



**NATIONAL OPEN UNIVERSITY OF NIGERIA**

**FACULTY OF AGRICULTURAL SCIENCES**

**COURSE CODE: ANP 303**

**COURSE TITLE: Introduction to Animal Products Processing and  
Preservation**

**Course Writer: Olukayode Anthony MAKINDE, PhD  
Animal Nutrition, Products, Value Addition,  
Department Animal Sciences,  
Faculty of Agriculture,  
Obafemi Awolowo University Ile-Ife  
+2348033303438; +2348089674398**

**CONTENTS**  
**COURSE GUIDE**

**PAGES**

**Module 1    Animal Products and By-products**

Unit 1        Animal Products and By-products

Unit 2        Animal Products Industry in Nigeria

**Module 2    Meat Production and Processing**

Unit 1        Animal Growth and Development

Unit 2        Body composition

Unit 3        Slaughter and Conversion of Muscle to Meat

Unit 4        Meat Preservation, Processing and Storage

**Module 3    Egg production and Processing**

Unit 1        Egg Formation and Production

Unit 2        Egg processing and Storage

**Module 4    Milk Production and Processing**

Unit 1        Milk Production

Unit 2        Milk Quality

Unit 3        Milk Processing and Storage

## **ANP 303. Introduction to Animal Products Processing and Preservation (2 Units)**

### **Course Guide**

#### **1.0 Introduction**

Welcome to ANS 303: Introduction to Animal Products Processing and Preservation, which is a 2-Credit Unit course offered in the third year to students of the undergraduate degree programme in Animal Sciences. There are eleven study units in this course. The course is a guide for distance learners enrolled in the B.Agric. programmes of the National Open University of Nigeria.

In this guide, you will find very useful information about this course: aims, objectives, what the course is about, what course materials you will be using; and information on practical sessions. It also offers you guideline on the amount of time you are likely to spend on each study unit and your tutor marked assignments.

I wish you all the best in your learning experience and successful completion of this course.

#### **2.0 Course Aims and Objectives**

- This course aims to introduce and equip you with the knowledge and ability to differentiate between animal products and by-products from livestock production systems.
- The course also aims to help you to understand how the products are produced, handled, processed and stored.

There are objectives to be achieved in each module of the course on completion of this course. On the completion of this course you should be able to:

- differentiate between animal products and by-products
- explain the state of meat, egg and milk industry in Nigeria
- explain the difference between growth and development
- explain the factors that influence body composition
- describe the stages involved in the conversion of muscle to meat
- identify properties of fresh meat and the best way to process and preserve meat
- identify the importance of packaging and different types of packaging for meat
- describe how egg is formed and produced

- provide information on how egg can be processed and stored
- describe the state of milk production in Nigeria
- describe the nutritional and physio-chemical qualities of good milk
- explain milk storage and preservation techniques

### **3.0 Main Content**

#### **3.1 Course Materials and Structure**

To complete this course, you are advised to read through this course guide to familiarize yourself with the structure of the course; read the study units and attend all tutorial sessions where available; and consult recommended sources where available for further reading.

At the end of the course, there is a final examination. The course should take you not less than forty-two hours to complete. You have to draw up your own timetable and allocate time to complete each study unit in order to complete the course successfully and on time.

All the components of the course are listed and explained below.

#### **3.2 Study Units**

There are eleven study units in this course and they are:

- Animal Products and By-Products
- Animal Products Industry in Nigeria
- Animal Growth and Development
- Body Composition
- Slaughter and Conversion of Muscle to Meat
- Meat Preservation, Processing and Storage
- Egg Formation and Production
- Egg Processing and Storage
- Milk Production
- Milk Quality
- Milk Processing and Storage

#### **3.3 Course Summary**

Module 1 introduces you to animal products and by-products. Module 2 examines meat production and processing. Module 3 deals with aspects of egg production and processing. Module 4 examines issues concerning milk production and processing.

There are eleven study units in this course. The first two study units should take one week's work each. Study units 3-6 will take two weeks each and study units 7-11 will take one week each; each week requiring at least three hours. Each unit includes specific objectives, guidance for study, reading material, and Self Assessment Exercises. Together with tutor-marked assignments, these exercises will assist you in achieving the stated learning objectives of the individual study units and of the course.

### 3.4 Study Plan

The table below is a presentation of the course and how long it should take you to complete each study unit and accompanying assignments.

Unit	Title of Study Unit	Weeks/ Activity	Assignment
	Course Guide	1	Course Guide Form
<b>Module 1 Animal Products and By-Products</b>			
1	Animal Products and By-Products	2	Assignment
2	Animal Products Industry in Nigeria	3	TMA 1 to be submitted
<b>Module 2 Meat Production and Processing</b>			
1	Animal Growth and Development	4,5	Assignment
2	Body composition	6,7	Assignment
3	Slaughter and Conversion of Muscle to Meat	8,9	Assignment
4	Meat Preservation, Processing and Storage	10	TMA 2 to be submitted
<b>Module 3 Egg Production and Processing</b>			
1	Egg Formation and Production	11	Assignment
2	Egg Processing and Storage	12	TMA 3 to be submitted
<b>Module 4 Milk Production and Processing</b>			
1	Milk production	13	Assignment
2	Milk Quality	14	Assignment
3	Milk processing and Storage	15	TMA 4 to be submitted
	Revision	16	
	Examination	17	
	Total	17	

\*Now, use the overview to plan your personal time table.

# **ANP 303: INTRODUCTION TO ANIMAL PRODUCTS PROCESSING AND PRESERVATION**

## **MODULE 1: CLASSIFICATION OF ANIMAL PRODUCTS AND BY-PRODUCTS**

Unit 1 Animal Products and By-Products

Unit 2 Animal Products Industry in Nigeria

### **UNIT 1 ANIMAL PRODUCTS AND BY- PRODUCTS**

#### **CONTENTS**

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 What are Animal Products and By-products?

3.2 General Classification of Animal Products

3.2.1 Animal Food

3.2.2 Slaughterhouse By-products

3.2.3 Manure

3.3 Uses of Animal Products and By-products

3.3.1 Animal Products

3.3.2 Animal By-Products

3.3.2.1 Uses of animal by-products of external origin

3.3.2.2 Uses of animal by-products of internal origin

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

#### **1.0 INTRODUCTION**

The meaning of the term ‘animal products’ or ‘animal by-products’ is usually not fully understood or not really thought about though we consume or have used these products from time to time. This unit will introduce and describe to you what animal products/animal by-products are from different perspectives, depending on customs, traditions and beliefs. In addition, we will discuss different ways of grouping (classifying) animal products. This would help you to understand the basic function of animal production, which is to produce food and raw materials important to our well-being.

## **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- distinguish between animal products and by-products
- describe criteria for classifying animal products and by-products
- recount different uses of animal products and by-products

## **3.0 MAIN CONTENT**

### **3.1 What are Animal Products and By-products?**

Animal products refer to products that can be obtained from animals totally or partially. That is, they are either produced by the animal or taken from the animal. This term is generally not applied to products made from fossilized or decomposed animals, which include petroleum. Further, crops grown on soils fertilized with animal remains cannot be called animal products.

### **3.2 General Classification of Animal Products**

#### **3.2.1 Animal Foods**

Animal foods refer to the edible parts of the animal carcass (body of the animal after it is killed) or those products obtained from the live animal. The animal foods comprise meat, milk, eggs and the processed products from these as well as the edible parts of the carcass such as kidneys, brain, liver, heart, intestine and tongue (usually called offal).

#### **3.2.2 Slaughterhouse by-products**

These refer to inedible parts obtained from the animal after it is killed comprising rumen contents (undigested or partially digested food remaining in the largest intestine (called rumen) of animals such as cattle, sheep and goats); blood, bone, hair, horn, hoofs, feathers, skin (skin of small animals e.g. sheep, goats and rabbits) and hides (skin of large animals e.g. cattle). However, blood, bone, skin and hide may be classified as animal foods depending on the existing or acquired custom and tradition of the people. For example, in Nigeria, bone, skin and hide are used as human foods widely but blood by a few people. In contrast, the Masai tribe of Kenya drinks regularly the blood obtained from live cattle they keep.

#### **3.2.3 Manure**

This is the waste or remnant of food eaten by the animal that was not digested or absorbed but has gone through the whole of the intestine and is passed out through the rectum or anus. It is usually used as organic (natural) fertilizer that helps to promote plant growth. Manure can also be used in the production of biogas. Biogas is gas

obtained when manure is mixed with plant or crop material, which then decomposes by the action of microorganisms (especially bacteria) in the absence of oxygen. This is done in a small container or a large tank. The biogas, which is basically methane can be used for cooking or used as fuel to power generators to produce electricity.

### **SELF ASSESSMENT EXERCISE 1.1**

Give your understanding of the term ‘Animal Products’ and write an outline of the general classification of animal products.

### **3.3 Uses of Animal Products and By-products**

In the preceding section, we examined a general classification of animal products, where we discovered that some products could have dual classification specifically as slaughterhouse by-products as well as animal foods. However, a more technical classification based on utilization (uses) of animal products may minimize the confusion. Therefore, the new classification divides animal products into animal products and animal by-products strictly. Note that, virtually all animal products and by-product must be processed in some form before utilization. Most of those that require minimum processing are those used to meet individual food needs. Some other products require more processing and are the exclusive preserve of various industries.

#### **3.3.1 Animal Products**

Animal products include everything obtained from an animal, living or after slaughter, which is edible, intended for use as human food. These include meat, milk, eggs and processed products resulting from them. Meat refers to the tissues obtained from domestic, aquatic and non-domesticated animals used as food. These include beef, pork, mutton and chevon from cattle, pig, sheep and goats, respectively (referred to as ‘red meat’). Meat from other animals is also consumed such as from horse, camel and rabbits. Meat from non-domesticated animals is called ‘game’. Poultry meat (referred to as ‘white meat’) is obtained from chickens, turkeys, ducks, guinea fowl etc. Meat from aquatic animals include that from mostly fish, then to a lower extent, crabs, lobsters, oysters and other species.

In addition, many other minor parts of the carcass obtained during the slaughter and processing of animals are used as food. These include liver, heart, lung, sweetbread (pancreas), kidneys, intestines, brain, tongue, spleen, ox-tail, bone, blood, hide and skin, hoofs, fat, lips, eyes, skull (head) etc. These are generally called variety meats. As mentioned previously, use of these products as food depends on custom, tradition, purchasing power, religion and food habits. Therefore, many of these products are also considered as inedible (not useful as food) by some people and referred to as animal by-products.



Animal products are significant in planning a normal well-balanced diet. Animal foods significantly contribute to four of the basic nutritional components of man's diet. These nutrients are protein, fat, vitamins and minerals.

### **3.3.2 Animal By-Products**

Animal by-products strictly refer to products obtained from the animal not intended for use as food. Therefore, they are considered inedible and are usually exploited for their economic value. Efficient conversion of these into useful products contributes to a reduction in environmental pollution since they readily decompose to pollute the environment. The processing of these products is referred to as rendering.

Animal by-products can be of either external or internal origin. Animal by-products originating from the exterior of the body include wool, hair, fur, feathers as well as hide, skin, hoof and horn. From within the animal body comes a variety of by-products including rumen contents, faeces, blood, bones, fats and oil, liver, heart, lung, sweetbread (pancreas), kidneys, intestines, brain, tongue, spleen etc.

#### **3.3.2.1 Uses of animal by-products of external origin**

- Horns and hooves used in handicrafts, glue, combs, buttons, etc.
- Gelatin from skin and bone used in food, ointments, cosmetics, drugs
- Hair, bristles and wool for textiles, carpets, brushes, lanolin
- Hides and skin for all real leather goods
- Feathers are used as ornaments, in the manufacture of mattresses and pillows

#### **3.3.2.2 Uses of animal by-products of internal origin**

- Meat and bone meal used in animal feed for domestic animals.
- Animal blood is used with agar (as blood agar) for the identification of various microorganisms.
- Blood used as blood meal as protein source in livestock diets
- Bone used in manufacture of gelatine, bone meal, glue and dicalcium phosphate
- The intestines used as casings or skins for sausage
- Faeces and rumen contents used as organic manures, biogas, feed
- Tallow (animal fat) used in manufacturing of soap, cosmetic, lubricants, polish, etc.
- Many organs and glands serve as sources for pharmaceutical products. For example, pancreas for insulin; ovaries for estrogen; brain for growth hormone.
- In research, fertile eggs are useful in testing the effects of drugs and for production of toxins and vaccines

### **SELF ASSESSMENT EXERCISE 1.2**

Distinguish between animal products and by-products based on utilization.

## 4.0 CONCLUSION

Proper understanding and ability to distinguish between animal products and by-products is very important to aspiring entrepreneurs in livestock production. Knowledge of the potential uses of different parts of the whole body of the animal provides significant opportunities that can be exploited.

## 5.0 SUMMARY

In this unit, you have learnt:

- how to distinguish between animal products and by-products
- different ways of classifying animal products and by-products
- the various ways to use animal products and by-products for commercial exploitation

## 6.0 TUTOR-MARKED ASSIGNMENT

1. Write the general classification of animal products
2. State the criteria and write an outline for the classification of animal products based on utilization

## 7.0 REFERENCES/FURTHER READINGS

- Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling in the tropics*. Abuja FCT: Living Books Series. GV publications.
- Forrest J.C., Aberle E. D., Gerrard D. E., Mills W. E., Hedrick H. B., Judge M. D., Merke R. A. (2001). *The Principles of Meat Science*. (4 ed.) U.S.A.: Kendall/Hunt Publishing Company.
- Ikeme A. I. (1990). *Meat Science and Technology: A Comprehensive Approach*. African-Fep. Publishers Limited.

Sonaiya E. B. (1982). *Animal Products*. Ile-ife: Thelia Publishers

## UNIT 2 ANIMAL PRODUCTS INDUSTRY IN NIGERIA

### CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Animal Products Industry in Nigeria
    - 3.1.1 Milk Industry
    - 3.1.2 Egg Industry
    - 3.1.3 Meat Industry

- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings

## 1.0 INTRODUCTION

In the previous unit you learnt about the terms ‘animal products’ and ‘animal by-products’ and how to distinguish one from the other according to different perspectives. In this unit you will learn about the structure of the production of the major animal products (milk, eggs and meat) in Nigeria. This structure involves production, importation, processing, marketing and consumption. This would help you to know the potentials and opportunities existing in the production of these products.

## 2.0 OBJECTIVES

At the end of this Unit you should be able to:

- describe the structure of the milk industry in Nigeria
- describe the structure of the egg industry in Nigeria
- describe the structure of the meat industry in Nigeria
- explain why each of the industries is underdeveloped

## 3.0 MAIN CONTENT

### 3.1 Animal Products Industry in Nigeria

#### 3.1.1 Milk industry

Dairy is a branch of agriculture that involves milk production from milk-type animals, especially dairy cattle. Milk production in Nigeria can be grouped into systems comprising, transhumance pastoralists (Fulani herdsmen moving from place to place) collection and processing, government collection and processing plants and private sector collection and/or processing plants. The government and private sector plants are more organized than the pastoral system.

