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FACULTY OF AGRICULTURAL SCIENCES

Department of Agricultural Economics and Extension

Programme: Hospitality and Tourism Management

Course Code: HTM306

Course Title: Food Processing and Preservation

Credit Unit: 3 Units

HTM 306

Food Processing and Preservation

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HMT306 COURSE GUIDE

Introduction

HMT306: Food Processing and preservation is a one semester, three units, 300 level (year one) course. The course is designed for undergraduatestudents of Hotel and Tourism management. The aim of this subject is to provide students with an understanding of the science and technology associated with the processing of materials of plant and animal origin into food and food products and their preservation by traditional and modern techniques. The utilization and processing of food by products will also be extensively discussed.

The course will consist of twelve modules which include:

Principles of Food Processing and Preservation

Raw Materials and their Significance in Food Processing

Different Preservation Methods

Processing of Cereals, Legumes and Oil Seeds

Meat, Fish and Poultry Processing

Food Additives

Food Deterioration and Spoilage

Post Harvest Changes in Foods

Structure and Composition of Some West African Foods

Structure and Composition of Cereals, Tubers, Fruits and Vegetables

Factors that Affect Sensory Properties and Choice of Foods

This course guide tells you briefly what the course is all about, what course materials you will be using and how you can work your way through these materials. It suggests some general guidelines for the amount of time you might be spending in order to successfully complete

What You Will Learn in This Course

HMT306: Food Processing and preservation consists five major components

General principles of food processing and preservation

Processing and preservation of various foods

Utilization of food by-products/wastes

Food deterioration and spoilage

factors that affect food choice

Intended learning outcomes

On completion of this subject students should be able to:

- Demonstrate an understanding of the principles and application of food processing and preservation technologies
- Describe the technologies used to effect preservation
- Evaluate processing technologies for their appropriate application

- Describe the manufacture of a variety of foods and food products, including food beverages, meat and fish products etc
- Describe the technologies for the utilization of food by products and wastes
- Evaluate the principles of food deterioration and spoilage
- Discuss the factors that affect food choice

Course Requirements

To complete this course you are required to read the study units, read suggested books and other materials that will help you achieve the objective. Each unit contains tutor-marked assignments and at intervals in the course you are required to submit assignment for assessment purpose. There will be a final examination at the end of the course.

During the first reading, you are expected to spend a minimum of two hours on each unit of this course. During the period of two hours you are expected to read through the text of the unit and also answer the self assessment exercises and questions.

The Course Material

You will be provided with the following materials for this course:

1. Course Guide

The material you are reading now is called course guide which introduce you to this course.

2. Study Units

The textbooks prepared for this course by National Open University of Nigeria is called Study Guide. You will be given a copy of the book for your personal use.

3. Textbooks

At the end of each unit, there is a list of recommended textbooks which though not compulsory, for you to acquire or read, are necessary as supplements to the course materials.

4. Other Materials

In addition to the above materials, it is very essential for you to collect your assignment file.

Study Modules

There are twelve study modules in this course divided into 32 units as follows:

Module 1: PRINCIPLES OF FOOD PROCESSING AND PRESERVATION

Unit 1: FOOD PROCESSING AND PRESERVTION

Unit 2: FOOD DETERIORATION

Module 2: RAW MATERIALS AND THEIR SIGNIFICANVE IN FOOD PROCESSING

Unit 1: RAW MATERIALS SELECTION

Unit 2 RAW MATERIALS: TYPES, TREATMENT AND STORAGE

Module 3: DIFFERENT PRESERVATION METHODS

Unit 1: FUNDAMENTALS OF HEAT AND COLD IN PRESERVATION

Unit TWO: CHEMICAL AND BIOLOGICAL PRINCILPES OF FOOD PRESERVATION

Module 4: PROCESSING OF CEREALS, LEGUMES AND OIL SEEDS

Unit 1: PROCESSING OF CEREALS

Unit 2: LEGUME PROCESSING

Unit 3: PROCESSING OF OIL SEEDS

Module 9: POST HARVEST CHANGES IN FOODS

Unit 1: TRANSPIRATION

Unit 2: CAUSES OF POST HARVEST LOSSES AND CONTROL OF POST HARVEST CHANGES

Unit 3: PRECOOLING: AN IMPORTANT POST HARVEST PRACTICE

Module 10: STURCTURE AND COMPOSITION OF SOME WEST AFRICAN FOODS

Unit 1: CLASSIFICATION OF WEST AFRICAN FOODS

Unit 2: STRUCTURE AND COMPOSITION OF THE MILK AND MILK PRODUCT GROUP

Unit 3: STRUCTUREAND COMPOSITION OF MEAT, FISH, EGG AND LEGUMES

Module 11: STRUCTURE AND COMPOSITION OF CEREALS, TUBERS, FRUITS AND VEGETABLES

Unit 1: STRUCTURE AND COMPOSITION OF CEREALS

Unit 2: STRUCTURE AND COMPOSITION OF ROOTS AND TUBERS

Unit 3: STRUCTURE AND COMPOSITION OF FRUITS AND VEGETABLES

MODULE 12: FACTORS THAT AFFECT SENSORY PROPERTIES AND CHOICE OF FOODS

Unit 1: FACTORS THAT AFFECT FOOD CHOICE

Unit 2: FACTORS THAT AFFECT THE SENSORY PROPERTIES OF FOODS

Unit 3: FACTORS AFFECTING FOOD CHOICE

Assessment

There are two components of assessment for this course:

· The Tutor Marked Assignment (TMA)

· The end of course examination.

Tutor-Marked Assignment

The TMA is the continuous assessment component of your course. It accounts for 30% of the total score. You will be given four TMA's by your facilitator to answer before you can sit for the final examination.

Final Examination and Grading

This examination concludes the assessment for the course. The examination will account for 70% of total score. You will be informed of the time for the examination.

Summary

This course intends to provide you with underlying knowledge of food processing and preservation principles for the study of Hospitality Management and Tourism.

MODULE 1: PRINCIPLES OF FOOD PROCESSING AND PRESERVATION

UNIT 1: FOOD PROCESSING AND PRESERVTION

CONTENT

1.1 Introduction

Virtually all foods are derived from living cells from animals and plant origin and in some cases from some microorganisms by biotechnology methods. Thus, foods are for the most part composed of "edible biochemicals". One of the most important goals of the food scientist is to make foods as safe as possible whether they are used fresh or processed. The judicious application of food processing, storage and preservation methods helps prevent outbreaks of foodborne illness, that is the occurrence of disease or illness resulting from the consumption of contaminated food. The processed food industry has an outstanding record preventing such cases when it is considered that billions of cans, jars, packets and pouches of processed and fresh food products are consumed annually. Occasionally, however, this excellent record has been broken by limited outbreaks in which persons do succumb to the effects of toxic foods.

1.2 Learning Outcomes

By the end of this unit, you will be able to:

- Discuss food preservation and processing
- Explain the need for food preservation
- Explain different conventional Food Preservation Methods

1.3 Definition of Food Preservation and Processing

1.3.1 Food Preservation

Food preservation is an action or method of designed to maintain foods at a desired level of quality. A number of new preservation techniques are being developed to satisfy current demands of economic preservation and consumer satisfaction in safety, nutritional and sensory aspects (Potter and Hotchkiss, 1995). In addition, food preservation is necessary because foods are perishable or deteriorative by nature. Based on the mode of action, major food preservation techniques can be categorised as: slowing down or inhibiting chemical deterioration and microbial growth; directly inactivating bacteria, yeast, moulds and enzymes and avoiding recontamination before and after processing.

1.3.2 Food Processing

- Processing of foods is a segment of manufacturing industry that transforms animal, plant, and marine materials into intermediate or finished value-added food products that are safer to eat. The aims of food processing could be considered four-fold (Fellows, 2009): (1) extending the period during which food remains wholesome (microbial and biochemical), (2) providing (supplementing) nutrients required for health, (3) providing variety and convenience in diet, and (4) adding value
- The scope of food processing is broad; unit operations occurring after harvest of raw materials until they are processed into food products, packaged, and shipped for retailing could be considered part of food processing. Typical processing operations may include raw material handling, ingredient formulation, heating and cooling, cooking, freezing, shaping, and packaging.
- These could broadly be categorized into primary and secondary processing. Primary processing is the processing of food that occurs after harvesting or slaughter to make food ready for consumption or use in other food products. Primary processing ensures that foods are easily transported and are ready to be sold, eaten or processed into other products (e.g. after the primary processing of peeling and slicing, an apple can be eaten fresh or baked into a pie). Secondary processing turns the primary-processed food or ingredient into other food products. It ensures that foods can be used for a number of purposes, do not spoil quickly, are healthy and wholesome to eat, and are available all year (e.g. seasonal foods).
- **Self-Assessment Exercise 1**

1. Food preservation is an action or method of designed to maintain foods at a desired level of quality True or False?
2. What do you understand by the term Food processing?

1.4 Need for food preservation

- The preservation, processing and storage of the food are vital for the continuous supply of foods during seasons and off-seasons. One very important consideration that differentiates the agricultural from all other industrial processes is their seasonal nature. The main reasons for food processing and preservation are:
  - to overcome seasonal production in agriculture;
  - to produce value-added products;
  - and to provide variety in diets.
  - People like to eat wide varieties of foods, having different tastes, flavours, nutritional, dietetic and other characteristics.
- Unfortunately, it has been estimated that as many as 2 billion people do not have enough to eat and that perhaps as many as 40 000 die every day from diseases related to inadequate diets, including the lack of sufficient food, protein or specific nutrients. Inadequate nutrition in extreme cases can produce in children an advanced state of protein deficiency known as kwashiorkor or the more widespread protein.
- Major processes of food deterioration are caused by environmental factors such as temperature, humidity, oxygen and light which can be reason for several reaction mechanisms that may lead to food deterioration to such an extent that they are either

rejected by or harmful to the consumer. Microbial effects are the leading cause of food deterioration and spoilage.

Self-Assessment Exercise 2

1. List two main reasons for food preservation and processing.
2. The preservation, processing and storage of the food are vital for the continuous supply of foods during seasons and off-seasons. True or False?

1.5 Conventional Food Preservation Method

1.5.1 Food preservation by heat treatment

Heat is by far the most commonly used method of food preservation. There are various degrees of preservation by heating that ultimately dictate the type of final product manufactured, the terms used are pasteurization and sterilization. However, to be effective, these processes must be carried out under a combination of strict temperature and time control to ensure the killing of pathogenic and non-pathogenic microorganisms. These same factors also cause thermal inactivation of food enzymes and some destruction of food constituents.

Heat resistance of microorganisms:

- Heat resistance of microorganisms is a basic topic of thermo-bacteriology, which is a very important part of microbiology including food microbiology. The most heat resistant pathogen found in foods, especially those that are canned and held under anaerobic conditions is *Clostridium botulinum*.
- It is spore forming, proteolytic anaerobe, which is able to produce the most harmful known toxin since amount of about $10^{-6} - 10^{-8}$ g is able to kill one person. However, there are non- pathogenic, spore forming food spoilage bacteria, such as the

putrefactive anaerobe *Clostridium sporogenes* and *Bacillus stearothermophilus* which are more heat resistant than spores of *Cl. botulinum*.

- This means that if a heat treatment inactivates spores of these spoilage microorganisms, the spores of *Cl. botulinum* and all others pathogens will be also killed.

b. **Kinetics of heat destruction of microorganisms**

Thermal death time: The thermal death time is the time of heating required to kill all vegetative cells of microorganisms. Theoretically this is not possible but this expression is used in thermobacteriology for practical purposes. Microorganisms are killed by heat at a rate that is very nearly proportional to the number of cells of a specified organism (expressed on a logarithmic basis) present in the system (food, laboratory nutritive medium, water, etc.) being heated. This is referred as a logarithmic order of death. A typical thermal death rate curve is shown in Figure 1. It provides data on the rate of destruction of specific microorganisms in specific media or food at specific constant temperature,

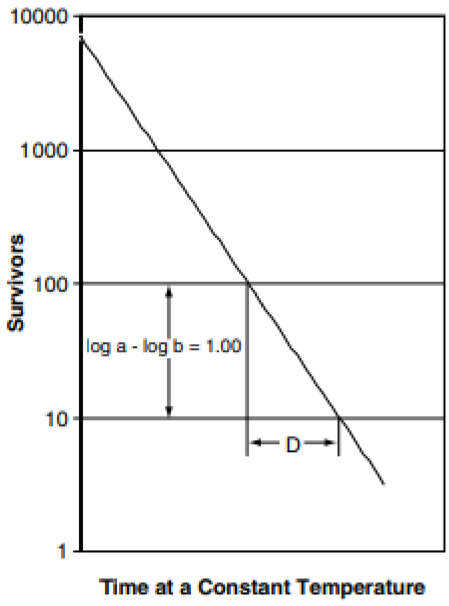

FIGURE 1. Bacterial destruction rate curve showing logarithmic order of death.

This "D-value", or decimal reduction time, is defined as the time, in minutes, at specified temperature required to destroy 90% of the cells at the respective microbial population. During each time interval (1 min or 3 min or 6 min) numbers of the cells is reduced 10 times, let say from 1000 to 100 or from 100 to 10, etc. This means that 90% of the cells are killed during each interval. In each case 1000/100 = 100/10 = 10 which is the reason it is called the decimal reduction time. In other words, the D-value represents the time for the number of cells to be reduced by one logarithmic cycle, for example from 10^6 to 10^5 cells per 1 g.

TABLE 1. Effective time-temperature relationships for destruction of *Clostridium botulinum* spores

Temperature (°C)	Time (min)
100	330
104	150
110	36
116	10
118	5.27
121	2.78
124	1.45
127	0.78

1.5.2. Preservation by low water activity (aw):

- Water activity can be reduced by partial removal of the water (drying, reverse osmosis, concentration) or by adding substances which increase the osmotic pressure of the food or media such as sugars, ethanol, glycerol, salts, etc.
- The majority of microorganisms are sensitive to the water status in their immediate environment and they can remain metabolically active only in a narrow range of high-water activities. There is a lot of information about low water activity limits for the growth of microorganisms. However, it is typical that those organisms that are tolerant to low aw be also tolerant of very high osmotic pressures.

- The lowest aw limits for growth recorded up to now illustrate the enormous range of tolerances that exist. The most aw tolerant species are able to grow when osmotic pressure is as high as about 800 MPa. They can grow slowly below aw 0.62. The nature of the solute exerts additional affect on potential for growth. Ionic solutes such as NaCl and KCl are more inhibitors than non-ionic solutes such as sugars. Solutes such as glycerol, unlike the salts and sugars, rapidly permeate most bacteria but not yeast, e.g. *Saccharomyces ronxii* and *Debaryomyces hanseni*.
- However, for the more low aw-tolerant species this simple relationship is no longer valid. *Staphylococcus aureus*, for example, is extremely salt-tolerant and more sensitive at a higher aw in glycerol than in sodium chloride. Lowering the a_w by various means may also influence the rate of enzymatic and chemical changes in foods. Whilst all microbiological growth is completely stopped below about aw = 0.6, some enzymatic reactions that cause food spoilage continue and some reactions, such as lipid oxidation, may even be accelerated at very low aw values.

1.5.3. Preservation by low pH and organic acid

a. **Preservation by low pH:**

- Foods is classified according to their acidity as follows: non-acid – 7.0-5.3; low or medium acid – 5.3-4.6; acid I – 4.6-3.7 and acid II – 3.7 and lower. Microorganisms have a characteristic range of pH values within which they can grow.
- Most bacteria have an optimum pH near 6.8 and may grow at pH values ranging from 4.0 to 8.0. A small number bacterial species can multiply when pH < 4.0 or pH > 8.0.
- Yeast and moulds can sometimes grow at pH less than 2.0.
- Usually, the growth rate decreases as the pH drops below the optimum value.

- **b. Preservation by organic acids**: Some organic acids and their esters are found naturally in many foods or as a product of microbial metabolism in fermented foods.
- Many foods are preserved by the addition of relatively low concentrations of such compounds, all of which show marked pH-dependant activity as preservatives. These compounds are primarily active against yeast and moulds at low concentration but bacteria are affected also. Lowering the pH increases the proportion of undissociated acid molecules, which increases the antimicrobial effectiveness of all such organic acids.
- It has therefore been generally assumed that the antimicrobial activity of these acids is directly related to the concentration of their undissociated molecules.
- Organic acids and esters cover a large group of substances but only a limited number are used as food. Acetic acid has only a limited action as a preservative. Its main action is linked to its pH-reducing capacity.
- Propionic acid: only the sodium and calcium salts are used as food preservatives. They are mainly used against moulds in cheese and bakery products. Effective concentrations are from 440 to 850 mM. Lactic acid is generally viewed as being less effective than other organic acids. It is excellent inhibitor of spore-forming bacteria at pH = 5,0 although totally ineffective against yeast and moulds.
- Sorbic acid is used either as such or as the sodium, potassium and calcium salts but most commonly as the potassium salt. It is more effective against moulds and yeast than bacteria. Growth inhibition of bacteria occurs at concentration of between 50 and 10 000 ppm, for yeast between 25 and 500 ppm and for moulds between 100 and 1000 ppm

- Benzoic acid is used as such or as its sodium salt, commonly against yeast (20 to 7000 ppm), moulds (20 to 10 000 ppm) and bacteria (50 to 1800 ppm) Bacteria are more variable in their sensitivity.

1.5.4. Preservation by carbon dioxide, sulphite, nitrite and nitrate

a. Carbon dioxide (CO_2):

- It is recognised that CO_2 has a major role in modifying microbial growth. Modified atmospheres enriched with CO_2 are a widespread natural means of extending the shelf life of a variety of non-sterile refrigerated foods. Concentration of CO_2 in normal air is 0.03% but when is more than 5%, it is particularly effective against the psychrotrophic microorganisms which cause spoilage of chilled foods.
- Significant preservative effects have been demonstrated with fresh fermented meats and fish and also fruits and milk. Mechanisms of inhibition of microorganisms by CO_2 are not fully understood. The most likely mode of action is the inhibition of the decarboxylation reaction in living cells.

b. Sulphur dioxide (SO_2):

- Sulphur dioxide, sulphite ($[SO_3]^{2-}$), bisulfite ($[HSO_3]^{-}$) and metabisulphite ($[S_2O_4]^{2-}$) are used as preservatives in wine, fruit juices, sausages and other foods.
- As antioxidants they are used to inhibit various enzyme-catalysed reactions notably enzymatic and non-enzymatic browning.
- Bisulfite has been shown to accumulate in yeast at concentrations 50-fold greater at pH = 3.6 than at higher pH. The bisulfite ion has greater inhibitory activity towards bacteria and fungi than the sulphite ion.

c. Nitrite and nitrate:

- Nitrite and nitrate, as their sodium and potassium salts, are widely used in fermentation of meat products and the curing of pork during ham producing and bacon.
- Originally added together with sodium chloride these compounds are important because they stabilise the red meat colour and inhibit the growth of pathogenic and spoilage microorganisms.
- Many bacteria reduce nitrate to nitrite and it is the latter that helps to prevent microbial spoilage. The antibacterial effectiveness of nitrite increases as pH is lowered. Nitrite inhibits the growth of *Cl. botulinum*, which would otherwise present an unacceptable risk in such products. Nitrite also helps to prevent rancidity in cured meats.

- **Self-Assessment Exercise 3**

1. List and explain three conventional methods of food preservation

2. Which of the following preservatives are used in meat curing and fermentation?
   A. Organic acids
   B. Carbondioxide (CO_2)
   C. Nitrite and Nitrate
   D. Sulphurdioxide (SO_2)

1.6 Summary

Environmental factors such as temperature, humidity, oxygen and light which can be reason for several reaction mechanisms that may lead to food deterioration to such an extent that they are either rejected by or harmful to the consumer. Microbial effects are also the leading cause of food deterioration and spoilage.

1.7 Reference/Further Reading

1. Heldman, D.R., & Hartel R.W. (1997). Principles of food processing. New York: Chapman & Hall. Hiddink, J. (1975). Natural convection heating of liquids, with reference to sterilization of canned food.
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3. Rozum, J. (1995). Smoke Flavouring in Processed Meat, Flavour of Meat, Meat Products and Seafood, Shahidi, F. ed., Blackie Academic and Professional, London
4. Sung, H. P., Lamsal, B.P. & Balasubramaniam, V.M. (2014). Principles of Food Processing In: *Food Processing: Principles and Applications*, Second Edition. Edited by Stephanie Clark, Stephanie Jung, and Buddhi Lamsal. Pp. 1-15.

1.8 Possible Answers to SAE's

Answer to SAE's 1

1.True

2. Processing of foods is a segment of manufacturing industry that transforms animal, plant, and marine materials into intermediate or finished value-added food products that are safer to eat.

Answer to SAE's 2

1a. To produce value-added products

1b. To overcome seasonal production in agriculture

2. True

Answer to SAE's 3

1a. preservation by low pH

b. preservation by organic acids

c. preservation by carbon dioxide, sulphur dioxide, nitrite and nitrate

2. Nitrite and Nitrate

UNIT 2.0: FOOD DETERIORATION

CONTENT

2.1 Introduction

Deterioration is a continuing process that begins the moment an animal is slaughtered or a plant is harvested and continues until the item is no longer recognizable as a food item or is literally reduced to dust. Some of the techniques that are used to slow down the continuous changes are freezing, drying, blanching, use of additives, and canning.

2.2 Learning Outcomes

By the end of this unit, you will be able to:

- Explain the concept of food deterioration
- Discuss major causes of food deterioration
- Discuss some techniques used in curbing food deterioration

2.3 Concept of food deterioration

2.3.1 Definition of food deterioration

Food Deterioration is defined as a series of continuous degradative changes occurring in a food item which may affect the product's wholesomeness, result in a reduction of its quality, and/or alter its serviceability. Some deterioration occurs through the spontaneous breakdown of complex organic molecules. Food can also be consumed by other animals, notably certain insects and rodents. However, most spoilage of food meant for human consumption is caused by microorganisms, which effectively compete with humans for limited and valuable food resources. To help prevent microbe-caused food spoilage, humans use two main strategies:

(1) obstructing colonization by reducing access to susceptible foodstuffs and

(2) inhibiting population growth and limiting population size by creating an unfavorable environment.

Because microbes are so small, have such enormous populations, and often disperse as resistant air-, water-, or soilborne spores, they rapidly colonize unprotected foodstuffs. Colonization can be retarded by covering or otherwise isolating foods, but it can be prevented only by sealing sterile food in an impermeable container. For example, many fruits, nuts, and bird eggs are encased in relatively impermeable skins, shells, or waxy layers that resist microbial invasion. This is also the principle behind canning. The alternative, more commonly employed strategy is to retard spoilage by creating conditions that inhibit the growth or limit the size of microbial populations. Washing food, for example, removes some microbes from the surface, and techniques such as pasteurization and irradiation kill microbes.

2.3.2 Major causes of food deterioration

The point that foods do deteriorate has been adequately made; but what are the causes of food deterioration? There are six major causes of food deterioration—

- Microorganisms
- action of enzymes
- chemical reactions
- physical changes
- insects and/or rodents.

These causes are not isolated in nature. Bacteria, insects, and light, for example, can all be operating simultaneously to deteriorate food in the field or in a warehouse. Similarly, such causes as high temperature, moisture, and air will all affect the multiplication and activities of bacteria, as well as the chemical and enzymatic activities of the food. At any one time, many forms of deterioration may be in progress, depending upon the food and environmental conditions. Total food preservation, an ideal that can only be approached, requires that we eliminate or minimize all of these causes that may affect a susceptible food.

