fish hygiene control.

Thus we, the authors, believe that this lecture note will be helpful for environmental health students and other health sciences students, for teachers in the higher education and for all health professionals especially for environmental health professional who are engaged in different sectors.

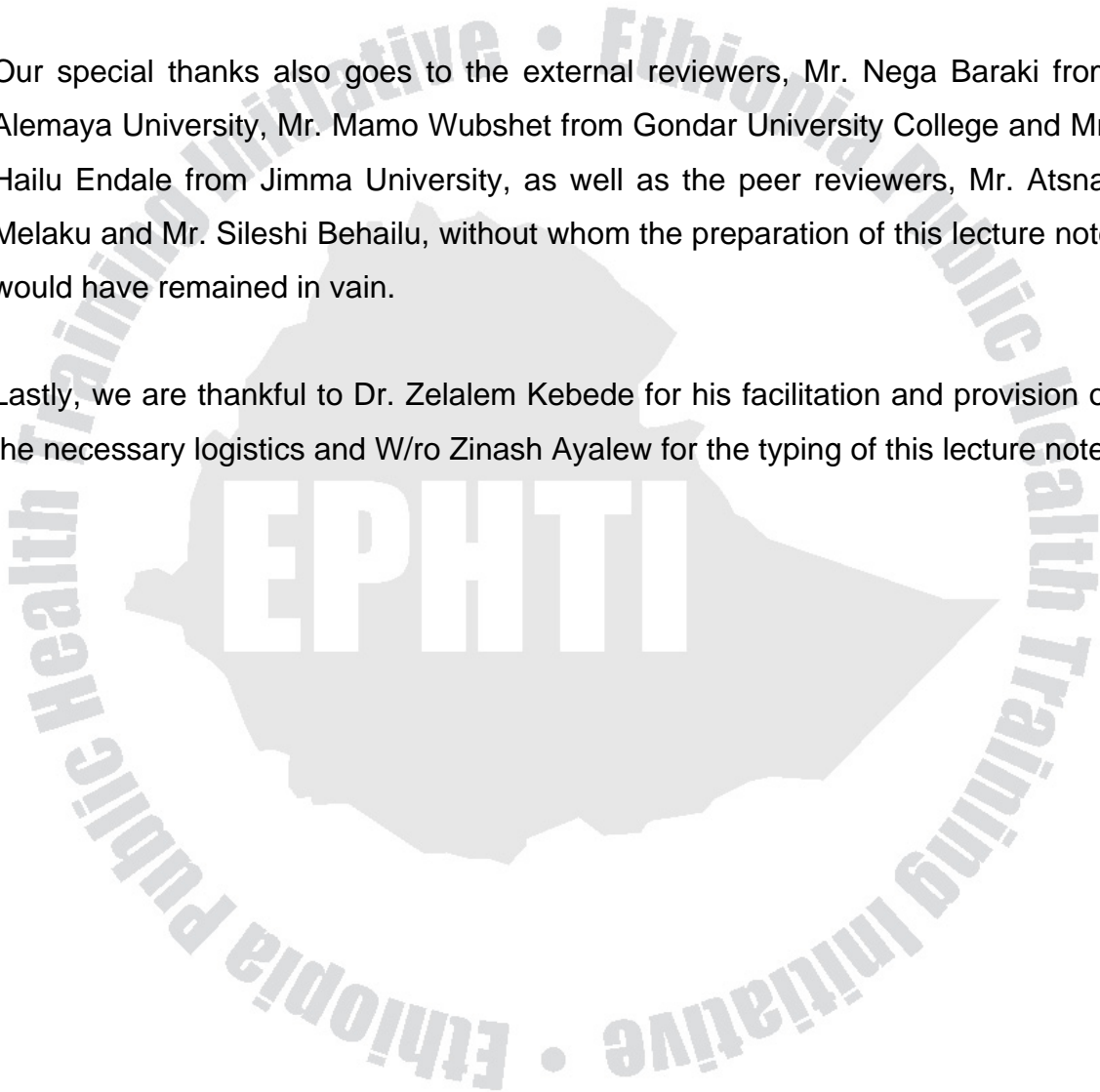


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UNIT ONE

Milk Hygiene

Objectives

At the end of the course, the students will be able to:

- Define milk
- Identify the chemical composition and physical properties of milk
- Identify milk products
- Identify diseases due to milk consumption
- Explain the sanitary practices and hygienic production of milk
- Explain how to make milk safe
- Elaborate the different types of laboratory examination of milk

1.1 Introduction

Milk is the first natural food of all young mammals during the period immediately after birth. The public health experts have defined milk as to be “the lacteal secretion of the mammary glands of a mammal, practically free from cholesterol, obtained by the complete milking of one or more healthy cows which contains not less than 8.25% milk solids-not-fat, and less than 3.25% milk fat.”

The public health reasons for the terms included in this definition are as follows: The food value of milk depends upon its milk fat and milk solids-not-fat content. If either of these contents is reduced to below

the range for normal market milk, the proteins, carbohydrates, minerals and certain vitamins are also reduced.

Practical experience shows that 3.25% of milk fat and 8.25% of solids-not-fat are a reasonable minimum for mixed herd milk. Cholesterol tends to produce intestinal disturbances in children. For this reason, milk obtained within 15 days before and 5 days after calving, the period during which cholesterol is produced, should be excluded.

1.2 Chemical composition of Milk

Milk is a complete food. It is the most nearly perfect food. It is not 'the' perfect food because it is not an entirely dependable source of all vitamins (vitamins C and D) nor does it contain sufficient iron. Why milk deserves this reputation is that it is the one food specifically prepared by nature for the young of mammals.

The composition of milk is extremely complex, consisting chiefly of water, protein in colloidal suspension, lactose and fats in emulsion, inorganic salts in solution, vitamins, enzymes, gases and other substances.

Table 1:1 Percentage composition of milk of different food animals.

Source of Milk species	Water	Fat	Lactose	Protein	Minerals
Human	87.58	3.74	6.37	2.01	0.30
Cow	87.35	3.75	4.75	3.40	0.75
Sheep	80.25	6.97	4.96	6.72	0.90
Goat	81.04	4.63	4.22	4.35	0.76
Camel	87.10	2.91	5.39	3.90	0.70
Donkey	90.12	1.37	6.25	1.78	0.48

1.2.1. Water

This is the principal constituent of milk and is the medium in which all constituents are in solution or in suspension. In some countries, such as Ethiopia, where the production and distribution of milk is not properly controlled, the adulteration of milk by the addition of water is commonly practiced.

1.2.2. Protein

Proteins are built up of amino acids in various combinations. The three principal proteins found in milk in colloidal suspension are casein, lacto albumin and lacto globulin. A complete protein contains all the essential amino acids and, therefore, has a high nutritive value, especially suited to the growth requirements of children.

Casein is a complete protein, insoluble in water and is found only in milk. It exists in milk in combination with calcium phosphate and this

combination causes precipitation. The acids in milk take the calcium from calcium phosphate and thus throw the insoluble casein out of the solution as curd. In the normal curdling or souring of milk the casein is precipitated by lactic acid produced through the action of bacteria upon lactose.

1.2.3. Lactose (Milk Sugar)

Lactose is composed of the simple sugar glucose and galactose. Lactose, like glucose, is a reducing sugar. Lactic acid bacteria present in milk readily germinates it. These bacteria produce an enzyme known as lactase which splits the lactose and ferments it into lactic acid and other products. This causes the milk to sour. Lactose by nature gives milk a sweet flavor and furnishes the body with heat and energy.

1.2.4. Fats (Lipids)

The milk fat is suspended in the milk in the form of an oil-in-water emulsion. Fats are a dispersion of fine particles or globules of milk in water. The milk fat, known as cream, occurs in the form of globules or droplets and is lighter than water and tends to rise to the surface of the milk if not homogenized. Since the fat globules are lighter than the milk whey, they tend to rise up to the top part of the milk and can be dispersed by the help of the homogenization process. The agitation of milk under certain conditions, such as churning, causes the fat globules to gradually coagulate into larger drops and lumps to form butter.

Chemically milk fat is composed of about 25 different fatty acids combined with glycerol forming a mixture of different neutral fats, such as olein, palanitin and stearin. When the fat is hydrolyzed the free fatty acids are liberated and as a result the fat becomes rancid.

Milk fat furnishes the body with heat and energy. It is rich in vitamin A and D. It also contains carotene (pro vitamin A) which gives a golden (reddish yellow) color to the milk.

The percentage of fat in milk has long been one of the standards by which milk is tested. Fat is the most variable in the constituents of milk. The amount varies with different animals and even in the same animal from time to time. A high fat standard encourages the breeding of better cows. The richness of fat in milk is more of an economic than a sanitary question.

Variations in the fat content are influenced by factors such as:

Breed of cow: Breeds producing large amounts of milk, such as Holstein, secrete milk of a lower fat content. Locally there are breeds which produce a low amount of milk but have a high fat content.

Age and health of cow: Fat content decreases due to old age and poor health.

Stage of lactation: Fat content decreases during the first 2 or 3 months of lactation.

Season of the year: Fat content is lowest in late spring or early summer.

Feeding habit: The fat content of milk varies depending on the type of fodder that the cows use.

Variation during milking:

- a. The “fore milk” or “first milk” drawn is lowest or poorest in fat content.
- b. The “middle portion” is average in fat content.
- c. The “stripping” or “last milk” drawn is highest or best in fat content.

1.2.5. Minerals

The major inorganic salts present in milk are calcium, phosphorous, sodium, potassium, magnesium chlorides and sulphates. Trace elements such as iron, copper, manganese, iodine and zinc are also present in milk. Milk is a source of calcium and a rich source of phosphorous. Both of these elements assist in the formation of bones and teeth of growing children. Since milk is deficient in iron, an exclusive milk diet may cause anemia due to iron deficiency.

1.2.6. Vitamins

Milk may be rated as a good source of many vitamins in certain variation. The most common vitamins present in milk are:

- Vitamin A: Milk is rich in, and the best source of, vitamin A, which is heat resistant

- Vitamin B1 (thiamine): Milk is a fairly good source of vitamin B1, which is heat resistant
- Vitamin C: Milk is a less dependable source of vitamin C, which is heat sensitive
- Vitamin D: Milk is a relatively poor source of vitamin D, which is heat resistant
- Vitamin E: Milk is a fairly good source of vitamin E, which is heat resistant
- Vitamin B2 (Riboflavin): Milk is a rich and outstanding source of vitamin B2, which is heat resistant

The fat of milk is a rich source of vitamin A. Therefore butter, cream and all kinds of cheese products which are made from whole milk are outstanding sources of vitamin A. Naturally the amount of vitamin C content is very minimal. It is also easily affected by heat treatment. Brief boiling of milk, as it is commonly practiced in most local homes, results in the loss of 20-50% of its vitamin C content.

1.2.7. Enzymes

Enzymes are protein compounds which act as biological catalysts having the ability to speed up or retard the chemical reaction without themselves being changed. Enzymes are specific in their action in that they act by splitting certain specific substances. For example, lipase acts only on fat, lactase acts only on lactose, phosphates acts only on phosphate etc.

Enzymes are relatively unstable. High temperatures, an unfavorable pH, light, and certain chemicals tend to destroy or inactivate them.

The principal enzymes present in milk are:

- Phosphatase: Acts on phosphates. It is a heat labile enzyme and is a normal constituent of raw milk. It is also important in connection with tests for the determination of proper pasteurization as it is almost completely inactivated at normal pasteurization temperatures.
- Lipase: Acts on fat or lipid.
- Lactase: Acts on lactose (milk, sugar).

Others like amylase, galactase, catalase, etc.

1.2.8. Gases

The principal gases in milk are CO₂, O₂ and N₂. They are introduced into the milk during the process of milking and handling.

1.3. Physical Properties of Milk

The major physical properties of milk are color, specific gravity, freezing point and boiling point. These are influenced by the composition of milk. They are also a great help in the processing and testing of milk for adulteration.

1.3.1 Color

The milk pigments influencing the color of milk are:

- Carotene (Vitamin A) of the fat in the milk that gives a golden color.
- Riboflavin (B2) of the whey that gives a bluish color.

1.3.2. Specific gravity

Milk contains many constituents whose specific gravity is greater than that of water. Therefore milk is heavier than water. Fat is the only important constituent with a specific gravity of less than 1. Hence the more fat present in the milk, the lower the specific gravity of milk. With the removal of fat, as in skimmed milk, the specific gravity is increased. In another words the addition of water to the milk tends to lower the specific gravity whereas the removal of fat increases it.

Normal, average milk has a specific gravity of 1.027 to 1.035. To determine roughly whether milk is adulterated with added water or by skimming, its specific gravity is measured with the help of an instrument called a Q-lactometer, which is a type of hydrometer.

Lactometer reading (Quevenne Lactometer):

Correct reading of lactometer (L) is at 60°_F (15.5°_C)

1. If L reading is above 60°_F , add 0.1 for each degree e.g. if L reads 30 at 68°_F , there is 8°_F ($68-60$) $^{\circ}_F$ therefore correct reading at 68°_F is $30 + (8 \times 0.1) = 30 + 0.8 = 30.8$.
2. If L reading is below 60°_F , subtract 0.1 for each degree e.g. If L reads 29.5 at 53°_F there is 7°_F ($60-53$) $^{\circ}_F$ therefore correct reading at 53°_F is $29.5 - (7 \times 0.1) = 29.5 - 0.7 = 28.8$.

NB: Add 0.1 Quevenne Degree for each degree F above 60⁰_F.

Subtract 0.1 Quevenne Degree for each degree F below 60⁰_F

Calculation of specific gravity of milk (S.G):

$$\text{S.G} = \frac{(\text{Quevenne Lactometer reading})}{1000} + 1$$

$$= \frac{32}{1000} + 1 = 0.032 + 1$$

$$\text{S.G.} = 1.032$$

Therefore the milk is normal as its specific gravity is within the range 1.027-1.035.

Calculation of specific gravity of milk solids:

Fleischmann has proposed the following rule for calculating the specific gravity of the total solids in milk:

$$\text{S.G. milk solids} = \frac{\% \text{ of total solids}}{\% \text{ of total solids} - \frac{100(\text{S.G of milk}-1)}{\text{S.G of milk}}}$$

e.g. a sample of milk containing 12.5% of total solids has a specific gravity of 1.031. What is the specific gravity of the milk solids?

Given: total solids = 12.5%

S.G. of milk = 1.031

Water boils at 100°C (212°F) while milk boils at 100.17°C (212.3°F) at sea level. A thermometer is used for measuring the boiling point.

1.3.5. PH of Milk

Although pH is a chemical parameter of milk, it is discussed here for convenience. pH tells us whether the milk is acidic or alkaline. Normal milk has a PH of 6.5 -6.8. To test the PH of milk, the following measuring devices can be used

PH meter (accurate and sensitive) measurement,
PH colorimeter (gross measurement), and
PH litmus paper (gross indicator).

1.4 Milk Products

Some of the common milk products that are made locally or commercially from whole milk are

1.4.1. Cream

A portion of milk containing not less than 18% milk fat. Cream may be taken from milk by “skimming” or “separating”

Skimming is the process of removing manually the cream, which rises to the surface, after milk stands in a container. The remaining part of the milk is called skimmed milk.

Separating is the process of removing cream mechanically. The remaining part is called separated milk.

1.4.2. Curd

The coagulated part of milk. If milk is stands in a container for sometime at room temperature, it forms clots called curds which are contained in a clear liquid called whey.

1.4.3. Whey:

This is the watery part of milk after separation of the curd from the whole milk. It contains protein, lactose, minerals and salts.