The Fulani control most of the cattle in Nigeria (> 90%). They drive their cattle along established routes in search of water and pasture during the dry season. The Fulani are either strictly nomadic, semi-nomadic or settled in communities where there is constant supply of pasture and water. Those settled are fewer than the semi- and strictly nomadic. Milk produced by their cattle are mainly for consumption and the remnant processed by their women into products such as *nono* (sour milk), *kindirmo* (thicker nono), *maishanu* (local butter), *cuku* (Fulani cheese) and *wara* (Yoruba cheese). The women take these products to markets and commercial transport transit points in the communities where they are settled or semi-settled. In spite of the

potentially high volume of milk obtainable from this source, most of it is wasted and not available for commercial application because of the lack of organization of milk collection and processing. There is little or no penetration in the urban markets for most of the products where premium value can be given. Another problem is the lack of standardization of products and worries about wholesomeness or safety. Proper organization of this sector would be most significant to national dairy development efforts.

Government involvement in dairy dates to before and after independence, when cattle ranches were established all over the country with local and exotic dairy cattle. Milk plants were attached to these ranches for collection and processing of milk. However, these plants were not viable because they were very limited in both absolute and utilised capacity, not properly managed and probably because there was a lack of an effective national dairy development plan. Nevertheless, current plans involve a development of a proper dairy development program and partnership with private dairy processing companies in establishing collection plants in areas where the Fulani are settled.

Most of the milk and milk products obtainable in Nigeria are from commercial private companies. These products are made mainly from imported powdered milk, which are reconstituted for production of a variety of products such as powdered milk, infant formula, evaporated milk, flavored milk, yoghurt, ice cream, butter and cheese. Few of these companies have cattle ranches where they process collected milk with or without addition of milk from the Fulani. Other companies do not have cattle ranches but just imports powdered milk and finished milk products for sale. These companies have well-established marketing channels and their products are sold mostly in urban markets. Examples of these companies include Friesland-Campina (formerly WAMCO – West African Milk Company) and Fan Milk Company.

### **SELF ASSESSMENT EXERCISE 1.3**

List the systems involved in milk production in Nigeria and mention the system with the greatest capacity to impact most significantly on dairy development in Nigeria.

#### **3.1.2 Egg Industry**

The egg industry in Nigeria comprises all the actors in egg production, distribution, and marketing. The typical egg value chain comprises egg production, trade and consumption. The egg processing sector is practically non-existent and eggs are sold in-shell despite that Nigeria is the top egg producer in Africa and 19<sup>th</sup> in the world.

Egg production in Nigeria ranges from highly organized systems to simple subsistence or scavenging systems. The highly organized systems undertake intensive production where large numbers of laying chickens are raised in purpose-built hen houses where

they are reared in cages or on the floor. Carefully formulated feed is supplied and eggs are collected mechanically or manually. The chickens reared are hybrids that have been genetically bred and imported. Few organizations are involved in the distribution and sale of the hybrids and they are sold as day-old chicks or point-of-lay chickens.

Local chickens are not used commercially for egg production. However, there are plans to develop and introduce a local breed called, Shika Brown. Most of the chickens used even at the less organized systems are hybrids, although, in the scavenging systems more of indigenous chickens are used but the objective is not commercial. The scavenging system involves chickens that are left to roam and seek (scavenge) for their food, and there is no purpose-built shelter or care. In between the well organized and scavenging systems are small- to medium-scale systems where chickens are kept in the backyard or on dedicated farms. The numbers of chickens range from hundreds to few thousands.

Feed for the chickens are either self-formulated or purchased from feed manufacturers. Health care is provided by veterinarians or self. There is no strict veterinarian control on egg production.

Eggs are sold directly to the market or through middle-men or distributors that have their own marketing channels. Eggs are sold in the shell and processing into products such as liquid, frozen, or powdered egg is absent. Such products are imported into the country by industries that require them. Eggs are sold mostly in trays of 30 eggs each or in units according to purchasing power.

#### **SELF ASSESSMENT EXERCISE 1.4**

List four shortcomings of the egg industry that needs improvement

#### **3.1.3 Meat Industry**

The meat industry comprises all processes concerned with the sale and production of meat. Meat sold in Nigeria comes mainly from cattle, chicken, pig, goat, sheep, and other sources smuggled into the country such as turkey and chicken despite a government ban. Imports of all live cattle, beef, and beef products are not allowed. Pork, mutton (sheep meat), and goat meat are also unilaterally banned. Nigeria also bans live poultry (excepting only day-old chicks) and poultry meat, including fresh, frozen, and cooked poultry meat. However, fish is mostly imported.

Beef comes from cattle (raised extensively) that are dual-purpose and not of a specific type (dairy or beef). Beef is mostly from cattle reared by the Fulani and the bulk of the beef consumed in the South comes from the North because of the limiting effect of trypanosomiasis on cattle production in the South. It is estimated that more than two million heads of cattle are slaughtered annually. Central slaughtering is limited and not well organized and significant numbers of animals are slaughtered in small scattered slaughter slabs on a daily basis. Mechanical slaughtering and processing is almost non-existent (except one privately managed in Lagos central abattoir) despite

the availability of facilities. This is probably due to the preponderance of traditional/religious slaughtering, which may be difficult to adapt to mechanical slaughtering.

The marketing system is not organized and beef demanded by consumers is not based on any grading system; and purchase is by bargaining with offals usually bought at higher prices than meat. Cattle are supplied to large or heavily populated cities (with very high demand) such as Ibadan and Lagos by Hausa/Fulani cattle dealers by arranging purchase from the north through their agents. The cattle are sold to wholesale butchers who sell to retail butchers. The market is characterized by multiple levels of middlemen. Cattle are also sold for slaughter along trade and/ trek routes. Fattening of cattle for sale through a feedlot system, where it exists, is severely restricted to few individuals.

The sources and market for mutton (sheep meat), and goat meat are similar to that of cattle because the Hausa/Fulani rear them as well. They are less demanded than beef except on festive occasions. There is also no specific preference for a particular quality or grade of meat, purchase is by bargaining, and meat not sold by weight in most places.

The production and market for poultry meat and pork are mostly located in the south and is better organized. The animals are raised intensively by large, medium and small farms. Large and medium farms supply poultry meat frozen directly or through contractors to institutions such as shopping malls, supermarkets, eateries, hotels, schools etc. Small farmers supply live birds to the local market. Large farms may also have sale outlets for their products. Nevertheless, there is a large dilution of the local supply with frozen chicken and turkey meat smuggled into the country, which is sold in local markets and small scattered retail outlets. Pork is produced almost exclusively in the south because of religious concerns in the North. Pork is sold fresh in local markets and frozen in supermarkets. Poultry to a larger extent is sold by weight more than pork and beef.

## **SELF ASSESSMENT EXERCISE 1.5**

Mention two requirements for a better organization of the meat industry

## **4.0 CONCLUSION**

The knowledge of the existing form and deficiencies in the structure of the meat, egg, and milk industries in Nigeria is important in order to create awareness of the challenges against a proper structure and development of appropriate solutions. This may provide opportunities to take advantage of the very high (or unsatisfied) demand in Nigeria for the products from these industries.

## **5.0 SUMMARY**

In this unit, you learnt about the structures of the meat, egg, and milk industries in Nigeria. You also learnt about the sources of the various inputs of production and short comings of the industries.

## **6.0 TUTOR-MARKED ASSIGNMENT**

1. List 2 each of the most important elements of the meat, egg and milk industry in Nigeria

## **7.0 REFERENCES/FURTHER READINGS**

Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling in the tropics*. Abuja FCT: Living Books Series. GV publications.

Sonaiya E. B. 1984. *Animal Products*. Thelia House, Ile-Ife

## **MODULE 2: MEAT PRODUCTION AND PROCESSING**

Unit 1 Animal Growth and Development

Unit 2 Body Composition

Unit 3 Slaughter and Conversion of Muscle to Meat

Unit 4 Meat Preservation, Processing and Storage

### **UNIT 1 ANIMAL GROWTH AND DEVELOPMENT**

#### **CONTENTS**

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 What is Growth?

3.1.1 Prenatal Growth

3.1.2 Postnatal Growth

3.1.3 Measures of Growth

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

#### **1.0 INTRODUCTION**

In Module 1, we discussed products we get from animals. Obtaining such products as meat, milk and eggs would not have been possible if the animals were not in the proper physiological state. Reaching the proper state is determined by the process of growth. In animal production, growth is perhaps the most significant factor that determines its efficiency. Several mechanisms are involved in growth but not all of these are fully understood. Nevertheless, a good understanding of growth is necessary in order to exploit the benefits of animal production.

#### **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- define growth
- distinguish between growth and development
- describe the characteristics of prenatal growth
- describe the characteristics of postnatal growth
- enumerate the phases of the growth curve



### **3.0 MAIN CONTENT**

#### **3.1 What is Growth and Development?**

There is no single definition for growth. Growth may simply be defined as an increase in size. It could be an increase in weight of an animal or any part of the animal as it approaches mature body size. Growth is an increase in body height, length, girth and weight that occurs when a healthy young animal is given adequate food, water and shelter. It is a fundamental characteristic of all living organisms. Growth can be more specifically defined as a normal process of increase in size, produced by accretion of tissues similar in constitution to that of the original tissue or organ. This increase in size is accomplished by any of these processes:

- Hypertrophy – an enlargement of cells
- Hyperplasia – an increase in the number of cells
- Accretion – an increase in the quantity of non-cellular material

Growth can be considered in two aspects in animal production. Firstly, true growth, which comprises an increase in the structural tissues such as muscle, bone and vital organs. Secondly, fattening, which comprises an increase in deposition of fat or adipose tissue (where fat is stored).

Growth usually involves increase in size and development. Growth, in terms of increase in size, can occur without development but development cannot occur without growth. Development is a gradual progression from a lower to a higher stage of complexity as well as gradual expansion in size. This increase in complexity involves differentiation and specialization for increased functionality.

Differentiation is the process by which cells and organs become unique and acquire completely individual characteristics such as simple cells of the embryo diversifying into muscle cells or brain cells or cells of different organs. Differentiation also involves morphogenesis, which involves the organization of various dividing cells into specific organs. Differentiated cells undergo maturation, which is when they become fully developed. Fully mature tissues have attained their highest stage of complexity. The end of growth and development is senescence, when individual tissues and organs are no longer maintained in their mature form but begin to degenerate without complete replacement or repair (Forrest et al., 1975). The growth of animals commercially exploited in animal production can be divided into two phases, prenatal and postnatal. Animals had started growing before being born, and thereafter continue to grow until slaughter or period where products are harvested.

##### **3.1.1 Prenatal Growth**

Growth in the prenatal period involves many distinct phases that ultimately ends in birth. It begins when a fertilized ovum divides rapidly to form a cluster of undifferentiated cells called morula, which differentiates to form blastocyst. Blastocyst has three layers of cells (called germ cells), which are ectoderm, mesoderm

and endoderm. It is from these germ cell layers that all the parts of the body are formed.

- Ectoderm: skin and hair; neural tube, which forms brain and spinal cord
- Mesoderm: somites, which forms osteoblasts and mesenchyme; osteoblasts form skeleton; mesenchyme forms myoblasts and fibroblasts; myoblasts forms muscles and fibroblasts forms connective tissue.
- Endoderm: digestive tract, liver, pancreas, lungs and bladder

All these tissues and organs are formed before birth.

Birth weight may be an indicator of how well the prenatal growth period has been. Birth weight could be affected by sex, maternal age and nutrition, breed and gestation length. The longer the gestation length, the greater the birth weight; males are carried longer than females and therefore, generally have higher birth weights. Severely restricted maternal nutrition affects the weight and vigour of the new born; and the older the mother the greater the birth weight. Early maturing breeds have a lighter or lower birth weight than late maturing breeds.

### 3.1.2 Postnatal Growth

Immediately after birth is a period of slow growth followed by a rapid increase to mature body size after which the growth rate slows down. The postnatal growth of all animals follows a sigmoid curve pattern when weight is plotted on a graph against time. This curve can be divided into three growth phases as, lag phase, log phase, diminishing growth phase and stationary phase (Figure 1).

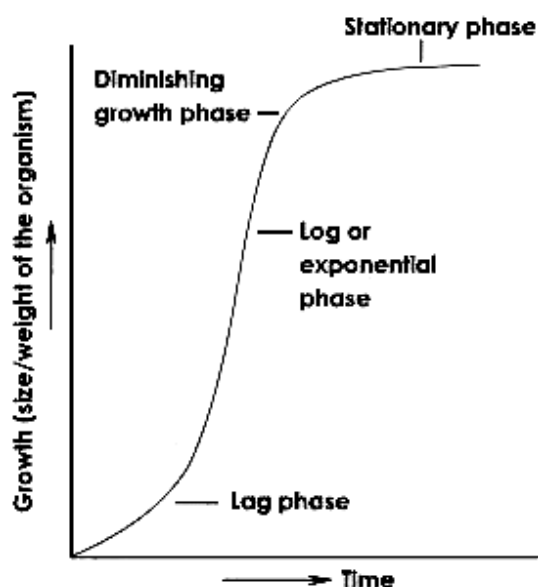


Figure 1. Growth curve

During the lag phase (period immediately after birth), the rate of growth is very slow. Rate of growth of muscles, bones and vital organs, then increases rapidly during the exponential phase. After some time the growth rate of these tissues slowly diminishes due to less efficient nutrient utilization; and fattening begins to accelerate. As the animal reaches mature size, growth begins to retard. This phase constitutes the stationary phase.

After birth, the structure and shape of animal changes as size increases due to different growth rates among various tissues of the body, bone, muscles and fat. Each of these tissues reaches a peak production rate at different stages of the animal's life. The nervous tissue is well developed before the animal is born so as to initiate processes necessary to support life. The first peak of growth occurs with the bone tissue, followed by the muscular tissue required to cover and attach to the bone. Afterwards, fat tissue predominates. For example, the proportion of fat in the body of the immature animal is less than that in the mature animal, as well as, proportion of skin and hide.

Postnatal growth may be affected by many factors, which can be categorized as endogenous (within) and exogenous (outside) factors.

- Endogenous: genetics or breed; sex; and hormones
- Exogenous: level of nutrition; health; and environment

For example, cattle raised for meat (beef cattle) have a higher muscle to bone ratio than cattle raised for milk (dairy cattle); and some animal breeds reach maturity earlier (early maturing) than others (late maturing). Sex influences carcass composition because males grow bigger and use feed more efficiently than female or castrates (animals that sex organs have been removed, either male or female). In addition, the lack of adequate somatotropin (growth hormone, responsible for bone elongation and uptake of nutrients by cells) results in a severe restriction in growth. Hormones are under genetic control.