2.3.3 Deterioration by microorganisms

- The microorganisms that are principally involved in food deterioration are bacteria, molds, and yeasts. There are thousands of genera and species of microorganisms. Several hundred are associated in one way or another with food products.
- Not all cause food spoilage, and many types are used in preserving foods, such as the lactic-acid-producing organisms of cheese, sauerkraut, and some types of sausage. Other microorganisms are used for alcohol production as in wine or beer making, or for flavour production in other foods.

a. **Bacteria.**

- Bacteria are unicellular microorganisms of many forms, although three principal shapes of the individual cells predominate.
- These are the spherical shape represented by several forms of cocci, the rod shape of the bacilli, and spiral forms possessed by the spirilla.
- Some bacteria produce spores which are remarkably resistant to heat, chemicals, and other adverse conditions. Bacterial spores are far more resistant than yeast or mold spores, and more resistant to most processing

conditions than natural food enzymes. All bacteria associated with foods are small.

b. **Moulds.**

- Moulds are larger than bacteria and yeast and more complex in structure. They grow by a network of hair-like fibers called mycelia and send up fruiting bodies that produce mold spores referred to as conidia.
- The blackness of bread mould and the blue-coloured veins of blue cheese are due to the conidia, while beneath the fruiting heads, the hair-like mycelia anchor the mould to the food.

c. **Yeasts**

- Yeasts are somewhat larger than bacteria, of the order of 20 microns in individual cell length and about half this size in diameter. However, yeasts are smaller than moulds. Most yeasts are spherical or ellipsoidal in shape.
- Yeasts are associated with nearly all types of food products. Foods such as fresh vegetables, meat, poultry,nd cheese often contain yeasts, but in these foods, bacteria outgrow the yeasts.

2.3.4. **Action of food enzymes**

- The second major cause of food deterioration is the actions of food enzymes. Enzymes are organic catalysts which are produced by the cells of animals, plants, or bacteria. We know that microorganisms possess enzymes which produce fermentation, rancidity, and putrefaction of foods. Likewise, uninfected food plants and animals have their own enzyme complement, the activity of which largely survives harvest and slaughter.

- Unless these enzymes are inactivated by heat, chemicals, or some other means, they continue to catalyze chemical reactions within foods. Some of these reactions, if not allowed to go too far, are highly desirable, for example, continued ripening of tomatoes after they are picked and natural tenderizing of beef on aging. But ripening and tenderizing beyond an optimum point become food deterioration. The weakened tissues are subject to microbial infections and the deterioration reaches the point of rotting. This can happen in the field, commissary, and home refrigerator, given sufficient time.

Self Assessment Exercise 1

1. State three microorganisms that cause food spoilage
2. State three causes of food deterioration

2.4 Chemical reactions and physical changes as causes of deterioration

2.4.1 Chemical reactions

Another major cause of food deterioration is chemical reactions. Chemical reactions in foods are sometimes very complex and subtle. Chemical reactions, excluding the action of enzymes, are responsible for such diverse deteriorative changes as oxidation, color changes, reactions between a food container and its contents, and the coagulation of proteins.

2.4.3 Causes of Physical changes: Low Temperature

Physical changes may not cause a food to become spoiled, but they do cause deteriorative changes which may cause the food item to be unsuitable for intended use. Some of the physical changes which cause deteriorative changes in foods are as follows.

a**. Low Temperature**.

a. **Freezing and undesirable changes**: Freezing of many foods will cause undesirable changes, such as the destruction of emulsions and texture. freezing may cause emulsified products, such as salad dressing and mayonnaise to lose their emulsion and the fat and water will separate into distinct layers. Fruits and vegetables that are allowed to freeze and then thaw will have their texture disrupted.

b. **Cold damage**: Cold damage to foods does not necessarily require the extreme of freezing. Many fruits and vegetables, like other living systems, have optimum temperature requirements after harvest. Held at common refrigeration temperatures of about 41ºF (5ºC), several fruits and vegetables are weakened or killed and deteriorative processes follow. The deteriorations include off-colour development, surface pitting, and various forms of decay. Bananas, lemons, squash, and tomatoes are examples of products that should be held at temperatures no lower than 50ºF (10ºC) for maximum quality retention. This provides an exception to the inaccurate generalization that cold storage preserves all foods, and the colder the better.

2.4.3 Causes of Physical changes: High Temperature

- There is a moderate temperature range over which much food is handled, such as 50º-100ºF (10º-38ºC). Within this range, for every 18ºF (10ºC) rise in temperature, the rate of chemical reaction is approximately doubled. This includes the rates of many enzymatic as well as nonenzymatic reactions. Excessive heat can denature proteins, break emulsions, dry out foods by removing moisture, and destroy vitamins.

a. **Effect on vegetables:** Excessive heat in green vegetables causes cell walls and membranes to lose their integrity and acids and enzymes to be released. All of these result in the development of a soft texture as well as the development of off colours and off-flavours.

b. **Effect on muscle tissue.** The consequences of excessive heat on muscle tissue are that proteins are denatured, the proteins clump together, and enzymes are inactivated. This results in a toughening of the texture, loss of water holding capacity, cooked or caramel flavours, and development of off-colours.

2.4.4 Causes of Physical changes: Dehydration

- Dehydration, another form of physical change that causes food deterioration, can be simply defined as the loss of water from the food product. Foods, especially fresh, chilled, and frozen, are subject to dehydration.
- **Signs of dehydration**: The signs of dehydration include dryness or shriveling on the surface of the food item. The development of off-colors, usually a darkening effect, will also be observed.

2.4.5. Causes of Physical changes: Mechanical damage

- **Entering point for microorganism**s: When an item receives mechanical damage, not only is the appearance of the item affected but the damaged food tissue also becomes more susceptible to other forms of deterioration. Mechanically damaged foods are more susceptible to invasion by microorganisms, for the damaged area serves as a port of entry.

- **Starting point for enzyme activity**: The cell walls of foods are also destroyed by mechanical abrasion, and the inherent enzymes in the food product are liberated from the cells. Once liberated, the enzymes begin the process of deterioration or, more specifically, autolysis. The changes noted would be a softening in the texture, development of off-colors, and development of off-flavors.

2.4.6 . Insects and Rodents

Insects are particularly destructive to cereal grains and to fruits and vegetables

a. **Opening for decay**: The insect problem is not just one of how much an insect can eat, but when insects eat, they damage the food and open it to bacteria, yeast, and mold infection. A small insect hole in a melon, not so bad in itself, can result in the total decay of the melon from bacterial invasion.

b. **Rodents**. The problem with rodents is not only the quantity of food they consume, but also the filth with which they contaminate foods. Rodents' urine and droppings may harbor several kinds of disease-causing bacteria. Rodents can be directly or indirectly involved in the transmission of such diseases as salmonellosis, leptospirosis, and murine typhus. One rat pill, or fecal dropping, can contain several million bacteria. Even if the pill does not get into food directly, it will become dry and fall apart or be crushed. The particles then may be blown or carried into food.

c. **Control of Insects and Rodents**. Insects and rodents may be effectively controlled by following three rules.

(1) Keep insects and rodents out of facilities by pest-proofing the building.

(2) Deprive pests of food and shelter by following good housekeeping practices.

(3) Use appropriate control measures to exterminate pests.

Rat eating stored grains.

Self -Assessment Exercise 2

1. Storing bananas at temperatures lower than 10^{o}C can cause their rapid deterioration. True or false
2. Rodents cause food deterioration by their direct attack on the food product only. True or false

2.5 Some techniques used in curbing food deterioration

- Spoilage organisms are not originally an integral part of foods but are widely present in water, soil, air, and other animals. Healthy living plants and animals can ward off bacteria and fungi, but as soon as they are slaughtered or harvested their defenses deteriorate and their tissues become susceptible to spoilage microbes.

- Good manufacturing practices with strict attention to sanitation and hygiene can prevent colonization by many, but not all, microbes and are the most important first step in delaying the spoilage process. Microbes require certain conditions for growth, and therefore management of the environment of foods can change these factors and delay spoilage:

2.5.1 Control of temperature and moisture

- Many, but not all, microbes grow slowly or not at all at low temperatures, and refrigeration can prolong the lag phase and decrease growth rate of microbes.
- Many microbes require a high water activity and therefore keeping foods such as grains and cereal products dry will help to preserve them.

2.5.2. Control of oxygen

- Some microbes require oxygen, others are killed by oxygen, and still others are facultative. Managing the atmosphere during storage in packaging can retard or prevent the growth of some microbes. Several types of modified atmosphere packaging (MAP) have been developed to retard growth of pathogenic and spoilage organisms.

Self -Assessment Exercise 3

1. The best way to preserve cereals is to first of all ----- them
2. The full meaning of MAP is ------------------

2.6 Summary

Healthy living plants and animals can ward off bacteria and fungi, but as soon as they are slaughtered or harvested their defenses deteriorate and their tissues become susceptible to spoilage microbes. Good manufacturing practices with strict attention to sanitation and hygiene can prevent colonization by many, but not all, microbes and are the most important first step in delaying the spoilage process. Hence, Processing technologies, in addition to thermal processing, are being developed to kill spoilage microbes.

2.7 References/Further Readings

1. Hammond, S. T., Brown, J. H., Burger, J. R., Flanagan, T. P., Fristoe, T. S., Mercado-silva, N., Nekola, J. C.& Okie, J. G (2015). Food Spoilage, Storage, and Transport: Implications for a Sustainable Future. *BioScienc*e, 1–11.

2.8 Answers to SAE's

SAE 1

1. Bacteria, moulds and yeasts
2.
   - Microorganisms
   - action of enzymes
   - chemical reactions
   - physical changes
   - Insects and rodents

Self -Assessment Exercise 2

1. True
2. True

Self -Assessment Exercise 3

1. Dry them

2. Modified atmospheric packaging

MODULE 2: RAW MATERIALS AND THEIR SIGNIFICANVE IN FOOD PROCESSING

UNIT ONE: RAW MATERIALS SELECTION

1.1 Introduction

1.2 Learning Outcomes

1.3 Raw Material Selection

1.3.1 Importance of proper raw material selection

1.3.2 Other reasons for proper raw material selection

1.4 Properties of raw materials

1.4.1 Geometric properties

1.4.2 Colour

1.4.3 Texture

1.4.4 Flavour

1.4.5 Functionality

1.5. Summary

1.6 References/Further Readings

1.7 Possible Answers to Self-Assessment Exercise(s)

1.1 Introduction

The selection of raw materials is a vital consideration to the quality of processed products. The quality of raw materials can rarely be improved during processing and, while sorting and grading operations can aid by removing oversize, undersize or poor quality units, it is vital to procure materials whose properties most closely match the requirements of the process.

1.2 Learning Outcomes

By the end of this unit, you will be able to;

1. Discuss the importance of raw material selection
2. The important properties of raw matrerials

1.3 Raw Material Selection

Proper Raw material selection is vital before processing because it will go a long way to determining the quality of the finished product. The food processor must therefore ensure that farmers supply raw materials of high quality.

1.3.1 Importance of proper raw material selection

1. The quality of end products is influenced primarily by the raw materials used. For this reason, close cooperation between agriculture and processing plants is needed.
2. In all cases the raw material must fulfill all hygienic requirements.
3. Great attention is paid to the presence of different kinds of contamination, such as heavy and toxic metals, toxic metabolites of microorganisms, residues of pesticides, the presence of GM material, and others.
4. In perishable raw materials, the microbiological quality of the raw material plays an important role and has to be controlled.

5. The water content of many raw food materials has the biggest influence on its storability. The water content and weight during acceptance are closely followed.

1.3.3 Other reasons for proper raw material selection

1. The farmers, in many cases, make agreements with the food industry, not only on the quantity of raw materials produced, but above all on their quality.

2. The quality of raw material is evaluated, and farmers are paid according to that quality (for example for wheat, milk, eggs, and so on).

For quality control of individual raw materials, different quality parameters are chosen, according to the quality requirements of products for which the raw material will be used. For example, wheat quality, after water content, will be tested on the amount and bakery quality of gluten. For quality evaluation of fruits, in addition to their appearance, the content of ascorbic acid, sugar, and acidity is controlled. In meat especially the fat content is followed.

Self-Assessment Exercise 1

1. Give two reasons why raw material selection is vital before processing.

2. The quality of end products is influenced primarily by the raw materials used. True or False?

1.4 Properties of raw materials

- The main raw material properties of importance to the processor are:

1. Geometry

2. Colour

3. Texture

4. Functional properties

5. Flavour.

1.4.1 Geometric properties

- Food units of regular geometry are much easier to handle and are better suited to high speed mechanised operations.
- In addition, the more uniform the geometry of raw materials, the less rejection and waste will be produced during preparation operations such as peeling, trimming and slicing.
- For example, potatoes of smooth shape with few and shallow eyes are much easier to peel and wash mechanically than irregular units.
- Smooth-skinned fruits and vegetables are much easier to clean and are less likely to harbour insects or fungi than ribbed or irregular units

1.4.2 Colour

- Colour and colour uniformity are vital components of visual quality of fresh foods and play a major role in consumer choice.
- However, it may be less important in raw materials for processing.
- For low temperature processes such as chilling, freezing or freeze-drying, the colour changes little during processing, and thus the colour of the raw material is a good guide to suitability for processing.
- For more severe processing, the colour may change markedly during the process.

- Green vegetables, such as peas, spinach or green beans, on heating change colour from bright green to a dull olive green. This is due to the conversion of chlorophyll to pheophytin.
- It is possible to protect against this by addition of sodium bicarbonate to the cooking water, which raises the pH.
- However, this may cause softening of texture and the use of added colourants may be a more practical solution.

1.4.3 Texture

- The texture of raw materials is frequently changed during processing.
- Textural changes are caused by a wide variety of effects, including water loss, protein denaturation which may result in loss of water-holding capacity or coagulation, hydrolysis and solubilisation of proteins.
- Texture is dependent on the variety as well as the maturity of the raw material and may be assessed by sensory panels or commercial instruments.
- One widely recognised instrument is the tenderometer used to assess the firmness of peas.
- The crop would be tested daily and harvested at the optimum tenderometer reading.

1.4.4 Flavour

- Flavour is a rather subjective property which is difficult to quantify.
- Again, flavours are altered during processing and, following severe processing, the main flavours may be derived from additives.
- Hence, the lack of strong flavours may be the most important requirement.

- In fact, raw material flavour is often not a major determinant as long as the material imparts only those flavours which are characteristic of the food.
- Flavour is normally assessed by human tasters, although sometimes flavour can be linked to some analytical test, such as sugar/acid levels in fruits.

1.4.5 Functionality

- The functionality of a raw material is the combination of properties which determine product quality and process effectiveness.
- These properties differ greatly for different raw materials and processes, and may be measured by chemical analysis or process testing.
- For example, a number of possible parameters may be monitored in wheat.
- Wheat for different purposes may be selected according to protein content. Hard wheat with 11.5–14.0% protein is desirable for white bread and some whole wheat breads require even higher protein levels, 14–16%.

Chemical analysis of fat and protein in milk may be carried out to determine its suitability for manufacturing cheese, yoghurt or cream.

Self-Assessment Exercise 2

1. Mention two properties of raw materials that are of importance to a food processor.

2. The combination of properties of a raw matrial which determine product quality and process effectiveness is known as -----------------

1.5 Summary

Every food processor desires to have good finished products at the end of the day. The first step to take towards obtaining high quality finished products that will be accepted by consumers is to ensure that the raw materials are equally of high quality. Bad raw materials cannot be made good during food processing.

A food processor must therefore must ensure that only good grade raw materials are supplied to him.

1.6 References/Further Readings

1.7. Possible Answers to Self-Assessment Exercise(s)

Self-Assessment Exercise 1

1. Reasons why raw material selection is vital before processing

a. To get end products of desired quality

b. To fulfill all hygienic requirements.

c. To maintain food safety

d. For proper storagebility

2. True

Self-Assessment Exercise 2

1. geometry, colour, flavour, texture, functionality etc.
2. functionality

UNIT 2 RAW MATERIALS: TYPES, TREATMENT AND STORAGE

Content

2.1 Introduction

In this unit, you will learn the different types of raw materials that may be used in a food processing industry. you will also learn the unit operations involved in the processing of these raw materials as well as their methods of preservation.

Factors that cause deteriorative changes in raw materials as well as the various treatments given to raw materials prior to processing are discussed. finally, the storage and transportation of raw materials are discussed.

2.2 Learning Outcomes

By the end of this unit, you will be able to

1. Explain the different types of raw materials
2. Discuss the causes of deterioration of raw materials
3. Discuss the proper storage materials for different raw materials

2.3 Classes and Types of Raw Materials

2.3.1 Classes of raw materials

1. Unprocessed agricultural raw materials

- They are in their natural state e.g yam tuber, cassava, orange, grape, banana, maize grains, soybeans

2. Semi-processed agricultural raw material- These have undergone some preliminary processing e.g dried cocoa beans, malted grain, cassava chips, brown sugar, pasteurized milk

3. Finished products- These are outputs made from unprocessed and semi-processed agricultural raw material e.g refined sugar, flavor concentrates, flour, colouring agents etc.

4. By-products/Effluents of an industry- This serves as an input or raw material for another industry e.g fish gut used as feed

2.3.2 Raw Materials, Unit Operations for Processing and Preservation Methods

Meat processing and preserving	Beef, lamb, pork, poultry	Slaughtering, cutting up, boning, comminuting, cooking	Salting, smoking, refrigeration, deep-freezing, sterilization
Fish processing	All types of fish	Heading, gutting, filleting, cooking	Deep-freezing, drying, smoking, sterilization
Fruit and vegetable preserving	Fresh fruit and vegetables	Blanching or cooking, grinding, vacuum- concentration of juices	Sterilization, pasteurization, drying, dehydration, lyophilization (freeze drying)
Milling	Grains	Grinding, sifting, milling, rolling	Drying cooking or baking
Meat processing and preserving	Beef, lamb, pork, poultry	Slaughtering, cutting up, boning, comminuting, cooking	Salting, smoking, refrigeration, deep-freezing, sterilization
Fish processing	All types of fish	Heading, gutting, filleting, cooking	Deep-freezing, drying, smoking, sterilization
Fruit and vegetable preserving	Fresh fruit and vegetables	Blanching or cooking, grinding, vacuum- concentration of juices	Sterilization, pasteurization, drying, dehydration, lyophilization (freeze drying)
Milling	Grains	Grinding, sifting, milling, rolling	Drying cooking or baking
Baking	Flour and other dry goods, water, oils	Kneading, fermentation, laminating surface treatments of seasoning	

Biscuit making	Flour, cream, butter, sugar, fruit and seasoning	Mixing, kneading, laminating moulding	
Pasta manufacture	Flour, eggs	Kneading, grinding, cutting, extrusion or moulding	
Sugar processing and refining	Sugar beet, sugar cane	Crushing, maceration, vacuum concentration, centrifuging, drying	
Distilling and manufacture of other beverages	Fruit, grain, carbonated water	Distillation, blending, aeration	Pasteurization
Milk and milk products processing	Milk, sugar, other constituents	Skimming, churning (butter), coagulation (cheese), ripening	Pasteurization, sterilization or concentration, desiccation
Processing of oils and fats	Groundnuts, olives, dates, other fruit and grain, animal or vegetable fats	Milling, solvent or steam extraction, filter pressing	Pasteurization where necessary

Self Assessment Exercise 1

1. Three types of raw materials are ---------------, --------------- and --------------
2. Three raw materials needed for the making of biscuits are ----------------, ---------------- and -------

2.4 Deterioration and Treatment of raw materials

2.4.1 Deterioration of raw materials

- All raw materials deteriorate following harvest, by some of the following mechanisms:

- Endogenous enzymes: oxidation of phenolic substances in plant tissues by phenolase (leading to browning), sugar-starch conversion by amylases
- Chemical changes: deterioration in sensory quality by lipid oxidation, non-enzymic browning, breakdown of pigments such as chlorophyll, anthocyanins, carotenoids.
- Nutritional changes: especially ascorbic acid breakdown.
- Physical changes: dehydration, moisture absorption.
- Biological changes: germination of seeds, sprouting.
- Microbiological contamination: both the organisms themselves and toxic products lead to deterioration of quality, as well as posing safety problems.

2.4.2 Treatment of raw materials (pre-processing operations)

- Cleaning
- Sorting
- Grading
- Dehulling
- Peeling
- Packaging
- Storage

2.4.3 Raw material cleaning and Sorting

- Cleaning methods-dry cleaning methods, wet cleaning methods

- Dry cleaning methods- screening, abrasion cleaning, aspiration cleaning, magnetic cleaning,
- Wet cleaning methods- soaking, spray washing, flotation washing,
- See Handout on
- Cleaning of raw materials,
- Sorting and grading of foods

Sorting

- It is the separation of raw materials into categories based on weight, size, shape, colour
- It allows separation of undesirable additional materials e.g leaves, stones
- It allows removal of immature or rotten raw materials, ensuring only good quality material are passed into the processing line
- Size sorting separates solids into different fractions based on size by sieving or screening
- Size sorting is important for materials which have to be heated or cooled as differences in size can lead to under-processing or over- processing
- Sieves and screens used in size sorting can have fixed or variable appertures and may be stationary, rotating or vibrating

2.4.4 Grading and Dehulling

- It is an assessment of different characteristics of a food material to determine its overall quality

- It is usually carried out by trained operators (inspectors) and hence is more expensive than sorting
- Meat is graded for fat distribution, carcasse size, disease and shape
- Grading is sometimes based on laboratory analyses/results

Dehulling

- It involves the removal of hulls, seed coats, brans or shells from legumes, cereals, cocoa beans etc.
- It can be achieved via wet or dry method and its efficiency depends on the thickness of the seed coat
- Dehulling may be preceded by heating process to facilitate removal of the hull, known as conditioning

2.4.5 Peeling

- Peeling aims at removing unwanted or inedible materials from food raw materials
- It improves the appearance and taste of the final product
- During peeling, losses must be minimized by removing as little as possible of the underlying raw material
- Peeling can be achieved by steam peeling, knife peeling (citrus fruits), abrasion peeling (using abrasive rollers), caustic peeling (1-2% sodium hydroxide), flame peeling (using high temperatures) e.g for removing root hairs and skins of onions.

Fig 1:Fruit sorting and grading machine

Self Assessment Exercise 2

1. Oxidation of phenolic substabnces in plant tissues by phenolase is an example of ------------ degradation

2. The separation of raw materials into categories based on weight, size, shape, colour is known as ----------

2.5 Storage, transportation and factors that govern quality of raw materials

2.5.1 Storage and transprtoation of raw materials

- Storage of food is necessary at all points of the food chain from raw materials, through manufacture, distribution, retailers and final purchasers.
- Today's consumers expect a much greater variety of products, including nonlocal materials, to be available throughout the year.
- Effective transportation and storage systems for raw materials are essential to meet this need.
- Storage of materials whose supply or demand fluctuate in a predictable manner, especially seasonal produce, is necessary to increase availability.
- It is essential that processors maintain stocks of raw materials, therefore storage is necessary to buffer demand.
- However, storage of raw materials is expensive for two reasons: firstly, stored goods have been paid for and may therefore tie up quantities of company money and, secondly, warehousing and storage space are expensive.

2.5.3 The main factors which govern the quality of stored foods

Factors that govern quality of stored foods include:

1. Temperature: The rate of biochemical reactions is related to temperature, such that lower storage temperatures lead to slower degradation of foods by biochemical spoilage, as well as reduced growth of bacteria and fungi.

2. Moisture/humidity: Uptake of water during storage is associated with susceptibility to growth of microorganisms, whilst water loss results in economic loss and more specific problems, such as cracking of seed coats of cereals, or skins of fruits and vegetables.