1.4.4 Cheese

This is the clotting casein of milk. Cheese is made from separated milk or whole milk. The milk curd, after being removed from the whey, is pressed into solids and through other processes and forms cheese. Genuine cheese must contain no fat other than that obtained from milk.

1.4.5. Butter

This is the solidified milk fat or cream prepared by churning. The cream produced from milk is violently churned up and shacken so that the fat globules are broken up and closed together into pieces of mass called butter.

1.4.6. Ghee

This is butter which has been heated and clarified. Butter is boiled over heat until the water is evaporated. It is then strained and ghee is produced.

1.4.7. Margarine

This is used for breakfast to spread on bread or for cooking. It is usually made from animal or vegetable fat. Milk or milk-products added to the margarine is only to give a buttery taste.

There are also some other milk products more popular with Europeans than Ethiopians:

Condensed milk: This is milk from which most of the water has been removed. The remaining part is canned or bottled and used as milk.

Sweetened condensed milk: This is milk that is evaporated after it is mixed with sugar. This type of milk stays fresh for a long time.

Evaporated condensed milk: This is also evaporated milk but with no sugar added. It is usually canned and hermetically sealed.

Condensed skimmed milk: This is milk with no cream before condensation. This is not good for infant feeding.

Ice cream: This is cream made by mixing milk products with other ingredients and then freezing them into a semi solid state. The principal ingredient of the cream is usually milk or cream flavoring and coloring materials, etc.

1.5. Milk-borne diseases

Milk is an excellent food for man but it is an ideal medium for the growth of micro-organisms. From the time milk leaves the udder of the animal, unless adequate safeguards are maintained, it may receive bacteria and other micro-organisms from the surroundings, for example the milker and other equipment used in milk processing, storage and transportation.

1.5.1. Diseases resulting from infected carriers

- Typhoid and paratyphoid fever such as salmonella typhi and salmonella aratyphi.
- Tuberculosis (human) such as mycobacterium tuberculosis.
- Epidemic diarrhea
- Diphtheria
- Scarlet fever

1.5.2. Diseases transmitted from infected cows

- Tuberculosis (bovine) such as mycobacterium bovis
- Undulant fever (Brucellosis) such as brucella abortus
- Anthrax such as bacillus anthracis
- Q-fever such as coxiella burnetii
- Mastitis (bovine) such as staphylococcus aureus
- Foot and mouth disease which is viral

1.6. Sanitary practices to be observed in producing safe milk

The main objective is to protect milk from external contamination such as animals, the milker and the environment in which the milking is done.

1.6.1. Sources of contamination

Preventive Measures

Contamination from human discharge and wastes:

- Construction of a proper waste disposal system
- Prevention of human discharge and wastes from contacting animals and milk
- Practices of good personal hygiene
- Segregation of animals from human habitation.

Contamination from air borne dust and droplets:

- Proper construction of the milking area
- Sneezing or coughing away from milking containers during milking
- Provision of clean surroundings and avoidance of dusty conditions during milking

Contamination from animal bodies, hides, udder and teats:

- Clipping, brushing, cleansing and sanitizing before milking

Milk containers (contamination from milking utensils and dirty water):

- Proper washing and storing of milking containers
- Using proper and easily cleanable utensils
- Using only safe water for washing and cleaning

Milk handlers and contamination from milkers and their clothing:

- Keeping the milker's level of personal hygiene high
- Washing of hands with detergents before milking
- The milker should always wear clean garments while milking.

Cow and contamination from diseased animals:

- Detecting and isolating affected animals
- Veterinary inspection and supervision of animals
- Treatment and vaccination of animals.

1.6.2. Sanitary requirements for dairy farms

Milking barn, stable, or cowshed

Construction

- The areas used for milking purposes shall:
 - Have floors constructed of concrete or any other impervious materials and provided with proper drainage
 - Have walls and ceilings which are smooth and painted, in good repair and dust proof
 - Have separated stalls or pens for calves and bulls
 - Be provided with natural and/or artificial light, sufficient and well distributed in the working area
 - Not be overcrowded but properly spaced
 - Be provided with sufficient air space and air circulation.

Cleanliness

Everything within the milking barn, stable or cowshed should be kept clean and tidy. These rooms should be free of threshings, filth and

animal droppings. They should be kept free of dust and the floor should be dry, clean and fly and rodent proof. The interior and the surroundings of the barn, stable or cowshed should be kept clean and tidy. The walls, ceilings, windows and equipment should be free of filth, litter and vermin. Animal droppings and manure should be collected and disposed of properly.

Milk house or milk room

Construction

- The milk house or room (moderate size) shall
- Be provided with smooth, impervious, well graded and of good repair concrete flooring
- Be provided with smooth, of good repair and well painted walls and ceiling
- Have adequate natural and/or artificial light and adequate and a proper ventilation system
- Be provided with proper washing facilities
- Be used for no purpose other than milk house operation
- Be provided with a proper stage for milk containers and utensils
- Be provided with proper storage for of milk and cooling devices

Cleanliness

Everything within the milk house should be kept clean and tidy, free from filth and animal droppings. It should be kept free of dust and the floor should be dry, clean and fly and rodent proof.

Utensils and Equipment

Construction

All containers, utensils and equipment used in the handling, storing and transporting of milk shall:

- Be made of smooth, non- absorbent, corrosion resistant material
- Be constructed in a manner that can be easily washed and cleaned
- Be in good repair
- Be seamless and free of cracks.

Cleanliness

All utensils and equipment used shall:

- Be cleaned after each usage
- Be washed thoroughly after each usage
- Be sanitized before each usage
- Be protected from contamination and mishandling prior its usage
- Be stored free from flies and other vermin when not in use.

1.7 Hygienic production of milk

The use of correct and sanitary milking methods is an important step in protecting clean milk. Correct milking methods will reduce udder

injuries and mastitis infections, increase milk production, result in cleaner milk and reduce milk contamination.

There are two types of milking methods, namely manual (milking by hand) and mechanical (milking by milking machine).

Steps of milking milk by hand:

- Prepare all milking materials prior to milking
- Massage and wash teats and udder thoroughly with cloth or piece of towel dipped in warm water; if possible in warm bactericidal (chlorine) solution
- Draw out foremilk in strip cup squeezing a few hand squirts from each teat
- Fore milking stimulates milk flow
- Fore milking helps detect an abnormal milk resulting from a diseased or injured udder
- Before starting milking be sure that milker's hands are clean and dry
- Milking is done carefully without letting any foreign objects or vermin enter the open milking jar
- After finishing milking transfer the milk into a clean container by straining and immediately keep or store the container at a temperature of 50⁰_F (10⁰_C) or less

1.8. Methods of making milk safe

Milk as secreted by the udder cells of a healthy cow is probably sterile, i.e. it contains no micro-organisms capable either of souring the milk or causing disease. But when milk reaches its reservoir within the udder, and particularly in passing through the teat of the udder and reaching the milking pail, the risk of picking up detrious micro-organisms steadily increases.

Raw milk must undergo heat treatment to prevent not only its rapid deterioration but also any risk of its conveying disease to the consumer. Heat treatment is generally most satisfactory because it causes the minimum of change in the composition of flavors and acceptability of the milk. Effective heat treatment does not necessarily entail the destruction of all micro-organisms originally present but it accomplishes the destruction of any pathogens in the milk.

N.B. Milk produced under sanitary conditions still contains many bacteria. Therefore it must be treated properly before consumption. The most common method of treating raw milk is by applying heat. There are at least five methods of treating milk.

1.8.1. Boiling

This is the easiest and most practicable method of making milk safe in every home. As soon as raw milk is produced or delivered it should be boiled.

Boiling is raising the temperature of the milk to boiling point and maintaining the milk at this temperature for a few minutes. Then the milk should be immediately cooled. If it has to be stored the temperature should be maintained below 10⁰c. Since these may be impracticable in a home, every care should be taken to keep the milk as cool as possible> Preferably the milk should be consumed as soon as possible after cooling and not stored for an extended period of time after it has been boiled and cooled.

Boiling of milk destroys all microorganisms except the spore formers but it changes the nutritive value of milk, its flavors and palatability and appearance. However this disadvantage should be disregarded in favor of the safety of boiled milk i.e. its freedom from disease-causing microorganisms. Boiling is technically difficult to process on a large scale and is commercially uneconomical.

1.8.2 Pasteurization

The term pasteurization, named after Louis Pasteur (1822-1895) the famous bacteriologist, was first devised to be applied to other fluids, the main one being milk and used for controlling spoilage in wine and beer. Afterwards pasteurization became popular.

Pasteurization of milk is a universally known method of rendering raw milk safe through controlled heat treatment and can be defined as the process of heating every particle of milk and milk products to a

predetermined temperature and holding this temperature for a predetermined time.

Pasteurization of milk is not sterilization but it is a destruction of all pathogenic micro-organisms, a good number of other non-pathogenic and non-spore forming bacteria and certain enzymes in the nutritive value and the chemical nature of the milk.

1.8.2.1 Objectives of pasteurization

Pasteurization of milk is usually done to meet at least three objectives. Since the rationale for pasteurization is to prevent milk-borne diseases, the first objective of pasteurization is to ensure that all pathogenic micro-organisms commonly found in milk are completely destroyed.

The second objective is to safeguard the food value of milk; to ensure that its chemical compositions/constituents are retained as much as possible.

The third objective is to ensure that other non-pathogenic bacteria and certain undesirable enzymes, which may cause spoilage, are inactivated or reduced to optimal levels.

1.8.2.2 Principles of pasteurization

The criterion for selecting a given combination of pasteurization temperature and exposure time is to maximize the objectives of pasteurization of rendering raw milk safe for human consumption.

In the early days of milk pasteurization the first task was to determine a temperature/exposure/time point at which the most heat-resistant non-spore-forming pathogen commonly found in milk would be destroyed completely. At that time this was *Mycobacterium tuberculosis*.

Thus the thermal death time of *Mycobacterium tuberculosis* was taken as the lower mark of pasteurization. Later it was found that *Coxiella burnetii* (*Rickettsia burnetii*) the etiologic agent of Q-fever, known for transmission by raw milk, is more heat-resistant than *Mycobacterium tuberculosis*. Consequently the temperature/exposure/time was readjusted to accommodate the thermal death time of this organism.

The upper demarcation line of the temperature/exposure/time for pasteurization should be a line or combination point where the food value of milk is not appreciably changed while at the same time all pathogenic organisms commonly found are assured to have been destroyed.

Since the proper pasteurization process depends upon a temperature and time combination, it is necessary to have an accurate thermometer with a time recording device such as

- A Recording thermometer which has a pen to continuously record temperature and time in a special chart during the pasteurization processes.
- An Indicating thermometer which is a straight stem mercury activated thermometer. This is more accurate than the recording thermometer.

1.8.2.3 Methods of pasteurization of Milk

Basically pasteurization of milk involves three essential steps:

- Heating raw milk to a predetermined temperature
- Holding at this temperature for a predetermined time
- Immediately cooling down to at least below 10⁰c (50⁰F).

Therefore, the two most important variables are pasteurization temperature and the exposure or holding time. At present there are at least three accepted methods of pasteurization of milk:

The holding or vat method

The holding or vat method, also known as the low temperature holding time process, is a method of holding the milk in a vat (container) to a temperature of 63⁰c (145⁰F) for 30 minutes.

In this process milk is heated in a large jacketed container by steam or hot water circulating in the interspaces of the vat or through a pipe coil in the vat to a temperature of 145⁰F. In order to ensure a uniform temperature throughout the milk some method of agitation is needed. The milk is then immediately cooled to at least 10⁰c (50⁰F) or less in the same container, which holds the milk or may be transferred

through an outlet valve and piped into another cooler to be bottled. There is a break in the operation between the holder vessel being emptied and another one being ready to be filled.

The high temperature-short time method

This is a continuous process by which milk is rapidly brought to a temperature of 71°C (161°F) and heated continuously for 15 seconds. During this process the milk has been preheated in the regeneration (heat exchanger) first and then its temperature is brought rapidly up to about 161°F and is held there through a holding tube for a period of 15 seconds, after which the milk is returned to the regenerator. The milk is then passed into the cooler and finally to a bottle filling device. During this process if milk is not properly pasteurized, it will not be passed into the cooler. It must then be automatically returned back into the raw milk tank to be pasteurized.

For all practical purposes if milk is said to be properly pasteurized it must satisfy the following three conditions:

- The milk must be cooled adequately (50°F or less) before pasteurization so as to prevent the formation of heat resistant staphylococcal enterotoxin
- The pasteurization equipment should function properly and adequately
- Precautions should be taken to prevent any post pasteurization contamination.

The ultra-high temperature (UHT) method

In this process the milk is heated to at least 88°C (191°F), held at this temperature for at least one second and then immediately cooled to at least below 10°C (50°F).

This method has been developed very recently and is used only in a few developed countries because it requires complex equipment and the highest levels of precision and handling.

As it can be seen, in all the three processes of heating, after the proper temperature and exposure time are achieved the milk is immediately cooled down to at least below 10°C (50°F). This is because a temperature below 10°C normally arrests the growth of most bacteria and thence extends the shelf life of the pasteurized milk.

After cooling the pasteurized milk is usually distributed in clean sterile containers. The containers are often of a single-service disposable type and should be discarded after use. In homes or institutions they should preferably be kept in refrigerators or in other means that can be kept at least below 10°C . Under conditions where this is impossible, consuming the milk as soon as it is brought home is important. The same care should be taken during transport or storage of pasteurized milk.

1.8.2.4 Limitations of pasteurization

In developing countries like Ethiopia pasteurization of milk has several limitations:

- It can only be effectively done on a commercial basis
- It requires special and expensive equipment and budget
- It requires skilled technicians to operate
- It requires a centralized collection, processing and distribution management center.

1.8.2.5 Sanitary problems in pasteurization plants

In order to market safe milk precautions have to be taken in such pasteurization plants:

- The plant should first of all be properly designed
- The equipment used for pasteurization, storage, bottling, cooling, etc should be of standard design, easily washable, sterilizable etc.
- There should not be any contact or leak of unpasteurized or raw milk into the finished product
- Time keeping and thermometers are necessary at all times
- Since foam and splashed milk on the vat surface will not be properly heated, steam or hot air should be applied from the top
- All valves used in milk pasteurizing plants should be leak protector types. If any leakage occurs, the leaking milk is wasted and should not pass down the holding tube
- Manual control of milk plants has proved to be unreliable because of contamination due to carelessness. For this

reason it is now being advocated that an automatic continuous flow type should be used

- An automatic milk flow stop is necessary to stop the forward flow of sub temperature milk in time when the heat source fails to provide the optimum temperature.

There are two types of automatic milk flow stops. One automatically shuts off the milk pump motor whenever the milk temperature falls below the pasteurization temperature. The other has a flow diversion valve that automatically directs the milk back to the heater whenever the temperature is too low.

1.8.3. Sterilization

In this process milk is heated to destroy all micro-organisms including spore forming and can only be done by keeping the milk at a temperature above normal boiling point (100°C or 212°F) for at least 20 minutes.

If the temperature of the heat treatment is higher and the sterilization effect is greater, there will be a more marked change in the color and taste of the milk. One important phenomenon is that with increasing temperatures spore destruction rates increase more than the influence upon the taste and the color of the milk. The nutritive value of the milk, namely some vitamins (heat sensitive vitamins) and proteins, is affected depending upon the type of the sterilization process.

1.8.4 Drying

This is a method where the entire water constituent is removed from the milk by evaporation. The solids remaining form what is called milk powder (dry milk). Milk powder can then be made into liquid milk by adding a proper amount of water. Drying is not a simple operation that can be accomplished by heating and evaporation in the home. It needs special equipment and arrangement. There are two known methods of drying.