Animals given a low level or low plane of nutrition at the exponential phase and switched to a higher plane at latter growth stages, have higher proportions of fat at maturity than those with a higher plane at the exponential phase switched to a lower plane subsequently. Various diseases affect the physiological state of animals and unhealthy animals will not grow well. The commonest indication of a disease state is anorexia (loss of appetite). Animals perform satisfactorily within an ideal temperature range of 15°C – 25°C. A lower temperature (outside the ideal) does not affect an animal or its growth as much as a higher temperature because a very high temperature discourages the animal from eating.

Growth is usually measured as a change in weight (gain or loss) over time. The time period could be in days, weeks, months and years. When gain is measured per day, it is referred to as average daily gain, which is the rate of weight increase each day of the time period.

$$\text{Growth rate} = \text{Final weight} - \text{Initial weight} / \text{Time period}$$

Growth can also be measured by using graphs by plotting weight against time.

Finally, growth can be measured by the use of growth equations (models). These equations describe/predict the relationship between weight and time and are usually complex to resolve. Some popular models are Gompertz model, Robertson model, von Bertalanffy model and Taylor model.

### **SELF ASSESSMENT EXERCISE 2.1**

What are the differences between growth and development?

### **4.0 CONCLUSION**

A good knowledge of growth and development and various factors affecting different stages in the life-cycle of production animals helps in the development of proper strategies for satisfactory and efficient production.

### **5.0 SUMMARY**

In this unit you learnt:

- the proper definition of growth and how it differs from development
- what constitutes development and its complexity
- the characteristics of prenatal growth and factors influencing it
- the characteristics of postnatal growth and factors influencing it
- the phases of the growth curve and how to measure growth

### **6.0 TUTOR-MARKED ASSIGNMENT**

1. Write an outline of factors affecting the prenatal and postnatal growth periods

### **7.0 REFERENCES/FURTHER READINGS**

Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling in the tropics*. Abuja FCT: Living Books Series. GV publications.

Forrest J.C., Aberle E. D., Gerrard D. E., Mills W. E., Hedrick H. B., Judge M. D., Merke R. A. (2001). *The Principles of Meat Science*. (4 ed.) U.S.A.: Kendall/Hunt Publishing Company.

Ikeme A. I. (1990). *Meat Science and Technology: A Comprehensive Approach*. African-Fep. Publishers Limited.

Sonaiya E. B. (1982). *Animal Products*. Ile-ife: Thelia Publishers

Swatland, H. J. (1995). *On-line evaluation of meat*. USA: Technomic Publishing Company, Inc.

## **UNIT 2 BODY COMPOSITION**

### **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Evaluation of Animal Body Composition
    - 3.1.1 Judging
    - 3.1.2 Grading
    - 3.1.3 Alternative Measures of Body Composition
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings

### **1.0 INTRODUCTION**

In the previous unit on growth and development, you learnt what growth is and various tissues that increase in quantity and size as the animal moves towards maturity or slaughter. Knowledge of how different quantity of these tissues in body of the animal impacts upon the value of the final product is important for those engaged in the production and sale of animals and their products. These are the issues we will examine in this unit.

### **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- explain the principles of evaluation of body composition
- distinguish between judging and grading
- classify carcass evaluation methods
- enumerate different measures for live, carcass, or live and carcass animal body evaluation methods

### **3.0 MAIN CONTENT**

### **3.1 Evaluation of Animal Body Composition**

The animal body is composed of mainly muscle, fat, bone and water, which could be chemically summarized to protein, fat, minerals (ash) and water, respectively. However, the most important tissues of interest in animal production are muscle and fat and bone to a lesser extent. Water is a variable component and it bears an inverse relationship to fat in the body or carcass of animals. The higher the water content the lower the fat and vice versa. Meat is pure muscle tissue with some connective tissue and inter- and intra- muscular fat, which determines the quality of meat. It is the estimation (visually, physically or chemically) of the proportions of muscle to fat or vice versa that comprises evaluation of animal body composition. This can be performed on the live animal as well as the carcass after slaughter. Evaluation of the live animal is called judging and of the carcass (dead body of animal), grading.

There are three basic reasons for evaluating body composition:

- To establish a herd of animals
- To aid in trading/selling animals
- To be able to determine the value of animals for breeding, processing and marketing of products.

#### **3.1.1 Judging**

Judging is evaluation of the live animal based on selection or estimation of the type of carcass that will be produced when slaughtered or the merit/suitability of a particular animal for a specific purpose. This requires experience and skills in the knowledge of the various parts of the animal and parts of major importance. Judging involves three aspects:

- Observation from a distance
- Close observation and inspection, which will involve touching and handling
- Movement of the animals in order to watch them in action

These actions are performed in order to be able to make a quantity or quality assessment. Quantity assessment is concerned with estimating the relative quantities of tissue (muscle, fat and bone), while quality assessment involves estimation of the quality of meat or muscle from an animal. For example, judges may determine the quantity of muscling by considering the thickness of the fore- and hind-legs, which are parts of the animal with the least fat deposition. More so, fatness is best assessed where most fat is deposited such as the back, hips and ribs.

Quality assessment is based on estimation of the maturity of the animal. The more mature the animal, the lower the quality of meat from it. For example, in cattle, sheep and goats, the wider the muzzle (the mouth of the animal when closed), the more mature the animal. This is because the width of the muzzle depends on the size and number of teeth in the mouth, which increases with age. Also, the bigger the horns,

the more mature the animal and the lower the quality of meat that will be obtained when slaughtered.

### **3.1.2 Grading**

Grading is evaluation or assessment of the carcass, meat, or meat products for an expected quantity or yield of muscle, fat and bone and quality or palatability of meat from it. A correct assessment helps in determining the value or suitability for processing into different products. For example, some meat products require lean meat without adhering fat or connective tissue, while others have a higher fat and/or connective tissue components. Therefore, grading allocates products into groups, which are rated high or low depending on the processing and the form of the finished product required.

Grading is very important in meat markets where the consumers are discriminating or demand a range of qualities for the same product. For example, the United States Department of Agriculture (USDA) has a range of grades for assessing the palatability and yield of carcasses or meat products such as USDA Prime, USDA Choice, USDA Good, USDA Yield Grade 1 etc. In Nigeria, such grades are not established or common and most people evaluate products subconsciously.

Quality grades are based on expected palatability, which depends on degree of maturity of the carcass. Maturity is most related to meat tenderness, and generally meat from a physiologically mature animal is less tender than meat from an immature animal. Useful indicators of maturity are:

- Bone and cartilage: the less the cartilage the more the maturity because cartilage is more abundant in the young animal
- Colour of meat: the darker the meat the more the maturity because the concentration of myoglobin (muscle pigment that carries or stores oxygen) increases with maturity
- Texture of meat: the tougher the meat the more the maturity because the size of the muscle fibre bundles increases with maturity and therefore less tender

Another indicator of quality other than maturity is marbling. Marbling is visible intramuscular fat between muscle bundles appearing as white streaks on the surface of the cut muscle. Marbling is considered to contribute to tenderness and juiciness of meat. Therefore, as marbling increases the higher the quality of meat. However, excessive marbling downgrades the quality, as well as, little or no marbling.

Colour and structure of meat may also affect quality grading. As mentioned earlier, dark colour supposes low quality but if the meat is firm (hard), and dry, then it is regarded as low in quality. Conversely, if the meat is pale, soft, and exudative, it is also regarded as low in quality. These conditions may result from improperly slaughtered animals or careless handling of the carcass post-slaughter as you will learn in later sections.

In poultry, carcass with protruding pin feathers, tears, exposed flesh, missing skin, broken or disjunct bones, skin discolorations, bruises, and defects from freezer storage downgrades the carcass (Forrest et al., 1975).

### 3.1.3 Alternative Measures of Body Composition

Other measures to determine body composition apart from the above involve physical and chemical procedures. These can be divided into three categories:

- Carcass measures
- Live animal and carcass measures
- Live animal measures

Carcass measures are performed on the body of the animal after slaughtering. One carcass measure involves the anatomical dissection of the whole animal into muscle, fat, and bone. Another is whole body analysis, where the whole body is ground and the protein (muscle) and fat components are determined by chemical analysis. These measures are laborious. A simpler measure involves cutting out and chemically analyzing the muscle attached to the backbone (vertebrae) of the 10<sup>th</sup>, 11<sup>th</sup>, or 12<sup>th</sup> rib (depending on the animal species – cattle, sheep or goat). The protein and fat components at these locations give estimates proportional to whole body analysis.

Live animal and carcass measures involve the use of ultrasound imaging device or X-ray to determine muscle, fat, and bone. X-ray images the bone and ultrasound is used to determine quantities of muscle and fat. Another measure is the determination of the specific gravity or relative density of the animal by a ratio of its weight in air to weight in water. The fatter the animal or carcass the lower the specific gravity compared with a leaner animal or carcass.

Different methods are employed for live animal measures. Some of these are:

- Morphometric measurements: Body length, body circumference, height etc., can be used in relevant equations or models to obtain estimates of body components
- Fat depth: The thickness of the back fat can be measured by inserting a ruler into an incision (cut) made down to the muscle on the back of the animal. Incisions may be made at three points on the back (shoulder, middle, and rump) for higher accuracy. Back fat thickness can be used comparatively between animals to determine the fatter.
- Biopsy: Involves the removal of a very small amount of tissue from the body of the animal with a specific tool. This can then be chemically analyzed to determine fat and protein composition to be used in an equation for the proportions of fat and muscle.
- Dilution technique: Involves the use of radioactive elements (naturally occurring in or injected into the body) to indirectly determine components of



fat and muscle or protein. The measurement of these elements in the body allows the indirect determination of fat and muscle. For example, potassium 40 ( $^{40}\text{K}$ ) is a naturally occurring radioactive element in the muscle and the quantity of  $^{40}\text{K}$  is directly proportional to the amount of muscle in the body.

## **SELF ASSESSMENT EXERCISE 2.2**

List the three categories of the physio-chemical body evaluation methods

## **4.0 CONCLUSION**

It is very important to know how the various tissues of the body of the animal affect the quality of meat obtained from it. Knowledge of various methods to assess the value of the body of an animal whether living or dead will be very important in production and commercial transactions.

## **5.0 SUMMARY**

In this unit you learnt:

- the principles of evaluation of body composition
- how to distinguish between judging and grading in evaluation of animal's body composition
- about different ways to evaluate the tissue composition of the animal's body whether living or dead

## **6.0 TUTOR-MARKED ASSIGNMENT**

1. What body composition evaluation methods can be used on live animals; on carcass; and on live animal and carcass.

## **7.0 REFERENCES/FURTHER READINGS**

Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling in the tropics*. Abuja FCT: Living Books Series. GV publications.

Forrest J.C., Aberle E. D., Gerrard D. E., Mills W. E., Hedrick H. B., Judge M. D., Merke R. A. (2001). *The Principles of Meat Science*. (4 ed.) U.S.A.: Kendall/Hunt Publishing Company.

Heinz G. and Hautzinger, P. (2007). *Meat Processing Technology: For Small- to Medium-Scale Producers*. Bangkok: FAO Publication

Ikeme A. I. (1990). *Meat Science and Technology: A Comprehensive Approach*. African-Fep. Publishers Limited.

Sonaiya E. B. (1982). *Animal Products*. Ile-ife: Thelia Publishers

Swatland, H. J. (1995). *On-line evaluation of meat*. USA: Technomic Publishing Company, Inc.

## **UNIT 3 SLAUGHTER AND CONVERSION OF MUSCLE TO MEAT**

### **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Muscle
    - 3.1.1 Contraction and Relaxation
  - 3.2 Conversion of Muscle to Meat
  - 3.3 Properties of Fresh Meat
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings

### **1.0 INTRODUCTION**

Muscle has been used previously to loosely refer to meat. However, in strict terms, muscle in the living animal is not the same as meat and meat can only be obtained from animals after they are dead. Different physical and chemical changes occur in the body of the animal after it is killed or slaughtered. These changes affect the quality of the final product positively or negatively. It is important to understand how these changes occur in order to be able to minimize undesirable outcomes. This unit will bring to your attention procedures and processes accompanying the slaughtering of animals and transformation of muscle to meat.

### **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

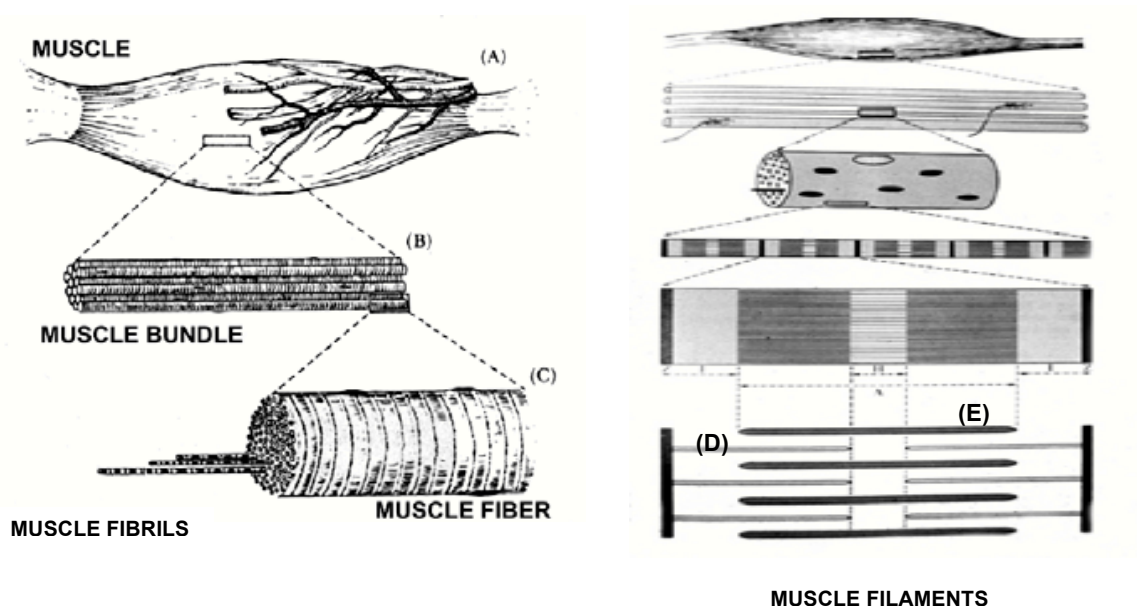
- state the types of muscle in the animal body
- describe the gross to the micro-structure of muscle
- explain muscle contraction and relaxation
- enumerate the process of conversion of muscle to meat
- state the properties of fresh meat

### **3.0 MAIN CONTENT**

### 3.1 Muscle

Meat is pure muscle tissue with some connective tissue, inter- and intra- muscular fat, and to a lesser extent epithelial and nervous tissue. There are three types of muscle:

- Skeletal muscle, which are attached directly or indirectly to bones through tendon or ligaments. This is the main muscle in the body, making up about 35 – 65% of the entire carcass. It is under voluntary control
- Cardiac muscle is found only in the heart. Both skeletal and cardiac muscles are striated (appear to have alternating dark and light bands along its length – see Figure 2)
- Smooth muscle is not striated and found in blood vessels, intestine, and reproductive tract. Both cardiac and smooth muscles are controlled involuntarily



**Figure 2. Gross and anatomical structure of skeletal muscle**

Source: Adapted from Forrest et al. (1975). D = Actin; E = Myosin

Figure 2 above shows a simplified gross and anatomical structure of skeletal muscle. It is important to be familiar with the structure of the muscle in order to properly understand the changes that occur when it is converted to meat. A whole or intact muscle is made up of a group of muscle bundles, the muscle bundles are made up of many muscle fibers (or myofiber; ‘myo’ means muscle), and each muscle fiber is made up of muscle fibrils (myofibrils). The myofibrils are made up of muscle filaments (myofilaments), which are arranged in repeating sections throughout the

length of the myofibrils (see Figure 2). It is this repeated pattern that gives skeletal and cardiac muscles their striated appearance referred to earlier.