- Controlling the atmospheric composition during storage of many raw materials is beneficial.
- Packaging may be used to allow the development or maintenance of particular atmospheric compositions during storage

3. Atmospheric composition

- With some materials, the major aim is to maintain an oxygen-free atmosphere to prevent oxidation, e.g. coffee, baked goods, while in other cases adequate ventilation may be necessary to prevent anaerobic fermentation leading to off flavours

Self- Assessment Exercise 3

1. Mention one advantage and one disadvantage of storage of raw materials
2. High humidity storage areas are beneficial for storage of dried products. True or false

2.6 Summary

In this unit, you have learnt the different types of raw materials that are used in n a food processing industry. Raw materials can come in form of the raw primary form for example raw tomatoes for the production of tomato paste or finished product from another industry for example flour for the baking of bread.

Raw materials have to go through a number of unit operations to convert them to finished products.. It is important to store and preserve both the raw and finished products to prevent deterioration and spoilage. the raw and finished materials need to be stored properly to maintain wholesomeness and food safety

2.7 Reference/Further Reading

2.8 Possible Answers to SAE's

Self Assessment Exercise 1

1. Unprocessed agricultural raw material, Semi-processed agricultural raw material, Finished products and By-products/Effluents of an industry.
2. Flour, cream, butter, sugar, fruit, seasoning etc

Self Assessment Exercise 2

1. Enzymic deterioration
2. sorting

Self Assessment Exercise 3

1. Advantage -Storage makes it possible to produce foods all year round ie both during season and off season of raw materials .

   Disadvantage - Storage costs money
2. **False**

MODULE 3: DIFFERENT PRESERVATION METHODS

UNIT 1: FUNDAMENTALS OF HEAT AND COLD IN PRESERVATION

Content

1.1 Introduction

Food preservation consists of the application of science-based knowledge obtained through a variety of available technologies and procedures to prevent spoilage of food and food products and extend their shelf life, ensuring the consumers at the same time that the product retains its nutritional value and is free of pathogenic microorganisms. Shelf life of food may be defined as the duration for which it is edible, that is, its nutritional value has not declined to an unacceptable level. Spoilage of foods will result in loss of quality attributes, including flavor, texture, color, and other sensory properties. Nutritional quality is also affected during food spoilage. Physical, biological, microbiological, chemical, and biochemical factors may cause food spoilage or losses in the food production line. Preservation methods should be applied as early as possible in the food production after postharvest handling of both plant and animal foods. Selection of technology and procedures for food preservation depends on factors inherent to the product, common pathogenic and spoilage microorganisms, and cost. Food preservation aims at preventing and reducing the loss of food in the production system and extending its shelf life.

1.2 Learning Outcomes

By the end of this unit, you will be able to

- Discuss different forms of cold preservation or storage
- Discuss the effects of low temperature on foods
- Explain the changes that occur in foods during refrigeration and frozen storage

1.4 Cold Preservation

1.3.1 Introduction to cold preservation method

- Preservation of food at low temperature includes two different processes *i.e.* chilling and freezing. Chilling comprises the use of temperature between 0°C to 8°C, whereas freezing involves the use of temperatures lower than the freezing point, normally below −18°C. The preserving action of the process of freezing is due to the low temperature as well as due to the low water activity created by the transformation of water to ice .

- Refrigeration, as well as freezing, has turned to be a crucial part of the food chain. These techniques are utilized in all stages of food chain depending on the type of food product to be preserved *i e.* from processing to distribution of product, and finally its consumption. In both of these unit operations, heat energy is taken out from foods and a lower temperature is maintained all through the storage period to slow down all biochemical reactions responsible for the deterioration of food. The refrigeration and freezing technologies, both are of great importance in that these slow down the progression of bacteria as well as other microorganisms and decrease the chances of food spoilage and wastage of food thereby reducing the economic losses to the manufacturer as well as preventing the various foodborne illness caused due to rapid multiplication of bacteria and other microorganisms. These technologies are widely used in food and beverage industries for the preservation of desired properties in the products (Mudgil & Barak, 2018).

1.3.2 Cold Storage and Freezing

- Cold or refrigerated storage involves keeping foods beneath ambient conditions and above freezing temperature, normally between −2 to ~16 ºC.
- Many highly perishable raw products (like poultry and milk) are quickly chilled before further processing to inhibit any microbiological growth in raw food products.
- During frozen storage, food products are kept at temperatures ranging from −12 to −18 ºC.
- Types of freezing methods

a. air-blast freezing - food packages are kept on a belt that is moved through a tunnel having a temperature of -29 to -40 ºC at air velocities of 10-15 m/s.

b. indirect contact freezing: solid foods are kept in metal plates chilled with the help of any suitable refrigerant, so that food remains in close contact with the metal wall but not with refrigerant

c. direct contact or immersion freezing: Food items are immersed in low boiling point refrigerants such as liquid nitrogen (BP -196 ºC), liquid carbon dioxide (BP -79 ºC) and freon 12 (BP -30 ºC).

Self-Assessment Exercises 1

1. ___________ and _______________ are the two different processes involved in low temperature or cold preservation.
2. During frozen storage, food products are kept at temperatures ranging from ___ to ____

1.4 Definitions of terms

- **1.4.1 Refrigeration**

  It is defined as the process of chilling a substance, space or any systems to reduce its temperature lower than the ambient conditions or we can say that it is an artificial cooling. Heat is extracted from a low-temperature pool and moved to a high-temperature reservoir usually by mechanical methods but other means such as magnetism, laser, heat, electricity can also be used. It has many applications in preserving food at the household or industrial level.

- **1.4.2 Chilling**

  The process of preserving food products at a temperature higher than that of freezing but lower than 15ºC is known as chilling. It decreases the speed of biochemical as well as microbiological alterations and prolongs the shelflife of raw as well as processed food products. There are minimal changes in the sensory and nutritional characteristics of food products.

- **1.4.3 Super-chilling**

The process of cooling foodstuffs to a temperature somewhat lower than the initial freezing point (1–2 °C) is known as super-chilling. Only a small proportion of the water present in food is converted to the ice at this temperature. There is a minor depression in water activity, but preservation is mainly caused due to maintenance of the low-temperature conditions. As most of the water in this method of food preservation exists in liquid form in different foods, the damaging effects of the complete freezing process are avoided in this process. This is of additional advantage especially in case of super-chilling of fish. There is no freezing of fish, during preservation by this technique, thereby maintaining freshness and shelf-life for a longer duration, in comparison to transportation and storage in frozen conditions (Duun et al., 2008, Fatima et al., 1988).

- **1.4.4 Freezing:**

This technique involves reducing the temperature of food product below their freezing point resulting in the conversion of all water content of food to ice-crystals (Fellows, 2009). Process of freezing is a combination of the advantageous effects of low temperature which helps in minimizing the growth of microorganisms, chemical changes in food products get decreased and metabolic reactions at the cellular level get delayed .

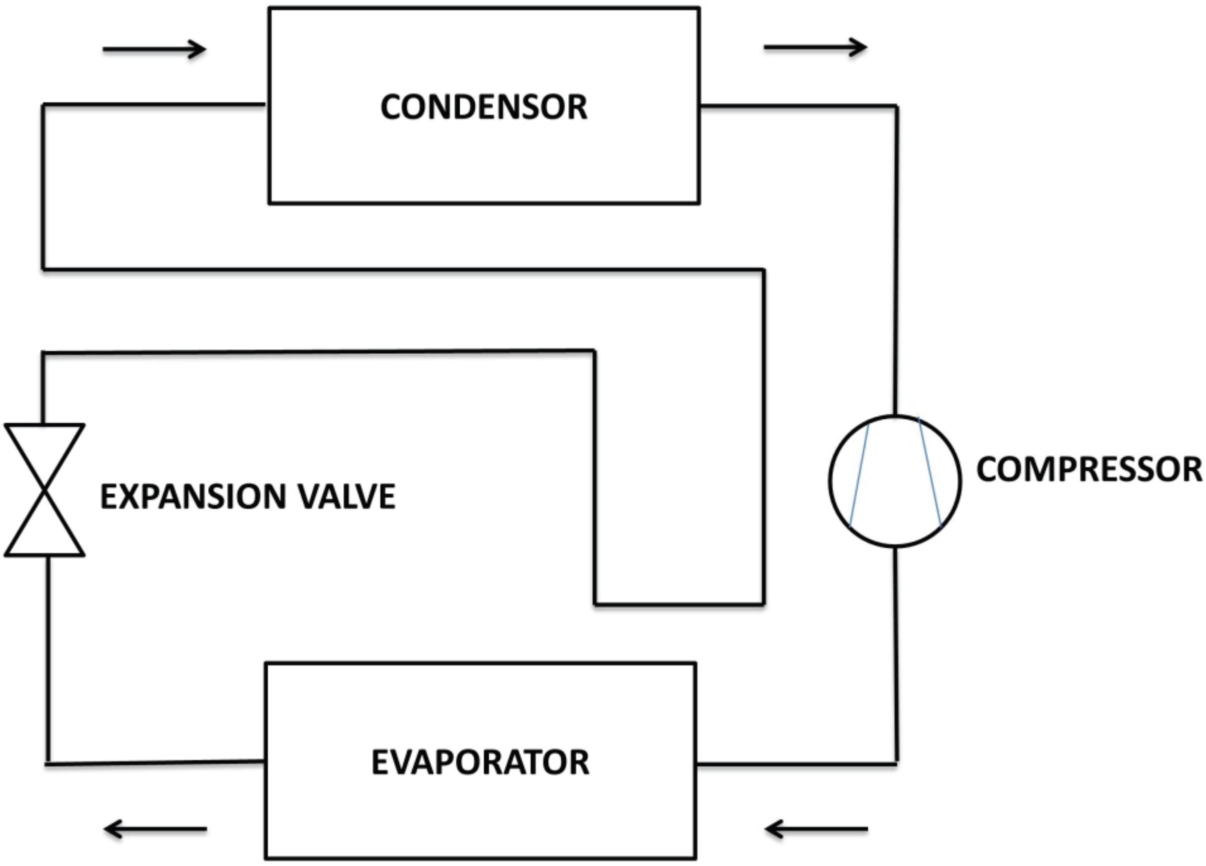

Figure 1. Mechanism of vapor compression refrigeration system

Self- Assessment Exercise 2

1. The process of preserving food products at a temperature higher than that of freezing but lower than 15ºC is known as -----------
2. The technique that involves reducing the temperature of food product below their freezing point resulting in the conversion of all water content of food to ice-crystals is known as ---------

1.5 Freezing and Food Quality

1.5.1 Effect of Low Temperature on Food

- Freezing denotes the best method of preservation in relevance to the quality of food
- . There is a minimum effect on nutritional value, as well as sensory characteristics such as color and flavor of foods.
- The texture is the major quality characteristic of frozen food that gets severely affected during the freezing process. Freezing causes foods to softening and poor texture of foods. This loss of texture in cellular foods can be reduced by speeding up the rate of freezing as very small ice crystals are formed in a fast freezing process as compared to slow freezing resulting in minimum damage to food tissues .
- In frozen foods, the rate of reactions is usually slower, than ambient and refrigerated storage that results in slower deteriorative changes and increased shelf-life of products.

1.5.2 Changes in Foods during Refrigerated and Frozen Storage

- A quality characteristic of foods such as meat and fish is enhanced by rapid cooling and it has been reported in several studies that a faster rate of chilling results in lower drip losses in such foods.
- Weight loss in food materials having high water contents like vegetables, fruits, and meats products during freezing can be decreased by controlling the temperature of storage resulting in a higher yield of these foods. The practice of using fast chilling systems for pork meats has been reported to reduce weight loss by 1% as compared to conventional chilling systems (James et al., 1983).
- The temperature has a significant role in affecting the flavor during initial cooling as well as storage. The lower the temperature of storage the more the sweetness in fresh sweetcorn is conserved.

- The rate of ripening of fruits gets decreased as the temperature is lowered and ceases under the temperature of about 4 °C .
- Storage at freezing temperature obstructs the speed of chemical reactions responsible for causing the development of off-flavors throughout frozen storage,
- Freezing is unable to prevent reactions causing lipid oxidation and rancidity in oil containing foods and denaturation of proteins.
- Exposing foods to temperatures below a critical temperature range, but above temperatures, can cause chilling injury resulting in external or internal browning, failure to ripening, superficial spots, off-flavors development, etc.

Self- Assessment Exercise 3

3. Freezing has minimal effects on the nutritional value of foods. True or false
4. Moisture loss from meat during freezing and thawing is called ------------------

1.6 Summary

Low temperature maintained in the food system helps to slow down the chemical activities, as well as physical and microbiological changes that cause spoilage of different kinds of foods.

1.7 References/Further Readings

1. Berry, M., Fletcher, J., McClure, P., & Wilkinson, J. (2008). Effects of freezing on nutritional and microbiological properties of foods. In: Judith A. E. (ed.), Frozen food science and technology, Blackwell Publishing Ltd., London, UK, pp. 26-50.

2, Fellows, P. J. (2009). Food processing technology: principles and practice, Elsevier.

1.8 Possible Answers to SAEs

Self- Assessment Exercise 1

1. freezing and chilling
2. -12 to -18 ºC

Self- Assessment Exercise 2

1. Chilling
2. freezing

Self- Assessment Exercise 3

1. True
2. Drip loss

UNIT TWO: CHEMICAL AND BIOLOGICAL PRINCILPES OF FOOD PRESERVATION

Content

2.1 Introduction

. Chemical substances are the artificial preservatives that stop or delay the growth of bacteria, spoilage and its discoloration. These artificial preservatives can be added to the food or sprayed on the food. Several kinds of chemicals can be used for food preservation including propionic acid, sorbic acid, benzoic acid **,** and sulfur dioxide.

On the other hand, Biological preservation technologies can be classified as "biopreservation." Biopreservation is defined as the use of lactic acid bacteria (LAB), their metabolic products, or both to improve or ensure the safety and quality of foods that are generally considered fermented. LABs produce organic acids (weak acids), show antimicrobial effect on microorganisms, and reduce pH, which in turn prevent microbial growth. LAB can produce bacteriocins. Bacteriocins inhibit growth of some microorganisms.

Fermentative microorganisms change chemical composition of foods to increase digestibility and may increase storage life of food by metabolic end products.

2.2 Learning Outcomes

By the end of this unit, you will be able

1. Discuss different chemical preservatives
2. Discuss the different biological methods of food preservation

2.3 Chemical Preservatives

2.3.1 Definition and types of chemical preservatives

Chemical Preservatives: The quality of food product keeps decreasing with time, from its harvest or slaughter to its consumption. Quality loss may be due to microbiological, enzymatic, chemical, or physical changes. Food antimicrobial agents are chemical compounds added to or present in foods that retard microbial growth or kill microorganisms. However, food preservatives are antimicrobial agents (such as benzoic acid, nitrate, citric acid, and SO2) and antioxidants (such as butylated hydroxyanisole and citric acid).

Types of Artificial/ Chemical Food Preservatives

These are generally grouped as:

1. Antimicrobial agents
2. Antioxidants
3. Chelating agent

In antimicrobial the benzoates, sodium benzoate, sorbates and nitrites are generally used. Antioxidants include the Sulfites, Vitamin E, Vitamin C and Butylated hydroxytoluene (BHT) and the chelating agent like the disodium ethylenediaminetetraacetic acid (EDTA), polyphosphates and citric acid.

2.3.2. Some common chemical preservatives – Nitrates, Nitrities and Sulfites

a) **Nitrates and nitrites:** Nitrates are converted to nitric acids which form stable red colour in meat. Nitrites have inhibitory action against *Clostridium botulinum* in meat products but forms carcinogenic nitrosamine. It is also used to preserve meats such as sausage, ham, bacon, beef, etc. The side effects are: allergy, asthma, nausea, vomiting and headaches and sodium nitrite can be converted to nitrous acid in the body and cause cancer.

b) Sulfites (sulfur dioxide and metabisulfite): Sulfites form sulphurous acid which is active antimicrobial compound and can kill the microbial cell by reduction of sulphide linkage, formation of carbonyl compounds and inhibiting the respiratory mechanism. These are used to prevent fungal spoilage and browning of peeled fruits and vegetables.The commonly used level of sulphites is 0.005 -0.2% . The side effects are allerg, asthma, nausea, vomiting, joint pain, palpitation, and headaches.

2.3.3 **Some common chemical preservatives – Benzoate, propionates and sorbates**

a) **Sodium benzoate or benzoic acid:** They are more effective against yeast and molds and are used at a concentration of upto 0.2%. The action of benzoates against microorganisms are by inhibiting enzymes necessary for oxidative phosphorylation, inhibiting membrane protein function and also by destroying membrane potential. They are added to carbonated drinks, margarine, flour, pickles, fruit purees, and fruit juices. The side effects are severe allergic reaction and cancer.

b) **Propionates:** Calcium and sodium propionate are effective against mold and bacteria at 0.1-0.2% but not effective against yeast at this concentration. The inhibitory action is due to cytoplasm acidification and destabilization of membrane proton gradient.

c) **Sorbate:** Sodium, calcium or potassium salt is used at the concentration of 0.05-0.2%. It is more effective against yeast and mold than bacteria. The activity of sorbic acid increases as the pH decreases. Sorbic acid and its salts are tasteless and odourless when used at levels below 0.3%. It is used in non-alcoholic drinks, alcoholic drinks, processed vegetables and fruits and dairy desserts.

2.3.4 Some common chemical preservatives – BHT, BHA and the glycerides

a) **Butylated Hydroxytoluene (BHT) and Butylated Hydroxyanisole (BHA):** They serve as antioxidants that prevent the oxidation of fats (rancidity). They are used in preserving fresh meat, pork, sausages, potato chips &crackers, beer, baked goods, drink powder, dry cereals, and frozen pizza. These compounds have several side effects and they can cause cancer and liver disease.

b) **Mono-glycerides and Diglycerides:** They are used as preservatives for cookies, cakes, pies, bread, peanut butter, roasted nuts, shortening, and margarine. They may cause cancer and birth defects.

2.3.5 **Some common chemical preservatives – Salt and Sugar**

Salt and sugar: Salt and sugar have long been used as effective means of extending shelf life of various products as these solutes bind water, leaving less water available for the growth of microorganisms. Essentially the water activity (a_w) of the product is reduced. Since most microorganisms require a high water activity, they are unable to survive.

Self-Assessment Exercises 1

1. The following are chemical preservatives except?

a. Sodium benzoate

b. Nitrite

c. Bacteriocin

d. Butylated hydroxyltuolene and Butylated hydroxylanisole

2. Mention two side-effects that arise from using Nitrites in foods.

2.4 Biological Method of Food Preservation

2.4.1 Background of biological method of food preservation

- In response to consumer demand for more natural food preservation methods, biotechnology has been used to find ways of replacing synthetic preservatives in food.
- Since the role of micro-organisms in spontaneous food fermentation processes became clear, man has tried to apply ‘controlled’ fermentations in order to preserve food products.
- An increasing number of consumers prefer minimally processed food products, prepared with less or without chemical preservatives. The consumer wants food products to be ‘fresh’, ‘natural’, ‘healthy’ and ‘convenient’.
- Many of the new ready-to-eat and novel food types bring along new health hazards and new spoilage associations. Against this background and relying on improved understanding and knowledge of microbial interactions, milder preservation approaches such as the use of bio preservation is being advocated.

2.4.2 Biopreservation

- Biopreservation or biological preservation can be defined as a preservation method to improve safety and stability of food products in a natural way by using ‘desired’ microorganisms (cultures) and/or their metabolites without changing the sensory quality
- Cultures can be defined as protective or antagonistic micro-organisms that are added to a food product only to inhibit pathogens and/or to extend the shelf-life, while changing the sensory properties of the product as little as possible. Biopreservation can be applied in food products by two basic methods:
    - Adding crude, semi-purified or purified microbial metabolites.
    - Adding pure and viable micro-organisms.
- The use of micro-organisms or their metabolites as food preservatives is not meant as a primary means of preservation but as a way to contribute to the hurdle approach in food preservation.
- Hurdle technology usually works by combining more than one processing approach as opposed to the use of one approach which may prove to be too severe on the nutrient.

Self-Assessment Exercises 2

1. ----------- can be defined as a preservation method to improve safety and stability of food products in a natural way by using ‘desired’ microorganisms
2. ----------------- is one advantage of biopreservation

2.5 Antimicrobial Metabolites of Lactic Acid Bacteria

2.5.1 Organic acids

The most important and best characterized antimicrobials produced by LAB are lactic and acetic acid. The amount and type of acids produced during fermentation influence the subsequent microbial activity in the fermented material. Acetic acid, for example, is more antagonistic against yeasts compared to lactic acid. Some oxidative yeasts are able to utilize organic acids as a carbon and energy source and consequently cause spoilage through deacidification in fermented, especially plant material where they are naturally present. The inhibitory effect of organic acids is mainly caused by undissociated form of the molecule, which diffuses across the cell membrane towards the more alkaline cytosol and interferes with essential metabolic functions. The toxic effects of lactic and acetic acid include the reduction of intracellular pH and dissipation of the membrane potential.

2.5.2 Hydrogen peroxide

Antimicrobial activity of hydrogen peroxide is attributed to its strong oxidizing effect on the bacterial cell and to the destruction of basic molecular structures of cell proteins. In raw milk, hydrogen peroxide produced by lactic acid bacteria can, after being catalyzed by lacto peroxidase, oxidise endogenous thiocyanate. The oxidized intermediary products are toxic to different bacteria. Hydrogen peroxide production has been considered as the main metabolite of LAB that could protect against urogenital infections, especially in the case of bacterial vaginosis.

2.5.3 Carbon dioxide

The influence of carbon dioxide on product preservation is twofold. Namely, except for its own antimicrobial activity, it creates an anaerobic environment by replacing the existent molecular oxygen. The antifungal activity of CO_2 is due to the inhibition of enzymatic decarboxylations and to its accumulation in the membrane lipid bilayer resulting in dysfunction in permeability.

2.5.4 Bacteriocins

The bacteriocins most studied for their biopreservative effect in food products, and more specific in meat and meat products, include nisin, pediocins and sakacins Nisin, produced by *L. lactis* subsp. *lactis*, is the only bacteriocin that has found practical application in food products. It is mainly applied in the prevention of late-blowing of cheese by inhibiting the outgrowth of *Clostridium* spores and in selected pasteurised cheese spreads to inhibit *Clostridium* and *Listeria*.

Self-Assessment Exercises 3

1. All these are antimicrobial metabolites of lactic acid bacteria except
   a. ethylene
   b. organic acid
   c. Bacteriocin
   d. hydrogen peroxide
2. Nisin, pediocins and sakacin are known as -----------

2.6 Applications of Protective LAB in Different Food Products

The effectiveness of Protective culture has been studied in different food products. The majority of these inoculation experiments were performed with the intention of demonstrating the effectiveness of bacteriocinogenic strains in controlling *L. monocytogenes.*

2.6.1 Milk and dairy products

Cheese suffers from spoilage through *Clostridium* spp. (late blowing) and is, furthermore, susceptible to contamination with *L. monocytogenes.* This latter problem arises mainly in cheeses in which the pH increases during ripening, such as the Italian cheeses Taleggio, Gorgonzola and Mozarella. The addition of this paired nisin producing starter system to make cheddar cheese provided enough nisin to increase the shelf life of pasteurised processed cheese, made from this cheddar, from 14 to 87 days at 22°C and to control *L. monocytogenes, Cl. sporogenes* and *S. aureus.* Antilisterial effects were also observed for a bacteriocinogenic *Enterococcus faecium* strain during Taleggio production.

2.6.2 Vegetable products

Bacteriocinogenic LAB are reported to have potential for the biopreservation of foods of plant origin, especially minimally processed vegetables and fermented vegetables. In minimally processed vegetables such as pre-packaged mixed salads and different types of sprouts, bacteriocinogenic LAB have been found to act on coliforms and enterococci and on *L. monocytogenes*). Moreover, bacteriocinogenic starter cultures may be useful for the fermentation of sauerkraut or olives to prevent spoilage. Biocompetitive control or the use of biocompetitive micro-organisms to inhibit mycotoxin forming moulds can be obtained by (1) the use of biocompetitive non-aflatoxinogenic moulds or (2) the use of antagonistic yeasts or bacteria.