1.8.4.1 Roller drying

The milk in small quantities is slowly poured over a heated and revolving roller. The roller is heated by steam or hot air. The heat in the roller will evaporate the water constituent of the milk. The solid parts will remain behind which will be collected and packaged.

1.8.4.2 Spray drying

This is also a mechanism whereby the milk is subjected to hot air. The process is simply spraying the milk through a current of hot air. The remaining powder will also be collected and packaged.

In both processes the milk powder is collected in sterile containers, usually cans. The cans are sealed airtight under sterile conditions, labeled and distributed to consumers in near and far away places.

1.8.5 Cooling

Since milk is an ideal medium for the multiplication of most disease-producing organisms, the milk should be kept at 50⁰_F or below starting immediately after milking. This is very important especially if milk is going to be delivered raw to consumers. This temperature range is essentially needed to arrest the growth of micro-organisms specially brucella organisms. However milk should not be allowed to freeze.

The simplest method of cooling milk is submerging the cans of milk in troughs or tanks of ice water if possible. A trough should be concrete, preferably insulated by layers of cork or cotton pads. A 120-liter tab of water kept at 37⁰_F will cool 40-liters milk from 85⁰_F to 45⁰_F, the recommended temperature.

1.9 Laboratory examination of milk

The laboratory examination of milk is one of the most valuable and necessary aids to the overall milk quality control program. Without this service the safety and sanitary quality of milk is difficult to determine. Although the environmental health worker may not personally conduct such tests, he or she must be able to send samples to the laboratory and able to interpret the results of laboratory tests.

In order to make milk safe it may have to be handled with maximum care during milking, processing or storage. Milk may also undergo pasteurization or other types of heat treatment. Regardless of this the condition of the milk has to be checked at all stages. For example:

- It has to be checked for its bacteriological content just after milking to see the extent of the bacterial colony
- It also has to be checked after pasteurization to see if the process has inactivated all enzymatic activities.

1.9.1. Sample taking

- If the milk is contained in bottles, one unopened bottle is enough.
- If the milk is in bulk containers it must be mixed with a sterile plunger before a sample is collected from well below the surface with a sterile dipper and poured into a sterile stopper or screw capped bottle with a capacity of about 125ml.
- Place the sample in an insulated box, label and dispatch to the laboratory.

1.9.2. Types of laboratory examination of Milk

Sediment Test

This is done in the field or laboratory. The purpose is to determine the amount of insoluble visible filth or extraneous matter in the milk.

To undertake the test: From a mixed milk sample force a measured amount of milk through a tester made of stiff cotton or pad discs measuring about 1 inch in diameter whereupon the sediment is collected. If this is not available a simple filtration through a filter paper can do the same job.

Interpretation: Although the amount of sediment on test discs often has little relation or no relation to the bacterial content of the milk, results of this test provide information about the care exercised during the handling of the milk. The sediment on the pad is graded as clean or fairly clean, compared with ready-made photographic standards. Therefore poor/dirty sediment is indisputable evidence of carelessness while clean sediment may merely represent efficient straining on the farm.

Methylene-Blue Reduction Test

The purpose is to determine the quality of milk before pasteurization. This test is particularly applicable to raw milk. The test involves determination of time required for the disappearance of color when methylene blue thiocyanate solution is added to raw milk.

In a test tube with 10 ml of milk add 1 ml of standard methylene blue solution. The sample is mixed and then place either in a hot water bath or in an incubator at 35°C - 37°C . Observations are made at intervals of 15-20 minutes for an 8 hour period to determine the time required for the disappearance of the blue in the sample.

Interpretation: Milk with a high bacterial content will decolorize the dye quite rapidly whereas milk with a low bacterial content retains the blue color for several hours. On the basis of this test milk can be graded as follows:

Excellent: Very low bacterial count. Its decolorized time is about 8 hours i.e. not decolorized in 8 hours

Good: Low bacterial count. Decolorization time is 6-8 hrs i.e. decolorized in less than 8 hours but not less than 6 hours

Fair: High bacterial count. Decolorization time is below 2 hours i.e. decolorized in less than 2 hours

Poor: Very high bacterial count. Decolorization time is below 2 hours i.e. decolorized in less than 2 hours

Results of the test may be effectively used as a basis for improving the milk supplies, particularly milk intended for pasteurization. This test, combined with field investigations, serves as an effective means of correcting improper production methods and improving the general sanitary conditions of the dairy farm.

Resazurin Reduction Test

The purpose is to determine the sanitary quality of raw milk. This test is quite similar to that of the methylene blue test, except with changes in color in a very short time. This test also undergoes a series of color changes whereas methylene blue changes from blue to colorless.

In a test tube with 10ml of milk add 1/10 (0.1ml) of resazurin solution (0.05%). After mixing properly the sample is placed in a water bath or incubator at 35⁰C-37⁰C. Observations for color changes are made at 15 minute intervals. The two most common applications of the resazurin test are:

The one-hour test: In this test the color of the milk is compared after 1 hour at 37⁰C with several exactly described color standards.

The three hours (triple reading) test: In this test 3 readings are made at 1-hour interval to see changes in color.

Interpretation: Milk with a high bacterial count and other infections of the animal is detected quite sharply with the resazurin test. A resazurin pink of 3 hours or longer represents a good quality of milk. High-grade (acceptable) milk requires at least 3 hours.

Standard plate count (agar plat count)

The purpose is to estimate the bacterial population of the milk and dairy products prior to heat treatment.

In this test a 1ml portion of the milk sample is diluted with distilled water to give dilutions ranging from 1/10 to 1/1000. A 1 ml portion from the dilutions is then placed in a Petri dish/plate containing a growing media (milk agar). This sample is incubated at 350C-370C for 48 hours. At the end of 48 hours a count of colonies developing on the plates is done with help of a “Queven bacterial colony counter.”

Interpretation: The number of colonies counted multiplied by the dilution factor gives what is known as the standard plate count (SPC) or the estimated number of bacteria per milliliter of sample. For

example, if 30 colonies are counted in a Petri dish of 1/100 dilution, the SPC is $30 \times 1000 = 30,000$.

The standard is as follows:

- Raw milk: 200,000 maximum acceptance
- Pasteurized milk: 30,000 maximum acceptance. .

The interpretation of the results is based upon the fact that the bacterial population in milk serves as an index of sanitary quality i.e. a low bacterial population indicates correct handling and processing, whereas a high count many indicate the reverse.

Coliform Test

The purpose is to determine the presence of organisms of coli form group in milk. It is used primarily to detect contamination after pasteurization. In this test the dilutions 10ml, 1ml, 0.1 ml from the milk sample are transferred into appropriate media and then incubated for 48 hours at 37°C. At the end of this period these preparations are observed for the presence of gas (refer to water analysis for complete procedures).

Interpretation: A positive test on pasteurized milk indicates contamination after heat treatment. That is the presence of coli form organisms in pasteurized milk is a signal for the source of contamination in the milk processing plant.

Babcock Test (Fat Test)

The purpose is to determine the fat content of milk. After mixing well by shaking the raw milk sample, take about 17.6 cc (ml) by using a pipette and fill it into a graduated Babcock bottle. Carefully add to this bottle a 10cc. concentrated. Without delay shake it for 3 minutes and then centrifuge the bottle at 1400F. (if the milk sample is pasteurized add 7 cc H_2SO_4 to the 10cc already filled and shake it for 1 minute.)

After centrifuging stand it for 5 minutes and add to it hot water up to the base of the neck and centrifuge for 1 minute. Take out the bottle from the centrifuge and put it on a hot water bath for sometime and do the readings.

Interpretation: The fat which rises into the graduated neck of a special Babcock bottle is measured directly with the aid of a caliper or geometrical divider, the length of the fat column from the lower surface to the highest point of the upper meniscus. Results are expressed in percent.

Fat content (%)	Quality
Below 3	Poor
3-3.25	Fair
3.25-3.50	Good
Above 3.50	Excellent

Phosphate Test

The purpose is to determine the efficiency of pasteurization or to check the adequacy of pasteurization. The test is based on the fact that raw milk contains an enzyme, phosphatase, the presence of which is easy to detect and which is practically destroyed by heating at pasteurization temperature and time. The test depends upon the hydrolysis of a disodium phenyl phosphate to form phenol and phosphate.

The addition of BQC (dibromo quimone chloramines) causes a blue color reaction to occur with the phenol. Thus the presence of phosphatase is demonstrated by a blue reaction while the destruction of phosphates by proper pasteurization fails to produce a blue color. The intensity of color is measured by a colorimeter.

Interpretation: If the test reveals little or no phosphatase, one may assume that the milk was adequately heated, but if the enzyme is present it means that pasteurization was incomplete or that raw milk has been added to pasteurized milk. It is possible to detect a 10F temperature differential or 5 minutes under heating or the addition of only 0.5 % raw milk.

Review Questions

1. Discuss the chemical composition and physical properties of milk.
2. Mention at least four diseases due to raw milk consumption.
3. What is the difference between a sediment test and a methylene blue reduction test?
4. Discuss the various methods of milk preservation.



UNIT TWO

Egg and Fish Hygiene

Objectives

At the end of the course, the students will be able to:

- Identify the constituents of an egg
- Explain the causes of egg spoilage
- Elaborate the methods of inspection and preservation of an egg
- Identify the types, anatomy and characteristics of fish
- Identify signs of freshness and decomposition in fish
- Explain methods of inspection and the diseases of fish

2.1 Egg Hygiene

A hen's egg, although it is not a complete food for humans, is a complete food for a chicken embryo. A hen's egg weighs about 57 grams and its specific gravity (excluding the shell) is 1.048. The PH of an egg is 7.7.

An egg consists of three main parts:

The outer shell: This forms a hard protective layer that accounts for about 10% of the total weight of an egg. It is porous and allows air exchange to the growing embryo and its color is mostly white.

The egg white (inside the shell): This is a viscous colorless liquid that accounts for about 60% of the total weight of an egg and consists of protein, water, salts and vitamins.

The egg yolk (in the center): This is a thick yellow or orange emulsion that accounts for about 30% of the total weight of an egg and consists of fat, protein, salts and vitamins.

2.1.1. Constituents of an egg

Protein: This is an average of 12.85% and eggs are a good source of protein.

Fat: This is an average of 11.15% and eggs are a fairly good source and fat is present in egg yolk.

Water: This is about 73.80% and the white egg holds most of the water.

Mineral salts: This is an average of 1.60%, an egg has a very small amount.

Eggs are deficient in carbohydrates, but rich in vitamin A, B₂, D and E.

2.1.2. Causes of spoilage

An undamaged eggshell allows the passage of oxygen, carbon dioxide and water vapor through the pores. The shell carries a vital membrane covering these pores but allows gaseous exchange. Microbes are hindered from passing through the shell. Although the shell is intact, simple manual handling may destroy the membrane. Microbes are then able to invade and infect the egg. Removal of the

covering by washing with water also permits the entry of micro-organisms.

Some of the common defects found in eggs are:

Black or red spots: This is when on candling an egg red and black spots are seen in an egg yolk, which was originally yellow.. If on candling the yolk is very dark the egg should be condemned.

Blood spots: This is when a drop of blood is detected in egg yolks through candling. If the spots are small, the egg can be used immediately for cooking but if stored longer it will decompose.

Fishy taste: This is usually due to feeding materials. It can be also due to improper storage. If the taste is pronounced the egg should be condemned.

Mold on shells: This is found mostly on cracked eggs. This defect is due to a poor storage system. Mold can cause quick decomposition and the egg should be condemned.

2.1.3. Egg inspection

Eggs may be examined in various ways for freshness:

Shaking using hands: A fresh egg gives no sound when shaken and a stale (bad) egg makes a sound when shaken.

Brine test or immersion in water: A fresh egg will sink in water or 10% salt solution. The 10% salt solution is prepared by dissolving 2 oz of salt in 1 part of water and stale (bad) eggs will float in a solution.

Candling: This is projecting light through eggs. The eggs are held between the observer and a source of bright light to detect the size of

the air space and any other changes within the egg. When the egg is fresh it is translucent, the yolk faintly seen and the air space is not more than a $\frac{1}{4}$ inch in depth. But when the egg is stale, dark spots or blood spots are seen within the shadow of the yolk and the air space is more than $\frac{1}{4}$ of an inch in depth.

2.1.4. Preservation of eggs

Eggs are preserved for a long time by preventing the entrance of air through their pores i.e. by smearing the egg shell with wax, butter, lard or oil or immersing the egg in a solution of sodium silicate (glazing).

Silicate solution: Sodium silicate is added to water to form a solution. The eggs are immersed in, and covered with, this solution.

Oil dipped: Eggs are dipped for a few seconds in tasteless clear mineral oil. Surplus oil is then removed and the egg dries in 24 hours.

Lime water: A solution is made of 4 parts of slacked lime, 1 part salt and 20 parts of water. This solution should be mixed properly and stand for a week. The clear liquid is drained off and poured over the eggs.

Cold storage: Eggs are stored in cold storage usually a degree or so below the freezing point of water i.e. at -1°C (30°F). The relative humidity should be 70-80%. Incorrect relative humidity may cause mold to form on the eggs, so they should also be kept dry and well ventilated. If the storage humidity is too low this can lead to loss of weight. If the storage humidity is too high this can encourage the

growth of mold. The washing of eggs often does more harm than good.

2.2 Fish hygiene

Fish are cold-blooded vertebrates, that is their body temperature is close to and varies with that of atmosphere, varying considerably in size and shape. When fish are brought out of water into air they quickly perish.

Fish can be divided in two classes:

Round fish: These are swimming fish, which live at varying depth from the surface of sea and possess darkly colored dorsals but whitish ventral surfaces.

Flat fish: These live at the bottom of sea. They have asymmetrical bodies. They live on one side, usually the left, which is white, the upper side being a brownish color.

2.2.1 Types of fish

White fleshed fish: These include haddock, cod, sole, turbot and whiting.

Red fleshed fish: These include salmon and trout.

Greasy fleshed fish: These include mackerel, sprats, herrings, sardines and eels.

Shell fish: These include crabs, lobsters, oysters and mussels.

2.2.2 Anatomy of Fish

It is essential that a slight knowledge of the anatomy of fish should be gained in order to facilitate fish inspection.

Fins: Fish for their movement in water possess a number of limbs called fins:

- Dorsal fins that are situated along the back
- Ventral fins that are situated on the body
- Pectoral fins that are situated posterior to each gill and upon the shoulder.
- Anal fin that is situated underneath, near the anus.
- Caudal fin that is situated on the tail.

Skin: This is a layer of connective tissue to which scales are attached. The outer layer is called the epithelium.

Bones: A vertebral column passes down the middle of the body from the brain, long bones radiate from this column. The skull is cartilaginous and contains organs of smell and hearing. The eyes possess spherical crystalline lenses and protrude when newly caught or in water but collapse when exposed to the atmosphere.

Gills: Fish have gill flaps on each side of their heads adjacent to their jaws and opening into their pharynx.

2.2.3 Characteristics of fish

Fish freshness: The freshness of fish depends principally on its temperature and the time that has elapsed since the death of the fish. The bacterial living in the fish multiply more rapidly as the temperature rises. In this process some malodorous compounds are produced. In addition the effect of a slight alteration in temperature becomes more noticeable in the region just above the temperature at which fish freezes (-1°C).