The myofilaments are the smallest structural unit of the muscle where contraction and relaxation of the muscle occurs. It is also the point where important transformations occur in the conversion of muscle to meat. There are two myofilaments and each is made up of two different proteins, which are actin and myosin. Actin is also referred to as thin filament (D in Figure 2) and myosin, thick filament (E in Figure 2). The space that both actin and myosin occupy is called a sarcomere, and the two dark structures forming the boundary of the space or sarcomere are called Z-lines (Figure 2). There are many other proteins that contribute to the integrity of the myofilaments, but the most important are troponin and tropomyosin, which function as regulatory proteins in contraction and relaxation. Actin and myosin have a strong affinity for each other but are prevented from binding by troponin and tropomyosin working together. Tropomyosin forms a physical barrier between actin and myosin and troponin helps it to maintain this position. This is the state of the filaments when muscle is in a relaxed state. Other important metabolites to contraction and relaxation are adenosine triphosphate (ATP), and creatine phosphate (or phosphocreatine).

### **3.1.1 Contraction and Relaxation**

Nervous signals, called action potentials are sent from the brain to start contraction of muscles. The signal causes calcium to be released into the sarcomere, which binds to troponin and this change results in a loss of control over tropomyosin. Therefore, tropomyosin is moved away from its position between actin and myosin and they bind. The effective formation of the bond is also enhanced by ATP. Myosin is bound to ATP before calcium is released but removed from it in the presence of calcium and broken down into adenosine diphosphate (ADP) and inorganic phosphate (Pi). The removal of ATP results in a change in the shape of myosin to move it closer to actin.

This bond is an active one where myosin pulls actin filaments (on either side) towards the centre of the sarcomere thereby shortening the space. This activity occurs throughout the lengths of the myofibrils, which make up the myofibers, which make up muscle bundles, which make up the whole muscle. Therefore, the whole muscle shortens or contracts.

Contraction is relaxed when action potentials are sent for the removal of calcium and therefore, troponin returns to its original form and brings back tropomyosin between actin and myosin. In addition, the removal of the calcium results in new ATP being formed from ADP and Pi, and this binds again to myosin thereby moving it away from actin breaking the bond. Therefore, the sarcomere returns to its original size and the whole muscle relaxes.

Creatine phosphate acts as a ready source of Pi for ADP to be converted to ATP, when normal ATP sources are exhausted when the muscle is under stressful conditions such as occur after the animal is slaughtered.

### 3.2 Conversion of Muscle to Meat

The conversion of muscle to meat refers to the physical and chemical changes that occur to the muscle after slaughtering the animal. Such post-mortem changes may result in a wide variation in the quality of meat. Primary aspects of post-mortem changes of immediate concern to the producer are:

- Production of meat of good keeping quality, which maintains an attractive appearance.
- Realization of a limited degree of degeneration, which improves texture of the meat.

Conversion of muscle to meat starts mainly with slaughtering, which involves exsanguination or the removal of blood. However, only about 50% of the blood in the animal's body can be removed. The following are the changes that have important bearing on production of good quality meat with limited degeneration:

- Loss of blood, which carries oxygen to the tissues results in a shortage of oxygen and there is a shift from aerobic to anaerobic metabolism, which leads to a decrease in ATP or energy production. Reduction in ATP production affects proper contraction and relaxation of the muscle. This may result in very tough meat if not properly handled.
- Circulatory system collapses and metabolic wastes and waste products accumulate within the muscle cells. This is because the circulatory system was responsible for transport of nutrients and wastes. Therefore, most of the blood must be removed as much as possible in order to have good quality meat.
- Shift from aerobic to anaerobic metabolism leads to the production of lactic acid because glycogen (carbohydrate) stored in the muscle is converted to lactic acid in the absence of oxygen. Most of the glycogen would have been broken down in the first 12 hours after slaughter. Therefore, muscle pH drops and normal pH of muscle at slaughter is 7 but the ultimate or final pH of normal meat after 24 hours of slaughter will drop to pH 5.4-5.8. The extent of the drop depends on the amount of glycogen before slaughter and this will have significant effect on the quality of meat. If the pH drops rapidly to about 5.0 one hour post-slaughter, the meat will be pale in colour, soft, and with very wet surface (exudative). This is called PSE meat for pale, soft, and exudative because the meat has very poor water holding capacity as most of the proteins that bind to water would have been digested or denatured. This condition usually happens in pigs susceptible to stress. The opposite occurs with animals

that have not been fed for a very long time before slaughter, or have had stressful transport/handling. In this case, most of the muscle glycogen would have been broken down before slaughter and the pH cannot drop to less than 6.0 24 hours post-slaughter. This produces a dark, firm, and dry meat (DFD). In this case, most muscle proteins still remain intact (since there is very little acid to digest or denature them) and remain bound to water. The typical taste and flavour of meat is only achieved after sufficient pH drop. The pH is also important to storage of meat as the lower the pH the lower the conditions favourable for growth of harmful bacteria.

- Reduction in heat production and dissipation occurs because of the collapse of the circulatory system responsible for temperature control in the muscle. Heat from within the body can no longer be carried to the lungs or other surface areas for dissipation. Therefore, denaturation of protein increases rapidly and this can reduce the quality of meat except the temperature can be reduced by for example, processing the carcass in a cooled room. Heat dissipation is also reduced in carcasses that are scalded (hot water or fire applied to remove or burn off the hair), which negatively affects the quality of meat.
- Rigor mortis is a condition where the muscle becomes very stiff soon after slaughter because actin and myosin filaments remain permanently bound or contracted because of insufficient ATP to relax the muscle (see section on contraction and relaxation above). This normally occurs in the muscle post-slaughter but is resolved or removed (gets softer) with time due to enzymatic action by cathepsin enzymes. However, if the muscle is cooled rapidly in the rigor state, the bond between actin and myosin will not be broken and the resulting meat will be very tough. Rigor is resolved faster in fish than other meat types.
- Loss of protection from bacterial infection occur post-slaughter because the mechanisms for protection in the living animal are compromised. Such mechanisms are connective tissues, lymphatic system, and circulating white blood cells. Therefore, extra care must be exercised to prevent the contamination of meat from spoilage microorganisms during post-slaughter handling and storage.

### **SELF ASSESSMENT EXERCISE 2.3**

Mention the two aspects of primary concern to the meat producer on post-mortem changes

### 3.3 Properties of Fresh Meat

In the previous sections, you learnt the structure of animal muscle and its importance in determining the quality of meat after undergoing various chemical and physical changes after slaughter. Fresh meat is converted muscle that has not undergone processing such as cooking, freezing, smoking etc. The properties that fresh meat possesses will affect its usefulness for processing into products; determine the kind of products that can be obtained from it, sale, and acceptability to consumers. The most important properties are those of water holding capacity, colour, tenderness and flavour.

Water holding capacity (WHC) and some of its effects on the quality of meat was mentioned in the previous section. It can be defined as the ability of meat to retain water during the application of external forces such as cutting, heating, grinding or freezing. As mentioned earlier, muscle proteins are capable of holding many water molecules to their surface because protein molecules are charged or polar due to the ionized amino and carboxylic functional groups, which bind to polar hydrogen and oxygen groups. Water bound to the muscle protein affects the eating and processing quality of meat because it contributes to juiciness and firmness for cutting. A low WHC could lead to significant shrinkage (reduction in size) in meat during storage and processing, even cooking. Therefore, for good processing and eating qualities, the WHC needs to be high. However, in some products such as uncooked and/or dried products, which need to lose water during processing, WHC does not need to be high. It could also affect the colour of meat as found in pale, soft, exudative meat and dark, firm and dry meat due to absorption (in DFD) and reflection of light (in PSE). Water holding capacity varies greatly among the muscles of the body and among animal species. Beef has the greatest capacity to retain water, followed by pork, and poultry the least.

The typical red colour of meat is determined by myoglobin (oxygen store in muscles), which is a red pigment that is similar to haemoglobin in blood. Animals that have been well bled have most of their colour due to myoglobin other than haemoglobin. The difference in myoglobin concentration is why some muscles are darker than others in the same carcass. For example, breast muscles are lighter in colour than thigh muscles in chicken. In addition, myoglobin concentration in meat differs among animal species. For example, beef is darker than pork, mutton, poultry and fish. Myoglobin also increases in the muscle with maturity; therefore, meat from older animals is darker than from the younger. Interaction of myoglobin with oxygen determines the colour of fresh meat. The most acceptable meat colour to consumers is a bright red colour of meat, which results from abundant supply of oxygen. If the

oxygen supply is short, the meat colour will be an unacceptable brown colour. In intact muscles (muscles that have not been cut) the colour is purple because myoglobin is bound to water.

Tenderness is important when entire (large) pieces of meat are cooked, fried or barbecued. Tenderness is the same as toughness but becomes less significant when meat is cut into pieces (comminuted). Tough meat could also result from unresolved rigor mortis and DFD. Toughness also increases with maturity and older animals have tougher meat than younger animals.

The taste or flavour of meat is different for different animal species. For example, pig (pork), sheep meat (mutton/lamb), or some fish species have stronger flavours than beef. Some of the flavours are due to imprints from inter- and intramuscular fat on the muscle. Feed may also influence the taste of meat such as the 'fishy' flavour that is imparted on the meat of animals fed fishmeal till slaughter. Moreover, sex may affect the taste of meat such as the strong urine smell present in meat from old male pigs (boars - boar odour). The typical taste of meat is due mostly to lactic acid, and organic acids such as amino acids, di- and tri-peptides from meat proteins.

Regardless of how different the meat obtained is different from the properties of normal fresh meat, the most important thing is to remove such limitations as much as possible in order to present a more desirable product appropriate to achieve processing objectives.

#### **SELF ASSESSMENT EXERCISE 2.4**

List all the desirable properties of fresh meat you know.

#### **4.0 CONCLUSION**

Meat quality depends on many important factors of which post-slaughter factors are most significant. Application of measures that alleviate undesirable effects will go a long way in the provision of good quality meat and ensuring that premium value is obtained for meat products.

#### **5.0 SUMMARY**

In this unit, you learnt what the functional structure of muscle is, and how it is involved in the process of contraction and relaxation. You also learnt how muscle is converted to meat, which begins after slaughter and the properties of good quality fresh meat desired by consumers. The next unit will teach you different processing, preservation and storage methods for meat.



## **6.0 TUTOR-MARKED ASSIGNMENT**

1. Show in a diagram the structural components of a whole muscle
2. Write three changes that occur to muscle after slaughter and three essential attributes of fresh meat

## **7.0 REFERENCES/FURTHER READINGS**

Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling in the tropics*. Abuja FCT: Living Books Series. GV publications.

Forrest J.C., Aberle E. D., Gerrard D. E., Mills W. E., Hedrick H. B., Judge M. D., Merke R. A. (2001). *The Principles of Meat Science*. (4 ed.) U.S.A.: Kendall/Hunt Publishing Company.

Heinz G. and Hautzinger, P. (2007). *Meat Processing Technology: For Small- to Medium-Scale Producers*. Bangkok: FAO Publication

Ikeme A. I. (1990). *Meat Science and Technology: A Comprehensive Approach*. African-Fep. Publishers Limited.

Sonaiya E. B. (1982). *Animal Products*. Ile-ife: Thelia Publishers

Swatland, H. J. (1995). *On-line evaluation of meat*. USA: Technomic Publishing Company, Inc.

## **UNIT 4 MEAT PROCESSING, PRESERVATION AND STORAGE**

### **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Why Preserve or Process Meat?
  - 3.2 Meat Processing and Storage
    - 3.2.1 Curing
    - 3.2.2 Heat Treatment or Cooking
    - 3.2.3 Drying
    - 3.2.4 Smoking
    - 3.2.5 Cooling or Refrigeration
    - 3.2.6 Freezing
    - 3.2.7 Packaging
- 4.0 Conclusion
- 5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

## **1.0 INTRODUCTION**

In the previous unit we examined the principles involved in obtaining and properties of good quality fresh meat. Consumption of fresh foods is usually preferred to processed and/or preserved food because of a possible decrease in nutritional value. However, most animal products have to be processed and/or preserved by one means or the other before they are consumed so that they can be eatable or palatable and safe. Another reason for processing and/or preservation is to make long storage possible or storage of excess food. It is difficult to effectively separate processing from preservation and even storage, because processing usually leads to preservation, and storage is a form of preservation.

This unit will explain different meat processing and preservation/storage methods such as salting, curing, cooking, cooling, freezing, packaging, etc. Knowledge of these methods is important in order to be able to use meat more efficiently.

## **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- write the objectives of meat processing and preservation
- state the factors responsible for spoilage in meat
- enumerate different methods for processing, preserving or storing meat

## **3.0 MAIN CONTENT**

### **3.1 Why Preserve or Process Meat?**

The main reason for preserving meat is to prevent spoilage. Traditional meat processing involved sun drying, then drying over burning wood fire, and salt was added later in order to preserve meat for future use. Advances in preservation technology especially refrigeration and packaging provided opportunities for many new processed products. The reasons for processing in modern meat products are:

- Development of unique flavours and forms of products
- Provision of a variety of products
- Development of new products
- Preservation

As we have learnt spoilage of meat or flesh from animals starts soon after they are killed. Fish will spoil quicker than meat from terrestrial animals, and organ meats

(such as liver) spoil quicker than these. Spoilage is the deterioration of food, which makes it taste bad and/or makes it a carrier of disease organisms. Typical spoilage in flesh can be caused by the following:

- Microbiological due to bacteria on the surface of flesh or from within the body or intestines. It can also be from external contamination due to unhygienic post-slaughter handling
- Autolytic due to internal enzymes, which break down different compounds that affects smell, taste and texture. For example cathepsins breaks down rigor in flesh
- Rancidity due to oxidation of the fat in fatty fish and meat exposed to air for a long time. This causes an unpleasant smell or taste

Application of proper processing techniques such as heating and fermentation can remove these negative effects.