2.6.3 Fish, fish products and seafood

Spoilage of fresh fish is generally caused by Gram-negative bacteria. However, when vacuum packaged the spoilage of fresh fish, smoked fish and seafood is dominated by mainly Gram-positive bacteria, in particular LAB, and also *L. monocytogenes* can cause problems. The potential of *Carnobacterium* spp. to control *L. monocytogenes* in cold-smoked salmon has been used.

2.6.4 Other food products

Bacteriocin-producing and acid producing LAB have applications of in refrigerated ready-to-eat food products, e.g. soups, meals and salads, to prevent them from growth of food borne pathogens, in particular *Cl. botulinum* and/or *L. monocytogenes*. A mixture of a nisin-producing *L. lactis* and a pediocin producing *P. pentosaceus* are effective to prevent growth of *Cl. botulinum* and botulinal toxin formation after 10 days at 10°C .

Self-Assessment Exercises 4

1. *L. monocytogenes.* is a spoilage organism for cheese. True or false
2. Nisin is the least studied bacteriocin. True or false

2.7 Food Preservation through Fermentation

2.7.1 The concept of fermentation

- Fermentation is the process of bioconversion of organic substances by microorganisms and/or enzymes (complex proteins) of microbial, plant or animal origin.
- It is one of the oldest forms of food preservation which is applied globally.
- Fermented foods such as bread, cheese and wine, have been prepared and consumed for thousands of years and are strongly linked to culture and tradition, especially in rural households and village communities.
- During fermentation processes, microbial growth and metabolism i.e. the biochemical processes whereby complex substances and food are broken down into simple substances, result in the production of a diversity of metabolites.
- During fermentation breakdown of carbohydrates under limited supply of oxygen or under anaerobic conditions take place e.g. yeasts converts sugar to alcohol and CO_2.
- Some aerobic, specific conversions may also be referred as fermentation such as *Acetobacter* convert ethylalcohol to acetic acid in the presence of oxygen.

2.7.3 Some traditional fermented foods

Some traditional fermented foods in Nigeria include gari which is fermented cassava, ogi (fermented product from maize), fufu, lafun, dawadawa (fermented product from African locust beans), ogiri, (from castor oil seeds) ugba (from African oil beans), kunu zaki (from maize), palm wine, shekete and the traditional fermented milks, cheese etc. Lactic acid bacteria and yeasts are responsible for most of these fermentations.

Self-Assessment Exercises 5

1. ------------- is the process of bioconversion of organic substances by microorganisms and/or enzymes (complex proteins) of microbial, plant or animal origin.
2. All these are traditional fermented foods except
   a. fufu
   b. garri
   c. corn flour
   d. ogiri

2.8 Summary

. Chemical substances are the artificial preservatives that stop or delay the growth of bacteria, spoilage and its discoloration. some of these artificial preservatives include nitrates, nitrities, sorbates etc. each one has a unique function to perform in food preservation.

On the other hand, Biological preservation technologies can be classified as "biopreservation." Bacteriocins inhibit growth of some microorganisms. Fermentative microorganisms change chemical composition of foods to increase digestibility and may increase storage life of food by metabolic end products.

2.9 References/Further Readings

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2 Vaishali., Jhandai, P., Jadhav, V.J. & Gupta, R. (2019). Bio-preservation of Foods: A Review. *European Journal of Nutrition & Food Safety*. 11(4): 164-174.

2.10 Possible Answers to SAEs

Answers to SAEs 1

Self-Assessment Exercises 1

1. G – Bacteriocin
2. They can cause allergy, asthma, nausea, vomiting and headaches and sodium nitrite can be converted to nitrous acid in the body and cause cancer.

Self-Assessment Exercises 2

1. Bio preservation
2. they are natural and safe

Self-Assessment Exercises 3

1. A- Ethylene
2. Bacteriocins

Self-Assessment Exercises 4

1. True
2. False

Self-Assessment Exercises 5

1. Fermentation
2. C-corn flour

MODULE 4: PROCESSING OF CEREALS, LEGUMES AND OIL SEEDS

UNIT 1: PROCESSING OF CEREALS

Content

1.1 Introduction

Cereal processing represents an important part of the food production chain, but the contribution of cereals to the nonfood sector should not be overlooked. Milling represents the principal procedure in the cereal industry and is classified in two categories: dry and wet, while each has its own characteristics. Dry milling separates the outer fibrous materials and germ, which are considered by-products of the grain endosperm.

1.2 Learning Outcomes

By the end of this unit, you will be able to

1. Identify different types of cereals we have
2. Enumerate two main processing methods of cereals
3. Use flow chart to explain different processes given to cereals

1.3 Cereals

1.3.1 Definition of the term "cereals"

The term "cereals" refers to members of the Gramineae family and determines nine species: wheat (Triticum), rye (Secale), barley (Hordeum), oat (Avena), rice (Oryza), millet (Pennisetum), corn (Zea), sorghum (Sorghum), and triticale, which is a hybrid of wheat and rye.

Cereal processing represents an important part of the food production chain, but the contribution of cereals to the nonfood sector should not be overlooked. Milling represents the principal procedure in the cereal industry and is classified in two categories: dry and wet, while each has its own characteristics.

1.3.2 Pre- milling operations

- Dry milling of cereals is one of the oldest methods of the milling industry to provide milled fractions of cereal grains. Cleaning and conditioning of grains precede milling.

- **Cleaning** is important because, generally, grain received in bulk contains grain impurities that depend on the type of cereal. The main grain impurities following formal definition are shriveled grains, other cereals, grains damaged by pests, grains in which the germ is discolored, sprouted grains, miscellaneous impurities such as extraneous seeds, damaged grains, extraneous matter, husks, ergots, decayed grains, dead insects, and other undesirable material.
- Cleaning employs equipment such as a magnetic separator that removes ferrous metal particles, disc or sieve separators that remove almost anything else too big or too small to be the desired grain (i.e., straw), an aspirator to remove lighter impurities (i.e., dust), a destoner that separates materials with different densities (e.g., stones) but of the same size as the desired grain, color sorters, etc.

1.3.3 Conditioning or tempering

- This is the process during which the kernels are moistened with controlled addition of water for the inner endosperm to become softer and the bran harder. This process aims to prevent breakup of bran, helps gradual separation during milling, and also improves sieving efficiency
- Generally, the soaking time and temperature of grain kernels can vary depending on the type of grain, the variety, and also the initial moisture level.
- Corn kernels may need up to three stages of moistening to reach the desired final moisture (18%e27%) followed by resting time in tempering chambers . The size and shape of the grain, the way outer layers stick to endosperm, and hardness are grain characteristics of great importance in milling. Dry milling consists of two processes: grinding and sifting.


Corn grains

sorghum grains


Millet grains

Rice grains


wheat grains

Oats

Self-Assessment Exercises 1

1. Mention three cereals that are grown in Nigeria
2. -------- and ---------- are the two types of milling

1.4 Milling of different cereal grains

1.4.1 Milling of Corn

- The milling process of maize is shown in figure 1. below.
- Degermination represents an extra process step (dry or wet) that takes place on corn whenever low-fat and high-purity finished products are needed. It aims to efficiently separate germ and pericarp.
- Following the degermination process, kernels are dehydrated to a moisture content of approximately 14% and then most of the remaining pericarp and germ are separated by air aspiration and gravity separators, respectively.
- Next is the rolling and sifting step. The remaining corn kernel without the germ and a great part of the pericarp is milled to fine particles by roller mills.
- During rolling, in addition to endosperm pieces, small pericarp and germ species and tip caps that are still present after degermination are gradually released. These pieces are separated from the endosperm fraction through sifting, aspirating, and roller milling using a specific gravity table or purifiers.
- From the refined endosperm, flours of different particle size are obtained and are widely used to produce brewer’s grits, snack food grits, and corn flour.

Corn cleaning
↓
Conditioning
↓
Degermination
↓
Drying/cooling
↓
Aspiration
↓
Grading
↓
Grinding

Fig 1. Milling of corn

1.4.2 Rice (*Oryza sativa* L.)

Husking and paddy separation

- Before further processing, grains are cleaned and graded according to size.
- Winnowing machines can be used to separate out the chaff, soil and dirt.
- Some machines have integral sieves that combine cleaning with grading.
- Several grains have an unpalatable husk or shell that needs to be removed by a decorticator.
- A range of specialized machines are available for this task. A range of small rice hullers (both manual and powered) is available.
- Less rice is broken during hulling if the rice is parboiled first. Rice polishers are available for removing the rice bran after hulling
- The brown rice is then separated from the rough paddy rice using paddy separators.
- Brown rice is polished by a series of operations that removes the bran layers producing rice grains that are whiter in colour and translucent. The removed bran is collected by aspirators, whereas the polished rice is graded since it contains different-sized broken rice pieces, bran, and dust.

- White rice may further be ground to produce rice flour that could be used in baking gluten free bread, making infant cereals, breakfast cereals etc.
- The physical factors affecting the degree of milling are hardness, size and shape, and surface ridge on the grain .

Paddy rice
↓
Cleaning
↓
Cleaned paddy
↓
parboiling
↓
Dehusking/dehulling
↓
Brown rice
↓
Polishing
↓
White rice
↓
Grinding
↓
Rice flour

Fig 2: Rice milling

Fig 3: Parts of a rice grain

1.4.3 **Wheat (Triticum sp.)**

- After conditioning, the wheat kernels are first passed through an abrasive machine that eliminates impurities present on the pericarp and break-damaged kernels. Two types of roller mills, break and reduction roller mills, are involved in the milling of wheat kernels.
- First, break rollers break the wheat kernel and remove the endosperm and germ from the pericarp.
- The separation of milled wheat kernels isusually performed with sifters and purifiers.
- Second, the reduction rolls reduce further the sizings and middlings into flour.

Wheat cleaning
↓
Conditioning
↓
Breaking
↓
Sieving
↓
Reducing
↓
Sieving
↓

Grinding

↓

Flours

Figure 4: Flow chart of the wheat dry milling process.

Self Assessment Exercise 2

1. Degermination of corn grain before milling is to produce flour with ---------
   a. high fat content
   b. medium fat content
   c. low fat content
   d. low starch content
2. Polsihed rice is a type of rice that the ------------ has been removed
   a. husk
   b. endosperm
   c. starch
   d. bran

1.5 Wet milling

1.5.1 Definition of wet milling

In contrast to dry milling, wet milling consists of grinding the soaked grain and then separating the grain chemical compounds (starch, proteins, fiber, and oil). Wet milling of mainly corn aims to extract the maximum possible amount of native or undamaged starch granules.

The wet milling process involves different physical, chemical, biochemical, and mechanical operations. This process is used industrially primarily for corn and secondarily for wheat but it could also be successfully applied to other cereals such as sorghum, barley, and oats. Yet every cereal grain can be wet milled if appropriate modification of the equipment or processing is made.

1.5.2 Steeping

- Steeping of corn usually lasts from 30 to 48 h.
- Steeping is performed by soaking the kernels in a warm water containing sulfur dioxide, which is used as a reducing agent to soften the corn endosperm structure. The final moisture content during this step reaches around 48%e50% of the kernel weight.

1.5.3 Corn grinding and sifting

- After steeping comes the first milling step, where the moistened corn kernels are wet milled in plate or disc attrition mills into large pieces so that the germ is released. then dewatered and dehydrated to be used for oil extraction .
- During the second milling step the denser endosperm pieces that may also contain pericarp tissues are milled to release the pericarp in flakes. Pericarp pieces are separated in a metal sieve, whereas the endosperm particles are milled into fine slurry to release the starch granules from the protein matrix.
- Wet milling aims to release starch granules with minimal mechanical damage.
- Next, proteins are separated from starch granules by centrifugation and further purification. The resulting refined starch and proteins are dehydrated, respectively.
- The starch has great industrial application. it used to manufacture alcohol and food sweetners by either acid or enzymic hydrolysis. The germ is used for oil extraction.

1.5.4 Rice grinding and sifting

- Following the steeping procedure, rice is passed to mills and allowed to rest for up to 24 h.
- The fiber is then removed by screening, whereas the starch, the main wet milling product of rice, is first recuperated by centrifugation and then washed with water to remove excess alkali and finally dried to a final moisture content of 10% .
- Centrifugation wastes contain proteins that could be recovered following the same procedure for the recovery of proteins in the steeping water.

1.5.5. Traditional and industrial products from cereals

Traditional products

Pap, tuwo, Dankwo, Kokoro, pop corn etc.

Bakery Food Products:

Bread, Toasts, Buns, Sweet rolls, Biscuits, Cookies, Cakes, chin chin, buns etc.

Nutraceutical/Industrial Food Products:

Diabetic flour, High fiber food products, Starch, Beer, Weaning foods, Fortified food products, Syrups, Alcohol/Ethanol, etc

Self-Assessment Exercises 3

1. The major product from wet milling of maize is ----------
2. Corn oil can be extracted from ----------- of the corn grain.

1.6 Summary

Cereal processing represents an important part of the food production chain. Cereals are milled into primary products that are further processed into secondary and even tertiary products. Wheat grains are milled to wheat flour, the wheat flour could be used further to produce bread.

There are two types of milling depending on the desired products – dry and wet milling., each with its own characteristics. Dry milling separates the outer fibrous materials and germ, which are considered by-products of the grain endosperm. Wet milling is mainly used for the production of starch having as coproducts steep solids (rich in nutrients valuable for the pharmaceutical industry), germ (intended for the oil-crushing industry), and bran

1.7 References/Further Readings

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1.8 Possible Answers to SAEs

Self-Assessment Exercises 1

1. **maize or corn, millet, sorghum, rice**
2. **dry and wet milling**

Self Assessment Exercise 2

1. C - Low fat content
2. D- Bran
   a. germ

Self-Assessment Exercises 3

1. The major product from wet milling of maize is starch
2. Corn oil can be extracted from germ of the corn grain.

UNIT TWO: LEGUME PROCESSING

CONTENTS

2.1 Introduction

Legumes belong to the family *Leguminosae*. In the tropics, they are the next important food crop after cereals. They are sources of low-cost dietary vegetable proteins and minerals when compared with animal products such as meat, fish and egg. Indigenous legumes therefore are an important source of affordable alternative protein to poor resource people in many tropical countries especially in Africa and Asia where they are predominantly consumed. In the developing countries, research attention is being paid to better utilization of legumes in addressing protein malnutrition and food security issues.

2.2 Learning Outcomes

By the end of this unit, you will be able to

1. Discuss different classes of legumes
2. Discuss the advantages of legume processing
3. Explain different unit operations involved in legume processing

2.3 Legumes

2.3.1 Classification of legumes

Legumes can be classified as:

1. Pulses or grain legumes which are various peas and seeds that are low in fat content examples cowpea, pigeon pea, bambara groundnut etc

2. Oilseeds such as soybean and groundnut

3. Forage leguminous crops such as *Mucuna pruriens*, *Psopocarpur tetragonolobus* (winged bean).

2.3.2 Legume processing

One major way of utilizing legumes is through food processing. Food processing involves techniques of converting raw materials into semi-finished and finished products that can be consumed or stored. Food can be processed at different levels including home-based food processing and at industrial level. Industrial food processing could be at the cottage level or on a large scale. The advantages of legume processing include:

- transformation of raw produce into edible forms
- improving digestibility of foods improving the nutritional quality of foods
- reducing and eliminating anti-nutritional factors
- improving consumer appeal and acceptability of foods
- destruction of food enzymes causing food spoilage thus extending shelf-life
- deactivation of spoilage and pathogenic microorganisms in the food products
- serving as a means of income generation

2.3.2 Legume processing

- Common legumes grown in the tropics include cowpea, soybean, pigeon pea, African yambean, bambara groundnut, kidney bean, lima bean etc. Right from harvesting of the pods from the field, the seeds of these legumes pass through common post-harvest processes to obtain the dried seeds. The dried seeds are further processed into semi-finished or finished products through several processing steps called unit operations. Different unit operations are intended to fulfill different purposes.

Self-Assessment Exercises 1

1. Legumes are divided into three classes ------------, --------------- and -----------
2. --------------, -------------------, and -------------- are the common legumes in Nigeria

2.4 Primary unit operations in the processing of legumes

2.4.1 Sundrying

Raw mature grains at harvest are at about 20% moisture content and are subject to spoilage unless dried. They come in long husk or pods which are removed by hands or mechanically. In some areas, grain legumes are steeped in water for hours (2-8 hours) before sun-drying. Seeds are dried on raised platform. In some other cases, grains are treated with oil before drying. The purpose of steeping and oil treatment is to aid dehusking process.

2.4.2 Husking

This process is also called hulling. Husking can be done by dry method or the wet method. Traditionally in African and Asian countries, the dry method involves pounding of the dried grains in mortar with pestles or in hand- operated wooden or stone sheller. Improved power-operated shellers have been designed and abrasive hulling machines

have also been developed to improve the hulling process. Wet grinding process for husking involves soaking of the grains before drying. Improvement in husking process has been done through conditioning techniques through moisture adjustment to allow easy husking.

2.4.3 Winnowing

The separated husks are removed from the cotyledons by winnowing. Winnowing can done manually which is time consuming and laborious. Improved abrasive hulling machines which separate husk form cotyledons have been developed.

2.4.4 Separation

This process is used to remove or separate whole grains from split, broken and powdery ones. It is done manually using sieves or mechanically with machines designed with a sieving device. Sieving manually is laborious and time consuming.

2.4.5 Storage

Proper post-harvest handling of legumes will prevent both qualitative and quantitative

losses. It is important that legumes should be dried to safe moisture level of 12-14% to ensure good storage. Table 3 shows the safe moisture content of some tropical legumes. Dried seeds with high moisture content have increased the rate of mold attack and infestation. Dehulled seeds are often dried to a safe moisture level. Milled seeds are packaged and stored under dried conditions that will not allow absorption of moisture thereby leading to spoilage (33).

Legumes	Safe moisture content (%)
Broad bean, cowpea, kidney bean,white bean	15.0
Lentil, pea	14.0
Groundnut (shelled)	7.0
Soybean	13.0

Self-Assessment Exercises 2

1. The unit operation that involves the removal of separated husks from the cotyledons is called -------------
2. Drying of grains before processing is to reduce spoilage caused by --------------

2.5 Secondary processing of legumes

2.5.1 Sorting and cleaning before use

Legumes are sorted and cleaned to remove dirts, stones, chaff, broken and spoilt seeds and other foreign materials. Sorting is done by hand sorting which is laborious and time consuming or through mechanical or electronic sorting device. Cleaning can be done by dry or wet methods. Dry cleaning is intended for grain legumes meant for storage purpose. Wet cleaning is usually done by washing with water.

2.5.2 Soaking and blanching

Different seeds are soaked in water for different periods of time. Soaking in water allows the seeds to absorb water, to decrease and eliminate anti-nutritional factors in legumes. However, soaking for long periods of time has been found to reduce nutritional quality of legumes through leaching of nutrients into the soak water.

Blanching

Blanching is a mild heat treatment of seeds. Legumes are usually blanched by soaking in hot water or boiled in water for few minutes. This process destroys food enzymes and some anti-nutritional factors in the legumes. Blanching can also aid the dehulling process.

2.5.3 Boiling / cooking and roasting

This process improves the appeal and sensory properties of legume. Boiling is usually at 1000 C for some minutes. It tenderizes the seeds through water absorption. Traditionally, cooking of beans can be done using firewood. Pressure cooking pots allows legumes to be cooked under pressure and it reduces cooking time. This process eliminates heat labile antinutritional factors such as trypsin inhibitors .

Roasting

Legumes are roasted on the open frying pan in the presence or absence of salts or ash. Roasting improves the taste and edibility of legumes. It is important also in reducing and eliminating anti-nutritional factors. Roasted legumes are characterized by unique flavours which can increase their sensory appeal.

2.5.4 Fermenting and germinating

The process increases the digestibility of plant proteins and also reduces the anti-nutritional factors. Fermentation enhances flavour, colour and texture of legumes. Changes in these attributes are major stimuli in development of legume fermented products. It reduces heat stable anti-nutritional factors such as phytate. Fermented legumes are consumed as condiments e.g fermented locust bean (*iru*).

Germinating

Germination enhances desired qualities such as improved digestibility, reduced antinutrients like trypsin inhibitors. It improves nutritional quality of the proteins by hydrolyzing them into absorbable polypeptides and essential amino acids. Germinated or malted legumes are eaten in form of sprouts and are better than ungerminated ones. Sprouting improves the availability of vitamins B and C. It also reduces polyphenols content. Chicken pea and broad beans are commonly germinated before eating, cooking or use in salad dressing.

2.5.4 Milling and sieving

Dehulled legumes may be wet-milled or dry-milled. Milling is a size reduction process of the seeds into smaller particle forms. Wet-milling of seeds will produce a paste while dry–milling results in flour production. Different types of equipment have been designed for milling for household or industrial purpose. Wet milled legume may be mixed with other ingredients and steamed in leaves to produce pudding (*moinmoin)* or fried in hot oil to obtain bean cake (*akara*). The rehydrated flour maybe used to obtain these products

Sieving

Sieving removes unwanted materials from whole ground legume seeds (dry or wet). Example of wet sieving is in the filtration of ground soybean paste in the production of soymilk. The sieving process removes the unwanted residue called *okara*. For the dry-milled legume flour, sieving helps to achieve different ranges of particle sizes. Wet sieving can be done using cheese-cloth or muslin cloth while dry sieving can be done with different kinds of local or standard sieves. Some milling equipment have sieving devices incorporated into the design.

2.5.5 Frying and canning

Several legumes are wet milled, mixed with other ingredients in preparing different local or oriental dishes. Frying improves the appeal and eating quality of legumes. It also improves digestibility and reduces anti-nutritional factors.

Canning

This is a sophisticated technology of packaging cooked beans in cans. The packaged beans are usually in brine, sugar or tomato purees. This technology allows for all year round availability of the product and for food preservation. Legumes processed in this form are however expensive.

Self-Assessment Exercises 3

1. Blanching is done to destroy -----------------
   a. enzymes
   b. protein
   c. cotyledon
   d. starch
2. Sprouted legumes are more digestible than the unsprouted ones. True or False

2.6 Household utilization of some tropical legumes

2.6.1 Cowpea

Cooked beans: This can be in the form of cooked whole beans or cooked dehulled beans. Whole beans take longer period of time to cook than dehulled beans. Whole beans are boiled for about 45 to 60 minutes on the cooking stove or gas cooker depending on the hardness of the hull at household level. It is eaten whole or mashed. It used in or may be eaten alone or in combination with other food products like bread, *gari*, boiled yam with vegetable soup or fish meat sauce.

Bean soup: In this food preparation, beans are washed, soaked, dehulled , boiled, mashed and sieved. The sieved beans is then cooked with palm oil along with other ingredients such as pepper, spices and seasoning with or without fresh or dried fish to taste to produce *gbegiri*. It is eaten with reconstituted yam flour product *amala.*

Bean cake and pudding: beans are washed, soaked, dehulled and milled into paste. In making the bean cake, the paste is mixed to a fluffy texture by trapping in air. Other ingredient such as onion and pepper are milled with the dehulled beans and the paste is fried with oil. Among the Yorubas of Nigeria , this product is called *akara* while the steamed pudding is called *moinmoin*. The pudding however is mixed with other ingredients that include vegetable oil. Traditionally, the mixture is packaged in leaves and steamed.