Fish spoilage: Fish that are unfit for human consumption can be subdivided into four categories:

- Those affected by diseases.
- Spoilage or putrefaction type
- Contamination (contaminated fish)
- Rancidity (high degree of offensive odor)

Putrefied fish are known by one or more of the following characteristic changes:

- The odor changes from fresh odor to sour, rancid or rotten
- The gills turn into a grayish or brownish color and become slimy
- The entrails (intestines) are decomposed. When not eviscerated, the digestive enzymes are frequently active and soften the belly in a short time and it finally bursts.
- The belly and the surface of the outer flesh turns slimy and often shows yellowish or brownish discoloration. The flesh

becomes soft, loose and inelastic. It is easy to press the fingers through the belly.



2.2.4 Signs of freshness and the decomposition of fish

Fresh

- I. **Eyes** - full and bright
- II. **Flesh** - firm, solid and elastic when pressed
not pit when pressed
- III. **Scales** - full and firm
- IV. **Abdominal cavity** - clean, not discolored
- V. **Gills** - clean, bright, not swollen
- VI. **Fresh fish** - will sink if placed in water.

Stale

- Eyes** - gray and sunken
- Flesh** - soft, strips form with fingers, flesh does bones, pits form when pressed with fingers
- Scales** -easily rubbed out
- Abdominal cavity** - smelling and with reddish discoloration
- Gills** - gray, brownish slimy, swollen
- Stale fish** - floats in water

2.2.5 Inspection of fish

- Check the condition of eyes, scales and flesh of the fish
- Check if gills are firm and elastic; test with fingers if any doubt exists
- Split the fish and examine backbone for decomposition. If bone is pink or red from end of the tail towards the head, condemn/discard it
- Test the blood of the fish with the fingers; if the fish is stale there is a faint smell on the fingers
- Split down the lateral line and examine the backbone
- The abdominal cavity shows discoloration when the fish are stale.

2.2.6 Fish-borne diseases

The known diseases of fish are few and it is only a very small part of the vast harvest that is taken from water that is affected. Generally speaking with the exception of one or two cases, the rest of the harvest produces no ill health upon human beings.

Fish that to all appearances are healthy are sometimes responsible for symptoms of poisoning in people, producing a slight fever and rash. They are afflicted with parasites. Some of the common diseases are:

Fish pox: This is caused by Myxosporidiea and affects fresh water fish.

Signs of the pox are located on muscles, skin and viscera. The flesh is soft, yellow and gelatinous and gives a bitter taste.

Action: Affected fish should be condemned /discarded.

Salmon disease (plague): This is caused by bacillus salmonis pests and affects fresh and seawater fish. Transmission is through abrasion or ulceration of the skin. Signs are the formation of white patches on sides, belly and head ulcer formation.

Action: Fish of this nature is rarely seen in a market. They are unfit for human consumption.

Furunculosis: This is caused by bacillus salmonicida and affects fish in fresh water only as seawater destroys it. Transmission is through skin contact. Signs are the formation of furriness and skin with several patches. When the tissue is affected it extends deeply into the bones. There are soft swellings, inflammation of the intestine and hemorrhages in peritoneum and liver.

Action: Fish with Furunculosis are unfit for human food and are rarely seen in a market since there is decomposition on the flesh. Fish are rapidly killed through the spread of the disease.

Tuberculosis: This is caused by tubercle bacilli and affectes fish such as cod and turbot. The signs are lupitus-like growths on skin near the tail (containing cheesy mater), soft yellow deposits in the liver, stomach and intestines.

Action: Fish are unfit for human consumption.

Parasitic diseases: These are caused by diphylobothrium latum. and affect fresh water fish. Transmission is through swallowing parasite larvae. Signs are found encysted in the muscles of fish.

Action: Fish affected with this parasite should be seized as being unfit for human food. It may be consumed if sufficiently cooked.

2.2.7 Methods of fish preservation

Refrigeration: This is when fish is properly gutted and washed, then preserved using ice or other cooling devices.

Drying: This is when fish are opened, cleaned and soaked in brine for several hours and left to dry in the open air for several days.

Smoking: This is when fish are gutted, cleaned, sprinkled with salt and hanged to be smoked with the help of a smoking fire such as saw dust or wood clippings.

Pickling: This is when a fish is gutted, cleaned and washed properly and finally placed in brine and pickled.

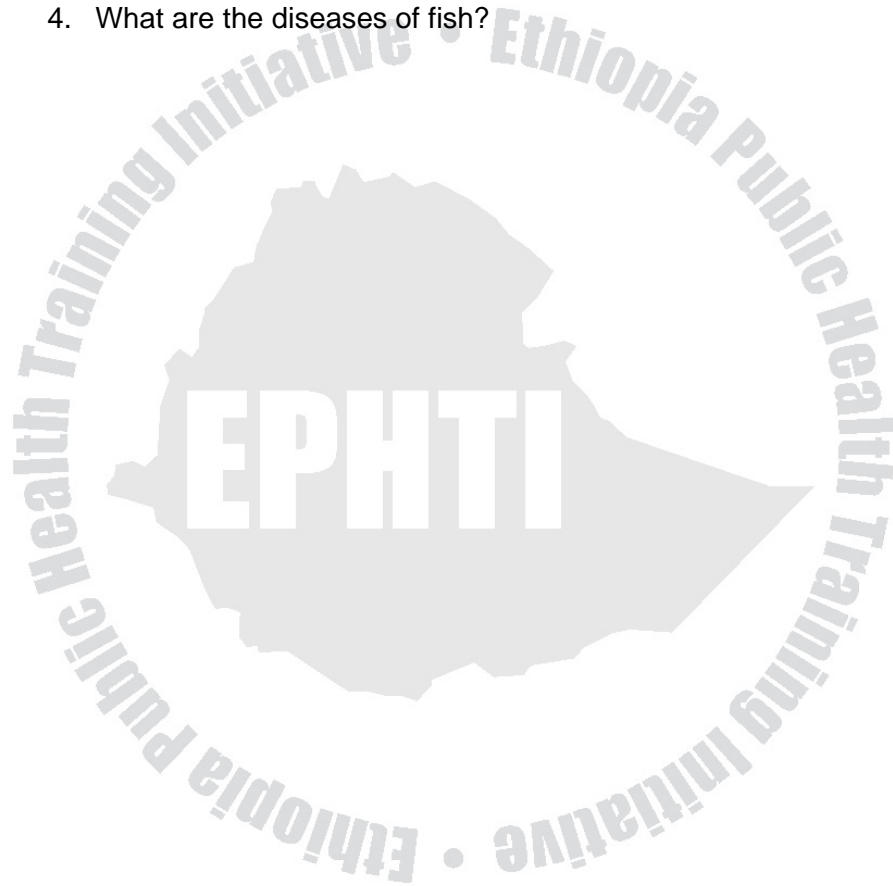
Salting: This is when a fish is gutted, cleaned and mixed with salt and packed into boxes or other containers.

Frying: This is when a fish is washed properly, filleted, skimmed and dipped in frying oil.

Canning: This is when a fish is gutted, cleaned and placed in brine. After it is properly prepared it is put into a can to be cooked and finally properly sealed.

Review Questions

1. Write down the constituent of an egg.
2. Discuss the different methods of egg preservation.
3. Discuss the signs of freshness and decomposition of an egg.
4. What are the diseases of fish?



UNIT THREE

Meat Hygiene

Objectives

At the end of the course, the students will be able to:

- Explain the purpose of meat hygiene
- Identify the comparative anatomy of food animals
- Explain the main features of slaughter houses
- Elaborate methods of inspection of meat.

3.1 Purposes of meat hygiene

The primary purpose of good meat hygiene practice is:

- To prevent the transmission of animal diseases to man
- To provide safe, wholesome meat products for human consumption

The secondary purpose is an economic aspect:

- The reduction of loss of meat and its by-products
- The prevention of animal disease transmission to other domestic animals

The tertiary purpose is due to the adulteration of carcass meat, which is not required by consumers other than for food for animals:

- To prevent the sale and consumption of carcass meat, which is not demanded by consumer other than as food for animals

- To prevent the sale and consumption of meat that is inferior in value

3.2 Comparative anatomy of food animals

One of the basic purposes of meat inspection is to be able to identify and differentiate the carcasses of food animal meat from that which is not demanded by the consumers. Generally in Ethiopian culture domesticated animals are killed and used for meat. There is of course variety from one locality to another in choosing the favorable type of food animals. This depends upon religion, cultural belief and ethnic habits. Whatever choice there is for all consumers countrywide, the marketable meat products should be restricted to the commonly wanted types of food animals. To determine this any meat inspector should be able to identify one type of carcass meat from another considering the following important differential features..

3.2.1 Skeletal differentiation

Skeleton: The skeleton is the framework of hard structure that supports and protects the soft tissues of animals. It is made up of bones and cartilages joined together by ligaments. The skeleton can be divided into three main parts:

- Axial skeleton - skull, vertebral column, ribs and sternum
- Appendicular skeleton - bones of the limbs (fore and hind legs)

- Splanchnic or visceral skeleton - bones found embedded in viscera (internal organs). Example include ossacardis (bone of heart) in the heart, and hyoid bone at the base of the tongue.

Vertebral Column: The vertebral column or backbone consists of many vertebrae, which form a long fairly flexible chain extending from the head to the tail. The vertebrae are divided according to their position into five regions:

- Cervical or neck vertebrae - located in the neck
- Thoracic or dorsal vertebrae - attached to the backbone and articulate with the ribs
- Lumbar vertebrae - situated in the region of the loin
- Sacral vertebral - fused in the pelvic region.
- Coecygeal or caudal vertebral - located in the tail part of the animal

The vertebral formula for the various animals helps to differentiate between them by counting the number of vertebral in each region of the backbone as shown in tables 3.1 and 3.2.

Table 3.1: Comparative anatomy of different meat animals

Ser. No	Anatomical structure	BOVINE	HORSE	SHEEP	PIG
1	Teeth	No incisors on upper jaw	6 incisors on each jaw	4 pairs of incisors on lower jaw	3 pairs of incisors and 1 pair of canines on lower jaw
2	Tongue	Thick at the base, pointed firm in texture, upper	Flattened and broad at free extremity two well marked circumvallate papillae	Thick at the base broad at the tip.	Smooth, one well defined circumvallate papillae, tip rounded.
3	Ribs	18 pairs round rather than flat.	13 pairs	13 pairs	14 pairs
Ser.	Anatomical	BOVINE	HORSE	SHEEP	PIG

No	structure				
4	Lungs	Left- 2 lobes Right –3 lobes	Left- to 3 lobes right- 4- 5 lobes	Left to 3 lobes right-4-5 lobes	Left – 2-3 lobes, right –3 or 4 lobes
5	Liver	Usually 4 lobes, dark. No gall bladder; wt-11 lb.	Two large lobes, wt-2 lbs, bladder- present.	Two large lobes wt-2lbs Bladder- present	
6	Kidneys	Non lobulated right- heart and shaped left- long and narrow	Non- lobulated bean shaped, shorter, round.	Non-lobulated, bean shaped, shorter, round	Flat and bean- shaped
Ser. No	Anatomical structure	BOVINE	HORSE	SHEEP	PIG

7	Spleen	Long and scythe-shaped	Oyster-shaped, reddish brown, elastic	Oyster-shaped, reddish brown, elastic	Long, narrow, bright red strip.
8	Stomach	Single stomach	4 compartments	4 compartments	Round at apex-flat softer than in sheep
9	Heart	Less conical than in bovine; No bone; two grooves on exterior.	Similar to bovine but no bone, fat white and very firm	Similar to bovine but no bone, fat white and very firm	

Table 3.2: The vertebrae of different food animals

Animals	Cervical	Thoracic	Lumbar	Sacral	Coccyges
Horse	7	18	6	5	15-21
Ox	7	13	6	5	13-20
Sheep	7	13	6	5	12-20
Goat	7	13	6	5	12-20
Pig	7	14-15	7	4	18-23
Dog	7	13	7	3	20-23

Note: All those animals have seven cervical vertebral even the giraffe with its long tail has only the same number. Each of these animals has almost the same number of lumbar and sacral vertebral respectively. The number of tail vertebral varies in range, depending on the species of animals. The number of vertebral in the tail is greater than any vertebrae in the region.

Teeth: An animal has two sets of teeth, the first or temporary set appears at birth or soon after, thus referred as “milk teeth”. This set of teeth are shed at specific times and their place is replaced during growth by the permanent set of teeth. Ruminating animals have incisors on the lower jaw while the upper jaw has a dense fibrous pad.

The teeth are classified according to their position in the jawbones:

- Incisor teeth (I) - situated in the front row
- Canine teeth (C) - situated on the side next to the incisor
- Premolar teeth (P) - situated at the anterior of the cheek teeth, in the temporary and permanent dentition.
- Molar teeth (M) - occur next to the pre molar in the permanent set only

The “Dental formula” for the various animals helps to identify the kind of animal by counting the number of temporary and permanent sets of dentations as indicated below:

Horse	$2(I\ 3/3 + C\ 1/1 + P\ 3\ \text{or}\ 4/3 + M\ 3/4) = 40-42\ \text{teeth}$
Ox	$2(I\ 0/4 + C\ 0 + P\ 3/3 + M\ 3/3) = 32\ \text{teeth}$
Sheep/Goat	$2(I\ 0/4 + C\ 0 + P\ 3/3 + M\ 3/3) = 32\ \text{teeth}$
Pig	$2(I\ 3/3 + C\ 1/1 + P\ 1/1 + M\ 6/6) = 44\ \text{teeth}$
Dog	$2(I\ 3/3 + C\ 1/2 + P\ 4/4 + M\ 2/3) = 42\ \text{teeth}$

Note: The letters indicate the kind of teeth. The figures above/ below gives the number of teeth on one side only of the upper and lower jaws. Multiplying the figures times two derives the total number of permanent teeth.

3.2.2 Sex differentiation and estimation of age

Sex characteristics of carcasses

Sex determination from an expert is important during any inspection of meat quality because of the possibility of substitution of cow's meat for that from a heifer or bullock or the substitution of ewe mutton for that of lamb. This may not be very important for day to day experience but when certain disputes arise between dealers and consumers expert judgment of the quality and type of meat can be important.

For example: Cattle or bovines can be classified into four classes: Cows, heifers, bullocks and bulls. The classification of other food animals according to sex is the same as in bovines. A sheep has four classes: Ram (tub), wither, glimmer and ewe.

1. Cattle

The cow is a female bovine after calving. After slaughtering the carcass has the following characteristics:

- The muscular development in the neck is almost completely absent
- At the udder region the removal part is obviously seen
- Supra mammary glands or a part may be left on the carcass
- Gracilis muscle is bean-shaped
- The pelvic cavity is wide And the pubic bone is thin

- Fat is irregularly distributed (scanty) and yellowish in color
- Bone size is comparatively small e.g. carpus

The heifer is the female cow before calving. After slaughtering the carcass has the following characteristics:

The muscular development around the shoulders and hindquarters is well formed

- The udder left after carcass is white, smooth and fatty
- The cartilage part is not ossified
- Fat is more evenly distributed and lighter in color
- The gracilis muscle is smaller and semicircular in shape

The Bullock or steer is castrated at an early age i.e. its testicles are removed to lessen its sexual characteristics. After slaughtering the carcass has the following characteristics:

The muscles are more developed with larger bones than the female bovines but with less development of the neck, shoulder and hindquarter as in the bull

- The scrotal fat is abundant in a larger round mass
- The root of the penis is present
- The gracilis muscle is triangular in shape
- The pelvic cavity is narrow and the pubic bone is large

The bull is a fully developed male animal. After slaughtering the carcass has the following characteristics:

- The massive muscles of the neck and shoulder are well developed
- The fleshy muscle is dark red in color with scanty fat
- The bones are relatively large
- The pubic bone is thick and strong
- The root of the penis is present and strong

2. Sheep

The ram or rup is a fully developed male sheep. After slaughtering the carcass has the following characteristics:

- Open inguinal rings
- Fat is sparse or absent
- Root of the penis is present
- Strong muscular forequarters

The wether is a castrated male. After slaughtering the carcass has the following characteristics:

- Muscle with evenly distributed fat
- Lobulated cod fat
- Root of the penis is present

The grimmer is a virgin female sheep. After slaughtering the carcass has the following characteristics:

- Characterized by its symmetrical shape
- The udder is smooth and fully fat

The ewe is a female sheep after lambing. After slaughtering the carcass has the following characteristics:

- Has a long thin neck and poor legs
- The udder is brownish and spongy
- Supra mammary node seen distinctly

Estimation of Age

By the teeth:

The method universally adapted for ascertaining the age of food animals is by the number and condition of the incisors or teeth. Dealers in cattle markets examine animals prior to purchasing by catch hold of the muzzle with one hand and pull down the lower lip with the other and by quick observation can estimate the animals' age.