## **SELF ASSESSMENT EXERCISE 2.5**

List three causes of spoilage in animal flesh

### **3.2 Meat Processing and Storage**

All processed meat products can be grouped into comminuted and non-comminuted products. Comminution involves sub-dividing or cutting raw meat so that the product will consist of small meat pieces, chunks or slices. Such products include sausages, hamburger, ground or minced meat, corned beef etc. Comminution is important because it results in improved uniformity of products due to a more uniform particle size and distribution of ingredients. In addition, it leads to increase in tenderness as the meat is sub-divided into smaller particles.

Non-comminuted products are prepared from whole or intact cuts of meat with or without bone. All processing techniques can be applied to both comminuted and non-comminuted products. Such processing techniques include curing, cooking, drying, smoking, fermentation etc.

#### **3.2.1 Curing**

Curing is the application of salt, colour fixing ingredients, and seasonings to meat in order to impart unique properties to the end products. The traditional objective of curing was to preserve the meat with a very high concentration of salt but high salt concentration oxidizes myoglobin giving meat an unattractive greyish or greyish brown colour. Therefore, colour-fixing ingredients were applied to give a bright reddish-pink colour such as sodium nitrite and potassium or sodium nitrate.

Sodium nitrite reacts with myoglobin to form a heat stable red colour and a small amount of nitrite is needed for this purpose. The level of nitrite is about 150 mg/kg in meat products. To reduce the risk of overdosing nitrite, it is made available in a homogenous mixture with common salt in the proportion 0.5% nitrite plus 99.5% sodium chloride. The mixture is called nitrite curing salt, and it is applied to meat products at a dosage level of 1.5 – 3% to achieve a salty flavour and the reddish colour. High concentrations of nitrite is toxic and could be carcinogenic (cause cancer) if used in meat products that are heated to a very high temperature. Nitrite is preferred to nitrate because of the longer time it takes before the red colour is produced. Some seasonings used in curing include spices, herbs, vegetables and sweeteners.

Incorporation of cure ingredients must be uniform throughout the entire product. Cure ingredients are incorporated according to the following methods:

- **Dry Cure:** The cure ingredients are rubbed in dry form over the surface of meat cuts and then placed one on top of the other in a curing container or box or tank. The curing mix gradually permeates the meat, which can take very long from several days to several weeks. This method is usually used for meat products that are also fermented called cured raw fermented products.
- **Wet Cure or Pickling:** The meat cuts are immersed in a cure solution, which completely covers all the pieces. A room temperature of 8 to 10°C is recommended and curing takes several days to two weeks for equal penetration.
- **Injection Cure:** This is an alternative and quicker way than those above to accelerate the diffusion of the cure solution by pumping it into the meat tissue. Injection of the cure solution can be done manually by using simple pumping devices such as a syringe (small or large) or mechanically by semi-automatic multi-needle injectors, which inject the solution into many parts of the meat at the same time.

## **SELF ASSESSMENT EXERCISE 2.6**

List the different methods of curing meat that you know

### **3.2.2 Heat Treatment or Cooking**

Heat treatment of processed meat products serves two purposes:

- Enhancement of desirable texture, flavour and colour (increase palatability)
- Reduction of microbial content to achieve preservation and food safety

High temperature induces coagulation and denaturation of meat proteins and the structural and chemical changes in fats and carbohydrates, which make meat tastier and tenderer. The numbers of microorganisms increase steadily through slaughtering, then meat cutting and initial processing. Therefore, heat treatment is important for microbial control to reduce or eliminate contaminating microorganisms.

There are two types of heat treatment, which are:

- Pasteurization (or cooking): Heat treatment at temperatures below 100°C, mostly between 60-85°C
- Sterilization: Heat treatment at temperatures above 100°C

There are three principal cooking methods, which are dry-heat, moist-heat, and microwave.

- Dry-heat occurs when meat is surrounded by hot air such as found in boiling (meat placed in oven); Pan frying (meat browned on both sides in the pan); Stir frying (small meat pieces constantly stirred in a large bowl-like frying pan called wok); Deep fat frying (meat completely immersed in fat); Roasting (meat placed on a grill).
- Moist-heat occurs when meat is surrounded by hot liquid such as found in Braising (meat cooked with water and ingredients such as milk or vegetables); Stewing (cooking in liquid with small meat pieces); Simmering (cooking in liquid with large meat pieces under low temperature and a long time).
- Microwave cooking occurs in a microwave machine where electromagnetic waves cause the molecules in meat to vibrate against each other to create friction and heat from within the meat pieces. Cooking here is more rapid than you find in the other two methods and temperature and cooking time can be pre-set.

## **SELF ASSESSMENT EXERCISE 2.7**

Differentiate between pasteurization and sterilization

### **3.2.3 Drying**

Drying is the lowering of water activity in meat and meat products. Water activity is the measure of free unbound water available for microbial growth. The growth of microorganisms is halted when the available free water is lower than that required for the particular species to grow. Meat drying could be done to preserve or extend storage life (shelf life) or could just be part of the steps in the manufacturing of

specific meat products. The manufacture of fermented meat products is an example where drying is an important step in the process. The drying of such products is mostly done in climate controlled chambers where temperature and humidity can be controlled. Drying could also be done in ovens at temperatures between 70-80°C.

However, drying of meat can be done under natural conditions in the air or sun. This is a popular method in many developing countries because of its cheapness and effectiveness. Pieces of meat are cut into specific uniform shapes (long strips and flat pieces) that permit the gradual and equal drying of whole batches of meat. It is predominantly carried out for meat preservation. Meats suitable for sun drying include lean meat (meat with little or no fat) from beef cattle, goat, and camel but not pork (pig meat) or such that have fat.

Continuous evaporation of water from within the meat tissues brought to the surface results in meat pieces becoming smaller, thinner, slightly wrinkled, darker, and harder in texture. However, the protein content remains unchanged.

Meat strips with strings or hooks attached, are usually suspended to dry in the sun on long sticks similar to hanging clothes on wires to dry; and flat pieces of meat are placed in drying trays exposed to the sun. Some of the disadvantages of sun drying are limitation to the dry season, and exposure to contamination from dirt, wind, rain, insects, rodents and birds. Microbial contamination is also possible. An example of sun-dried meat product in Nigeria is *kilishi*. Here, thinly sliced flat meat pieces are semi-dried in the sun and then spiced or dry-cured before finally drying over fire.

However, there is an improvement over this method, which is called solar drying. Solar drying involves the use of a solar dryer, which is an equipment constructed to collect solar energy through the aid of materials that can store it (solar collectors such as a black surface). The heat absorbed by the collector heats the air around it, which is passed or moved into a chamber to dry meat pieces arranged there. This system avoids most of the disadvantages of sun drying.

### **SELF ASSESSMENT EXERCISE 2.8**

State the basic principle behind drying as a preservative method

#### **3.2.4 Smoking**

Smoking is the process of allowing smoke generated from natural woods to act on the surface of meat or meat products. Smoke is produced by thermal decomposition of wood to molecular weight products, a process called pyrolysis. Other reactions take place with decomposition such as condensation, polymerization, and oxidation to produce more than 1000 compounds from smoke. The most important of these products are phenols, aldehydes, organic acids, carbonyls, hydrocarbons, and alcohols.

Freshly produced smoke has the following effects on meat:

- **Preservation:** The preservative effect comes from the drying action of smoke with the destruction and/or inhibition of microbial growth. In addition, anti-oxidants (phenols and aldehydes) from smoke delay rancidity of fat. Most of the smoke components are present or deposited on the meat surface and do not penetrate more than a few millilitres into the meat.
- **Colour Production:** This is caused by aldehydes, phenols and carbonyls, and the development of Maillard reaction products. Maillard reaction is also browning or caramelization.
- **Aromatization:** This is caused by phenols, aldehydes, carbonyls, and volatile organic acids that give the peculiar smell and taste or flavour to smoked meat.

However, smoke has been found to contain polycyclic hydrocarbons (benzopyrene) that have been implicated to be carcinogenic. One way to remove hydrocarbons is the production of liquid smoke. Liquid smoke is obtained from the condensation of wood smoke. This allows for fractional distillation to enable the separation and removal of smoke components such as polycyclic hydrocarbons. The liquid smoke can be painted on the surface of the products or mixed into the ingredients of the products such as in some sausages.

There are two basic smoking techniques, cold smoking and hot smoking. Cold smoking is the traditional way of smoking meat products and was primarily used for meat preservation. The optimal temperature of the smoke in cold smoking is 15-18°C and is long process that may take several days. Hot smoking is carried out at temperatures greater than 60-80°C and this enables a rapid colour and flavour development. Hot smoking ranges from about ten minutes to one hour.

Smoking is usually done in smoke chambers where pieces of meat or meat products are placed for application of smoke generated within (traditional method) or outside (modern method) the chamber. Smoke generators outside the modern smoke chambers generate smoke by burning saw dust slowly by direct fire or by very hot steam or by friction on a log of wood by a fast rotating steel drum. The separate smoke generator allows for the removal of unwanted smoke components such as benzopyrene.

### **SELF ASSESSMENT EXERCISE 2.9**

State the basic effects of smoke on meat

#### **3.2.5 Cooling or Refrigeration**

Refrigeration is a preservative and a storage method for meat and meat products. The most common method for prolonging the shelf life of meat is refrigeration, which

involves storage of meat at temperatures between -2 and 5°C. Refrigeration should begin immediately after slaughtering and continue through subsequent processing to consumption.

The internal temperature of the carcass, which is between 30 – 39°C after slaughter must be reduced rapidly to about 5°C at the thickest portion of meat in order to slow down the degeneration of the meat. Beef, pork, and lamb carcasses are usually cooled or chilled at temperature ranges of between -4 to 0°C, while fish and poultry carcasses are cooled by immersion in ice water. The rate of cooling a carcass depends on the size of the carcass, amount of external or internal fat, and the temperature of the cooling environment. The rate of cooling will be slow if the carcass is large, fat is much, and the temperature of cooling environment is high.

Meat or meat products should only be stored under refrigeration for a sort time because degenerative changes continue to occur and accelerates with time. The major factors that influence the storage life of meat under refrigeration are the initial microbial load, temperature and humidity conditions during storage, the presence or absence of protective covering or packaging, the species of animal, and the type of product stored (raw or processed). The storage life of meat will be shorter if the initial microbial load is high, humidity is low and temperature high, covering is absent, meat is from fish or poultry, and the meat is raw.

Fresh meat purchased for consumption should not be stored under refrigeration for more than four days before consumption unless frozen.

### **3.2.6 Freezing**

Freezing is an excellent method for preserving and storing meat. It results in less undesirable changes in qualitative and sensory (flavour, taste, juiciness and texture) properties of meat. Very low temperature retards microbial growth, enzymatic or chemical changes thereby retaining nutritive value. Freezing also prevents access by microbes to water available for microbial growth. However, freezing can cause damage by discolouration (freezer burn), formation of ice crystals in meat and the precipitation of cell constituents depending on whether freezing is done at a fast rate or at a slow rate. Freezing at a fast rate is more desirable than at a low rate.

There are different methods for freezing meat and meat products, which are:

- Still air: Air is the heat transfer medium and freezing depends on convection with meat freezes very slowly. The home freezer unit and the refrigerator freezer operate on this principle. Temperature ranges from about -10 to -30°C.



- Plate freezer: Metal is the heat transfer medium and freezing depends on conduction, which is slightly faster than still air. Products are placed in direct contact with the freezer metallic plate or shelves. Temperature also ranges from about -10 to -30°C.
- Blast freezer: Air is the medium of heat transfer but the heat is transferred at a higher velocity on account of the fans installed for rapid air movement. Temperature also ranges from about -10 to -40°C and air velocity from 30 to 1070 meters/minute.
- Liquid immersion and liquid sprays: This is used mostly for packaged products especially poultry and fish. Freezing rate is rapid and comparable to blast freezing. The products are wrapped in plastic and immersed in the freezing liquid or the cold liquid is sprayed over them. The liquid must be non-toxic, cheap, have low viscosity, low freezing point and high heat conductivity. Examples are sodium chloride brine (salt solution), glycerol, and glycol.
- Cryogenic freezing: This is the most rapid method of freezing. It involves extremely low temperatures where the freezing agent such as liquid or gaseous nitrogen or liquid, gaseous or solid carbon dioxide is applied. They can be applied as liquid immersion or spray.

Before meat under freezer storage can be used it has to be changed from the frozen state to the former state before freezing. This process is called thawing. The quality of meat after thawing will depend on conditions under frozen storage, thawing method, freezing rate (slow or fast), and condition of meat before freezing. There are five ways of thawing frozen meat products:

- Cold air: meat put into a refrigerator or cooler
- Warm air: meat left under ambient temperature
- Water: meat put in water or under running water
- Cooking: meat cooked directly as soon as taken from freezer
- Microwave: meat thawed according to the microwave thawing option

The cold air option is recommended as the best thawing method if the products are not going to be cooked or microwaved directly from the frozen state.

### **SELF ASSESSMENT EXERCISE 2.10**

List the different methods for freezing and thawing meat and meat products

### 3.2.7 Packaging

Packaging refers to the material that holds or surrounds meat and meat products in order to prevent them from direct handling and enables compactness in usage. Basic functions of packaging are the following:

- Protection of products from undesirable impacts on quality regarding microbiological and physic-chemical damage or alterations. In this perspective, products are protected from secondary contamination during processing, storage, and distribution due to dirt, microorganisms, parasites (e. g. insects), toxic substances, and influences affecting colour and taste and loss or uptake of moisture.
- Presentation of products to consumers in the most attractive manner.

In spite of the fact that packaging can prevent secondary contamination, the further growth of microorganisms, which are already present in meat, cannot be prevented except when combined with other measures such as heating or sterilization, freezing etc. There are many materials suitable for meat packaging but the choice of a specific type will depend on whether the meat product is fresh or processed. For example, the packaging requirements for frozen meat include low moisture vapour transmission (to prevent dehydration), pliability, strength, and grease resistance from fat. Moreover, packaging material used for fresh meat display must allow ample amounts of oxygen to pass through in order for oxymyoglobin to be stable and maintain reddish colour. However, cured meat products need to be protected from light and oxygen so that the colour imparted by cure ingredients will not fade.