2.6.2 Soybean

This has been known as an excellent source of protein, fat and minerals especially calcium. Soybean also has its unique characteristics in that it can be processed into a number or variety of products. Many economically challenged families in Nigeria utilize soybean processing as a means of income generation for household as well as ensure food security.

Soymilk: This is a popular soybean product rich in protein, fat and minerals. It is usually processed by soaking soybean in water, followed by milling, sieving, boiling and adding ingredients such as sugar and desired flavours to taste. A common hindrance or limitation to soymilk consumption is the beany flavour.

Soy cheese: This in the Orient is called *tofu*. In Nigeria, the local name is *soya-wara* or *soy warankasi*. It is a highly digestible product that is good for people suffering from lactose intolerance. Locally, it is processed by first preparing soymilk and further precipitating the milk with a coagulant. Different cheap locally sourced coagulants have been used in soy cheese processing. This includes the enzyme based *Calotropis procera* leave water extract or acidic based lime juice, lemon juice, fermented maize water liquor . Fermented maize water liquor is the most common type. Some local processors also use alum.

Tempeh: This is a soy product that orginated form Indonesia. It is made from whole soybean seeds which are soaked, dehulled and partly cooked. Spores of *Rhizopus oligoporus,* used a s fermenting culture is mixed with the seeds. The seeds are spread thinly on a tray and allowed to ferment for 24 to 36 hours at 300 C. Good *tempeh* is characterized by proper knitting together to have a firm texture. This can be cut, soaked in brine or salty sauce and

then fried. *Tempeh* has also been processed from other types of beans or mixture with whole grains.

Soy yoghurt: Yoghurt is a fermented milk product produced from mixed culture of *Lactobacillus bulgaricus and Streptococcus thermophillu*s (6). Soy yoghurt is processed from soybean which is quite cheaper than yoghurt from milk. It is a good source of protein and minerals.

Soy sauce: This is a condiment common in East and South East Asia. It is processed by fermenting soybean seeds with two molds of *Aspergillus oryzae* and *Aspergillus soaje* in the presence of salt and water. The fermentation process yields a product called *Moromi* which is pressed to obtain a liquid called soy sauce. Soy sauce is also called *Miso* which may also be prepared from rice or barley.

2.6.3 Groundnut

Boiled and roasted groundnut: In some West African countries, groundnuts are cooked with the pods to get the cooked/ boiled groundnuts while shelled or unshelled groundnut are usually roasted. The shelled groundnut can be roasted in the presence or absence of salt. This can be consumed directly. Roasted groundnuts can also be grounded into powder and used in the preparation of sauce or as ingredients in other food dishes.

Peanut butter: This is usually used as sandwich spread. Groundnuts also called peanuts are dry roasted and ground into a smooth paste. Stabilizers in form of partial or complete hydrogenated vegetable oil, sweetener, spices, emulsifier and salt are also added.

2.6.4 African locust bean

Dawadawa: Fermented African locust bean is called dawadawa or Iru. Dawadawa is generally processed from fermented oilseed called African locust bean. This product is a traditional Nigerian condiment. The seeds are cooked, dehulled, spread thinly in containers usually calabash lined with leaves and fermented for 24-36 hours. African locust bean seeds are very hard to cook. Traditionally they are cooked overnight over firewood.

Dawadawa has characteristic ammoniacal smell with its unique flavour in dishes. Dawadawa is used as natural seasonings in preparing soups, stews and traditional delicacies. Dawadawa has been processed also from other legumes such as soybean, bambara groundnuts and pigeon pea seeds.

Nigerian indigenous legume – Pigeon pea

Bambara groundnut

African yambean

Self-Assessment Exercises 4

1. All these are products from soybeans except
   a. wara
   b. ogiri
   c. soy milk
   d. tempeh
2. Dawa dawa is made from -------------- seeds

2.7 **Summary**

Indigenous legumes are an important source of affordable alternative protein to poor resource people in many tropical countries especially in Africa and Asia where they are predominantly consumed. legumes are processed into a variety of products.

the consumption and utilization of our local legumes should be encouraged since they serve as cheap sources of protein and other important nutrients.

2.8 References/Further Readings

1. Borget M. (1992). Food Legumes. Technical Centre for Agricultural and Rural Cooperation, Wageningen, The Netherlands.

2. Mulei, W.M., Ibumi, M. & Woomer, P.L. 2011. Grain Legume Processing Handbook: Value Addition to Bean, Cowpea, Groundnut and Soybean by SmallScale African Farmers. Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture. Nairobi. 42 pp.

2.9 Possible Answers to SAEs

Self-Assessment Exercises 1

1. pulses, oil seeds and foliage leguminous crops
2. soybean, cowpea, pigeon pea, bambara groundnut etc

Self-Assessment Exercises 2

1. Winnowing
2. microorganisms

Self-Assessment Exercises 3

1. A- Enzymes
2. True
3. **Self-Assessment Exercises 4**

1. B – ogiri
2. African locust bean seeds

UNIT THREE: PROCESSING OF OIL SEEDS

Content

2.6 Summary

2.7 References/Further Readings

2.8 Possible Answers to Self-Assessment Exercise(s)

3.1 Introduction

Oilseeds are leading suppliers of superior quality and specialty vegetable oils to nutritional products, natural food and premium snack food worldwide. Oil producing crops are corn, oat, cotton, soybean, mustard, camelina, crambe, safflower, sunflower, peanut, rapeseed, coconut, oil palm and olives.

Oilseeds produced in most of the countries are mostly used for oil extraction. The oil content of small grains for example, wheat is only 1 to 2%, but that of oilseeds ranges from about 20% for soybean to over 40% for sunflower and rapeseeds like canola. The major world sources of edible seed oils are soybean, sunflower, rapeseed, cotton and peanut. Seed oils from flax (linseed) and castor bean are used for industrial purposes.

3.2 Learning Outcomes

By the end of this unit, you will be able to

1. Discuss the major oil seeds
2. Explain oil extraction methods
3. Explain the process of oil refining

3.3 Processing of Oil seeds

3.3.1. The major oil seeds

The major oilseeds are soybean, cottonseed, groundnut, Sunflower, Rapeseed, Sesame seed, Copra, Castor seed and Palm Kernels. India occupies the place of pride as the world's largest producer of Groundnuts, Sesame seeds, Linseeds and Castor seeds.

The oils and fats are composed of mixtures of glycerides of various fatty acids. The fats and oils are broadly classified in to edible and non- edible. Groundnut, soybean, mustard are some of the sources of the edible oil. The edible oil is main source of fat taken in daily meals and is used for cooking purposes and salad dressings.

Oils are also used in the soap industry, paint, varnishes and plasticizers industry. The mechanical expression and solvent extraction methods are employed for the manufacture of oil from the oil seeds.

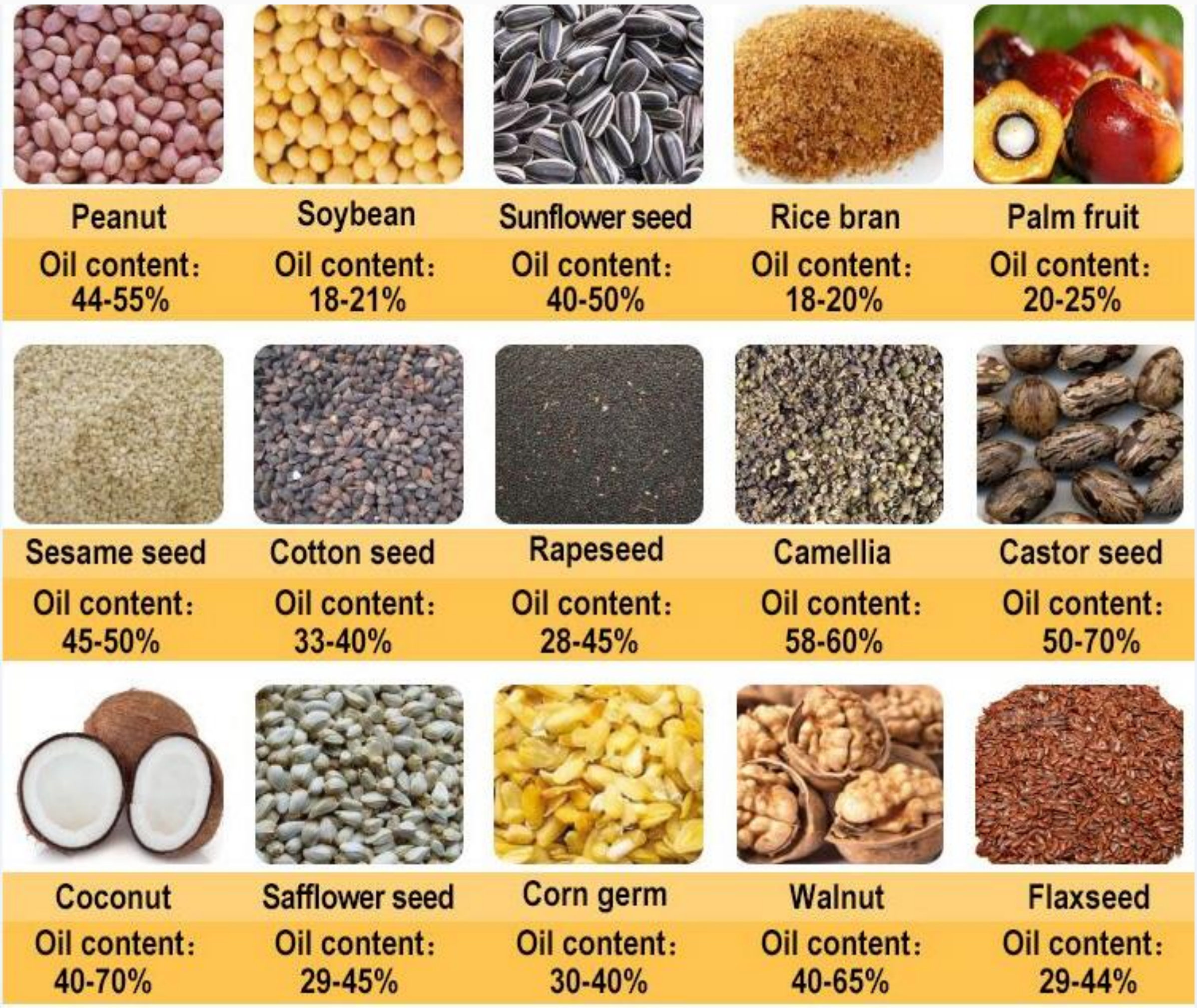


Fig 1. Major oilseeds

3.3.2 Raw material preparation for oil extraction

Oilseed and nut should be properly dried before storage, and cleaned to remove sand, dust, leaves and other contaminants. All raw materials should be sorted to remove stones and moudly nuts. Some moulds, especially in the case of groundnuts, can cause aflatoxin poisoning.

Some raw materials (for example groundnuts, sunflower seeds) need dehusking (or decorticating). Decortication is important to give high yields of oil and reduce the bulk of material to processed.

Coconut is dehusked and split manually by skilled operators. Most oilseeds (copra, palm kernels and groundnuts) need grinding in mills before oil extraction to increase the yields of oil. All oil-bearing materials need to have correct moisture content to maximize the oil yields.

3.4 Oil Extraction methods

3.4.1 Mechanical expression

During the process of mechanical expression, the oil seeds are compressed in various types of compression devices/equipment. Expression is the process of mechanically pressing liquid out of liquid containing solids. Screw press, roll presses, collapsible plate are some examples of wide range of equipment used for expression of liquid.

3.4.2 Hydraulic press:

The hydraulic press is considered of a series of horizontal corrugated iron plates. These plates are separated by 4 – 14 premoulded oil seed cakes. Pressing is completed in two stages.

In first stage, the oil seeds are pressed at about 5 MPa for 15-20 min and then pressure of 28 MPa is applied for 5-10 min to complete the expression process. The recovery of the oil varied depending upon the sizes and seed being pressed. But, the at commercial level, the hydraulic press is replaced by screw type presses.

3.4.3 Screw press

A screw press has a horizontal main shaft. The screw assembly is formed integrally with this shaft. The screw rotates within a cage or barrel. The barrel is made of case hardened, tool steel bars or rings to allow drainage of the oil as the pressure on the feed material is increased. At the discharge end, a movable choke or cone controls the operating pressure. It is achieved by changing the width of annular space through which the oil cake passes. The choke is adjusted by a hand wheel on the opposite end of the screw. The configuration of screw is such that the volume displacement at the feed end of the press is considerably greater than at the discharge end. As a result of such configuration, as the material is conveyed from feed end to discharge end, it is subjected to increasing pressure. As pressure increases, the material is compressed and oil is expelled through the spacers between the cage lining bars.

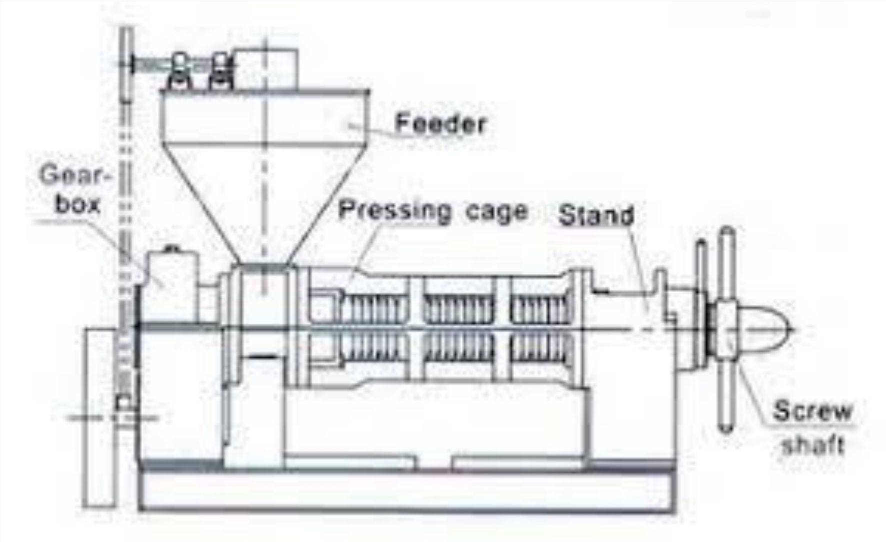
3.4.4 Ram press

A long pivoted lever moves a piston backwards and forewords inside a cylindrical cage constructed from a metal bars spaced to allow the passage of oil. At one end of the piston’s stroke, it opens an entry port from the seed hopper so that seed enters the press cage. When the piston is moved forward, the entry post is closed and the oilseed is compressed in the cage. As a result, oil is expelled from the oilseed the emerges through the gaps in the cage. Compressed seed is pushed out through the gaps in the cage. Compressed seed is pushed out through circular gap at the end of the cage.

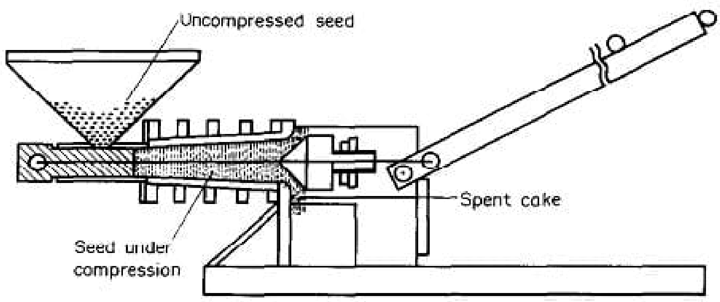
3.4.5 Solvent Extraction

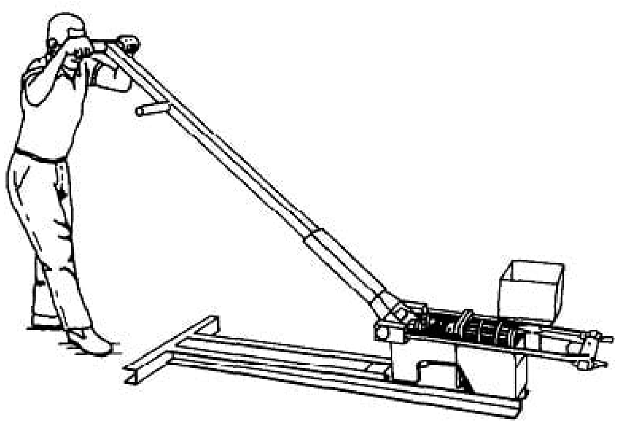
solvent extraction is a process of separating a liquid from a solid system with the use of a solvent. Extraction is also a process of diffusion with the help of low boiling point solvent. This process gives a higher recovery of oil and a drier cake than expression. Solvent extraction is capable of removing nearly all of the available oil from oilseed meal. This extraction process provides meal of better preservation qualities and with higher protein qualities.

The most common solvent used is *n-hexane* having boiling point of 65.5 ºC. The oil is separated from mixture of oil and hexane called miscella by distillation and stripping under vacuum.



A Screw press





A Ram Press

Self-Assessment Exercises 1

1. ----------- and -------------- are two common oil seeds in Nigeria
2. The three types of mechanical presses for oil extraction are ------, ----------- and -------

3.5 Process of Oil Refining

In many local markets further refining is not required as the complexes of unrefined oils are preferred. International markets tend to prefer lighter less intense oils for cooking which means further processing of the oil. There is serious of refining processes that can be carried out after the oil has been filtered.

3.5.1 De-gumming and neutralization

De-gumming is a way of treating seed that have high phosphatide content. The phosphetide, which makes a gummy residue, is removed by mixing the oil with 2 to 3% water. This hydrated phosphatide can then be removed by settling, filtering or centrifuged.

Fatty acids can be neutralized by adding a sodium hydroxide solution, also known as caustic soda, or by stripping, which is a similar process to de-odorising.

3.5.2 Bleaching and wintering

Bleaching

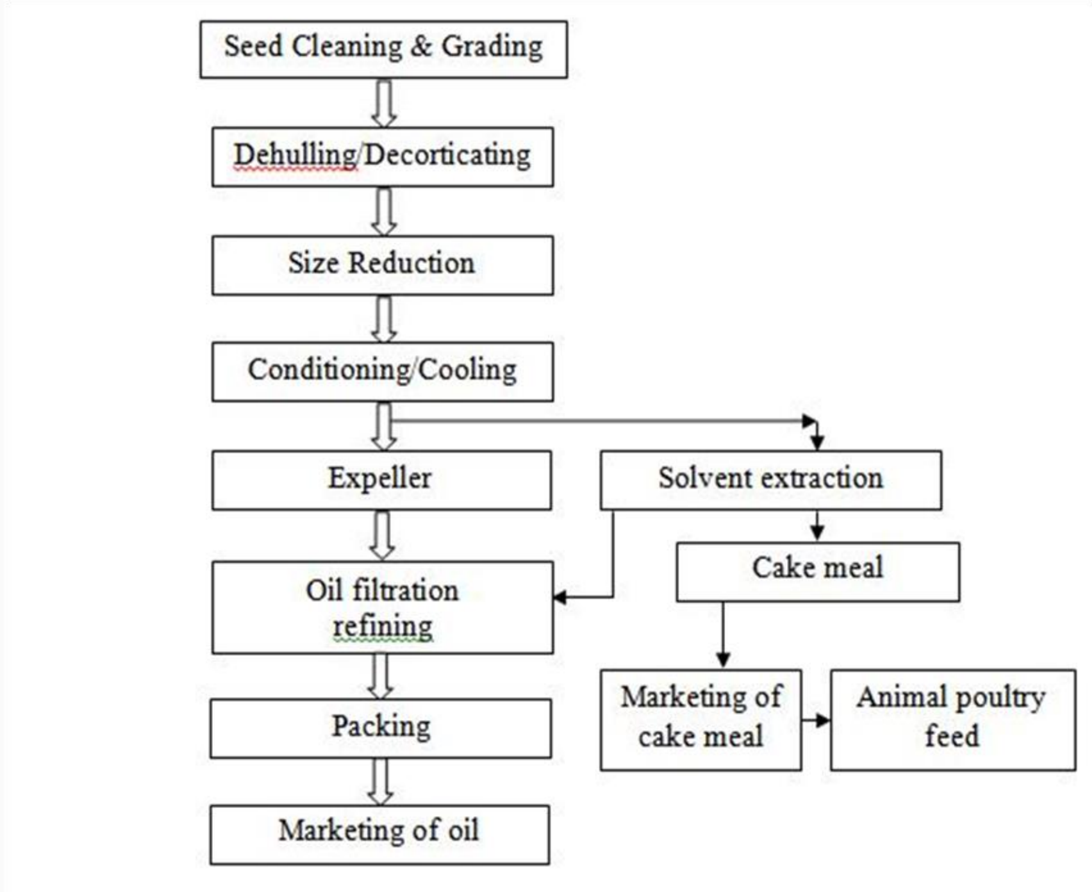
Some oils have a very dark colour to them that is unpopular with consumers. The appearance of the oil can be lightened by bleaching.

Wintering

Allowing the oil to stand for a time at low temperatures so that glycerides, which naturally occur in the oil, with higher melting points solidify and can then be removed from the oil by filtering. Over time glycerides can degrade releasing fatty acids into the oil increasing the acidity levels and reducing the quality.

3.5.3 Deodorising

Volatile compounds that produce bad odours can eliminated through the process of sparging, i.e. bubbling steam through the oil, under a vacuum.



Oil extraction process

Self-Assessment Exercises 2

1. All oils must be refined before consumption. True or false
2. During ----------- process, the fatty acids in extracted oil are removed by the addition of caustic soda

3.6 Summary

In the market today, we see many brands of vegetable oil. these oils have been extracted from one oil seed or the other. the most common oil seeds used in Nigeria are palm fruit, palm kernel, groundnut and soyabean.

These oil seeds have to go through the process of oil extraction to separate the oil from the seed and sometimes these oils are further refined to get oils with desirable qualities.

3.7 References/Further reading

1. Chakraverthy, A. (1995). Post harvest technology of cereals, pulses and oilseeds. Oxford & IBH publishing Pvt. Ltd., New Delhi.

2. Srivastava, P. K. and Kachru, R. P. (1995). Compendium of technologies for oil seed processing and utilization. Central Institute of Agricultural Engineering, Bhopal.

3.8 Possible Answers to SAEs

Self-Assessment Exercises 1

1. soyabeans, groundnut, palm fruit, palm kernel

2. Screw, hydraulic and ram press

Self-Assessment Exercises 2

1. False
2. Neutralization

MODULE 5: MEAT, FISH AND POULTRY PROCESSING

UNIT ONE: MEAT PROCESSING

Content

1.8 Possible Answers to Self-Assessment Exercise(s)

1.1 Introduction

The meat processing involves the slaughter of animals and fowl, processing of the carcasses into cured, canned, and other meat products, and the rendering of inedible and discarded remains into useful by-products such as lards and oils. Meat is exposed to a series of wide range of processes viz. curing or preserving processes such as salting, wet pickling, drying, cooking and canning, sausage manufacture, ham curing. All these processing techniques are aimed at inhibiting the microbial spoilage and increasing the shelf life of the meat. Major principles involved in meat processing are use of heat, low temperature, smoking, modified atmosphere packaging and ionizing radiations. The methods of preservation are mainly grouped in three categories i.e. control by temperature, by moisture and by lethal agents (bactericidal, fungicidal etc.)

1.2 Learning Outcome

By the end of this unit, you will be able to

1. Explain your understanding of meat processing
2. Explain the important principles involved in of meat processing
3. Discuss the various methods of meat processing

1.3 Preservation of Meat

1.3.1 Use of low temperatures

Chilling and freezing are most commonly used preservation system for meat and meat products.

a. Chilling

Chilling is most widely used technique to preserve raw and processed meat. Chilling preserves muscle tissue by retarding the growth of microorganisms and by slowing many chemical and enzymatic reactions. Storage temperature may vary from - 1.4 to 2.2^{0}C for storage of beef for 30 days depending upon the number of microorganisms.

b. Freezing

Freezing is an excellent process for preserving the quality of meat for long periods. Freezing is often used to preserve meats during shipment over long distances or for holding until long times of storage When the temperature of storage is below - 18^{0}C, changes occur at a very slow rate in the muscle of warm blooded animals. Quality of frozen meat depends on various factors such as rate of freezing, packaging etc.