The age is estimated by the period of time required for the permanent incisor teeth to erupt and come into wear. The periods of time that it

takes to wear them out are subjected to variations, depending on sex, breed and feeding habits.

In bovines the two-center incisors dropout soon after the animal reaches the age of one year and are replaced by the permanent teeth at a period of one year and nine months..

The next pair of temporary incisors is replaced by permanent teeth at the age of two years and six months. The third pair of permanent teeth attains their full size at three years and three months while the last external pair comes to be fully developed in the fourth year. In time the teeth wear out through the shrinking of the gums. The neck of the teeth are exposed with small spaces in between that indicates an animal of old age, about seven to eight years. In the other food animals such as sheep, the permanent incisor teeth attain full size as central teeth at two years and three months and as external teeth at two years and nine months.

By the bones: Another method of ascertaining the age of an animal is by the amount of cartilage present around the bones or the degree of ossification that they have. In old animals cartilage is found covering the ends of the bones at the joints. Where the teeth of the bovine animal are unavailable for inspection, the age can be estimated with reasonable accuracy by the examination of the carcass.

The ossification of cartilaginous extensions of the spines of the first five dorsal vertebral develop as the animal gets older. As the condition and degree of ossification develops showing of cartilage extension and color changes as the age of the animal increases.

By the horns: Estimation of the age of cattle by means of the horns entails counting the number of rings on the horns. The first ring appears at about 2 years and one appears every year thereafter so that the age of cattle with horns equals the number of rings present plus one.

By the flesh: In old animals the fat is scanty, the flesh is generally dark red in color and tight in texture. Muscles become tougher with age. The condition of the meat gives rise to more consumer complaints.

3.2.3 Other differential features in the skeleton

The following main differential features will help to distinguish between the different bones of animals most commonly used for food.

Carcasses of Horses and Oxen

- The spinal processes of the anterior vertebrae of the horse are shorter and stouter. They are also attached closer together and directed forwards, while in the ox they are separated and pointed slightly backwards.

- The thoracic cavity is longer in the horse. It has 13 pairs of ribs which are narrow and markedly curved whereas the ox has 13 pairs of ribs which are smoother and the lower thirds are broader.
- The scapula of the ox is more regularly triangular than that of the horse. It also has a thinner neck. There is a distinct notch in the glenoid.
- The ulna extends only half way down the radius in the horse. In the ox it is more developed and extends to articulate with the carpus.
- The fibula is rudimentary (undeveloped) in an ox, the small head of the fibula in the ox is hook-shaped, but in the horse it is separated and extends two-thirds down the length of the tibia.
- The sternum of the ox is flat and broad but in the horse it is keel-shaped or heaped.
- The pelvic bones of the ox are longer and narrower than those of the horse.
- Bones of the horse are generally more oily, the bone marrow is fatty and yellow and has an unpleasant odor. In the ox it has a fresh smell and it is firm and white in color.

Carcasses of Sheep and Goats

- The leg bones of the goat are usually slender and longer and spinous processes are also longer and more prominent than in sheep.
- The throat is barrel-shaped in sheep, but laterally flat in goats.
- The scapula of sheep is shorter and broad and the edge of the spine in the center is bent back and thick-ended, while goats possess a distinct neck and the spine is straight and narrow.
- The tails of sheep are fairly broad while they are thin in goats.

3.2.4 Differential of internal organs

Organs of the digestive system: The alimentary canal of the digestive system consists of the following consecutive segments: the mouth, the pharynx, the esophagus, the stomach and the intestines.

The tongue

The tongue is part of the mouth and is a muscular organ covered with thick, tough mucous membrane. The main differential features of the following four food animals are shown below in table 3.3

Table 3.3: Main differential features of the tongues of food animals

Features	Ox/cow	Horse	Sheep/Goat	Pig
Shape	Tip pointed	Tip spatulated	Tip round	Tip slightly pointed
Size	Large and swollen	Long and flat	Short and thick	Long and narrow
Color	Black pigment	No black spot	Pigmented	No pigment
Texture	Firm and rough	Not firm, and smooth	Nor horny	Soft
Hyoid bone	Present	Absent	Present	Absent
Circumvallates papillae	Several	One on each side	Few	One pair

The stomach

The stomach of food animals is situated in the anterior part of the abdomen where it is connected with a muscular tube called the esophagus or gullet from the mouth. Ruminants (bovines, sheep, goats, etc) have stomachs containing four separate compartments: the rumen, reticulum, omasum and abomasum.

1st stomach: The Rumen (paunch) has leaf like papillae, storage of papillae.

2nd stomach: The Reticulum (honeycomb) has honeycomb compartments that regulates the flow of food.

3rd stomach: The Omasum (manipulus) has folds like leaves of a book and squeezes food.

4th stomach: The Abomasum (true stomach) has spiral folds that secretes gastric juices.

Horse stomach consists of a small and simple sac, sharply curved in shape. This animal has a single stomach compartment.

Pig stomach is simple, semi lunar or kidney in shape with a small pocket or diverticulum at one end. This stomach is a single compartment and white in color.

The intestine

The intestine is a long tube beginning at the pylorus in the stomach and ending at the anus. It is divided into two parts:

The small intestine is narrow and starts at the outlet of the stomach, the pylorus, and terminates at the entrance to the caecum. It is divided into two parts i).the fixed part, called the duodenum, is about 1m long ii) The menistic part, called the jejunum and ileum, is about 40 meters long.

The large intestine is greater in size and extends from the end of the ileum to the anus. It is divided into the following sections

- i) The caecum which is situated between the ileum and colon. It has a comma or curved shape appearance. Its length is about 1.25 meters
- ii) The great colon which begins at the caecum and ends at the small colon. It is 3-4 meters long.
- iii) The small colon begins at the termination of the great colon and ends by joining the rectum. It is 3-4 meters long.
- iv) The rectum is the end part of the alimentary canal of the animal, which starts from the end of the small colon to the anus, the last opening. Its length is about 30 centimetres.

The average length of the intestines of the different food animals is shown in table 3.4.

Table 3.4: The intestines of the different food animals

	Small intestine (m)	large intestine (m)
Cattle (ox, cow)	36.5	9
Horse	24.3	6
Sheep/Goat	25.6	6
Pig	17.1	4.8

Note: The ratio of the length of small intestine to the large intestine is roughly 4 to 1.

Accessory organs of the digestive system

The accessory organs, which include the liver and pancreas, are part of the digestive system. The differential structures of these two organs are shown in table 3.5 and 3.6.

Table 3.5: The different features of liver of food animals

Differential features	Ox	Horse	Sheep/Goat	Pig
Color	Reddish brown	Purplish	Light brown	Slightly dark
Weight	4.5-6.5 kg	4-5kg	450-700 gm	1-2kg
Lobes	3	4	3	5
Gallbladder	Pear shaped	No gallbladder	Cigar shaped	Pear shaped

Table 3.6: The differential features of pancreas of food animals

Differential features	Ox/cow	Horse	Sheep/Goat	Pig
Color	Yellow brown		Lobulated	Pale
Lobes	Lobulated	Lobulated	Lobulated	Lobulated
Lobes	220-340 gm	300-340 gm	85-145 gm	28-60 gm

Table 3.7: The differential features of spleen food animals

Differential features	Ox/cow	Horse	Sheep/Goat	Pig
Color	Bluish gray	Purplish	Light brown	Saphtlyderes
Shape	Elongated oval	4-5kg	450-700 gm	1-2kg
Weight	0-9-1.5 kg	4	3	5
Hilus	Present	No gallbladder	Cigar shaped	Pear sheped
Lobes	None	None	None	None

Circulatory system

The heart is the most important muscular organ acting as a pump in the circulatory system of the animal body. It lies in the pericardial sac of the thorax region between the lungs. On the external surface of the heart there are various groves (on the right, left and intermediate surface) which help in the identification of different animals. The differential features of the heart are shown in table 8.

Table 3.8: The differential features of the heart of food animals

Differential features	Ox	Horse	Sheep/Goat	Pig
Shape	Pear or conical	Blunter	Small same as ox	Broad and short
Weight	1-8-2-4 kg	4.5- 3.2 kg	80-120 gm	150-200
Ossacardis	Present	Absent	Absent and rare	Absent
Ventricular Furrows	3	2	3	2-3
Condition of fat	Well fattened, firmer and not so yellowish	Scanty, oily and yellowish	White fat and firm	Less fat, soft and greasy

Excretory System

The kidneys are the most important excretory organs that facilitate and remove contents, urine. The kidneys are situated in the abdominal cavity, inside of the upper lumber legion of the vertebras column.

Table 3.9: The differential features of the kidneys of food animals

Differential features	Ox	Horse	Sheep/Goat	Pig
Color	Reddish brown	Purplish	Dark brown	Light brown
Shape	Right k-bean Left K-3 sided	Right K. bean Left K-bean	Right and left Bean shaped	Elongated bean and flatter
Weight	280-340 gm	500-900 gm	50-80 gm	80-170 gm
Lobules	15-25	None	None	None
Renal papillae	15-25	One	One	10-12
Renal pelvis	Absent	Present	Present	Present

Respiratory system

The lungs are the central organs of the respiratory system where the exchange of gases between the blood and the air takes place. The other parts of the system are passages by which the air exchange passes to and form the lungs. The right and left lungs occupy a large part of the thoracic cavity. The differential features of the lungs helps to identify the different food animals as shown in table 3.10.

Table3.10: The differential features of the lungs of food animals

Differential features	Ox	Horse	Sheep/Goat	Pig
Trachea length	6.5 cm	75-80 cm	22-25 cm	15-20 cm
Trachea ridges	Present	Absent	Percent	Absent
Trachea rings	40-50	50-60	30-40	32-35
Lobes right	4-5	3	4	3-4
Lobes left	5	2	3	3
Accessory bronchus	Present	Absent	Present	Present
Weight	2-3 kg	2-3 kg	350-900gm	35-500 gm

Lymphatic system

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

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

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

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

The sites of the principal lymph nodes are:

Internal lymph nodes of bovines

Protectoral glands (Lower cervical)

- Superficially lying on the entrance to the thorax, in front of the 1st ribs embedded in little fat
- Deep and lie just beneath the super facial gland, covered by a thin layer of muscle

Supra sternal glands

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

Thoracic glands

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

Renal glands

- Lie in the kidney hilum embedded in fat

Lumber glands

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

Iliac glands

These are two separate glands

- Internal illial gland, situated near the vertebral column and close to the external iliac gland
- Ischiatic gland, lies between the anus and other portion of the ischium, near the tail that has been removed

Supra mammary gland (in the female)

- Lies above and behind the udder, while the inguinal gland is situated in the neck of the scrotum, at the side of penis in male animals.

External lymph nodes of Bovines

Pre scapular gland

- Lies immediately in front of the shoulder joint that is at the junction of the humerus and the scapula. This is a large gland embedded in front; it can be exposed by a deep incision in front of the head of the humerus.

Precrural gland (pre-femoral gland)

- Situated at the anterior edge of the tensor fasciae latae muscle, immediately above the patella of the hind-leg. This is also a large gland. Needs to be exposed by an incision.

Popliteal gland

- Lies deep in the popliteal cavity or half way down the back of the thigh. When the joints are cut from the hind leg the gland is usually exposed between the two joints, embedded in fat.

Head lymph glands of bovines

Parotid glands

- Situated on the posterior part of the masseter muscle or at the root of the ear. The parotid salivary glands must be incised to expose them.

Pharyngeal glands (upper-femoral gland)

- Lie at the back of the pharynx, on either side. They are most easily examined after the removal of the tongue.

Sub mandibular or sub-maxillary glands

- Situated on the inner side of the mandible (jaw bone). They are usually attached to the tongue. When this organ is carefully removed it may be found attached to the tongue but may sometimes be left on the inner side of the jaw bone.

Lungs lymph nodes of Bovines

Bronchial glands

- Lie embedded in fat on either side of the tracheas, near its point of bifurcation. The left bronchial gland lies deeper than those on the side.

Mediastinal glands

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

3.3 Slaughterhouses

3.3.1 Traditional animal slaughtering

Raw meat is the most favoured food product enjoyed by many consumers in Ethiopia, in spite of its ill effects. This type of meat is

mostly not produced in organized slaughterhouses and put out for sale in meat shops. Rather it is the usual practice that the livestock is bought in the market through individual interest and choice. It is then brought to their homes and put to slaughter where the meat is consumed according to the preferences of each family.

In Ethiopian social culture a sheep or goat is to be killed for individual family use at any time when they are in need or during festivals or other occasions. Big animals such as a cow or an ox can be killed in an open place for a number of families or group of related co-workers and be shared equally. In certain situations, such as a wedding ceremony or other occasions, one or more cattle may be slaughtered in the area where the occasion is taking place.

All these traditional practices may be acceptable from the deep-rooted culture and spiritual belief of the society. However many underestimate the direct or indirect ill health and economic ill-effects it gives to the consumer. Some of the problems that may arise where open and indiscriminate slaughter of an animal takes place are:

- An immediate inspection by meat inspectors of animals when they are alive or killed is impossible
- The people who are included in killing and assisting in the handling of the meat will be the first victims of any disease that may occur

- Since it is the usual practice that all the people who attend the animal slaughter will share and eat raw meat, such as the tongue and a portion of tripe called “semer”, immediately after slaughtering they may contact tapeworm
- The stunning and slaughtering practice may be incomplete and as a result a portion of the blood may remain within the body of the animal and may lead to spoilage of the meat during storage
- The hygienic handling of meat during animal slaughter in open fields is at a minimum and the keeping quality of the meat will be affected
- The handling of meat outside the slaughterhouse may reduce some essential meat products and/or wastage of certain by-products which normally require special collection and care for further processing to be converted to valuable by-products
- The quality of hides and skins of ruminant animals that may be collected from rural and urban areas where traditional slaughter practice is undertaken are highly affected to the extent that their market value will be diminished and unacceptable for industrial production
- Above all illegal and indiscriminate animal slaughter practice in a community will create an insanitary environment that causes the breeding of flies, smell and nuisance to the nearby inhabitants.

To overcome the above and other related problems the fundamental principles of hygiene, as well as economic considerations, demand that the slaughtering of animals for human consumption be carried out in establishments especially designed and constructed for this purpose and kept under constant sanitary control.