Different types of packaging materials available include paper, aluminum foil, glass, films or foils manufactured from polyethylene, polypropylene, polyesters, nylon, polystyrene, and polyvinylchloride (PVC). Combinations of these materials are called laminates, which possess a wide variety of functional properties depending on the components. Some basic attributes required for the films and/or foils are that they must:

- Be flexible
- Have mechanical strength
- Be lightweight
- Be odourless and hygienic
- Easily recycled

- Resistant to hot/cold temperature
- Resistant to oil and fat
- Have good barrier properties against gases
- Be heat sealable
- Have low cost

More advanced forms of packaging include vacuum packaging and modified atmosphere packaging (MAP). Vacuum packaging involves the removal of air so that air is not in contact with the product. This will be suitable for cured products that require very little oxygen. Modified atmosphere packaging involves the removal of air in order to be replaced by carbon dioxide and nitrogen. Nitrogen prevents rancidity and carbon dioxide prevents the growth of bacteria and moulds in processed products. For fresh meat, a combination of oxygen and carbon dioxide is used to replace air. After the removal and replacement of air the packaging material is heat sealed to maintain the new atmosphere.

#### **SELF ASSESSMENT EXERCISE 2.11**

List four attributes required for using film/foils as packaging material

#### **4.0 CONCLUSION**

Meat is one of the most important foods to man and this attribute can only be maintained if its wholesomeness (good quality) can be guaranteed. Continuous development and application of processes that ensure the quality of meat and meat products have significant bearing on use as food.

#### **5.0 SUMMARY**

In this unit, you learnt why meat exists in different forms and products and how to avoid meat spoilage. You also learnt the most common methods used in processing, preserving, and storing meat and meat products. The importance and types of packaging and its dependence on initial processing were explained.

#### **6.0 TUTOR-MARKED ASSIGNMENT**

1. What are the basic functions of packaging and six attributes of a good packaging material?

#### **7.0 REFERENCES/FURTHER READINGS**

Aduku A. O. and Olukosi, J. O. (2000). *Animal Products, Processing & Handling*

*in the tropics*. Abuja FCT: Living Books Series. GV publications.

Forrest J.C., Aberle E. D., Gerrard D. E., Mills W. E., Hedrick H. B., Judge M. D., Merke R. A. (2001). *The Principles of Meat Science*. (4 ed.) U.S.A.: Kendall/Hunt Publishing Company.

Heinz G. and Hautzinger, P. (2007). *Meat Processing Technology: For Small- to Medium-Scale Producers*. Bangkok: FAO Publication

Ikeme A. I. (1990). *Meat Science and Technology: A Comprehensive Approach*. African-Fep. Publishers Limited.

Sonaiya E. B. (1982). *Animal Products*. Ile-ife: Thelia Publishers

Sivasankar B. (2009). *Food Processing and Preservation*. New Delhi: Meenakshi Art Printers

Swatland, H. J. (1995). *On-line evaluation of meat*. USA: Technomic Publishing Company, Inc.

### **MODULE 3 EGG PRODUCTION AND PROCESSING**

Unit 1 Egg Formation and Production

Unit 2 Egg Processing and Storage

# **UNIT 1 EGG FORMATION AND PRODUCTION**

## **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Egg
    - 3.1.1 Egg Formation and Production (process from day-old to first lay)
  - 3.2 Egg Quality
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings

### **1.0 INTRODUCTION**

The egg is one of the major animal products. You would have eaten an egg before, just like many other people but have you ever wondered how it is formed? In addition, what is the nutritional importance of the egg? Is the egg only eaten at home or also useful for industries? These and some other issues concerning the egg are the focus of this unit. It is important to know what the egg is and its importance domestically and industrially.

### **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- describe the components of egg
- explain the process of egg formation from ovulation to lay
- state the internal and external quality attributes for evaluating the egg

### **3.0 MAIN CONTENT**

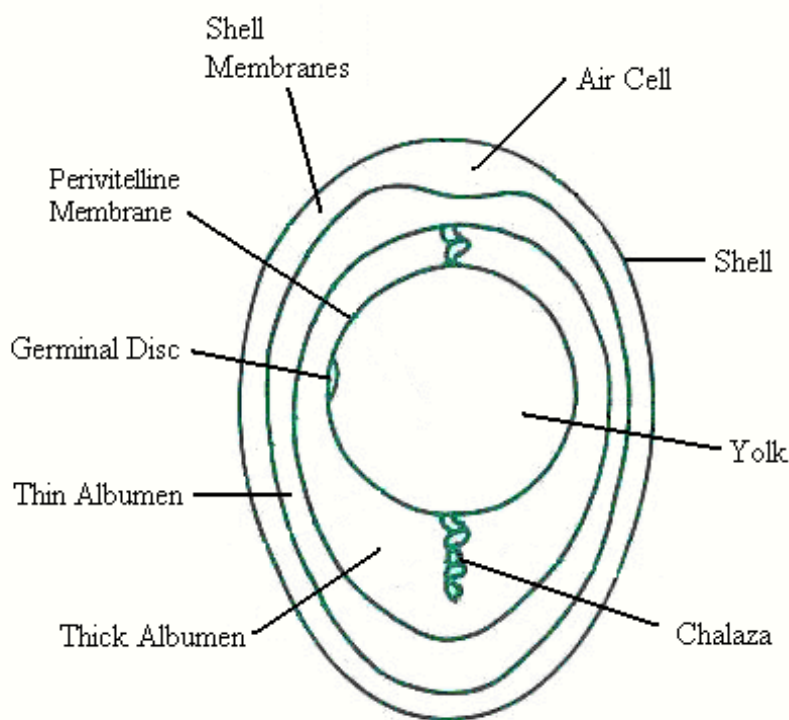
#### **3.1 Egg**

An egg is an oval or round object laid by a female bird, reptile, fish, or invertebrate, usually containing a developing embryo, which it nurtures and sustains. It is a reproductive cell useful in multiplying or increasing the numbers of animal species. Eggs are produced or laid by different species of poultry such as chickens, turkeys, ducks, guinea fowls, quail etc. Chicken eggs are the most commonly consumed eggs and they lay both fertilized and unfertilized eggs. Fertilized eggs develop from the

embryo into the chick, which hatches after twenty one days. Unfertilized eggs are those mostly eaten and are referred to as table eggs because they contain no embryo that will develop into a chick.

In general, eggs are composed of several parts (Figure 3): they have a hard outer shell, which would help protect a growing bird embryo (if the egg is fertilized); and inside the shell are two main components the albumen or “white” of the egg and the yolk. There are also some thick milky white membranous structures on the inside of the shell (shell membranes). An egg consists of the yolk (30 – 33%), albumen (~ 60%), and shell (9 – 12%). Eggs are a source of nutrition for people and have been described as one of the most perfect food sources for man.

In developed countries, table eggs are sorted into different grades of sizes. In general, eggs come in newly laid, small, medium, large, and extra-large but specific grades are used by different countries. However, in most developing countries, no specific grading system is applied to eggs for sale and eggs are sold subjectively.

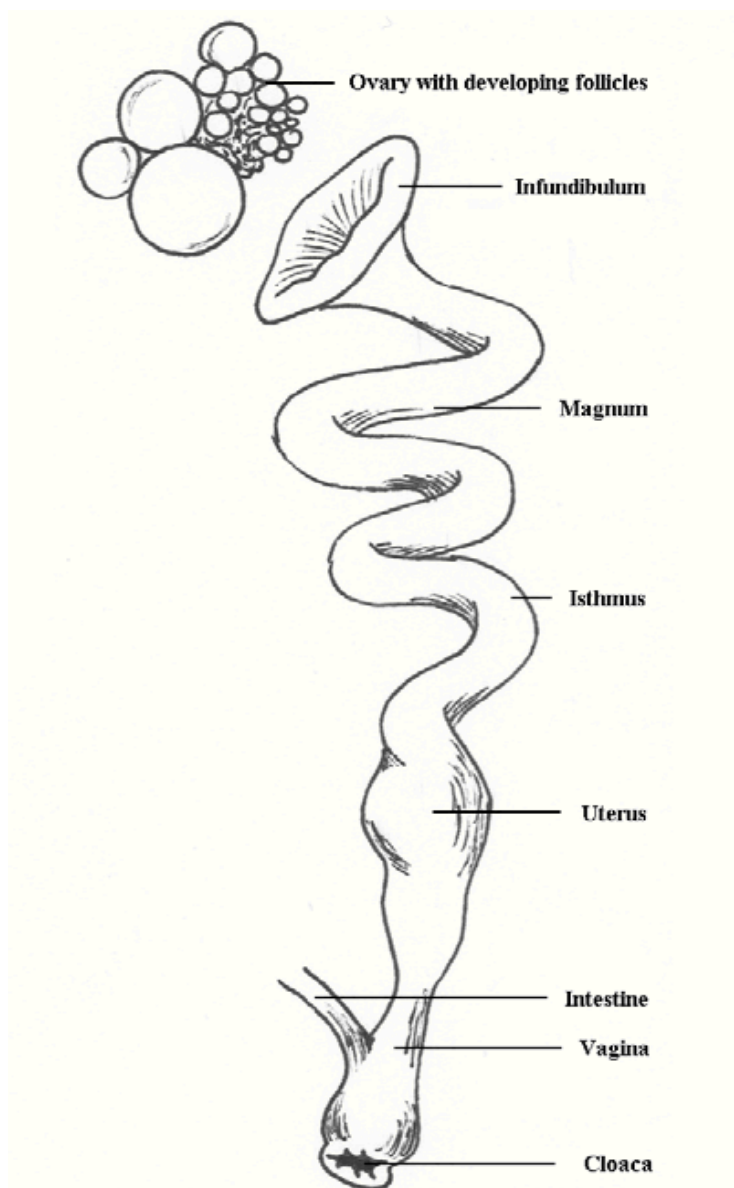


**Figure 3. The structure of an egg** (Source: Oluyemi and Roberts, 1979)

### 3.1.1 Egg Formation and Production

The egg is formed through the hen's (female chicken) reproductive system (Figure 4). The formation of an egg takes just over a day, from ovulation to oviposition. Ovulation is the release of an ovum (yolk or egg not fully formed) from a ruptured follicle (structure in the ovary where ovum develops). The ovum drops into or is captured by the infundibulum. Ovulation generally occurs about a half an hour after the previous egg has been laid. Oviposition is the laying of the egg.

Fertilization occurs in the infundibulum, which stores sperm for seven to fourteen days if the hen was inseminated (introduction of sperm by the male chicken (cock) at mating). Formation occurs as the egg travels down the oviduct (made up of magnum and isthmus) and is encased in the various layers that make up a chicken egg.



**Figure 4. Reproductive system of the chicken hen** (Source: Oluymi and Roberts, 1979)

Although two sets of ovaries and oviducts are present during embryonic development, only the left set fully develop in chickens. The mature ovary will have several follicles in different development stages at any one time (Figure 4). The largest follicle is the one that is ovulated to produce an egg. The ovary will normally produce one mature yolk in about 24 hours. The formation of the chalazae and perivitelline membrane (membrane surrounding the yolk) occurs in the infundibulum of the oviduct. It will take approximately 15 minutes for the yolk to pass through the infundibulum to the magnum.

The albumen is deposited when the yolk is in the magnum. The magnum is the longest part of the oviduct and the yolk will take 2-3 hours to pass through the magnum. The albumen has several functions, which include a nutritional source for a developing embryo, a cushion to protect the yolk against mechanical injury, a bactericide to prevent infection and as a template for the deposition of the shell membranes. Next, the developing egg passes into the isthmus, where the inner and outer shell membranes are formed. This process takes approximately 1½ hours. The egg then enters the shell gland or uterus, where it will spend 18 to 21 hours. During that time, the albumen takes up electrolytes and water through a process called “plumping” (or simply filling up). The shell, which consists of roughly 95% calcium carbonate and 5% organic material, is also formed in the shell gland. The hen’s calcium requirements are highest at this stage of egg formation. Once the shell is completely formed, a protective coating called the cuticle is laid down over the shell. The laying of the egg, or oviposition, is induced by the effect of hormones, which contract the uterus forcing the egg out through the vagina and cloaca with the large end (broad end of the egg) of the egg coming out first before the small end (narrow end of egg). Though the egg travels through the oviduct small end first, it is laid large end first.

### **SELF ASSESSMENT EXERCISE 3.1**

List the parts of the reproductive system of the chicken hen

### **3.3 Egg Production**

Egg is produced commercially by specialized type of chickens called layers. These chickens are produced by male and female chickens called breeders. The fertilized eggs are hatched by machines called incubators that automatically provide the conditions necessary for the eggs to hatch. The chickens are hatched after 21 days and are called pullets.

The pullets are raised in poultry houses for about five months before they start laying their first eggs. As mentioned earlier, it takes about 24 hours to lay an egg. Therefore, ideally all chickens in a flock should lay an egg a day. However, this is not perfectly so because of differences in the time that individual birds started to lay for the first



time, but most lay everyday within a time range. About 70-80% of the birds in a flock lay eggs every day.

The number of eggs laid by chickens reaches a maximum at about three months after the first lay and continues optimally for nine months, although at a decreasing rate. However, birds can still be kept in lay for 12 to 18 or 24 months with a specific management procedure called moulting, where birds are forced lose feathers by dietary manipulations for a period after which they start laying increasingly again but not like before.

### **3.4 Egg Quality**

Egg quality refers to all the attributes of the egg that contributes to its value. This is very important to the producer, the traders and the consumer because consumers will not buy or give low value to poor quality eggs. The importance of egg quality may not be readily obvious in developing countries because of the absence of a grading system for egg quality. For example, the United States Department of Agriculture (USDA) has quality grades that range from AA, A, to B, in a decreasing order of value; and eggs are sold with proper markings or labels indicating these. Nevertheless, even in developing countries, eggs that have misshapen shells, watery or spotted yolk and albumen will be rated low or avoided by consumers.

Numerous methods have been used to study the quality of eggs. These methods involve evaluation of each component that makes up the egg. The most common methods can be divided into external and internal qualities according to the following:

- **External Quality:** refers to a shell's appearance (e.g. shape), cleanliness and strength. Appearance is important because the shell is the first thing you notice about an egg. Cleanliness is important because the shell is the egg's first defense against bacterial contamination; the cleaner the shell, the easier it can do its job. Strength influences the egg's ability to remain intact until it is ready for use. The shell is made up of 94 percent calcium carbonate and accounts for about 12 percent of the weight of a large egg. The shell quality is measured as breaking or crushing strength, amount of shell as a percentage of egg weight, and shell thickness (measured with a micrometer gauge). Shell thickness is adjudged as the simplest, rapid and adequate measure of shell strength.
- **Internal Quality:** refers to the appearance and consistency of the egg's contents, which is determined easily by breaking the egg into a glass plate for examination. Methods that evaluate the internal quality consider the thickness of the albumen, colour and thickness of the yolk in various measures. The most common of these measures are albumen index, yolk index, Haugh units, and

yolk colour. Haugh unit measures the quality of the albumen. As an egg ages, both its white and yolk deteriorate and internal measures of quality give lower values.