1.3.2 Use of heat

The canning of meat is a very specialized technique in that the procedure varies considerably with the meat product to be preserved. Since meat products are low acid foods so the rate of heat penetration is fairly low. Commercially canned meats can be divided into two groups on the basis of heat processing used ;

(a) Meats that are heat processed in an attempt to make the can contents sterile.

(b) Meats that are heated enough to kill part of spoilage organisms but must be kept refrigerated to prevent spoilage.

1.3.3 Dehydration

Deprivation of available moisture (reduction of water activity) for microbes not only prevent their growth but also kills them, thus results in increased shelf life and better quality product.

Drying meats can be successfully employed for both raw and cooked meat. Texture is most severely altered by dehydration. The tough texture of dehydrated meat can be overcome by preparing products of intermediate levels of water. drying can be done under the sun or with ovens.

1.3.4 Smoking

Smoking is often used with salting and curing. It gives desired flavour, aroma and aids in preservation. It was noted that preservative substances added to the meat together with the action of heat during smoking have a germicidal effect and that drying of the meat together with chemicals from the smoke inhibit microbial growth during storage. Smoke consists of phenols, alcohols, organic acids, carbonyl compounds and hydrocarbons. The desirable effects of smoking of meat can be listed as below:

- Meat preservation through aldehydes, phenols and acids (anti-microbial effect)
- Antioxidant impact through phenols and aldehydes (retarding fat oxidation)
- Smoke flavour through phenols, carbonyls and others (smoking taste)
- Smoke colour formation through carbonyls and aldehydes (attractive colour)
- Surface hardening of sausages/casings through aldehydes (in particular for more rigid structure of the casing)

Self-Assessment Exercises 1

1. Preserving meat at temperature of below -18^{o}C is known as ----------------

3. List three desirable effects of smoking of meat.

1.4 Other Methods of Meat Preservation

1.4.1.Modified atmospheric storage

Fresh meat held at refrigerated temperature has a limited shelf life because of microbial growth. Modified atmosphere refers to the adjustment in the composition of the atmosphere surrounding the product. At higher concentration of CO_2 surface browning of meat occurs due to the oxidation of myoglobin and hemoglobin pigments to ferric state. The most desirable concentration of CO_2 to use in a modified atmosphere is a compromise between bacterial inhibition and product discoloration.

1.4.2 Ionising radiation

Ionising radiation constitutes the potentially useful form of preservation. Besides from its desirable ability to inactivate micro- organisms, it also has the undesirable effect of altering meat pigments. Radiation for the treatment of food is achieved through the application of gamma rays (with Co-60 or Cesium-137 radioisotope), electron beams (high energy of up to 10 MeV), or X-rays (high energy of up to 5 MeV).

Sterilizing doses of ionizing radiation results in the breakdown of various lipids and proteins to often undesirable odours. Tenderization of muscle may also occur during this treatment. Temperature of $\leq 80^0$C or below greatly reduces undesirable effect without affecting lethal effect on microorganisms. Generally, enzymes are not inactivated by irradiation treatment, it is necessary to heat approximately 70^0C prior to irradiation and storage. The safety of irradiated foods for human consumption has been questioned because ionizing radiation can lead to chemical changes.

Self-Assessment Exercises 2

1. The preservation of food based on the adjustment in the composition of the atmosphere surrounding the product is referred to as ----------

3. The treatment of food products with gamma rays for preservation is known as ----------------------

1.5 Processing of Meat into different products

1.5.1 Comminuted meat products

Comminution is the mechanical process of reducing raw materials to small particles called as minced meat.

Sausages

Sausages are usually defined as comminuted seasoned meats, stuffed into casings; they may be smoked, cured, fermented and heated. They are made from any edible part of the slaughtered, veterinary-inspected animal, and a series of non-meat ingredients.

Sausages are meat products that are salted & usually seasoned or spiced and are an example of comminuted meet products that are generally recognized as emulsified, stuffed, linked, smoked, and cooked meat products. Based on the product characteristics and processing methods, they are broadly divided into three categories: **fresh sausages, cured sausages and fermented sausages**

Selection of ingredients
↓
Grinding
↓
Mixing
↓
Chopping and emulsifying
↓
Stuffing
↓
Linking or tie
↓
Hanging
↓
Smoking
↓
Cooking
↓
Showering with chilling
↓
Peeling or slicing
↓
Packaging

Fig. 4 Process flow diagram of sausages manufacture

Sausages

- Self-Assessment Exercises 2

1. What are sausages?
2. Based on the product characteristics and processing methods, suasages are broadly divided into ____,______ and _____.
3. List Five major ingredients for sausage making.

1.5.2 Cured meat products

Curing of meat involves the essentially addition of **sodium chloride, sodium nitrite or sodium nitrate** and adjuncts to meat for increasing shelf-life and to obtain desirable colour and flavour. Sugar may or may not be added along with other ingredient to improve flavour. Curing can be done for both raw/cooked meats cut products as well for comminuted meat products e.g. sausages and similar preparations. Most popular raw cured meat includes ham and bacon which are pork products. However, the technique can be applied to any meat group.

Ingredients used in curing

(i) Salt
(ii) Sugar
(iii) Nitrate or nitrite

Essential curing ingredients

(iv) Phosphates
(v) Spices
(vi) Baking Soda
(ii) Sodium erythroborate
(iii) Ascorbic acid
(iv) Mono sodium glutamate
(v) Hydrolysed vegetable proteins,
(vi) vinegar

Optional ingredients/curing adjuncts

The use of nitrite in cured meat may be hazardous if it is used at higher concentration with improper mixing, as it reacts with amines, especially secondary amines, to form N-nitrosamines, which may be carcinogenic. High temperature may also induce nitrosamine formation.

1.5.3 Indigenous meat based products

Suya (Hausa word for “to fry““““ or “fried meat”) is an intermediate moisture meat product that is easy to prepare and is highly relished . Suya is a popular, traditionally processed ready to eat Nigerian meat product, originally produced from beef and later extended to other ruminant animals. However, in recent years, non-ruminant animals are being utilised in suya making

'Suya'and 'kilishi' are made by roasting the spiced, salted slices/strips of meat (usually beef). 'Kilishi' differs from 'suya' in that the two-stage sun-drying process precedes roasting. Consequently, 'kilishi' has a much lower moisture content (6-14%) than 'suya' (25-35%).

Dambu-nama is a Nigerian traditionally spiced, cooked, pounded, shredded and dried meat product which is commonly obtained using beef, goat meat, mutton, or camel meat and is popularly consumed in the Northern parts of Nigeria. The product appears to have developed as a means of preserving meat, in the absence of facilities for refrigerated storage by the early Fulani and Hausa herdsmen.

Suya meat

Kilishi meat

Self-Assessment Exercises 3

1. The mechanical process of reducing raw materials to small particles called as minced meat is known as ---------------
2. The production of nitrosamine during meat curing is of food safety concern. True or false.

1.6 Summary

Meat is the most valuable livestock product and for many people serves as their first-choice source of animal protein. Meat is either consumed as a component of kitchen-style food preparations or as processed meat products.

meat can be preserved by using low temperature, drying, smoking and the use of modified atmosphere storage. meat products include communited meat like sausage and cured meat.

in Nigeria, the traditional meat products are suya, kilishi, dambu-nama among others

1.7 References/Further Readings

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2. North, M.F. and Lovatt, S.J. (2012). Chilling and Freezing Meat. In: Handbook of Meat and Meat Processing, Hui, Y.H. *et al*. (eds). CRC Press Taylor & Francis Group

1.8 Possible Answer to SAE's

Self-Assessment Exercises 1

1. Freezing
2. Preservation, good flavour, antioxidant addition, desirable colour

Self-Assessment Exercises 2

1. Modified atmosphere packaging
2. ionizing irradiation

Self-Assessment Exercises 3

1. Communition

2. True

UNIT TWO: FISH PRESERVATION

Content

2.1 Introduction

A fish is any member of a group of animals that consist of all gillbearing aquatic craniate animals that lack limbs with digits. Included in this definition are the living hagfish, lampreys, and cartilaginous and bony fish as well as various extinct related groups.

Fish is a very good source of protein but it is very perishable therefore preservation should start immediately after catch. Fish can be preserved using different methods and that is what we are going to discuss in this unit.

2.2 Learning Outcomes

By the end of this unit, you will be able to

1.Explain freshness of fish

2.Discuss methods of fish preservation

3.Discuss some processed products from fish and their uses

2.3 Freshness of Fish

2.3.1 Fish Handling

- Fish is one of the protein foods that needs careful handling. This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of bacteria, enzymes and chemical oxidation of fat in the fish. Due to poor handling, about 30 – 50% of fish harvested are wasted in Nigeria. These losses could be minimized by the application of proper handling, processing and preservation techniques.
- The purpose of processing and preserving fish is to get fish to an ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before the fishing expedition starts, and do not end until the fish in eaten or processed into oil, meal, or a feed. Fish begins to spoil as soon as it is caught, perhaps even before it is taken out of the water. Therefore, the key to delivering a high quality product is close attention to small details throughout the entire process of preparation, catching, landing, handling, storage, and transport.
- Fish that becomes spoiled or putrid is obviously unusable. Fish that is poorly cared for may not be so obviously bad, but it loses value because of off-flavors, mushy texture, or bad color that discourage, a potential purchaser from buying.

2.3.2 Freshness of fish

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

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

2. The odour of the gills and belly cavity;

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

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

5. The appearance of the belly walls.

Self Assessment Exercise 1

1. The loss of fish due to poor handling and processing in Nigeria is big. True or false
2. Explain two features in fish that can be used to determine its level of freshness

2.4 Causes of Spoilage of Fishes

2.4.1 Factors that cause spoilage of fish

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

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

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

2.4.2 Types of fish spoilage – Enzymatic spoilage

- Shortly after capture, chemical and biological changes take place in dead fish due to enzymatic breakdown of major fish molecules. The digestive enzymes cause extensive autolysis which results in meat softening, rupture of the belly wall and drain out of the blood and water which contains both protein and oil.
- A number of proteolytic enzymes are found in muscle and viscera of the fish after catch. These enzymes contribute to post mortem degradation in fish muscle and fish products during storage and processing. During improper storage of whole fish, proteolysis is responsible for degradation of proteins and is followed by a process of solubilization. Belly bursting is caused by leakage of proteolytic enzymes from pyloric caeca and intestine to the ventral muscle.

2.4.3 Microbial spoilage

- Composition of the microflora on newly caught fish depends on the microbial contents of the water in which the fish live. Microbial growth and metabolism is a major cause of fish spoilage For unpreserved fish, spoilage is a result of Gram negative, fermentative bacteria (such as Vibrionaceae), whereas psychrotolerant Gram-negative bacteria (such as Pseudomonas spp. and Shewanella spp.) tend to spoil chilled fish.

2.4.4 Chemical spoilage

- Lipid oxidation is a major cause of deterioration and spoilage for the pelagic fish species such as mackerel and herring with high oil/fat content stored fat in their flesh. Lipid oxidation involves a three stage free radical mechanism: initiation, propagation and termination.
- Initiation involves the formation of lipid free radicals through catalysts such as heat, metal ions and irradiation. These free radicals react with oxygen to form peroxyl radicals.
- During propagation, the peroxyl radicals reacting with other lipid molecules to form hydroperoxides and a new free radical. Termination occurs when a build up of these free radicals interact to form non radical products. These non radical products produce the off flavour and off colour of oxidized oil.
- Oxidation typically involves the reaction of oxygen with the double bonds of fatty acids. Therefore, fish lipids which consist of polyunsaturated fatty acids are highly susceptible to oxidation.
- The enzymatic hydrolysis of fats by lipases is termed lipolysis (fat deterioration). During this process, lipases split the glycerides forming free fatty acids which are responsible for: (a) common off flavour, frequently referred to as rancidity and (b)

reducing the oil quality. The enzymes involved are the lipases present in the skin, blood and tissue.

Self-Assessment Exercises 2

1. All these aid the spoilage of fish except
   a. high moisture
   b. high protein
   c. high fat
   d. high salt
2. One of the products of chemical spoilage of fish is
   a. free radical
   b. free protein
   c. free water
   d. free enyme

2.5 Methods of Preservation of Fish

2.5.1 **Chilling:**

- The first and simplest method to both preserve and process fish is to keep it cool. Cool fish keeps longer than uncooled fish, although both will spoil in a matter of hours. This is obtained by covering the fish with layers of ice. But ice is effective for short term preservation such as is needed to transport landed fish to nearby markets or to canning factories, etc.

a. It reduces the growth rate of bacteria by reducing the temperature of the fish; and

b. It also washes the bacteria and slime away as it melts. Because of this, it is important to keep melt water drained away from the fish.

2.5.2 Salting:

- There are many different kinds of salt, some being better than others for fish curing. A distinction must be made between the two chief techniques of salting: wet salting and dry salting
- **Wet Salting:** The principle is to keep the fish for a long time in brine. The equipment needed consists of a watertight container, which can be a tin, drum, canoe, barrel, etc. To make the brine, one takes four parts of clean water (sea or fresh water) and mix with one part of salt. If the salt is coarse, it has to be ground or pounded first.
- The next step depends on what kind of fish one wants to salt. It is best first to cut off the head, and gut and clean the fish, though small fish can also be salted whole. Large fish must be cut open, and it is preferable to take out the backbone. Fish with a heavy armour of scales must be scaled.
- Very large fish should be cut in thin fillets. After the fish has been prepared according to its size, it must be cleaned and put in the brine.
- **Dry Salting**: In this method the fish is salted but the juices, slime and brine are allowed to flow away. For two parts of fish, one needs one part of salt. Layers of fish must be separated by layers of salt. Some people like the salty taste of fish prepared in this way, but it is always possible to wash the salt away by soaking it in fresh water before use.

2.5.3 Drying:

- Very small and thin fish can be dried straight away in the sun if they are brought in early enough in the morning (and if, of course, the sun is shining). If fish are laid on mats or other material to dry, it is best to turn them over every two hours so that they will dry quickly and not become maggotty. In the case of large fish, hanging is better if they are merely split.

2.5.4 Smoking:

- Any kind of fish can be smoked. There are three main methods of smoking: (a) Smoking and roasting; (b) hot smoking; (c) long smoking. Smoking and Roasting: This is a simple method of preservation, for consumption either directly after curing or within twelve hours.

2.5.6 Fish canning:

- This is a process involving heat treatment of fish in sealed containers made of tin plates, aluminum cans or glass, until the product has been fully sterilized. During caning, heat treatment should be sufficient to destroy all heat sensitive bacterial and spores, in activate, the enzymes and cook the fish so that the product remains acceptable to the consumer after prolonged storage.
- The canned food fish is also prevented from contamination by pathogenic organisms by storing them in a virtually airtight package. If heat treatment is properly carried out canned fish may remain in storage for several years without refrigeration . Traditional canned fish are obtained from small pelagic fish species such as herrings (Clupea spp), Sardines (Sardinella sp), Mackerels (Scomberomerus sp), Anchovies (Engraulis sp), Tuna (Thunnus sp). Bonga (Ethmalosa sp)

Modern fish smoking kiln

Traditional fish smoking

Self-Assessment Exercises 3

1. Chilling fish with ice is effective for long time storage. True or False
2. Can fish can remain safe for consumption for many ---------
    a. days
    b. weeks
    c. months
    d. years

2.6 Some Processed Fish Products

2.6.1 Fish mince

- This can be defined as flesh separated in a communited form, from the frames, scale, bones and fins of fish. Fish mince can be prepared either mechanically by the use of flesh bone separator or non-mechanically.
- A flesh/bone (or meat/bone) separators also called Deboning machines can be used to retrieve flesh attached to bones and frames of fish and thus make them better utilized instead of discarding them as a waste.
- Minced fish is obtained from filleting leftovers to headed and gutted fish using a bone/flesh (meat-bone) separator to remove bones from the edible flesh. Fish mince is very versatile and can be used to make a variety of products such as fish portions, fish fingers, fish cakes, fish sausage and fish cheese.

2.6.2 Fish sauce:

- This is an amber-colored liquid extracted from the fermentation of fish with sea salt. It is used as a condiment in various cuisines. Fish sauce is a staple ingredient in numerous cultures in Southeast Asia and the coastal regions of East Asia
- In addition to being added to dishes during the cooking process, fish sauce is also used as a base for a dipping condiment, prepared in many different ways in each country, for fish, shrimp, pork, and chicken. In parts of southern China, it is used as an ingredient for soups and casseroles. Fish sauce, and its derivatives, impart an umami flavor to food due to their glutamate content.

2.6.3 Fish meal

- Fish meal is a commercial product mostly made from fish that are not generally used for human consumption but for animal feed; a small portion is made from the bones and offal left over from processing fish used for human consumption, while the larger percentage is manufactured from sustainable, managed, and monitored fish stocks of wild-caught, small marine fish.

- It is powder or cake obtained by drying the fish or fish trimmings, often after cooking, and then grinding it. If the fish used is a fatty fish it is first pressed to extract most of the fish oil.

Self-Assessment Exercises 4

1. Communited fish is also called -------------
2. A fish product that is for animal feed is called ----------------

2.7 Summary

Fish is an important source of protein and healthy fat but it is highly perishable. Fish should be preserved as soon as it is caught.

preservation methods for fish include chilling, salting, smoking, canning etc. fish can also be processed into other product like fish mince, fish sauce, fish meal etc.

2.8 References

1. Clucas, I. J. & Sctcliffe, P.J. (1987). An introduction to fish handling and processing. Report of the Tropical Products Institute, pp 143-186.

2. Eyo, A.A. (2001) Fish processing Technology in the Tropics. National Institute for Freshwater, Fisheries Research (NIFFR), New Bussa, 37-39

2.9 Possible Answers to SAE's

Self Assessment Exercise 1

1. True

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

   The odour of the gills and belly cavity;

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

   The presence or absence of rigor mortis or death stiffening;

   The appearance of the belly walls.

Self-Assessment Exercises 2

1. D- high salt
2. A- free radical

Self-Assessment Exercises 3

1. False
2. D- years

UNIT THREE:PROCESSING OF POULTRY MEAT

Content

3.1 Introduction

In global meat production poultry meat is taking the second place after pork. Due to its widespread availability and popularity and its mostly very competitive production cost, poultry meat has an increasing share as a raw material in processed meat. Turkey and chicken meat is very suitable for further processing purposes. Poultry meat is of higher nutritive value than that of other red meats, because of its higher protein content and better digestibility.

3.2 Learning Outcomes

By the end of this unit, you will be able to

1. Explain composition of poultry carcass
2. Discuss the primary objective of poultry processing
3. Discuss different methods of poultry processing

3.3 Processing of poultry meat

3.3.1 Characteristics of Poultry Meat

Poultry is meat from domesticated birds such as chicken, duck, turkey etc. Muscle to bone ratio in the case of poultry is 1.8% thus the carcass yield is less as compared to other warm blooded animals. The composition of poultry meat is shown below.

Composition of carcass

Species	Meat %	Fat %	Bone %	Skin %
Broilers	52	6	30	12
Hen	37	12	40	11
Duck	34	18	38	10

Chicken meat is pinkish white in breast and wings and in other parts pink to light red. In general poultry meat is described as white meat while meat from other animals is called red meats.

3.3.2 Preservation of Poultry Meat – Chilling and Freezing

a) **Chilling:** Chilling storage of poultry is for only less than a month. Birds to be stored longer should be frozen. The lower the temperature of storage, the longer the birds stored without undesirable changes. Compared to room temperature, the storage life was extended 2 days at 10^0C, 6 days at 4.4^0C and 14 days at 0^0C. However, the rapid chilling is always advisable in the cases of poultry meat as the onset and outset of rigor takes at early.

b**) Freezing** - Poultry can be kept in good conditions for months if freezing is prompt and rapid and storage temperature is low enough. Fairly rapid freezing is desirable since it produces a light golden colour because fine ice crystals are formed within the fiber while slow freezing causes the flesh to be darker. The storage temperature should be below -17.8^0C and RH above 95% to reduce surface drying. Rapid freezing of poultry is desirable since it causes tissues to become very pale, which is desirable since it cause tissues to become very pale, which is desirable. However, most poultry is sharp frozen at about 29^0C or less in circulating air or on a moving belt in a freezing tunnel.

3.3.3 Preservation of Poultry Meat – Modified atmospheric storage and ionizing radiation

Modified atmospheric storage: Increasing carbon dioxide concentration to 10 to 20% in the atmosphere of store chickens inhibits the growth of psychrotrophs. The use of films of both high and low gas permeability in combination with CO_2 atmosphere shows that the CO_2 atmosphere is the significant factor in reducing microbial counts.

Ionising radiation : It is a potentially useful form of preservation. Besides from its desirable ability to inactivate micro -organisms, it also results in the breakdown of various lipids and proteins to often undesirable odours.

Self Assessment Exercise 1

1. Chilling of chicken is a short term preservation method. True or false
2. in modified atmospheric storage, ------------ is the significant factor in reducing microbial growth

3.4 Methods of Cooking Poultry

3.4.1 Cooking of Poultry

Raw chicken meat has no flavour, it is developed during cooking and sometime due to addition of spices. For the cooking of tough poultry meat moist heat is preferred on the other hand for soft variety of meat dry heat methods are recommended. Major physico-chemical changes taking place due to cooking are listed as below:

1. Heat causes coagulation of proteins ,
2. Melting of fat

3. Change in colour of red meat to pink & finally brown or grey. In the presence of moisture when is present naturally in the meat
4. Collagen is hydrolyzed to gelatin when the meat is heated.
5. Heat affects the tenderness of meat is coagulation of protein causes to toughening in meat tissues & hydrolysis of collagen to gelatin makes it tender.
6. The change on flavor due to heat is caused partly due to volatiles, decomposition of protein or fats and/or caramelization of carbohydrates & coagulation of protein
7. The shrinkage of meat is due to loss of the moisture and fat which are released from the meat and collect at the bottom of cooking pan.

Sometime marination is done of the chicken portions to improve flavor and texture of the product. In marination meat is soaked in the acidic seasoned liquid (known as marinade) before the cooking.

Marinade contains vinegar, lemon juice, or wine or enzymes and oils, herbs and spices to add further taste and tenderize the meat. Before cooking sometime chicken is coated with flavoured batter to improve flavor.

Breading of chicken is done prior to coating to provide crisp outer layer of beaten egg covered later with flour.

3.4.2 Frying

- Only young tender and low fat poultry meat should be cooked by frying.
- Generally carcasses are cut into portions suitable for serving and then they are seasoned, salts, pepper and other spices as required are added, chicken should be rolled in floor or dipped in a batter generally containing eggs, milk, flour, and seasoning. Another medium sometime used for dipping of poultry meat pieces is the egg and milk batter.

- Coated meat pieces are then dipped into the cooking medium i.e. oil/fat heated to 358^0F. Generally temp of fats/oils between 300-325^0F during frying.

3.4.3 Broiling

- Broiling**,** is a type of cooking which involves exposing food to direct radiant heat, either on a grill over live coals or below a gas burner or electric coil. Broiling differs from roasting and baking in that the food is turned during the process so as to cook one side at a time.
- Temperatures are higher for broiling than for roasting; the broil indicator of a household range is typically set around 550^0F (288^0C), whereas larger commercial appliances broil between 700 and $1{,}000^0$F (371 and 538^0C).
- Fish, fowl, and most red meats are suitable for broiling. Young tender poultry e.g. chicken, turkeys and duckling can be cooked by broiling. Before cooking the meat is brushed with fat, seasoned with salt and pepper and some sauce instead of adding fat. Then portion is placed in a shallow pan with a skin side down and pan of meat is placed in preheated broiling. After cooking for about 30 minutes the pieces are turned and again basted.
- Low fat content of the broiled chicken and basting of melted fat results in improved flavour and texture and palatability of the chicken. The chicken is considered to cook when the drum stick or the wings twist out of their poultry.