3.3.2 Main features of slaughterhouses

The slaughterhouse or abattoir is a general term applied to an establishment engaged in killing livestock, or one or more species, for human consumption. It varies in size from the back yard of a local butcher to the great meat processing plants. In most countries slaughterhouses are either privately owned, depending on the local need, or are large premises capable of providing slaughtering accumulation for an entire city and are administered by the local authority. In Ethiopia this is the most common type of slaughterhouse

Generally a slaughterhouse must be planned and constructed for the purpose which is intended, being functional in design and economical in its operation related to its capital expenditure and estimated operating costs.

Accommodation and facilities are required for the humane and hygienic slaughter of animals, the sanitary handling of meat and meat products. There should be a provision of facilities for inspection and

quality control, readily available facilities for equipment cleaning and operators' locker rooms as well as special and separate rooms for the receiving of by-products, and animal lair age etc.

There are certain general principles to be considered in relation to the sanitary and economic standards for construction and operation, once the essential preliminary administrative and planning decisions have been finalized. Community involvement and acceptance in the planning stage is a prime factor with the technical approval from the health sector. Based on these the main features to be considered in the design and construction of slaughterhouses are:

Location and site

Locating will have to be decided under preliminary planning, that is from the already drafted town plan or future expansion zone areas. This should be legally approved by the designated agency who consider certain essential requirements such as the transport and supply of livestock, final product disposal system and other aesthetic factors. The prime consideration in connection with the building of any slaughterhouse is the site. The most important points to be considered in the choice of site are:-

- Accessibility by road and rail for the transportation of animals, meat and other products as well as staff workers.

- Availability of a safe and abundant water supply system preferably with a public pipe connection and on-site water storage tanks holding at least one-days consumption without interruption. The recommended water requirement is a minimum of 100 liters and a maximum of 200 liters per day per adult bovine animal
- Proper and convenient final sewage and other waste disposal area and facilities
- Accessibility to electrical power
- The slaughterhouse should be freely exposed and if possible sited in the outskirts of town
- A naturally sloping area assists both in the disposal of sewage and storm water
- Availability of adequate space for future expansion possibilities
- The immediate environment should be safeguarded from all possible alternatives that may endanger the health or safety of the inhabitants

Area and size

Depending on the need of the local community careful consideration must be given to the size of the site with future possible expansion space for buildings and vehicle movement.

The size and design of the rural slaughterhouses are standardized to meet local needs and to satisfy their operational objectives.

In such establishments a maximum 50 animals per day can be handled satisfactorily. This may occupy a plot of about one acre of land for all purposes.

The urban type of slaughter house which handles all ruminant animals and pigs, a 100-200 units per day, requires at least double the size of space in acres, while meat plants of larger capacity with a complete packing operation, occupy at least 3 times of plot size of that of a normal rural slaughterhouse.

Design and main facilities

The overall layout of the buildings of the slaughterhouse depends on the size and operational capacity that it undertakes, the environmental and climatic factors, such as prevailing winds, the land slope for both internal and external drainage systems and the handling of the by-products for useful materials with minimum nuisance.

The construction of the building parts and surfaces should fulfill the sanitary requirements that satisfy the essential housing standards.

Floors: These should be impermeable, rough finished and hard with a non-slip material to avoid accidents, easily cleanable and resistant to corrosion. They must always be in good repair and should have a well-graded drainage system, giving a slope of 1 to 60 to the external drains.

Walls: These should be smooth and hard, of an impervious material up to a height of not less than 3 meters from the floor and preferably reaching to the ceiling. If the splash height of the wall is 2 meters then remaining portion of the walls should be lime washed. To avoid dirt that remains fixed in the corner edges between the walls and the floor, this junction should be at a curve to facilitate washing and splashing and to remove dirt easily.

Roof and ceilings: The top part of the building should be framed with preferably pre-fabricated iron rafters or local materials such as eucalyptus tree or other materials which do not disintegrate. In all rooms used for edible products the interior surface of the ceiling should be covered with a smooth and easily cleanable material. If it requires a surface, which minimizes the deposit of dirt and dust on the inner roof, a thin cement lining or chip wood materials should be used.

Lighting: An adequate natural or artificial lighting system must be provided throughout the establishment. The natural lighting should be

permitted to allow sufficient intensity of light through the normal windows or sidewall openings to all workrooms where daylight operations are conducted; light inlet of an area approximately 25% of the floor area is recommended. However since most slaughterhouses operate during the night, it is necessary to install an efficient artificial light system to all the room and especially in those areas where maximum activity and detailed inspection techniques are required. It is generally recommended that the overall intensity should not be less than

50 foot - candles – at all inspection points

20 foot - candles – in all-purpose workrooms

10 foot - candles - in all other areas

All electrical line system should either be insulated and fixed in proper arrangement or most preferably buried inside wall lines to prevent fire, accident and human contact. In addition protective shields should be fitted to all artificial light lamps to minimize dust or insect deposits.

Ventilation: Adequate ventilation must be provided to prevent excessive heat, steam and condensation. Where possible all wall spaces and air inlets should be properly screened to prevent the entrance of insects, birds and other vermins. In case of urban type of slaughterhouses with or without meat packing processes the exchange of air should be taken either naturally through open side windows and other roof vent systems or by means of mechanical extraction fans. The efficiency of this ventilation process is

determined by the proper design and construction method. Properly installed screen mesh or doorways, well spaced for the easy movement of products, should be provided to supply light and air to the rooms.

Water supply and waste disposal: The mains water supply must be pure, safe and adequate for all purposes and at a sufficient head pressure to reach all working areas. The continuous flow of water using rubber hoses facilitates the washing of carcasses and all-purpose cleaning. To guarantee a continuous supply of water, an elevated tank, which holds sufficient for at least daily usage, should be provided in an accessible area. An installation of hot water for the sterilizing of slaughtering tools is required for rural slaughterhouses.

Slaughter at all levels uses large quantities of water which eventually produce a significant amount of waste that requires attention in its disposal. An inefficient waste disposal system may create possible pollution of watercourses in the vicinity. To prevent such problems and to facilitate the disposal of the waste products within the meat plant a simple and effective sewage disposal system should be arranged. The choice and design and construction should be based on the type and size of the establishment and should include installations such as septic tank, soakage pit, oxidation ponds, manure pits etc. Handling all waste content should reduce the amount

BOD to a minimum level in the effluent that finally will be absorbed into the surrounding surface area or joined with local watercourses.

Drainage: In the proper design and construction of any slaughterhouse it is vital to handle all waste products inside and outside the building. All animal waste, blood, offal content and other wash wastes should flow without interruption into the final disposal system. These drains should be closed but their size and slope should be carefully designed for their efficient operation. If these are not met the sanitary requirements will remain a nuisance and may affect the edible products. Any drainpipe of whatever material it is made of should have inspection chambers or gully traps at all possible line systems or connections. Regular inspection for maintenance and cleaning should be practiced to avoid blockages and unsightly conditions.

A model slaughterhouse with or without a meat packing plant entails a varying number of buildings or sections. The slaughterhouses in townships or rural areas of Ethiopia which are only limited to producing edible meat products should have the following essential working parts:

Lairage

Slaughtering hall

Meat hanging and inspection hall

Gut and tripe compartment sink
Hide and skin shed
Employee's dressing room
Office and store
Manure bay
Separated slaughtering place

Lairage: This is the accommodation provided for animals brought to the slaughterhouse before they are put to be slaughtered. In here animals are kept to rest for a period of 12-24 hrs by providing them with water and undisturbed resting conditions. For those animals needing isolation for observation grass should be available. In addition ante mortem inspection is done during the resting period. The main sanitary requirements for lairage construction are

- To be well spaced and large enough to accommodate at least one day's slaughter and, depending on the source of supply, a 3 days collection of stock
- For the floor to be made of impermeable concrete and a non-slippery material with a proper drainage system
- A divided partition for different animals and a separate lair to serve as a quarantine space for sick and suspected animals
- To be easily accessible with a continuous pipe supply water trough
- For the passage from the lairage to the slaughtering hall to be built to permit a one-by-one flow of animals

Slaughter hall: This is the place where the actual slaughtering is done followed by complete a bleeding process and dressing. All blood and all external body parts are removed immediately to outside of the hall. In larger meat plants separate slaughtering places for each type of animal may be required. The sanitary requirements for the hall construction are

- For the internal walls and the floor structures to be smooth and washable
- For a sloppy drain to permit blood and wash waste to flow out easily
- For there to be properly installed meat-hanging chains with overhead rails
- Conveniently located running tap water with a well fastened washing hose
- For a on-site electrical steam boiler or sterilizer to be installed for slaughtering tools

Meat hanging hall: This is a place where all carcasses and organs are kept temporarily and serves primarily for inspection. The entire sanitary requirements that are applied should be the same as in the slaughtering hall.

Gut and tripe compartment sinks: This is a separate unit conveniently attached to the outside the slaughtering hall for initial separation and emptying of stomachs and intestine contents for gut

and tripe preparation. Since this is a very important unit from a contamination point of view; it should be properly constructed and used.

The essential sanitary requirements and facilities for this unit are

- Impervious washing sinks with drained concrete slabs
- Running water taps with a continuous supply of water
- Properly built drainage systems throughout the final system
- Temporary waste contents collection container at close proximity

Hide and skin shed: This is a sidewalls open structure where after curing wet hides and skins of slaughtered animals can be permitted to dry for about a week. The structure is designed and built for a capacity of at least 50 hides and 100 skins each day, seven days a week. After the curing the hides and skins are tied to a strengthening frame made of wood and held in orderly arrangements to dry out in the open. Space or suitable accommodation for the storage of hides and skins should be provided until they are collected by licensed contractors.

Employee's Dressing room: This is a place for the exclusive use of the employees who are directly engaged in the slaughterhouse. This may have lockers for employees' belongings and work clothing. Since most of the animal slaughterhouse hours are at night the employers

should have resting or sleeping facilities. Toilets with an incorporated washing system must be provided.

Office and store room; This is a small sized room strictly for administration and storing certain meat inspection equipment nearer to the main gate, to permit a direct access to those who are authorized or to certain other visitors. The meat inspector or veterinarian and a clerk will use this room.

Manure bay: This is a structure specially prepared to handle all animal stomach and intestine materials and the manure part is collected to be loaded onto the transport vehicle. It is usually built in an elevated position to facilitate the transfer of waste contents. This may be sited on the dirty side of the meat plant, either near to the lairage area or the gut and tripe preparation vats. The final disposal of waste material must be carried out without creating objectionable conditions.

Separate slaughtering for Muslims use: This is by itself a separate section, small in size but with complete parts as in the Christian side. In Ethiopia meat for Muslim use has to be prepared in a separate slaughtering place and directly dispatched to the township in a separate vehicle.

Depending on the size and type of slaughterhouse additional facilities may be required for the work to be carried out satisfactorily. In areas where the slaughter of animals rather than ruminants is to be carried out, such as pigs, a separate slaughtering and scalding room is necessary. There are times where suspected animals need special attention, it is then that a separate room for killing and the handling of the carcasses is required. Side-by-side with this a condemned meat distracter unit should be available. If the meat produced in the plant is to be used for packing or to remain in the place for an unlimited time the daily products need to be stored without being spoiled. For this purpose a sizable cold storage room with a cooling system and all other essential facilities should be provided close to the slaughtering hall section.

3.3.3 Transport of livestock

In general animals used for slaughter originate mostly from rural areas at variable distances. It is a normal trend that animals from rural villages are brought to market centers and sold to cattle dealers who finally drive the animals on foot to the slaughterhouses. As a result of long distance travel and other injury effects their meat products may be affected.

From the meat inspection point of view the proper transport of animals must satisfy the following requirements:

- The avoidance of unnecessary suffering during transport
- Improvement of the keeping quality of the meat
- Prevention of the spread of diseases
- Promotion of proper bleeding during slaughter
- Prevention of bruises and spoilage of the skin

The commonest method of transport is the driving of stock on foot which will impart certain effects on the animal's body and later, on the quality of the meat. To revitalize such occurrences all animals should get rest of 12-24 hours and adequate watering and feeding before slaughtering. The other methods of animal transport, such as big trucks, trains and boats is limited to certain parts of the country. This, even though it is advantageous in that it minimizes physical fatigue on the animals, may subject animal to loss of live weight, injury and unnecessary suffering, suffocation and diseases induced by the journey.

3.3.4 Essentials of slaughter

The traditional way of slaughtering food animals by any skilled individual is that after tightly tying the four legs, the animal to laid flat on the ground and its neck is positioned for cutting. Depending on religions beliefs, a prayer is recited and immediately using a sharp knife the throat is severing and the body bleeds to death.

The practice applied in slaughterhouses is adopted from traditional experiences with the exception that since the number of animals attending for slaughter is large, one may not follow the same procedure as stated above. Depending on the species and body strength, animals may not be so cooperative as to easily lie down and bleed to death. They may instead struggle and reduce the efficiency of bleeding.

Every effort must be made to reduce the amount of stress on the animal prior to slaughter, carryout the slaughtering without unnecessary suffering and the bleeding should be complete as speedily as possible.

Chief Method of slaughtering

In conventional slaughtering methods in most developed countries, it is normal practice to render the animal to be killed without unnecessary suffering or cruelty, except in the Jewish and Muslim practices where the animal is slaughtered without previous stunning. There are three common choices of slaughtering methods

Slaughtering without previous stunning: All food animals are killed by means of severing the main blood-vessel in the neck and thus bleeding to death. This is a humane method of slaughtering because of slow bleeding to death and suffering of the animal. In this method

the animal's throat is severed (cut) across the carotid arteries and jugular veins or it is stabbed in the chest area or throat.

Puncture of the neck prior to bleeding (pitying): The neck is punctured using a sharp knife especially prepared for this purpose. This is inserted through the first cervical vertebrae, near the occipital bone. This causes damage of medulla oblongata, reduces breathing and heart action and finally makes the animal unconscious.

Stunning prior to bleeding: Use of this method is effected by a mechanically operated instrument and electricity or gas anesthesia without any adverse effects on the condition of the meat or its products. This process is to put the animal into a state of insensibility that lasts until it is slaughtered. The different techniques used in the stunning of animals are

- A striking instrument, such as a pole axe or any other appropriately hard tool, to blow on the forehead of the animal which causes a fracture of the frontal bone and damages the cerebral brain
- Captive bolt pistol, with penetrating and non-penetrating types of bolts, which when shot to different sites of the head of various animals cause unconsciousness as a result of brain damage
- Electrical instruments,, using a pair of tongs having 60-80 volts of power, depending on the size and type of animal. This

method of stunning produces a better bleeding by passing an alternating current through the brain or heart of the animal

- Anesthetic gas, such as carbon dioxide (CO₂), is commonly applied to pigs by a special apparatus. Once the pigs are exposed to the gas for a sufficient time it will render them insensible to pain until slaughtering. It is important that with the correct concentration of 65-70% CO₂, the period of exposure should be 45 seconds and bleeding should take place within 30 seconds.

All the above methods of stunning are not applicable in all slaughterhouses in Ethiopia, but their choice is worth considering especially in areas where high meat production is undertaken. Except where there are objections on religious grounds, compulsory stunning prior to slaughter has now been enforced by legislations in many countries. The ritual methods of slaughter vary from one religious sector to the other and all must be respected according to the consumers' need. In Ethiopia, as in other countries, there are three ritual methods of slaughtering: Christian, Muslim and Jewish. In traditional ways of slaughtering these are strictly followed. In public slaughterhouses Christians and Muslims kill animals either by previously stunning or directly by severing the throat to complete bleeding by individuals of the respective faiths and in their designated areas. At present even though there is no separate slaughterhouse for Jews the method of slaughtering is strictly followed from the

selection of the live animals to the correct applying of a knife across the neck to permit an acceptance of the meat for Jewish food. The cutting of the throat is done, using a knife specially prepared by a rabbi, transversely across the neck in one slash. If the knife receives any nick during the act of slaughter, the performance is incorrect and thus the meat cannot be consumed by Jews.