Albumen and Yolk Index = (Albumen or Yolk height in mm / Albumen or Yolk width in mm) x 100

The following describes how the Haugh unit is determined. An egg is weighed, then broken onto a flat surface (breakout method), and a micrometer used to determine the height of the thick albumen (egg white) that immediately surrounds the yolk. The height, correlated with the weight, determines the Haugh unit rating. The higher the number, the better the quality of the egg (fresher, higher quality eggs have thicker whites).

$$\text{Haugh Unit} = 100 \log_{10} (h - 1.7w^{0.37} + 7.6)$$

Where,

h = observed height of the albumen in millimeters

w = weight of egg in grams

The Haugh Units are expressed in a figure. The Haugh unit value ranges from 0 to 130. If the Haugh Units found are 75 and 90+, the internal quality/freshness of the sample egg is excellent, however, if the Haugh Units are between 60 and 30 or even less the internal quality/freshness can be considered as poor or very bad.

Yolk color is measured by the use of a color fan (device that has a spectrum of colors of different shades of yellow to orange) or a digital spectral machine to determine the specific color of the yolk. The color of an egg yolk is directly influenced by the quality of the chicken feed. Egg yolk color is generally improved with a high quality feed with a large component of yellow, fat-soluble pigments, such as the carotenes in dark green plant material. Although much emphasis is put onto the color of the egg yolk, it does not reliably reflect the nutritional value of an egg. Some of the natural pigments that produce a rich yolk colour are xanthophylls without much nutritional value, rather than the carotenoids that act as provitamin A (precursors to the formation of vitamin A) in the body. A diet rich in vitamin A itself, but without A-provitamins or xanthophylls, can produce practically colourless yolks that are just as nutritious as any richly coloured yolks.

## **SELF ASSESSMENT EXERCISE 3.2**

Mention two each of the external and internal factors important to egg quality

### **4.0 CONCLUSION**

The exploitation of the natural attribute of the chicken to lay an egg a day is a very important step in ensuring availability of food with a high nutritional value. The portability of the egg and its high nourishing value will be significant in contributing towards alleviation of global quality food shortages.

### **5.0 SUMMARY**

In this unit, you have learnt:

- what egg is and its components
- the process of egg formation from ovulation to lay
- the internal and external quality attributes for evaluating the egg

### **6.0 TUTOR-MARKED ASSIGNMENT**

1. Mention three attributes of a good quality egg and explain the significance of Haugh's unit and Yolk Index.

### **7.0 REFERENCES/FURTHER READINGS**

Daghir N. J. (2008). *Poultry Production in Hot Climates*. U. K.: Cromwell Press, Trowbridge

Oluyemi J. A. and Roberts, F. A. (1979). *Poultry Production in Warm Wet Climates*. London: Macmillan Press Ltd

Eiri (2007). *Hand Book of Poultry Farming and Feed Formulations*. India: Engineers India Research In

## **UNIT 2 EGG PROCESSING AND STORAGE**

### **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Egg Processing

3.2	Egg Preservation and Storage
4.0	Conclusion
5.0	Summary
6.0	Tutor-Marked Assignment
7.0	References/Further Readings

## **1.0 INTRODUCTION**

So far you have learnt more things about eggs such as how they are formed, laid, and produced. Eggs are used in various forms apart from just hard boiling or frying for food. In fact, the forms that egg can be used are very many and they have very important industrial applications. Further, eggs are not always handled in the form they were laid with the shell intact, and because they are perishable or easily contaminated, proper storage is essential.

This unit will examine the issues raised above with the focus on the most important processing and storage methods.

## **2.0 OBJECTIVES**

At the end of this Unit you should be able to:

- state the attributes of the egg exploited in industrial processing
- enumerate different types of industrial egg products
- state the general methods for preserving and storing eggs

## **3.0 MAIN CONTENT**

### **3.1 Egg Processing**

Eggs have very important attributes that make industrial application possible. These attributes are thermal coagulation, foaming ability, and emulsifying effect.

- Thermal coagulation: Egg white coagulates at about 62°C and yolk at about 65°C, and therefore could serve as thickening or binding agents such as in the manufacture of custard.
- Foaming ability: When egg white is mixed together quickly (beaten/whipped) it forms a foam, which entraps air. Therefore, it is used as a leavening agent (helps introduce air) in many baked food products and salad dressing.
- Emulsifying effect: Egg yolk emulsifies (breaks large oil droplets into very small or fine droplets and allows mixing with water) when mixed with oil and water and is used in the production of mayonnaise. Mayonnaise contains egg yolk, olive oil, lemon juice, vinegar and seasonings.

Industrial egg products are manufactured in liquid, frozen and dried forms using either whole egg (white and yolk) or white or yolk. Therefore, you can have liquid or frozen or dried whole egg; liquid or frozen or dried egg white; and liquid or frozen or dried egg yolk. The initial preparation for any of the egg products are almost the same involving the use of fresh eggs, which are washed, dried, cracked, and contents and shell separated before processing into the specific product whether whole, yolk or white. Regardless of the type of product, all are mixed properly for a uniform consistency (homogenization), purified by centrifuging, and sugar is removed in case of dried egg to prevent browning.

Dried egg products or powdered eggs are eggs that have been dehydrated (usually dried in a spray dryer) and made into a simple powder, with a texture similar to that of powdered milk. As mentioned before the product could be powdered whole egg, yolk or white and other ingredients may be added to enhance the flavour or the texture of the eggs. Powdered eggs have a longer shelf life than fresh eggs and can be stored for almost 10 years and it is not necessary to store the eggs under refrigeration; all that is required is a cool to moderate temperature and a dark environment. Powdered eggs are also easier to transport, handle (no breakage), and occupy less storage space than fresh eggs.

Frozen eggs are whole, yolk or white that is frozen at very low temperatures after purification. The specific product is frozen at between  $-23$  to  $-25^{\circ}\text{C}$  and subsequently stored at  $-15^{\circ}\text{C}$ . This can keep for between eight to ten months. It is important to note that composition of the yolk is such that freezing will thicken the yolk and render it useless for use later when it is thawed. To circumvent this problem, the whole and yolk can be pre-treated with proteolytic enzymes such as papain or a small amount of salt or sugar is added and then homogenized into a smooth consistency. Containers used for freezing the eggs should be airtight in order to prevent having a product of low value when about to be used.

After purification, eggs to be used for liquid egg have to be pasteurized because of pathogenic (disease causing) microorganisms most especially *Salmonella*. Salt and sugar are not added to liquid egg because it tends to increase the resistance of microorganisms to heat treatment. Therefore, pasteurized liquid egg is preserved by addition of ascorbic or benzoic acid. Liquid egg can be stored under refrigeration but they have a very short shelf life of about six days.

In Nigeria, the egg industry is not well developed and is rudimentary. The egg products mentioned above are not produced in the country, and they have to be

imported by food, confectionary, and pharmaceutical companies that may require such products. The high cost of equipment and lack of infrastructure to process eggs industrially probably present a strong barrier to its take off.

### **3.2 Egg preservation and Storage**

Fresh eggs deteriorate rapidly during storage under ambient conditions. The reason for this rapid spoilage is that the shell is porous, which can allow escape of carbon dioxide and moisture and entrance or contamination by bacteria, insects, etc. Although a fresh egg is highly perishable, the shell is naturally protected by a surface coating of mucilaginous matter, which prevents for a time the entrance of these harmful organisms into the egg depending on the climate and storage conditions.

However, if this coating is removed or softened by washing or any other means, the keeping quality of the egg is much reduced. These facts explain why many methods of preservation have not been entirely successful, and suggest that the methods employed should be based upon the idea of protecting and rendering more effective the natural coating of the shell, so that air bearing the germs that cause decomposition may be completely excluded.

Coating of the shell with a white paraffin base mineral oil containing antifungal and bacteriostatic agents have been found to aid in maintaining the quality. A technique that has been developed preserves the eggs by a combination of washing and coating using egg washing powder and egg coating oil. The egg washing powder has a combined detergent and sanitising action. It lowers bacterial load, increases shelf life, sale value and consumer acceptability. The egg coating oil formulation preserves the shell eggs for about 4 weeks at 25°C to 30°C and 10 days at 38°C. Eggs keep well for 12 weeks at 13°C and 24 weeks at 7°C. The primary concern is to prevent *Salmonella* infection.

General methods of preservation, cleaning, handling and storage are:

- Collect eggs in an easy to clean container like coated wire baskets or plastic egg flats. This will prevent stains from rusted metal and contamination from other materials which are difficult to clean and disinfect.
- Never cool eggs rapidly before they are cleaned. The egg shell will contract and pull any dirt or bacteria on the surface deep into the pores when cooled. Try to keep the temperature relatively constant until they are washed.
- Wash eggs as soon as you collect them. This helps limit the opportunity of contamination and loss of interior quality. Washing eggs with water 10° (degrees) warmer than the egg will make the egg contents swell and push the

dirt away from the pores of the egg. If you have extremely dirty eggs, a mild detergent approved for washing eggs can be used. Never let eggs sit in water. Once the temperature equalizes the egg can absorb contaminants out of the water.

- Cool and dry eggs quickly after washing. Store eggs small end down in an egg carton to keep the air cell stable and at 10-12°C and 70-75% relative humidity. Never hold eggs at or above room temperature or at low humidity more than necessary. If eggs sit at room temperature (25°C) they can drop quickly in quality daily. Leaving eggs in a warm, dry environment will cause interior quality to drop quickly.
- Do not stack (place them one above the other) eggs too high. If collecting in baskets do not stack eggs more than five layers deep. If using plastic flats do not stack more than six flats. If you stack eggs too deep you will increase breakage.
- Never store eggs with materials that have an odour. Eggs will pick up the odours of apples, fish, onions, potatoes and other food or chemicals with distinct odours.
- Sell the oldest eggs first and try to use or sell all eggs before they are three weeks old.

### **SELF ASSESSMENT EXERCISE 3.3**

List nine possible industrial egg products

## **4.0 CONCLUSION**

The opportunity of industrial application to egg processing increases its importance as a food source. Corresponding development of processing capacity in developing countries as developed countries will be significant in contributing to solving serious food shortages existing there.

## **5.0 SUMMARY**

In this unit, you have learnt:

- the attributes of the egg exploited in industrial processing
- the different types of industrial egg products as liquid, frozen or powdered egg
- why eggs deteriorate rapidly and how to avoid this by applying the general methods for preserving and storing eggs

## **6.0 TUTOR-MARKED ASSIGNMENT**

1. Write three important attributes that make industrial processing of eggs possible

## **7.0 REFERENCES/FURTHER READINGS**

Daghir N. J. (2008). *Poultry Production in Hot Climates*. U. K.: Cromwell Press, Trowbridge

Oluyemi J. A. and Roberts, F. A. (1979). *Poultry Production in Warm Wet Climates*. London: Macmillan Press ltd

Eiri (2007). *Hand Book of Poultry Farming and Feed Formulations*. India: Engineers India Research In



## **MODULE 4 MILK PRODUCTION AND PROCESSING**

Unit 1 Milk Production

Unit 2 Milk Quality

Unit 3 Milk Processing and Storage

### **UNIT 1 MILK PRODUCTION**

#### **CONTENTS**

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Milk

3.1.1 Composition of Milk

3.1.2 Nutritional value of Milk

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

7.0 References/Further Readings

#### **1.0 INTRODUCTION**

When we consume milk and its variety of products, it is not always apparent in our minds that it came from an animal and was meant to nourish its growing offspring. There is no other place to obtain milk than from an animal, even humans suckle their new born babies on milk. Milk is unique in its form and substance, and a very important source of nourishment all over the world. Therefore, further knowledge on what it is and the source will reinforce its importance in our minds; and this is the focus of this unit.

#### **2.0 OBJECTIVES**

At the end of this unit you should be able to:

- describe the essential nature of raw milk
- enumerate the basic composition of milk
- describe the nutritional value of milk

#### **3.0 MAIN CONTENT**

##### **3.1 Milk**

Milk is supposed to be the first and sole food for offspring of mammals as it is an almost complete food necessary to sustain life. It is secreted by female animals and is white or yellowish-white and an opaque (non-transparent) liquid. Fresh milk has a

pleasant soft and sweet taste and carries hardly any smell. It contains in a balanced form all the necessary and digestible elements for building and maintaining the human and animal body. In addition it contains immuno-globulins which protect the newly born against a number of diseases. In addition, milk contains various properties, which make it easy to convert into different milk products or to use it as an ingredient for other food items. Various human cultures have their own traditional ways of using milk and preparing different milk products.

### **3.1.1 Composition of Milk**

The composition of milk is not constant, but shows a wide variation. Composition depends on the species of animal but also within a species there are variations between the breeds and between individual animals within a breed. The composition might even change from day to day, depending on feeding and climate. In addition, when animals are milked, the first milk differs from the last milk drops. For example, average water content for cows, goats and sheep are 87, 86, and 82%, respectively; fat content, 4, 5, and 6.5%, respectively; and protein, 3, 4, and 7%, respectively. This shows milk consists mainly of water and what remains are the total milk solids. These are the sum of fat, protein ( mostly casein), lactose and minerals. In case the milk fat is not included in the Total Solids we speak of the Solids Non Fat (SNF). The nutritional as well as the economic value of milk is directly associated with its solids content. The higher the solids content the better its nutritional value and the more of a milk product can be made out of it. For example, cheese yields are directly related to the protein and in particular to the casein content of milk.

### **3.1.2 Nutritional Value of Milk**

Milk is very tasteful and is an excellent source of high quality protein, that can be digested easily. Milk also contains lots of important vitamins and minerals. In many countries milk and milk products provide 5 – 10% of the total calories of the daily human diet. It represents one of the best natural sources of essential amino acids for human nutrition. Moreover, milk is an outstanding source of calcium and a good source of phosphorus and is therefore essential in building the bones and teeth in the body. In fact milk is the most important source of calcium in the diet of almost all people. These nutritional attributes have made milk a mainstay in the diet, particularly of growing children. It is recommended to drink 3 – 4 glasses of milk per person per day. Milk is an exceptionally versatile raw product because it is estimated that worldwide, some 8,000 to 10,000 different milk products are available.

## **SELF ASSESSMENT EXERCISE 4.1**

State the components of milk that make it nutritionally valuable

## 4.0 CONCLUSION

The value of milk as a food source is underscored by its intended exclusive use as the sole food for the new born. Development of the dairy sector in developing countries as an outlet for food will contribute favorably to improving their economies.

## 5.0 SUMMARY

In this unit, you have learnt:

- the attributes of raw milk
- usefulness of milk as food

## 6.0 TUTOR-MARKED ASSIGNMENT

Describe milk and explain the terms, 'total solids' and 'solids non-fat'

## 7.0 REFERENCES/FURTHER READINGS

Ebing, P. and Rutgers, K. (2006). *Preparation of dairy products. Agrodok-series No. 36.* Agromisa Foundation and CTA, Wageningen.