3.4.4 Roasting

- Young broiler pieces of any weight may be used for the purpose of roasting. It may be stuffed or unstuffed. While roasting whole birds, tender parts e.g. breast may be overcooked before the legs and thighs are cooked to the desirable state. In order to avoid any food poisoning the temperature of the internal parts of the stuffed chicken must reach to 74^0C.

- If the poultry is roasted without stuffing, it is cooked to temperature of 163^0C till the temperature of the interior side reaches to 85^0C. However, the exact time temperature combination of the roasting depends upon the size of the carcass.

3.4.5 Braising and stewing

- **Braising** is a combination cooking method using both moist and dry heat. This is the technique which is used to cook older and tougher birds. Disjointed pieces of chicken are generally cooked this way. Initially frying is done to darken the colour to the brown which is then followed by addition of water and simmering of the meat until it gets tender.
- In the **stewing** the frying step is eliminated and the bird whole or its pieces are cooked in water with seasonings and some vegetables till they get tenderized.
- A stew is a combination of solid food ingredients that have been cooked in liquid and served in the resultant gravy. Ingredients in a stew can include any combination of vegetables (such as carrots, potatoes, beans, peppers and tomatoes, etc.), meat, especially tougher meats suitable for slow-cooking, such as beef. While water can be used as the stew-cooking liquid, wine, stock, and beer are also common. Seasoning and flavourings may also be added.

Self-Assessment Exercises 2

1. --------- and ------------- are two physic-chemical changes that take place in poultry during cooking.
2. The process of soaking chicken cuts in acidic seasoned liquid prior to cooking is known as -------------

3.5 Summary

Turkey and chicken meat is very suitable for further processing purposes. Poultry meat is of higher nutritive value than that of other red meats, because of its higher protein content and better digestibility.

Poultry meat can be preserved by chilling, freezing, modified atmospheric storage etc. Poultry meat can be cooked by frying, roasting, broiling, stewing etc.

3.6 References/Further Readings

This section comes at the end of each unit. Provide further readings and references to all the citations in the unit. Follow APA 8th Edition style for the references.

3.7 Possible Answers to SAEs

Self Assessment Exercise 1

1. True
2. CO_2

Self-Assessment Exercises 2

1. See section 3.4.1
2. Marination

UNIT FOUR: TECHNOLOGY OF DAIRY PRODUCTS PROCESSING

Content

4.1 Introduction

Dairy products are generally defined as foods produced from commercially domesticated cows, goats or buffalo's milk. They are usually high energy-yielding food products. Raw milk for processing of dairy products comes mainly from cows and to a lesser extent from other mammals such as goats, sheep, yaks, camel or horses. Dairy products are commonly found in the European, middle-Eastern and Indian cuisines, whereas they are almost unknown in Eastern cuisines.

Dairy products hace been defined as "foodstuffs" made from mammalian milk. Most dairy products contain large amounts of saturated fat and most of them are usually fermented. Examples of dairy products include Cheese, Kefir, yoghurt, etc.

4.2 Learning Outcomes

By the end of this unit, you will be able to

- Discuss the production of ice cream and

4.3 Definition of Milk and Ice Cream

4.3.1 Definition of Milk

Milk is defined as the secretion of the mammary glands of female mammals, its primary natural function being nutrition of the young. As defined by the milk ordinance and code recommended by the US Public Health Service, milk is the lacteal secretion, practically free from colostrums and obtained by complete milking of one or more healthy cows and contains not less than 8.25% milk-solids-non fat and not less than 3.25% butter fat . Milk is a complete food for the young calf, and it can also provide good nutrition to humans. It contains virtually all nutrients, most of these in significant quantities. However, it is poor in iron and the vitamin C content is not high. It contains no anti-nutritional factors, but it lacks dietary fibre.

Milk of some animals, especially cows, buffaloes, goats and sheep, is also used for human consumption, either as such or in the form of a range of dairy products. Dairy products such as fermented milk products (yoghurt),butter, cheese, cream, ice cream are discussed below

4.3.2 Processing of Ice Cream

Ice cream is a sweetened frozen food typically eaten as a snack or dessert. It is usually made from dairy products such as milk and cream and often combined with fruits or other ingredients and flavours. It is typically sweetened with sucrose, corn syrup, cone sugar, beet sugar and or other sweetners. Typically, flavourings and colourings are added in addition to stabilizers. The mixture is stirred to incorporate air spaces and cooled below the freezing point of water to prevent detectable ice crystals from forming. The result is a smooth, semi-solid foam that is solid at very low temperatures (<35^{o}F 12^{o}C). It becomes malleable as its temperature increases.

Ice cream must contain at least 10% milk fat and at least 20% total milk solids, and may contain safe and suitable sweetners, emulsifiers and stabilizers and flavouring materials. Ice cream is sold as hard ice cream or soft serve. After the freezing process only a portion of the water is actually in a frozen state. Soft ice cream is served directly from the freezer where only a small amount of the water has been frozen. Hard ice cream is packaged from the freezer and then goes through a hardening process that freezes more of the water in the mix.

Self Assessment Exercise 1

1. Milk is ---------------------

2 Two dairy products I know are --------- and -------------

4.4 Ice Cream Manufacture

4.4.1: The basic steps in the manufacturing of ice cream

The basic steps in the manufacturing of ice cream are generally as follows:

Blending of the mix ingredients

(Liquid ingredients and dry ingredients)

↓

Pasteurization

↓

Homogenization

↓

Aging the mix

↓

Freezing/whipping of ice cream

↓

Packaging

↓

Hardening

Fig 7: Flow Chart for Ice Cream Manufacture

4.4.2 Blending and Pasteurization

Blending: The ingredients are selected based on the desired formulation and the calculation of the recipe from the formulation and the ingredients chosen, then the ingredient are weighed and blended together to produce what is known as the "ice cream mix". Blending requires rapid agitation to incorporate powders, and often high speed blenders are used. The milk fat source, nonfat solids, stabilizers and emulsifiers are blended to ensure complete mixing of liquid and dry ingredient.

Pasteurization: The mix is then pasteurized. Pasteurization is the biological control point in the system, designed for the destruction of pathogenic bacteria.

The product is then heated in the vat to at least 69^{o}C (155 F) and held for 30 minutes to satisfy legal requirements for pasteurization, necessary for the destruction of pathogenic bacteria. Various time temperature combinations can be used.

4.4.3 Homogenization and Ageing

Homogenization: The mix is also homogenized, which forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream. Homogenization provides the following function in ice cream manufacture:

i. Reduces size of fat globules
ii. Increases surface area
iii. Forms membrane
iv. Makes possible the use of butter, frozen cream etc.

By helping to form the fat structure, it also has the following indirect effects:

i. Makes a smoother ice cream
ii. Give a greater apparent richness and palatability
iii. Better are stability
iv. Increases resistance to melting

Ageing of Mix: The mix is then aged for at least fours and usually overnight. This allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate. Aging provides the following functions;

i. Improve whipping qualities of mix and body and texture of ice cream. It does so by

- providing time for crystallization, so the fat can partially coalesce,
- allowing time for full protein and stabilize hydration and a resulting slight viscosity increase;
- allowing time for membrane rearrangement and protein lemulsipier interaction, as emulsifiers displace proteins from the fat globule surface, which allows for a reduction in stabilization of the fat globules and enhanced partial coalescene.

Aging is performed in insulated or refrigerated storage tanks, silos etc.

Mix temperature should be maintained as low as possible without freezing, at or below 5^{o}C. An aging time of overnight is likely to give best results under average plant conditions. A “green” or unaged mix is usually quickly detected at the freezer.

4.4.4 Freezing/Whipping of Ice Cream and Hardening

Freezing/Whipping of Ice Cream : After the mix processing, the mix is drawn into a flavour tank where any liquid flavour fruit purees, or colours are added. The milk then enters the dynamic freezing process which both freezes a portion of the water and ships air into the frozen mix.

Hardening

After the particulates have been added, the ice cream is packaged and is placed into a blast freezer at -30^{o}C to -40^{o}C where most of the remainder of the water is frozen. Below about -25^{o}C, ice cream is stable for indefinite periods without danger of ice crystals growth; however above this temperature, ice crystal growth is possible and the rate of crystal growth is dependent up or the temperature of storage. This limits the shelf life of ice cream.

Self Assessment Exercise 2

1. Ice cream mix is homogenized to ----------------------
2 Ageing of ice cream mix is for -------- and ------------

4.5 Processing of Butter

4.5.1 Flow diagram for Butter processing

Butter is a water-in-oil emulsion typically consisting of at least 80% fat, 15-17% water and 0.5 - 1% carbohydrate and protein. The two principal types of butter produced are sweet cream butter and ripened cream butter. An outline process for butter manufacture is shown below:

Raw milk

↓

Warned, separated cream blended/standardized to desired fat content

↓

Cream

↓

Pasteurization

(heat to 85^{o}C 15 sec. min)

↓

Sweet cream butter | Ripened cream butter

↓ Cool and partially | ↓ Addition of LAB 4%

4.5.2 Pasteurization and Cooling

The cream used for butter production is generally pasteurized after separation, and heat treatments of 85-95^{o}C for 15-30 seconds are commonly used. After the heat treatment, the cream should be cooled rapidly to 10-11^{o}C and then held for at least 4 hours. This allows the complete liquefied buffer fat to crystallize into large numbers of small crystals. This process, known as ageing, allows a stable matrix of fat crystals to develop, this is important for the physical properties of the final product.

4.5.3 **Ripening/Ripened Cream Butter and Churning**

Ripened cream butter has traditionally been made by inoculating the pasteurized cream with pure or mixed stains of LAB, then maintaining the temperature at 19-21^{o}C until the required level of acidity is reached (usually 4-6 hours). The starter cultures consist of a mixture of acid producers (*Lactococcus latis* subsp. *Lactis* and *lactococcus lactis* subsp. *Cremoris*) and diacetyl-producing species (*Leuconostoc mesentenoides* subsp. *Cremoris* and *Lactococcus lactis biovardiacetylis*). Cooling the soured butter to 3-5^{o}C stops fermentation, butter is then aged.

The purpose of ripening is to sour the cream and to crystallize the fat. Without solid fat, churning is impossible, and too little solid fat goes along with excessive fat loss in the butter milk.

Churning

Churning involves agitation of the cream at low temperature, which produces fat granules that separate from the aqueous phase of the cream to leave buttermilk. The butter milk is drained off, giving a doubling of the fat content of the ice cream. Most of the microorganism present in the ice cream are retained in the aqueous phase and are therefore removed in the buttermilk. In traditional processes, butter granules are then washed to remove off-flavours.

4.5.4 Salting, Working and Packaging

Salting and Working: If butter is to be salted, the salt is now added to give a concentration of about 2% in the butter.

The butter is then worked mechanically both to disperse the salt and water and to obtain the correct physical structure.

Packaging

Butter may be packaged either in bulk or in retail size containers. Parchment wrappers are the traditional packaging material, but plastic tubs and laminated foil packs are also common.

4.5.5 Properties of butter

- Butter must contain at least 80% milk fat. Water and milk solids make up the other 20%. Salt and colouring may be added of desired, some unsalted butter is sold as sweet butter, but most people prefer the salted product.
- Butter also naturally contains the vitamins A and. The colour of butter varies with the content of carotenoids, which make up from 11 to 50% of the total vitamin A activity of milk. Butter should also be dense and taste fresh.
- The water content should be dispersed in fine droplets so that the butter looks dry. The constituency should be smooth, so that the butter is easy to spread and melt readily in the mouth.
- Sour cream butter should smell of diacetyl, while sweet butter should taste of cream. Butter made from sour cream has certain advantages over the sweet cream variety. The aroma is richer, the butter yield higher, and there is less risk of reinfection after temperature treatment as the bacteria culture suppresses undesirable microorganisms.

Self Assessment Exercise 3

1. The treatment given to cream to destroy the pathogenic microorganisms is called -------

2 The process of churning is to -------------

4.6 Cheese Processing

4.6.1 Definition of cheese

Cheese is an established curd of milk solids produced by casein coagulation and entrapment of milk fat in the coagulum. The water content is greatly reduced in comparison with milk, by the separation and removal of whey from the curd. With the exception of some fresh cheeses, the curd is textured salted, shaped, and pressed into moulds before storage and curing or ripening.

Cheese-making is based on application of LAB in the form of defined or undefined starter cultures that are expected to cause a rapid acidification of milk through the production of lactic acid, with the consequent decrease in pH, thus affecting a number of aspects of the cheese manufacturing process and ultimately cheese composition and quality. The basic unit operation in the production of cheese is shown below.

4.6.2 Standardization and pasteurization

Milk is often standardize before cheese making to optimize the protein to fat ratio to make a good quality cheese with a high yield.

Pasteurization

Cheese may be made from raw milk, pasteurized, or milk that has undergone a sub-pasteurization (thermisation) treatment. Pasteurization destroys the vegetative cells of pathogens as well as many spoilage organisms, and some of the enzymes naturally present in the milk.

4.6.3 Cooling, coagulum formation and curd formation

Cooling: Milk is cooled after pasteurization or heat treatment to 90^{o}F (32^{o}c) to bring it to the temperature needed for the starter bacteria to grow. If raw milk is used the milk must be heated to 90^{o}F (32^{o}c) .

Coagulum Formation (Inoculation with Starter Culture and Non-Starter Bacteria)

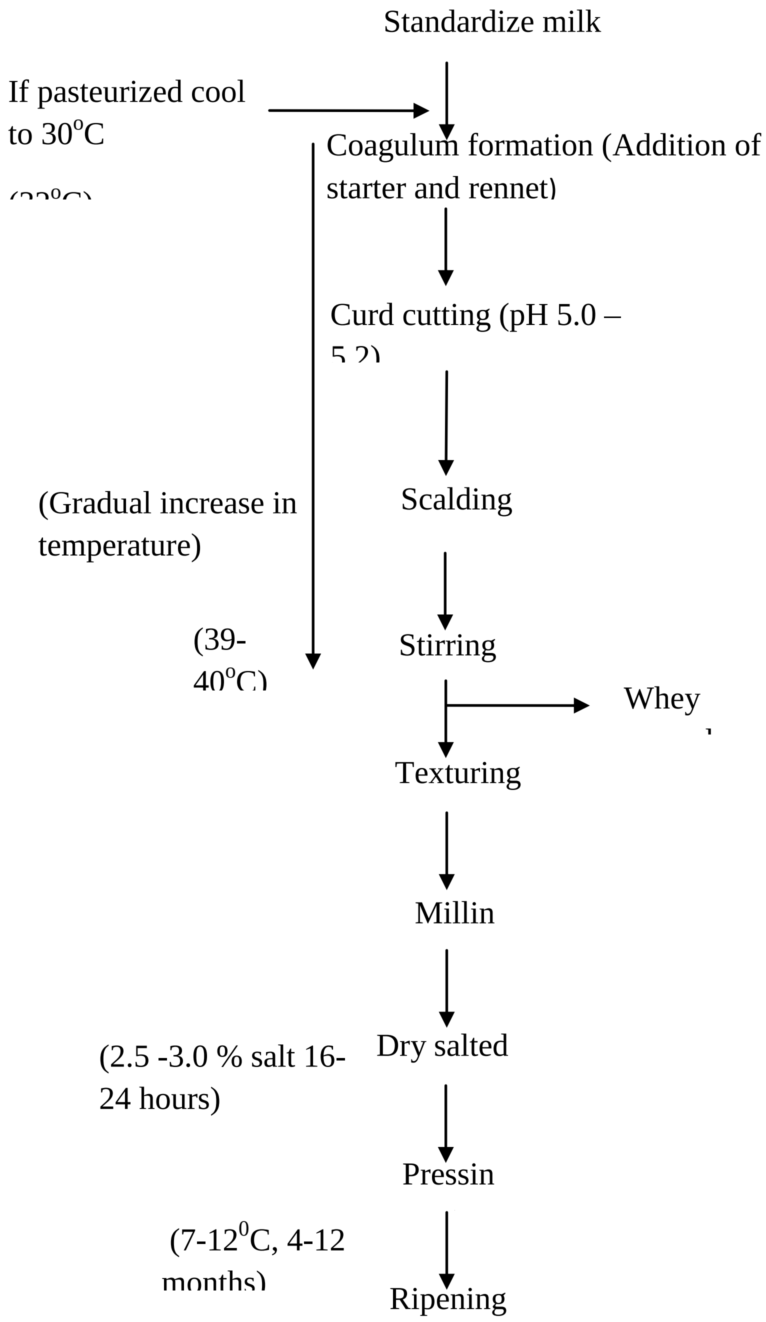


Fig 10: Flow Chart for the Production of Cheese (e.g. Cheddar)

Source: Fernandes, (2009)

The acidification of milk is the key step in the making of cheese. Acidification is essential for the development of both flavor and texture, it promotes coagulation, and the reduction in pH inhibits the growth of pathogens and spoilage organisms. Most cheese is now produced using a carefully selected starter, which gives predictable and desirable results. *Lactococcus lactis*, *Streptococcus thermophitus*, *Lactobacillus helvetocus* and *Lactobacillus delbrueckii* are the primary species of starter bacteria used in cheese manufacture.

Curd Formation: A coagulant is normally added to the acidified milk for cheddar cheese approximately 30-45 minutes after adding the starter, but in other cheeses acidification may be allowed to proceed further. Enzymic coagulation by rennet made from the stomach of young calves is employed. Recently, however, concerns about shortages of ruminal rennet, and increasing demand for vegetarian cheeses, have generated interest in microbial rennet. This may consist of acid protanases produced by moulds such as *Mucor Miehei*, or chymosin.

Rennet, in combination with acid from the starter, causes coagulation of the milk curd by precipitating casein as an aqueous gel. The curd is then allowed to set for a time depending on the cheese variety. For most hard or semi-hard cheeses, this would be approximately one hour

4.6.4 Texture Curd, Salting/Brining and Ripening

Texture Curd: The curd mats are cut into sections and piled on top of each other and flipped periodically. This step is called cheddaring. Cheddaring helps to expel more whey, allows the fermentation to continue until a pH of 5.1 to 5.5 is reached, and allows the mats to "knit" together and form a tighter matted structure. The curd mats are then milled (cut) into smaller pieces.

Salting/Brining: In the manufacture of Cheddar, salt is added to the milled curd before pressing (dry salting) at a concentration of 1.5 - 2% w/w. In other varieties, such as Gouda and Camembert, the moulded cheese is immersed in a concentrated brine. Some blue cheeses are salted by rubbing dry salt into the surface of the moulded cheese. Salting inhibits the growth of the starter culture and other microorganisms, contributes to the flavour, and affects texture.

Ripening: All but fresh cheeses require some degree of ripening for the full development of flavour and texture. During ripening, further moisture loss occurs, and a complex combination of microbial and enzymic reactions take place, involving milk enzymes, the coagulant, and proteases and peptidases from the starter culture and non-starter organisms, which remain viable although their growth is inhibited..

4.6.5 Properties of cheese

Cheese can be broadly categorized as acid or rennet cheese, and natural or process cheese. Acid cheeses are made by adding acid to the milk to cause the proteins to coagulate. Fresh cheeses such as cream cheese or queso fresco are made by direct acidification.

Most types of cheese, such as cheddar or Swiss, use rennet (an enzyme) in addition to the starter cultures to coagulate the milk.

The term “natural cheese” is an industry term referring to cheese that is made directly from milk. Process cheese is made using natural cheese plus other ingredients that are cooked together to change the textural and/or melting properties and increase shelf life.

Self Assessment Exercise 4

1. The key step in making of cheese is the ------------- step.

2 The conventional coagulant added during cheese making is ------

4.7 Processing of Yoghurt

4.7.1 Definition of yoghurt

Yoghurt is the food produced by culturing one or more of the optional dairy ingredients with a characterizing bacterial culture that contains the lactic acid-producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*.

There are two major types of yoghurt; set and stirred yoghurt. Set yoghurt (which includes fruit-on-the bottom) is formed in retail pots as lactic acid bacteria ferment lactise into lactic acid giving a continuous gel structure in the consumer container.

In stirred yoghurt, the acid gel formed during incubation in large fermentation tank is disrupted by agitation (stirring), and the stirred product is usually pumped through a screen which gives the product a smooth and viscous texture.

The main manufacturing procedures of these two types of yoghurts are described below.

4.7.2 Milk Standardization, homogenization and heat treatment

Milk is often mixed with skim milk and cream to standardize (or adjust) the fat content to the desired level.

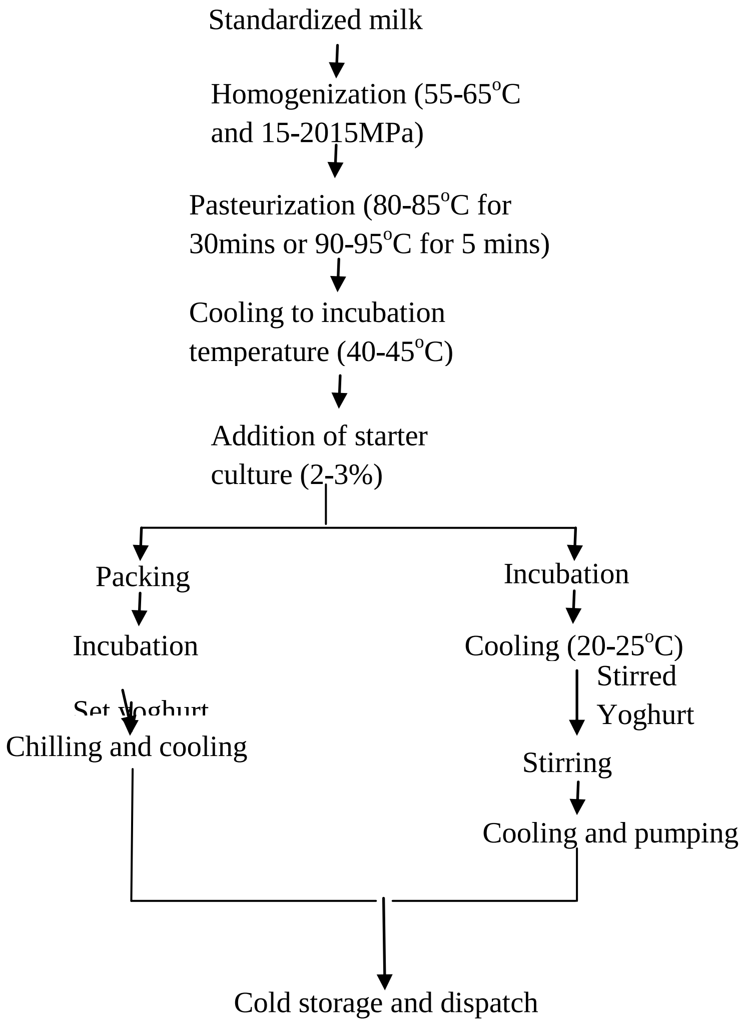


Fig. 12: Flow Chart for the Production of Set and Stirred Yoghurt

Homogenization

Homogenization of the milk base is an important processing step for yogurts containing fat. Milk is typically homogenized using pressures of 10-20 and 5 MPa first and second stage pressures, respectively, and at a temperature range between 55 and 65°C.

Homogenization results in milk fat globules being disrupted into smaller fat globules and the surface area of homogenized fat globules greatly increases.