Conditions of Bleeding

Bleeding is the process of draining out the blood from the animal's body by severing the large blood vessels of the neck. There are two main methods of bleeding; cutting of the carotid arteries and jugular veins by an incision across the throat region, and by stabbing in the jugular furrow at the base of the neck. Whichever method of bleeding is employed it should be as complete as possible. In general it should last for at least six minutes and the amount of blood allowed to flow out should be the maximum. A healthy animal usually may bleed well, while the ill ones may bleed badly in that most of the blood remains in the flesh. Imperfect bleeding is an indication of illness, moribund, suffering from fever and other situations. The efficiency of bleeding has a most important bearing on the subsequent keeping quality of the carcass. Efficiency of bleeding can be judged by:

- In a badly bled carcass the left ventricle contains blood, and the lungs and the liver remains with a high blood content

- In a badly bled carcass when the incision is made to the intercostal muscles blood can be squeezed out

Rigor mortis

Rigor mortis or settling of the carcass is the process characterized by a hardening and contraction of all the voluntary muscles and finally stiffening of the joints, some hours after death.

Presence of rigor mortis is due to a chemical reaction. After death the muscles lose their extensibility when the supply of the adenosine triphosphate (ATP) and glycogen is used up, or the lactic acid acts on the protein muscles where coagulation of myosin in the body takes place, which finally causes settling.

The development of rigor mortis is influenced by

- The atmospheric temperature: Quick onset takes place in high temperatures and slows down in low temperatures
- The health of the animal: Where in a fevered carcass rigor mortis is absent or scarcely noticeable
- The degree of muscular activity prior to slaughter: Where if the animal is subjected to stress and fatigue, rigor mortis will appear and disappear quickly
- The pH of the carcass: This affects the quality and color of the meat. In freshly killed animal the pH value of the meat is about 7.0 while in a properly set carcass it is about 5.5.

3.4 Methods of inspection

Proper meat inspection helps prevent the spread of meat-borne diseases and to produce a wholesome and safe supply of meat for human consumption.

Inspection of meat has two aspects

- Examination of live animals on entry to the slaughterhouse, referred to as *ante mortem* inspection
- Examination of the carcass and organs after slaughtering referred to as *postmortem* inspection.

In situations where animals are so injured or sick to death, or those involved in serious accidents or potential danger to life need not wait for ante mortem inspection but be immediately killed to save the meat. This is referred to as *emergency slaughter*.

3.4.1 Ante mortem inspection

This is the most important process of examination, without which no adequate inspection of the carcass of the meat is possible. Many diseases like rabies, anthrax and tetanus that may not produce visible lesions and any evidence of abnormality can only be detected on ante mortem inspection. An animal showing signs of illness, injury or

exposed to sudden accident must be subjected to a thorough examination and follow-ups before taking final action. Ante mortem inspection ought to be carried out solely by trained and certified inspectors.

Generally when examining live animals attention must be given to the following;

- Posture and movement
- Condition of hide and skin
- State of nutrition – fully developed or emaciated
- Reaction to external influences (environment)
- Feeding reaction – appetite, rumination, quality of droppings, etc,
- Breathing mechanisms - condition of the muzzle, nasal mucosa, respiration, etc,
- Anal opening, vagina or mammary gland.

Inspection of live Animals

Signs of health

1. Active and alert
2. Glossy (shiny) bright coat
3. Skin – loose and elastic
4. Muzzle - moist and wet, cool

Signs of sickness

- Inactive, dull and hanging head
Rough, dull coat
Skin - sticky (tight skin)
Dry muzzle, warm

5. Clear bright eyes	Dull, sunken and discharging eyes
6. Breathing – easy and regular	Difficult, rapid and painful breathing
7. Feed and drink normally	Loss of appetite, refusal of food
8. Normal temper	Abnormal behavior
9. Normal dung	Bloody diarrhea
10. Normal temperature	Abnormal temperature
11. Remain in herd	Separate from herd
12. General good body condition	Emaciated body

3.4.2 Post-mortem examination

This is carried out immediately after the slaughter and if possible a follow up inspection is done from slaughtering to dressing stages of the carcass. The most important requirement in conducting postmortem examinations is that it should be carried out in a methodical manner, following a definite sequence. Experienced inspectors can easily perform this. The main purpose of post-mortem examinations is to detect and eliminate abnormalities and states of contamination by ensuring that the meat is fit for human consumption. Routine post-mortem examinations must be carried out with care, in a hygienic manner and as much as possible avoiding unnecessary cuts and mishandling. Any incision made should be done in a proper

manner that it will not impair the market value of the meat. If the carcass or organs require detail examination then bacteriological examination needs to be done in detail for further examination in part or whole. All carcasses or organs found to be free from disease and abnormal conditions and must be stamped as fit for human use and those that are unfit should be condemned and immediately removed to a final disposal place.

Generally the method of postmortem examination recommended and adapted by most countries is as follows: -

Visual examination

- State of nutrition of the carcass
- Evidence of bruising or discoloration
- Efficiency of bleeding
- Abnormalities or swelling of bones, joints or muscles
- Signs of local and general edema
- Condition of pleura and peritoneum
- Check viscera as they are removed from the carcass

Palpation, incision and detailed visual examination

- Blood: color, clotting
- Head: eyes, pharynx, tongue, lips, sub-maxillary and retro pharyngeal lymph nodes

- Thoracic cavity: lungs, bronchial and mediastinal lymph nodes, heart, diaphragm
- Abdominal cavity: stomach, intestine, spleen, liver, and kidneys
- Reproductive cavity: uterus and ovaries, testicles and penis, udder, supra mammary and inguinal glands
- Connective tissue: fat, bones, joints, tendons
- Muscles: mostly active muscles
- Lymph nodes: at all sites of the carcass
- Feet: internal condition

After a general examination the carcass, organs and viscera must be subjected to a detailed postmortem examination for specific disease identification and judgment. Diseases vary in their severity, extent and spread within the animal body. They may occur as an acute stage and actively affect the animals or may be a mild and chronic type. In this case, judgment or action taken is the most difficult part of meat inspection. It is easy to reject meat and to be on the safe side but it is not so easy to know what to pass as fit for consumption.

Review Questions

1. What are the purposes of meat hygiene?
2. What is the rationale of knowing the sex of food animals?
3. Discuss the main features of slaughterhouses.
4. Discuss methods of inspection in meat hygiene.

UNIT FOUR

Meat-Borne Diseases

Objectives

At the end of the course, the students will be able to

- Identify meat-borne diseases
- Explain meat-borne diseases

Introduction

Raw beef meat is one of the most popular national dishes in Ethiopia for those who can afford it. Most people consume it irrespective of its quality. This is because people have a low awareness about food borne diseases. Some of the common misconceptions in certain local and ethnic groups are:

- Eating raw meat is considered by many as a sign of “masculinity” or how to be a real man. Some others believe that if one suffers from amoebas one should eat beef meat periodically because the tapeworm that may develop at its matured stage will possibly eliminate the amoeba organisms.
- Most rural people believe that if rabid cow or ox meat is consumed it does not affect humans but instead will help to immunize people against the disease.
- Local tanners carelessly handle hides from animals infected with anthrax because they believe that they cannot contract the disease.

- A liver highly infested with liver fluke worms is consumed raw irrespective of its inferior quality.

The most prevalent specific diseases in Ethiopia that require attention are explained under the following classification:

- Bacterial: Such as bovine TB, anthrax, blackleg or tetanus
- Viral: Such as foot and mouth disease, render pest or rabies
- Parasitic: Such as tapeworm, liver fluke or hydatid disease
- Fungal: Such as actinomycosis

4.1 Bacterial Diseases

Tuberculosis: This is the infectious disease for most animals and humans and is characterized by the development of tubercles in any part of the body. It is caused by mycobacterium tuberculosis. There are three common types of tubercle bacilli affecting man and animals, the human (*Mycobacterium tuberculosis*), bovine (*Mycobacterium bovis*) and avian (*Mycobacterium avium*). There is also a fourth type which affects fish. Most sheep are very rarely attacked. The routes by which tubercle bacilli gain entrance to the body are respiration, ingestion, inoculation and congenital and genital organs.

The tubercle bacilli when they enter the body of animals produce primary lesions in the respiratory or digestive tract, followed by lesions in the associated lymph nodes. The specific reaction of the body tissues to the multiplication of invading tubercle bacilli is

manifested by a proliferation of the phagocyte cells at the point of rest forming a nodule or "tubercle". This primary infection is localized in the organs or associated lymph nodes due to either breathing in the tubercle bacilli into the lungs or swallowing the bacilli with infected food or by autoinfection.

As a result, the indications of this condition are that the tubercle bacilli are not very numerous and are not uniform in size but vary greatly. This is because they are in different stages of development and degeneration. After about three weeks the tubercle is just visible to the naked eye as a gray translucent nodule but with the onset of "necrosis" it becomes opaque and gray or yellowish white in color. Necrosis is followed by "caseation" in which the necrotic tissue becomes at the periphery of the lesion forming a capsule limiting the local spread of the disease process. Finally the capsule material may undergo "calcification" and the lesions become paler, hard and feel gritty. When completely calcified no further spread takes place and there is no infection at the localized area. However if the defenses are overcome, further spread may occur.

When tubercle bacilli enter the blood stream and reach to all parts of the animal body, the disease will tend to change from primary into secondary infection. In the stage of generalized Tuberculosis condition, the tubercles become numerous and scattered throughout

the body. As they are of the same age they have almost the same size, similar to that of a millet seed.

Miliary tuberculosis is a good example. Since some organs or parts of the body afford a better medium for growth than others, the muscles, blood vessels and the heart are very seldom affected. However when generalization has occurred, the lungs and the liver are the first to be affected, then the spleen, kidneys, udder, bones and other lymphatic glands.

Signs in live animals

- If the lungs are affected there is frequent coughing, breathing is rapid and difficult and in severe conditions emaciation occurred
- If the pleura or peritoneum are affected then the coat becomes rough and dry, the skin hard and inelastic and the body becomes highly emaciated
- If the udder is affected then the lymphatic glands become enlarged, $\frac{1}{4}$ of the organ is swollen and a small hard tubercle is felt

Post-mortem examination

Inspect by touch and incision all surfaces of organs and associated lymph glands for tubercles

- Examine in detail by cutting the lymph nodes into slices

- If required use bacteriological examination

If during these inspection and examination processes lesions and tubercles are found in certain organs and associated lymph nodes this is evidence of localized infection. If however the lesions and tubercles are manifested over the entire carcass as millary tuberculosis of both lungs, multiple lesions, widespread infected lymphatic glands, congenital tuberculosis and acute lesions this is evidence of generalized tuberculosis and action is required to be taken.

Action to be taken:

- In a localized condition: Only the part or parts containing lesions are to be condemned. For example if the head of an animal is affected then the head and tongue are seized and properly disposed of
- In a generalized condition: Where tuberculosis with emaciation or evidence of the above conditions is shown, the entire carcass should be seized and totally destroyed.

Anthrax

Anthrax (spleen fever) is an infective disease of animals and man caused by spores forming bacteria called *Bacillus anthracis*. It occurs in pre-acute, acute and chronic forms. The disease is worldwide in

distribution though often restricted to particular areas. It is endemic in Ethiopia where cattle and sheep are highly affected, while the other food animals are more resistant. Man is affected when the bacilli enters the body by:

- Ingestion of flesh having the bacilli or its spores
- Contamination of wounds with bacilli or its spores
- Inhalation of bacilli or spores while working or handling in wool-sheep industry, tannery and hide and skin markets.

The blood of animals with anthrax contains numerous bacilli and once the animal is open to bleeding under favorable conditions in the open air where the presence of oxygen is sufficient, the bacilli will form spores. The spores are not found in the living animals and are formed at temperatures in the range of 12-43⁰c and when the oxygen supply is adequate. The sporulating form *Bacillus anthracis* is more resistant to distractive influences than the bacilli form. It is necessary to prevent the infusion of blood from all natural openings as well as other parts of the carcass. However for bacteriological examination drops of blood from the tips of the animal's ear or from under the surface the tail may be taken with great care. A blood smear is prepared on a slide making a normal staining laboratory procedure and then finally seen under a microscope. If positive, the bacilli appear blue surrounded by definite purple capsules.

Signs in living animals

In very acute cases animals become suddenly excited and fall dead. The disease is sudden in its onset and is usually manifested by high fever, up to 42⁰c, and death occurs within 48 hours of the onset of the illness. It may also have bloody diarrhea, dark red, tarry, unsaturated blood discharged from the nose, mouth and anus.

In less acute cases generally the animal separates from the herd with a hanging head and is very hard to move far. The body temperature rises up to 41⁰c, giving a bloody urine and dung. The muscles tremble or quiver and when hands are put over the body it shows crepitation of the skin.

Post-mortem examination

If the animal is killed and the body is opened without suspicion during the ante mortem examination or without the knowledge of the people, the following should be checked carefully:

- Spleen: Seen as swollen, up to five times its normal size, changes to black tarry color. Spleen enlargement in sheep is almost absent. In cross section it shows as a gray or white dot appearance
- Blood: The blood coming out from any opening of the animal's body is thick and black tarry in color and it does not clot easily.

Action to be taken:

The meat from anthrax-infected animals is dangerous to man although anthrax bacilli are readily destroyed by gastric juices. The spores are resistant and may gain access to the system through abrasions of the mouth or mucous membrane.

Therefore the following measures should be taken:

The carcass, including blood, hide, offal and internal organs, should be disposed of by burning, preferably by incineration or using a strong fire. The whole carcass and any other parts of the body available at the spot should be disposed of by burying in a pit. In preparing the pit the following points should be considered:

- Location: Choose a proper site for the burial place, one that should be away from sources of water and away from any dwelling areas
- Depth of the pit: At least 2 meters
- Pit covering: The carcass and other contents should preferably be covered with quicklime, up to 1 foot on top and 1 foot at the bottom of the body. Finally the pit should be covered with compacted earth material
- Fencing: This safeguards the burial place from wild animals. Therefore it should be protected by proper fence

The place where the carcass and all other contents are laying must thoroughly treated with an appropriate disinfectant. All slaughtering tools and articles used must be boiled and disinfected with a chlorine solution or formaldehyde.

All persons handling the animal must wear gloves, apron and plastic boots. An antibiotics (penicillin) injection is of great help for prophylactic treatment.

Black quarter, black leg or quarter leg

Blackleg is a world wide infectious disease of cattle and sheep. It is caused by bacteria called “clostridium chauvoei”. It is a spore-former bacterium that results from soil infection, which affects animals that more commonly grass feed than stall-fed. Blackleg spores are very resistant to destructive influences and may retain their virulence for over 10 years in dried muscle and indefinitely in the soil.

Susceptible animals may be infected by inoculation or more commonly by the ingestion of spores in soil, dust, grass and water. Most often, young animals, between six months and two years of age are attacked. Black leg is not communicable to man, man is immune.

Signs in living animals

Generally black leg is characterized by severe inflammation of muscles with toxocemia and high mortality. The infection is followed by crepitate swellings as a result of gas formation when developed in the subcutaneous tissue. During ante mortem inspection the following conditions are detected:

- Swelling on the shoulder, neck, legs, loins and thigh and crepitation over the swollen part is commonly present
- Manifested with high fever
- Death occurs within 24 hrs.
- Cause lameness, if the limbs are affected

Post-mortem examination

- Muscles: These become blackish red and edematous at the periphery of the swelling and have a spongy appearance. Above all it emits a rancid and unpleasant odor
- Lesion: If it is cut it gives off gas with a pus-like odor
- Visceral organs: The liver and kidneys show marked changes, being enlarged and congested.