Mattila-Sandholm, T., and Saarela M., ed. 2004. *Functional Dairy Products.* Cambridge: Woodhead Publishing Limited

Miller, G. D., Jarvis J. K., and McBean, L. D. (1999) *Handbook of Dairy Foods and Nutrition.* (2nd ed). National Dairy Council, CRC Press, Boca Raton, FL.

Tamime, A. Y. *Milk Processing and Quality Management.* (2009). UK: Blackwell Publishing Ltd. John Wiley & Sons Ltd

Walstra, P., Geurts, T. J., Noomen A., Jellema A., and van Boekel M. A. J. S. (1999). *Dairy Technology, Principles of Milk Properties and Processes.* NY: Marcel Dekker, Inc.

## UNIT 2 MILK QUALITY

### CONTENTS

1.0 Introduction

2.0 Objectives

3.0 Main Content

3.1 Quality characteristics of Milk

3.1.1 Flavour

- 3.1.2 Hygiene
  - 3.1.2.1 Total Bacteria Count
  - 3.1.2.2 Somatic Cell Count

- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings

## **1.0 INTRODUCTION**

In Unit 1 you learnt the importance of milk as regards natural essentiality for survival, composition and nutritional value. However, all these attributes will be of no value if the milk available for use smells bad, tastes bad or can cause disease. In developed countries where milk production and quality standards have been established, producers may be penalized for poor quality milk and/or obtain very low value or payments for it. Therefore, it is important that factors that can negatively affect the value of milk be identified and reduced as much as possible or alleviated. The key to producing quality milk is to have correct information, make the right decisions and carry out the recommended actions correctly. This is the focus of this unit.

## **2.0 OBJECTIVES**

At the end of this unit you should be able to:

- describe the quality characteristics of good quality milk
- identify the differences between good and poor quality milk
- distinguish between total bacteria count and somatic cell count

## **3.0 MAIN CONTENT**

### **3.1 Quality Characteristics of Milk**

Milk that has been harvested from animals and stored at appropriate cold temperatures in tanks is transported to processing centres where they are tested for quality before processed. The milk is checked for protein, fat, flavour, total bacteria count, somatic cell count, and residues. The protein and fat contents are checked against standard milk values to accept or reject the milk. Other attributes checked are discussed in the following sections.

#### **3.1.1 Flavour**

Milk is a yellowish-white non-transparent liquid. Fresh milk has a pleasant soft and sweet taste and carries hardly any smell. Consumer acceptance of milk is greatly affected by its flavour. There are several factors which may produce off-flavours

and/or odours in milk. Some of the more common causes of flavour and odour problems are:

- Strong flavored feedstuffs such as poor quality silage or feed
- Strong smelling plants, like wild onion or garlic
- High acidity flavours and oxidized flavours, from contact with copper or exposure to sunlight; and flavours from the use of chlorine, fly sprays, medications, etc.
- Rancid flavours: These are caused by excessive agitation of milk during collection and/or transport. Damage of the fat globules in the milk results in the presence of free fatty acids.
- Cow-barn flavors from dung, etc. These are found when milk is obtained from a dirty or poorly ventilated environment or from improperly cleaned milking equipment.

### **3.1.2 Hygiene**

Milk, when it emerges from a healthy udder (the mammary gland of the female animal, which has teats where milk comes out from) contains only a very few bacteria. However, milk is a perishable product. It is an ideal medium for micro-organisms and as it is a liquid, it is very easily contaminated and invaded by bacteria. Almost all bacteria in milk originate from the air, dirt, dung, hairs, dust, dirty equipment, operators, and other extraneous substances. In other words, milk is mainly contaminated with bacteria during milking.

The major group of bacteria in milk is the lactic acid bacteria, which grow and produce lactic acid rapidly when milk is kept at ambient temperature and it becomes sour. How soon the milk turns sour depends on the degree of contamination and on the temperature of the milk. Therefore, proper cleaning and sanitizing procedures are essential to control the quality of milk. Cooling milk to a temperature of 4°C as soon as the animal is milked (the first 2 – 3 hours) makes the bacteria inactive and prevents them to grow and produce the lactic acid.

#### **3.1.2.1 Total Bacteria Count**

The total population of bacteria in milk is termed Total Bacteria Count (TBC) and very good raw milk should contain only 500 to 1,000 bacteria per ml. The normal total bacteria count after milking is up to 50,000 per ml and many processors may not be willing to accept raw milk with a higher value. However, counts may reach several millions bacteria per ml. This indicates a very poor hygienic standard during milking

and the handling of the milk or milk from an animal with disease such as mastitis. Mastitis is a disease of the udder. This disease arises when bacteria enter the udder and establish an infection. The disease is caused by *Streptococcus* and *Staphylococcus spp* bacteria leading to clotting and discolouration of the milk, reddening, heat, pain, swelling and hardening of the udder.

Hygienic milk only originates from mastitis free and healthy animals. Cows suffering from a disease may secrete the pathogenic bacteria, which cause their disease, in the milk they produce. Consumption of raw milk therefore might be dangerous to the consumer. Some of these diseases, like tuberculosis, brucellosis and anthrax, can be transmitted to the consumer. Whatever the milk is used for during processing, the hygienic standard of the produced milk at farm-level forms the basis of the quality of the ultimate milk products.

### **3.1.2.2 Somatic Cell Count**

Apart from TBC, another measure of the quality of raw milk is the Somatic Cell Count (SCC), which is a direct indication of infection as there is a very high correlation between mastitis and bacterial infection. Somatic cells consist almost totally (98%) of white blood cells. When bacteria exist in the environment close to the teat end, the first line of defence against bacterial infection is the teat canal. If the bacteria succeed in entering the udder, then the second line of defence comes into play and inflammation occurs, i.e. white blood cells or somatic cells. These somatic cells try to destroy the bacteria and prevent it from infecting and damaging the udder tissue. Thus, these somatic cells (SCC) are the first reliable indication of mastitis infection. A certain level of somatic cells are always present in milk, as a protection for the cow against mastitis infection. Most cows that are free of mastitis and have no previous infections would be expected to have an SCC of less than 100,000 cells/ml, with many below 50,000 cells/ml. It is widely accepted that individual cow SCC greater than 150,000 cells/ml or individual heifer SCC greater than 120,000 cells/ml indicates presence of infection.

Milk with a high somatic cell concentration can be harmful to human health and contains less protein. In addition milk with a high cell count generally contains an increased amount of enzymes, which have effect on the quality of the protein and the fat in milk. The presence of these enzymes in milk increases the potential for off-flavours and odours. Because the somatic cell content of raw milk is important for the shelf-life, flavour and the quantity of products obtained, milk processors strive to obtain raw milk of the highest hygienic quality from their producers.

### **3.1.2.3 Residues in Milk**

Good quality milk must be free of various residues that may be deposited or remain in milk along the pre-processing handling of raw milk. Such residues are antibiotics, disinfectants, iodine, trichloromethane (TCM), added water, and sediments.

Milk must be free from antibiotics and traces are not acceptable. All milk supplies are tested for antibiotic residues. Antibiotic residues result from the milk collected from animals treated for various infections, which were not completely disposed. Milk from animals being treated must not be processed or consumed and the proper safe period after treatment must be strictly observed.

Disinfectants and TCM contamination result from improper washing or rinsing of equipment used in the pre-processing of raw milk. The most effective disinfectants have chlorine as the active component but chlorine can form TCM if it comes in contact with organic matter such as milk remaining in processing equipment pipes. Very low levels or zero levels of TCM are tolerated.

Iodine contamination results from the feed given to animals. In spite of the fact that iodine is very important to human physiology, an excessive level is not healthy. Therefore, proper monitoring of iodine levels in feed is required.

Water is the most abundant component of milk. However, excess water above acceptable levels is not proper because the consumer is paying for milk and not water. Excess water could arise from improper draining of water from pipes after washing or switching to automatic cleaning too early.

Physical cleaning of teats before milking is essential for lowering sediment in milk. Sediment in milk is generally due to poor pre-milking hygiene procedures that allow soil and other materials to enter the milking system. Proper environmental conditions are important in order to maintain cow cleanliness and to reduce soil on animals so that premilking hygiene procedures can be effective. Sediment in milk is measured by filtering the milk through a fine filter and visually examining it. High sediment levels in milk are associated with dirt and increased potential for bacterial contamination, thus adversely influencing milk quality.

### **SELF ASSESSMENT EXERCISE 4.2**

List items considered in determining the quality of milk

## **4.0 CONCLUSION**

The importance of milk as a valuable food source will be lost if it is unacceptable to the end users. Improving milk supply in any economy is not as important as

guaranteeing the quality in order to satisfy the objective of nourishing the most needy in the population.

## **5.0 SUMMARY**

In this unit, you have learnt:

- the quality characteristics of good quality milk
- to distinguish between good and poor quality milk
- factors affecting hygienic quality of milk

## **6.0 TUTOR-MARKED ASSIGNMENT**

Write briefly on the significance of somatic cell count, total bacteria count and residues in milk

## **7.0 REFERENCES/FURTHER READINGS**

Early R. (1998). *The Technology of Dairy Products*. (2nd ed.). London: Blackie Academic and Professional

Robinson R. K. (2002). *Dairy Microbiology Handbook*. (3rd ed.) New York: Wiley-Interscience, A John Wiley & Sons, Inc., Publication Tetra Pak Processing

Systems (1995) *Dairy Processing Handbook*. 1995. Sweden: Tetra Pak Processing Systems AB

Wehr, H. M., and Frank, J. H. (2004). *Standard Methods for the Examination of Dairy Products*. (17th Ed.) Washington, DC: American Public Health Association

## **UNIT 3 MILK PROCESSING AND STORAGE**

### **CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
  - 3.1 Processing Methods
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Readings



## **1.0 INTRODUCTION**

In the previous units, your knowledge was increased by information on the uniqueness of milk, its importance and attributes of good quality milk. The raw milk obtained from dairy animals is highly perishable and cannot keep for long even when the quality is high. Therefore, the milk has to be converted to more stable forms in order to increase its shelf life. As mentioned before, milk is very versatile and can be processed and is indeed processed to thousands of products globally depending on different traditions, habits and customs. This unit will discuss the most common products obtained from milk when it is processed.

## **2.0 OBJECTIVES**

At the end of this unit you should be able to:

- describe the basic processing methods for milk
- distinguish between pasteurization and sterilization/ultra-high temperature processing
- distinguish between forms of milk and milk products

## **3.0 MAIN CONTENT**

### **3.1 Processing methods**

Almost all the processing methods for milk all have the common objective of extending its storage or shelf life. Therefore, processing results in the conversion of the raw milk into other products. Whole milk, once approved for use, is pumped into storage tanks or silos where it undergoes pasteurization, homogenization, separation and further processing into different products.

- Pasteurization or heat treatment involves heating every particle of milk to a specific temperature for a specified period of time and cooling it again without allowing recontamination. is heating at 63 to 66 °C for 30 min or 72° C for 15 seconds. These conditions provide fresh tasting milk that meets the requirements for consumer safety. Higher heat processes, such as ultra-pasteurization (137.8°C for 2 seconds) or aseptic/ ultra-high temperature (135 - 150°C for 4-15 seconds) or sterilization (115.6°C for 20 min), are used to extend the shelf life of refrigerated products or allow for storage at room temperature, respectively, but may impart a cooked flavor to the milk.

- The fat in milk is in globules of non-uniform size, and the non-uniform size of the globules causes them to float, or cream, to the top of the container. Pasteurized milk does not necessarily need to be homogenized. However, homogenized milk should be pasteurized to inactivate native enzymes (lipases) that deteriorate fat and cause rancidity, which results in off-flavors and reduced shelf life in milk.

The purpose of homogenization is to reduce the milk fat globules size, which allows them to stay evenly distributed in milk. Homogenization is a high pressure process that forces milk at a high velocity through a small orifice to break up the globules. The result of homogenization is the creation of many more fat globules of a smaller size so that the fat is dispersed evenly throughout the milk, stopping the fat from floating to the top of the container to obtain a more uniform consistency.

- Separation involves spinning milk through a centrifuge to separate the cream (fat containing portion of milk) from the milk. After separation, the cream and remaining milk are remixed to provide the desired fat content for the different types of milk being produced. For whole milk, the cream is reintroduced until the fat content reaches 3.25-4%. For low fat milk, the fat content is 1%. For skim milk (sometimes called solids non fat milk) the fat content is .05%.
- Milk that has gone through pasteurization and homogenization can be processed into many different forms such as whole (full cream) milk, low fat (defatted) milk, skim milk, fortified milk (low-fat milk fortified with vitamins A and D), flavored milk (with chocolate, vanilla etc.), condensed milk, evaporated milk, powdered (dried) milk, and filled milk (animal fat replaced with vegetable fat). Different milk products are also produced with specific processing procedures such as yoghurt (curdled milk), ice cream, butter, cheese, casein (milk protein), lactose (milk sugar), whey (liquid remaining after milk is curdled), and whey powder (dried whey).

### **SELF ASSESSMENT EXERCISE 4.3**

List the basic steps employed in processing milk before conversion to different products

### **4.0 CONCLUSION**

The versatility of milk in conversion to many different products all over the world makes it one of the most important food sources globally. Focusing on ways to improve the quality of milk products available locally in various areas could improve the well-being of those people most vulnerable nutritionally.

## 5.0 SUMMARY

In this unit, you have learnt:

- the basic processing methods for milk
- how to distinguish between pasteurization and sterilization/ultra-high temperature processing
- how to distinguish between forms of milk and milk products

## 6.0 TUTOR-MARKED ASSIGNMENT

Write briefly on heat treatment, homogenization and separation in milk processing

## 7.0 REFERENCES/FURTHER READINGS

Early R. (1998). *The Technology of Dairy Products*. (2nd ed.). London: Blackie Academic and Professional

Ebing, P. and Rutgers, K. (2006). *Preparation of dairy products. Agrodok-series No. 36*. Agromisa Foundation and CTA, Wageningen.

Mattila-Sandholm, T., and Saarela M., ed. 2004. *Functional Dairy Products*. Cambridge: Woodhead Publishing Limited

Miller, G. D., Jarvis J. K., and McBean, L. D. (1999) *Handbook of Dairy Foods and Nutrition*. (2nd ed). National Dairy Council, CRC Press, Boca Raton, FL.

Tamime, A. Y. *Milk Processing and Quality Management*. (2009). UK: Blackwell Publishing Ltd. John Wiley & Sons Ltd

Tetra Pak Processing Systems (1995) *Dairy Processing Handbook*. 1995. Sweden: Tetra Pak Processing Systems AB

Walstra, P., Geurts, T. J., Noomen A., Jellema A., and van Boekel M. A. J. S. (1999). *Dairy Technology, Principles of Milk Properties and Processes*. NY: Marcel Dekker, Inc.