Action to be taken

If a live animal is found affected with black quarter, slaughter of the animal is forbidden. If however after slaughter the carcass and organs are found to be affected they should be rejected and disposed of properly because the flesh of such animals is highly affected and spoiled to the extent that it gives off a rancid taste and odor.

Tetanus (Lockjaw)

Tetanus is an acute, highly fatal and infective disease. It is caused by bacteria called "clostridium tetani". All animals can be affected, principally horses, sheep and cattle and rarely pigs. Tetanus

organisms have their natural habitat in the intestines of horses and other animals. They commonly exist in the top layers of the soil which has specially been fertilized with manure. In animals it is caused by contamination with soil of open wounds or the umbilical cord in newborn animals. In man contamination is by of wounds or penetration through skin or mucus membrane. The organisms themselves do penetrate the blood, but remain at the site of inoculation where they produce a very acute toxin, which cause the acute tetanus spasms, stiffness of the body and finally death.

Signs in living animals

The examination during ante mortem is incomplete by itself, but by taking specimens from the wound of the animal or drawing blood from the body a bacteriological test is done to confirm the disease.

- At the site of inoculation the tissue becomes edematous.
- Causes muscular spasm in the muscles of the jaw (master muscle)
- Causes stiffness of the body, starting from the jaw and spreading to the legs
- Attacks the nerve cells of the spinal cord and brain.

Post-mortem examination

Since there is slight alteration internally, the post mortem examination is very difficult unless it is preceded by ante mortem inspection. Certain characteristic changes shown are:

- Slight pathological change may be observed in the heart, liver and kidneys
- The internal muscles may become soft and change color to grey
- The dead animals show evidence of asphyxia.
- The blood of the animal becomes dark red showing some tendency to clot.

Action to be taken

Since the whole carcass is to be affected because of the reaction of the body, the carcass and the organs must be rejected as unfit for human consumption.

4.2 Viral diseases

Foot and Mouth disease

This is an acute, contagious, febrile disease caused by entrovirus and occurring in cloven-footed animals, such as cattle, pigs, sheep and goats. The virus of the disease is most concentrated in the infective fluid from the vesicles, which characterizes the infection. Grazing or stable animals with vesicles, while feeding and walking, will have their blisters burst out and contaminate the pasture and grazing land with viruses that have been discharged. These viruses will get access to other grazing animals through their feet when walking or their mouthparts while feeding. Infection with the virus of the foot and

mouth disease is rare in man and usually takes a mild form. The disease can be spread by means of infected fodder, by meat affected by the disease and by consuming milk from the infected cow.

Signs in living animals

- Excessive salivation as a result of affected mouthparts
- The principal locations of the vesicles or blisters are the membrane of the lips, muzzle, tongue and fibrous pad
- Lameness as a result of vesicles between the digit, at the base of the supernumerary digits, around the horns and pairs of hooves
- Lesions in

Cattle: Found on the tongue, lips, dental pad, feet and udder. The size of vesicles or blisters are $\frac{1}{2}$ to 2 inches and they have a white clear appearance and contain a yellow fluid.

Sheep and goats: Found generally on the feet and seldom in the mouth, the lesions in these animals are smaller than cattle ones.

Pigs: Found on the feet, inside the nasal septum and sometimes on the teat of the udder.

Action to be taken

Once the ante mortem inspection is done properly to identify the condition of the infection, the postmortem examination is not

necessary as a routine procedure, but for an overall check up of the internal condition of the lesions, it should be practiced.

In this case the whole carcass, organs, hide and teat of an animal suffering from foot and mouth disease must be seized and destroyed and when need arises should be burnt properly. In addition thorough cleansing and disinfection of all tools, materials and all places in contact should be done to safeguard any further contamination of meat products.

Render Pest (Cattle Plague)

Render pest is an acute, infectious and febrile disease affecting particularly cattle, which when once introduced spreads very fast and may lead to the almost complete extinction of animals over large areas. It is endemic in Ethiopia as in other places. This disease also affects game animals. It is caused by viruses that are characterized by inflammatory neurotic changes of the mucus membrane of the alimentary tract. The disease is spread through direct contact or through water and grass contamination to other animals.

Signs in living animals

- If the animal is affected with the disease, it is dull looking and it stands with its head down with its back hunched

- It has a high fever, 41⁰c-42⁰C.
- Onset of diarrhea with a black and smelly condition is frequent, which causes the animal to rapidly become emaciated
- The animal loses its appetite and stops ruminating
- The mouth shows an acute inflammation of the mucous membrane, with its muzzle dry and eyes having a discharge.

Post-mortem examination

- Inflamed patches are seen on lips and throat area
- Red streaks on the rectum are visibly
- Liver is enlarged and the gall bladder is distended
- The associated lymphatic glands are swollen
- Dehydration and emaciation of the carcass may be seen.

Action to be taken

Since it does not affect man but gives a poor quality meat and poor protein content, because of the high fever and toxemic condition of the animal, the carcass and organs affected must be totally condemned and destroyed. In areas where render pest is endemic, as in Ethiopia, vaccination coverage is of great help preventing the spread of the disease for fairly long time.

Rabies

Rabies (hydrophobia) is an acute, infective viral disease, which is usually transmitted by a bite from an affected animal. Man is

susceptible and is usually infected by a dog bite. Almost all carnivorous animals such as dogs, wolves, hyenas, jackals etc are also susceptible and become infected through the bite of other rabid animals.

Signs in living animals:

Rabies has 3 stages of symptoms.

1st stage- Melancholic (depression)

- Normal temper changes to irritation and aggressiveness
- Animal tends to hide away, becomes uneasy and moves actively
- Is frightened of any noise heard

2nd stage- mania (madness)

- Excitability increases and wanders aimlessly
- Animal's normal appetite is changed and attempts to eat strange articles
- Starts attacking other animals though man is rarely attacked
- Slight paralysis starts and the animal cannot swallow .

3rd Stage- paralysis

- Larynx and pharynx are first attacked and the voice of the animal changes
- Muscles of mastication are affected and the eyes become paralyzed
- Continuous dripping of saliva starts

- Muscles of locomotion and breathing are affected
- Finally, when paralysis is complete, the animal dies of asphyxiation.

Post-mortem examination

Post-mortem examination of rabid food animals that have died or have been slaughtered reveals no diagnostic lesions. The characteristic changes in the brain are only evident on microscope examination is negree bodies are seen it is positive for rabies. The stomach contains little food and the gastro-intestinal mucosa may be inflamed.

Action to be taken

Rabid animals for meat are unfit for slaughter because the handling of the meat of rabid animals is dangerous. To safeguard the spread of rabies, the following control measures should be taken:

- Careful follow up of all suspected animals
- Destruction of all stray dogs
- Compulsory vaccination of all owned dogs by the veterinary office
- Control of wild animals
- Quarantine of any suspected animals for 10-14 days, if is the animal develops the symptom the person in contact should start prophylaxis immediately.

4.3 Parasitic diseases and infestation

The most important parasites in meat inspection are those which are transmissible to man by the consumption of the flesh of affected animals or by coming into contact with such flesh. Other parasites, though not causing diseases in man, may render such flesh or organs to deteriorate and therefore, be unfit for sale for human consumptions. The three most common parasites of animals to be dealt here are: tapeworm, liver fluke and echinococcus.

Tape worms in humans

Tapeworms (cestodes) are parasites, when mature inhabitants of the intestines. The presence of numerous tapeworms in the intestine may exert a deleterious effect and discomfort on the host. The adult tapeworm possesses a head or scolex and a number of segments (proglottids) which vary from three to many hundreds. Tapeworms exist in two stages, each resident in a separate host, called the cysticercus's (cyst) stage and the adult (matured) stage. The cysts are non-feeding, immature stages are lodged in the muscles or other tissues and organs while in the adult form, the parasite attains complete sexual development, in the intestine.

The two common tapeworms requiring attention in meat inspection in Ethiopia are *Tania saginata* and *Tania Solium*.

***Tania saginata* (Cystecercus bovis)**

The adult beef tapeworm occurs in the small intestine of humans where the intermediate stage, *Cysticercus bovis*, is found in cattle. The adult tapeworm measures from 3 -10m in length with a head or scolex having four suckers and a long segment (proglottides). The life cycle of beef tapeworms takes place at two stages in a different host. The stage of development that concerns in meat inspection is that part which takes place in cattle. The eggs which are discharged contain an open fluid which may remain over the grass and will be ingested by cattle. In time these hatch out in the intestine, penetrate the gut wall and reach the blood stream by which they are carried to various parts of the animal body. The embryos that become attached to the muscles develop into cysts- *Cysticercus's bovis*. These cysts remain active for some years in the muscles, which later undergo degeneration, calcifications and calcification. The most affected parts of the body are the active muscles, namely the masseter muscles, heart, tongue, inter-coastal muscles, shoulder and neck muscles, diaphragm, liver and lungs and other muscles (Biceps and triceps).

Taenia solium (*Cysticercus cellulosae*)

The adult tapeworm inhabits the upper part of the small intestine of man while the intermediate stage, *Cysticercus cellulosae* is found in pigs. The adult tapeworm is 2-6 m long, with a globular head less than 1mm in diameter and segments. The life cycle of a pork tapeworm takes place in the same way as in a beef tapeworm, where the cysts are formed in the pigs' active muscles, namely the heart,

diaphragm, tongue, neck, shoulder, inter costal and abdominal muscles.

During ante-mortem inspection of tapeworms in living animals, it is not easy to identify the signs and symptoms of the disease. Therefore it is not done as a routine procedure. A meat inspector instead may have the knowledge of the area from where the animals originate and this may give him a hint for a thorough examination of the muscles during the postmortem examination.

Action to be taken

Since consuming meat raw or partially cooked meat with tapeworm cysts infects man, the following measures should be taken:

- Localized infection, where the organs or part of the muscles are offered with only a few in number of cysts, the only affected part has to be seized and disposed of properly.
- In generalized infection, where the cysts are found in most organs or parts of the muscles in a significant number, the whole carcass should be condemned.

In order to save the meat there are certain practical measures that may be taken if they are properly handled. Cysts in meat can be destroyed by adequate boiling or cooking, at least 140°F (60°C), or cysts in meat can be inactivated or killed by cold storage or deep

refrigeration at temperature 20⁰F (-6.6⁰C) for 3 weeks or at a temperature of 14⁰F (-10⁰C) of 2 weeks.

Liver Fluke (*Fasciola Hepatica*)

Fasciola hepatica is a common liver fluke that is responsible for the acute and chronic inflammation of the liver and bile ducts. It is distributed almost universally throughout the world. It is usually flat, leaf shaped and pale brown in color with an oral sucker. The parasite is 32 mm long and 8.4 -13 mm wide. The animals most commonly affected are sheep and cattle. The life cycle of the parasite takes place in different hosts. The stage of development in sheep or cattle is the part that concerns meat inspectors. The intermediate host, in which the cycle of maturity takes place, is in the snails who favorably inhabit marshy areas. After the eggs are discharged from the host they develop into meracidium and in a favorable condition they finally reach cercariae stage. These cercariae settle on the blades of grass and other plants in the pasture where grazing animals eat them.

Within the animal intestine the liberated embryos finally reach the liver and develop into the adult flukes. Flukes live in the liver and bile ducts of the animals, which then affects the organ.

In an acute case there is a condition of distinct swelling and congestion of the liver and bile ducts, as a result of invasion of the liver by a large number of young flukes. In chronic cases, the liver

become distorted, the bile ducts enlarged, thickened and turn to a bluish color.

It is not necessary to make ante mortem inspection for liver fluke infestation. There is no indicative sign for the infestation other than to know the areas from which the animals originated in the locality.

Post-mortem examination

Since the main organs that are affected are the liver and lungs, external observation and incision to expose the bile ducts can be done to check the organs. If the liver is infested with the flukes, they may be seen emerging when the surface of the liver is pressed with both hands. The same way may also apply to the lungs.

Action to be taken

The organs, the liver and lungs if highly affected should be rejected and disposed of properly. Since liver fluke is not transmissible to man by consumption of the meat, some parts of the meat may be saved if they are free from infestation.

Hydatid disease (*Echinococcus Granulosus*)

This is the smallest of the tapeworms, about 3-9 mm in length and composed of a head or scolex and three or four segments. Dogs are

the definitive host, while man does not harbor the adult worm. The incidence of echinocoecus infection in an area can be determined from its level in dogs. The food animals affected are cattle, sheep and pigs. Infection to man is only by contamination of water or vegetables with hydatid infection and not by infected cystic meat. The life cycle of echinocoecus passes through the definitive host, the dog and the intermediate host, the sheep or cattle. After the intermediate host ingests the fertile ova, the digestive juices dissolve the capsules and the embryos penetrate through the walls of the small intestine passing into the portal veins and are retained in the liver and on the parts of the body.

Once they reach the tissue muscles they form cysts. This cystic stage is known as echinocoecus or hydatid cyst. These organs with cysts when disposed of carelessly can be consumed by dogs and pass a cycle of development in their body. The discharged feces of dogs may contaminate vegetables or water, and the cycle continuous again.

The ante mortem inspection is not done to a identify hydatid disease condition, instead careful exploration is done during post mortem examination.

Post-mortem examination

The organs most commonly affected are the liver, lungs, kidneys and spleen. Occasionally cysts are also found in the heart, bones and

muscular tissues. Liver is heavily infected and in the long run cyst degeneration takes place through a process of cassation and calcification.

During the examination the cysts that form on the organs and other parts of the carcass should be checked carefully.

Prevention: The cycle can be interrupted by having proper human waste disposal, by preventing dogs from entering the slaughter place and if possible by boiling and the cooking of water.

Action to be taken

All affected organs and parts of the carcass are unfit for human consumption and so they should be condemned and disposed of properly.

Other Measures:

- Condemned meat parts should not be disposed of anywhere but burnt or buried with care.
- Dogs should be prohibited from entering slaughterhouses or similar places, proper fencing is required
- Food and vegetables should be prevented from being contaminated with dog faeces.

Actinomycosis (Lumpy Jaw)

This is a chronic disease of cattle commonly known as “Lumpy Jaw”. A fungus called “actinomyces bovis” causes it. Pigs are more affected than other animals. Actinomyces boviis is responsible for actinomycosis of the bone in cattle and the main cause of udder actionmycosis in the pig. The infection of bone may be regarded as the true form of actinomycosis, while infection of the softer tissues is caused by actinobacililus, another bacterial species. In cattle the lesions of actinomycosis are usually confined to the head, and may involve the jawbones to produce “lumpy Jaw”, the lower jaw is more affected than the upper one. The bone part of the jaw is thickened and forms a honey-combed appearance on section.

Signs in living animals

- The lower jawbones are distinctly seen to be affected
- Some extended lesions may be seen in the head part
- Tongue ulceration, enlargement and hard formation takes place
- Pigs (sow's) udder is affected.

Since the most affected parts of the head and other organs can be easily checked externally, there is no need for a post mortem examination.

Action to be taken:

Affected organs, such as head, tongue udder, stomach or lungs, should be condemned.

Review Questions

1. What are the common causes of meat-borne diseases:
 - a. Bacteria?
 - b. Viruses?
 - c. Parasites?
 - d. Fungi?
2. What are the main symptoms for anthrax identification during ante mortem examination?
3. What are the main symptoms for tetanus identification during post mortem examination?
4. Discuss the various measures to be taken to prevent anthrax diseases.

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