The use of homogenization prevents fat separation (creaming) during fermentation or storage, reduces whey separation, increases whiteness, and enhances consistency of yogurts.

Heat Treatment: Heating of milk is an important processing variable for the preparation of yogurt since it greatly influences the physical properties and microstructure of yogurt. In yogurt manufacture, milk is heated prior to culture addition. The temperature/time combinations for the batch heat treatments that are commonly used in the yogurt industry include 85°C for 30 min or 90-95°C for 5 min. However, very high temperature short time (100°C to 130°C for 4 to 16 s) or ultra-heat temperature (UHT) (140°C for 4 to 16 s) are also sometimes used . The heat treatment of milk is also used to destroy unwanted microorganisms, which provides less competition for the starter culture. Yogurt starter cultures are sensitive to oxygen so heat treatment helps to remove dissolved oxygen assisting starter growth.

4.7.3 Fermentation and cooling

Fermentation: After heat treatment, the milk base is cooled to the incubation temperature used for growth of the starter culture. An optimum temperature of the thermophilic lactic acid bacteria, i.e., *Streptococcus* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, is around 40-45 °C. Bacterial fermentation converts lactose into lactic acid, which reduces the pH of milk. During acidification of milk, the pH decreases from 6.7 to ≤4.6. Gelation occurs at pH 5.2 to 5.4 for milk that was given a high heat treatment.

Cooling

When yogurts have reached the desired pH (e.g., ~4.6), yogurts are partially cooled (~20°C) before fruit or flavoring ingredients are added. Yogurt products are often blast chilled to <10°C (e.g., 5 °C) in the refrigerated cold store to reduce further acid development.

In the production of set yogurt, yogurts are directly transferred to a cold store or blast chilled in cooling tunnels. For stirred yogurts, cooling is first performed by agitation in the jacketed fermentation vat and the product is sheared and smoothened by devices like back-pressure values, high shear devices or sieves.

4.7.4 Properties of yoghurt

Yogurt is a fermented milk product that contains the characteristic bacterial cultures *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. All yoghurt must contain at least 8.25% solids not fat. Full fat yogurt must contain not less than 3.25% milk fat, lowfat yogurt not more than 2% milk fat, and nonfat yogurt less than 0.5% milk.

The physical and sensory properties of yoghurt gels are greatly influenced by the total solids content of the yoghurt milk, especially the protein content. Increased yoghurt viscosity is observed when the total solids content of milk is increased.

Self-Assessment Exercise 5

1. Write the two microorganisms important for yoghurt production
2. ---- and --------- are the two types of yoghurt.

4.8 Processing of Cream

4.8.1 Chemical composition of cream

Cream may be defined as that portion of milk which is rich in milk fat or that portion of milk into which fat has been gathered and which contains a large portion of milk fat, or when milk fat is concentrated into a fraction of the original milk.

Table 1.1: Chemical composition of cream

Constituents Percentage

Water 45.45 - 68.2%

Fat 25 - 60%

Protein 1.69 - 2.54%

Lactose 2.47 - 3.71%

Ash 0.37 - 0.56%

Total solids 31.8 -54.55%

Solids not fat 4.55 - 6.80%

4.8.2 Production of Cream:

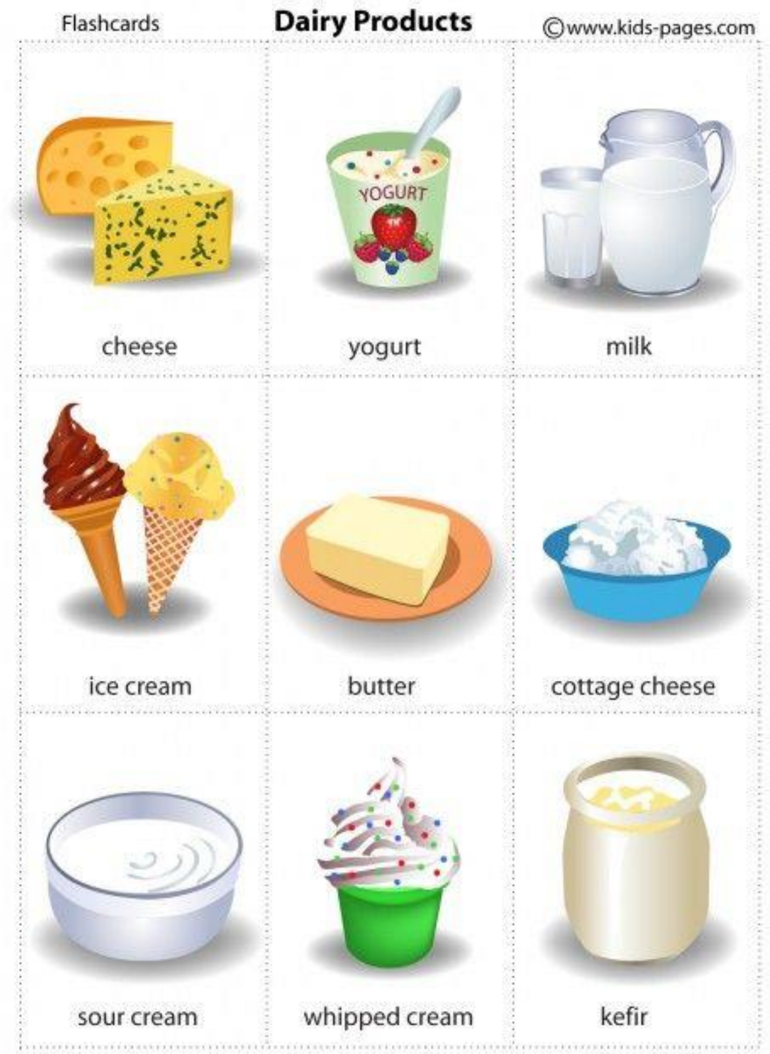
Hence when milk, which may be considered to be a mixture of fat (as cream)and skin milk, is subjected to either gravity or a centrifugal force, the two components, viz. cream and skin milk, by virtue of their differing densities stratify from one another.

Centrifugal method is used commercially to separate cream from milk. The remaining component of milk after separation of cream is called skim milk.

Self Assessment Exercise 6

1. Cream contains higher fat than the native milk. True or false?

2. The remaining component of milk after cream separation is called ----------



Milk Products

4.9 Summary

Milk is the secretion from the mammary gland of female mammals for the feeding of their young. Cow milk is the most consumed milk by humans. milk can be processed into a variety of products.

Ice cream and cream are made from unfermented milk while cheese, yoghurt and sour butter are made from fermented milk. Fermentation reduces the pH of the products and helps to extend shelf life of such products.

4.10 References/Further Readings

1. United Kingdom Food Standards Agency (UKFSA) (2009). Dairy Products. "foodstuffs made
from mammalian milk". Online @ http://www.food.gov.uk/multimedia/pdfs/publication/understandfoodlabellingterms.pdf. Accessed June, 2022.

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4.11 Answers to Self Assessment Exercises

Self Assessment Exercise 1

1. Milk is defined as the secretion of the mammary glands of female mammals, its primary natural function being nutrition of the young.

2. ice cream, yoghurt, cheese, butter, cream

Self Assessment Exercise 2

1. break down fat globules
2. fat to crystallize and proteins to fully hydrage

Self Assessment Exercise 3

1. Pasteurization
2. fat granules that separate from the aqueous phase of the cream to leave buttermilk.

Self Assessment Exercise 4

1. acidification

2. rennet

Self Assessment Exercise 5

1. *Lactobacillus bulgaricus* and *Streptococcus thermophilus*.

2. Set yoghurt and stirred yoghurt

Self Assessment Exercise 6

1. True
2. Skim milk

MODULE 6: FOOD ADDITIVES

UNIT ONE: USES OF FOOD ADDITIVES IN FOOD PROCESSING

Content

1.1 Introduction

Food additives have changed since they were invented and widely used over the past century. Today, food additives ensure that food can be delivered around the world without losses in an ever-growing competitive market. Their role is becoming more and more important with the increase in consumption of highly processed foods due to changing lifestyles of modern world citizens.

Despite the visible improvements in legislation and the production of safer additives, many issues still remain unsolved, leading to increasing controversy and constant demand for better ones. Today, more than 2500 additives are intentionally added to food in order to keep certain properties or to extend shelf-life, while many others were banned throughout the years, some of them at a global level and others only in specific countries.

1.2 Learning Outcomes

By the end of this unit, you will be able to

1. Explain the term food additive
2. Discuss the importance of using food additives
3. Discuss the use of some food additives in the food industry

1.3. Introduction to Food Additives

1.2.1 What are food additives?

“Food additive means any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result, (directly or indirectly) in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods.

In simpler terms, food additives are the substances which are added to food by the manufacturers to facilitate processing or to improve appearance, texture, flavour and keeping quality. The term does not include chance contaminants which might unknowingly enter our food, or substances added to food for maintaining or improving nutritional qualities. Food additives are classified as antimicrobial agents, antioxidants, artificial colours, artificial flavours and flavour enhancers, chelating agents and thickening and stabilizing agents.

The term does not include ‘contaminants’ or substances added to food for maintaining or improving nutritional qualities.

1.3.2. Uses of Food Additives

Food additives are added to food for a number of technological reasons –

1. to increase shelf life, facilitate processing

2. To improve eating characteristics or appeal to the consumer.

3. to retard spoilage

4. To enhance food flavors

5. To replace nutrient lost in processing and makes the food more visually appealing

6. Antimicrobial agents such as salt, vinegar, sorbic acid and calcium propionate are used in the products such as salad dressings, baked goods, margarine, cheese and pickled foods.

7. Antioxidants including vitamin C, E, BHT and BHA are used in the foods containing high fats.

8. Chelating agents such as malic acid, citric acid and tartaric acid are used to prevent the flavor changes, discoloration and rancidity of the foods.

1.3.3 Advantages and Disadvantages of Additives in Food.

Advantages

1. Some additives improve or maintain the food's nutritive value.

2. Makes food last longer

3. Makes food stay fresh for much longer

4. Makes seasonal crops and fruits available throughout the year

5. Saves time

6. Saves cost – loss of food products costs higher

7. Can make food more nutritious, eg Vitamin C in bread

8. Can be lower in calories, eg sweetener instead of sugar

Disadvantages

1. Some people, especially children, can have allergic reactions

2. Potential links to cancer - as yet unproved

3. Links to asthma

4. Some may have a toxic effect

5. Can contribute to high blood pressure

6. Can makes the food less nutritious in comparison to using real ingredient

7. May be higher in calories

Self Assessment Exercise 1

1. Define the term "food additives"
2. List two advantages and two disadvantages of using food additives

1.4 Types of food additives

1.4.1 Food Colours

According to the US FDA, "A colour additive is any dye, pigment, or substance, which when added or applied to a food, drug or cosmetic, or to the human body, is capable (alone or through reactions with other substances) of imparting colour" Food colours are used as food additives mainly to yield better sensory effects, specifically appearance contentment.

Reasons for adding colours to foods:

1. Colour may be lost due to the processing and storage conditions of food, and thus food colours are added to compensate such loss of color.
2. Food items with natural colors may show a variation of color, and thus food colors are added to correct such variations in color and make the colour uniform.
3. colours may be added to further improve the natural colour of the food.
4. food colors are added to give colour to food items with no colour

There are two types of food colours

Natural colours eg cuccumin and riboflavin and Cochineal, a red dye derived from the cochineal insect, Dactylopiuscoccus. • Betanin extracted from beets. • Turmeric • Saffron • Paprika

Synthetic colours such as Fast Green (Bluish green shade) • Allura Red AC, (Red shade) • Erythrosine, (Pink shade) • Tartrazine (Yellow shade) • Sunset Yellow (Orange shade)

1.4.2 Food Preservatives

Food preservatives have become an indispensible part of the food industry today. In simple terms, a food preservative is any substance that hinders food deterioration caused by microbes, enzymes, or any other chemical reaction.

Types of food preservatives

- Natural food additives e.g. essential oils such as clove essential oil and eugenol extracted from cloves, limonene extracted from citrus fruits, and essential oil extracted from cinnamon
- Artificial food preservatives e.g. Sorbic acid, Potassium sorbate, Calcium sorbate, Benzoic acid, Sodium benzoate, Potassium benzoate, Sulfur dioxide, Sodium sulphite, , Sodium metabisulphite, Potassium nitrite, Sodium nitrite, Sodium nitrate etc. Many artificial preservatives impart negative health effects at high doses. For instance, in vitro studies have

revealed that sodium benzoate and potassium benzoate exhibit genotoxic effects. However, this issue can be dealt with by adhering to the acceptable daily intake (ADI) values of food additives.

1.4.3 Antioxidants

The antioxidants are another subgroup of the preservatives, essential to extend the shelflife of many foodstuffs. Antioxidants prevent the oxidation of molecules by donating a hydrogen atom or an electron, becoming themselves reduced, in the radical form, but contrary to other radicals, antioxidants when in radical form are stable and do not allow further reactions to take place, therefore preserving the status quo of the system. Food antioxidants are used for extending shelf-life and impeding decay while not adding taste or odors to food or modify appearance.

Examples of natural antioxidants are vitamin C and vitamin E. The most common chemical antioxidants added to food to inhibit lipid peroxidation and rancidification are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl galate, (PG), ethoxyquin and tertbutylhydroquinone (TBHQ).

Self-Assessment Exercise 2

1. Essentials oils such as clove essential oils are examples of ---------------------
2. ------------- prevents oxidative deteriorative of oil containing foods

1.5 Sweeteners

1.5.1 Types of sweeteners

The most commonly used sweetener used in the food industry is sucrose as it is readily available. Thus, the performance of other sweeteners is frequently measured against that of sucrose. Glucose is also frequently used in the food industry, especially in the manufacturing of confectionaries.

However, substitutes for common sugars, natural or artificial, are in high demand due to:

- The prevalence of diabetes mellitus among a significant proportion of people worldwide.

- for weight loss,
- prevention of dental carries
- In addition, using sugar substitutes is cost effective since the sugar substitutes are many times (sometimes more than 100 or even 1000 times) sweeter than sucrose

. A list of sweeteners frequently used in food manufacturing is stated below:

List of sweeteners: Sorbitol, Sorbitol syrup, Mannitol, Acesulfame K, Aspartame, Cyclamic acid and its Na and Ca salts, lsomalt, Saccharin and its Na - K and Ca salts, Sucralose, Thaumatin, Neohesperidine DC, Steviol glycoside, Neotame (as a flavor enhancer), Salt of aspartame-acesulfame, Maltitol, Maltitol syrup, Lactitol, Xylitol, Erythritol

1.5.2. Some Common artificial sweetners - Acesulfame K and Aspartame

a. Acesulfame K - It is a zero calorie sweetener, 130- 200 times sweeter than sucrose. It is not metabolized by the body. The only limitation it has is that if used in large quantities, it has an after taste. It is used in fruit preserves, dairy products and all types of beverages. It is used to reduce the calories of the products. It is heat resistant and enhances flavors.

b. Aspartame - It is a low calorie sweetener about 200% sweeter than the sugar. It is disintegrated into aspartic acid, fenylalanine and methanol in the body on digestion. It's taste is similar to sugar only more sweet. It is used in all types of foods and beverages and medicines. It is found naturally in protein rich foods.

1.5.3 Cyclamate and Saccharin

a. Cyclamate - This is a calorie free sweetener 30-50 times sweeter than sugar. It is metabolized in the gut by few individuals and generally expelled as such. It is generally used in combination with other sweeteners. It has a pleasant taste, and is stable at high temperatures and is economical.

b. Saccharin - It is one of the earliest low calorie sweeteners that is 300-500 times more sweet than sugar. It doesn't metabolize and absorption is slow. Owing to this it is expelled as such from the body. Saccharin is the most widely used sweetener. It was earlier banned in certain countries but now is used quite commonly. There are other sweeteners like Stevioside, Alitame, Thaumatin, Sucralose, Neohesperidine DC and Aspartame-Acesulfame Salt. All artificial sweeteners have been approved by the U.S. Food and Drug Administration (FDA). They are considered harmless if taken in limited quantities

Self-Assessment Exercise 3

3. Two examples of natural sweetners are ----- and -------
4. List two reasons why artificial sweetners are added to food

1.6 Summary

Despite the food safety concerns about the use of food additives in food processing, there use cannot be entirely eliminated because their benefits far outweigh their advantages. these advantages are reduced by adhering to recommended levels of addition.
in this unit, we have discussed some common food additives like preservatives, colours, antioxidants and sweeteners. Their type of food additive added and the amount used depends on the food that needs to be preserved but the levels must not exceed the ADI.

1.7 References/Further Readings

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Pandey, R. M. & Upadhyay, S. K. (2018). *Food Additives*. Division of Genetics, Plant breeding & Agrotechnology, National Botanical Research Institute, Lucknow, India. Pp. 210.

UNIT 2: FOOD ADDITIVES II

Content

2.1 Introduction

In the last unit, we discussed food additives: their uses, advantages and disadvantages. we also discussed some major food additives like food colours, food preservatives, antioxidants etc.

food additives are essential in food processing as the prolong the shelf life of foods that would otherwise spoil very fast. They also add to the organoleptic properties of foods like colour, texture, flavour hence increasing their acceptability.

In this unit, we shall discuss some more food additives and their roles in food processing.

2.2 Learning outcomes

By end of this unit, you will be able to:

1. Explain the use of acid regulators, flavour enhancers and anti-caking agents in food processing
2. Explain the use of humectants, bleaching and glazing agents in food processing
3. Discuss the miscellaneous food additives/

2.3 Other Common Food Additives

2.3.1 Acidity regulators

Acidity regulators are used to change or otherwise control the acidity and alkalinity of foods or maintain a sour or sharp taste. An acidified food can retard the growth of some microorganisms.

Types of acidity regulator

a. acid

b. acidifier

c. acidity regulator

d. alkali

e. base

f. buffer

g. buffering agent

h. pH adjusting agent

Examples of acidity regulators

Sodium lactate, Potassium lactate, Calcium lactate, Citric acid, Sodium citrates, Potassium citrates, Calcium citrates, Potassium tartrates, Sodium potassium tartrate, Phosphoric acid, Sodium phosphates, Potassium phosphates, Calcium phosphates, , Sodium malates, Potassium malate, Calcium malates, Metatartaric acid, Calcium tartrate

2.3.2 Thickeners, stabilizers, emulsifiers, and gelling agents

- Thickeners, stabilizers, emulsifiers, and gelling agents have become an integral part in the current food manufacturing industry.
- Thickeners increase the volume, change the viscosity, and increase the processability of the food items.
- Stabilizers, as the name implies, stabilize the food products; sometimes through the utilization of fillers.
- Emulsifiers assist in the miscibility of otherwise immiscible substances possible. For instance water-in-oil (e.g. margarine) or oil-in-water (salad dressing) emulsions used in the food industry are made utilizing emulsifiers.
- Gelling agents mainly contribute to the viscosity and sensory properties of the food products. In sum, all thickeners, stabilizers, emulsifiers and gelling agents contribute to the stability and palatability of the food product.
- Examples include: starch, food gums like gum Arabic, Xanthan gum, Karaya gum, Tara gum, Gellan gum, Konjac, Soybean hemicellulose, Cassia gum, Polyoxyethylene sorbitan monolaurate; Polysorbate 20, Polyoxyethylene sorbitan mono-oleate; Polysorbate 80, Polyoxyethylene sorbitan monopalmitate; Polysorbate 40,

Polyoxyethylene sorbitan monostearate; Polysorbate 60, Polyoxyethylene sorbitan tristearate; Polysorbate 65, Pectins

2.3.3 **Anti-caking agents**

Anti caking agents, prevents the formation of lumps making these products manageable for packaging, transport, and for use by end consumer. Anticaking Agent is the food additive that prevents agglomeration in certain solids, permitting a free-flowing condition. It reduces the tendency of particles of food to adhere to one another.

Types of anti-caking agent

a. Anti-caking agent

b. Anti-stick agent

c. Drying agent

d. Dusting agent

Anti-caking agents consist of such substances as starch, magnesium carbonate, and silica and are added to fine-particle solids, such as food products like table salt, flours, coffee, and sugar. Some of the common examples of foods that contain anti-caking agents include:

i. Vending machine powders (coffee, cocoa, soup)

ii. Milk and cream powders

iii. Grated cheese

iv. Icing sugar

v. Baking powder

vi. Cake mixes

vii. Instant soup powders

viii. Drinking chocolate

ix. Table salt

2.3.4 Flavours and flavour enhancers

Flavours

Flavours are additives that give food a particular taste or smell, and may be derived from natural ingredients or created artificially

Flavour enhancers

Flavour enhancers enhance a food's existing flavours. They may be extracted from natural sources (through distillation, solvent extraction, maceration, among other methods) or created artificially.

Types of flavour enhancing agents

a. Flavour enhancer

b. Flavour synergist

Some flavour enhancers are as follows:

i. Dioctyl sodium-sulfosuccinate - used in processed foods.

ii. Disodium guanylate - used in canned meats, meat based foods.

iii. Hydrolyzed vegetable - used in mixes, stock, processed meats.

iv. Monosodium glutamate (MSG) - used in Chinese food, dry mixes, stock cubes, and canned, processed, and frozen meats.

Self Assessment Exercise 1

1. These are added to foods to prevent formation of lumps
   a. acid modifiers
   b. anti caking agents
   c. antioxidants
   d. glazing agents
2. Monosodium glutamate is an example of ---------–

2.4 More Food Additives

2.4.1. Humectant

A humectant is a hygroscopic (water absoroping) substance used to keep things moist; a humectant attracts and retains the moisture in the air nearby via absorption, drawing the water vapor into or beneath the organism's or object's surface.

Examples of some humectants include: Natural: • Aloe vera gel • Egg yolk and egg white • Honey • Molasses

Artificial • Propylene glycol, hexylene glycol, and butylene glycol • Alpha hydroxy acids such as lactic acid • Glyceryl triacetate • Lithium chloride, • Polymeric polyols such as polydextrose • Quillaia • Sodium hexametaphosphate • Sugar alcohols (sugar polyols) such as glycerol, sorbitol, xylitol, maltitol

Humectants are used in such foods as cakes, breads

2.4.2 Bleaching agents

A bleaching agent is used to lighten or whiten a substrate through chemical reaction. The bleaching reactions usually involve oxidative or reductive processes that degrade color systems. A food bleaching agent is simply used for the purpose of decolorizing food. For example, food manufacturers usually add flour bleaching agent to flour in order to make it appear whiter and to oxidize the surfaces of the flour grains and help with developing of gluten. Usual bleaching agents are: • Organic peroxides, namely benzoyl peroxide • Calcium peroxide • Nitrogen dioxide • Chlorine • Chlorine dioxide • Azodicarbonamide • Atmospheric oxygen, used during natural aging of flour

2.4.3 Glazing agents

A food additive, which when applied to the external surface of a food, imparts a shiny appearance or provides a protective coating. Glazing agents provide a shiny appearance or protective coating to foods. Glazing agents like egg white are used in baked products to bring about a glossy surface.

Types of glazing agent

a. Coating agent

b. Film forming agent

c. Glazing agent

d. Polishing agent

e. Sealing agent

f. Surface-finishing agent

Self Assessment Exercise 2

3. Humectants are food additives that ------------ of foods.
4. Peroxides are used as ------------ in foods.

2.5 Miscellaneous Food additives

2.5.1 Mineral salts

Mineral salts are added as nutritional additives though they may have other properties like anti-oxidant or a preservative. Many of them are essentials that need to be included in our daily diets, as they are the source of important nutrients required for the body. The important natural mineral salts that should be consumed are sodium, phosphorus, potassium, chlorine, sulphur and calcium. While the above mentioned happen to be the macro elements of the natural mineral salts, the micro elements are the ones that are essential nutrients for the human body. The micro elements in the minerals salts consist of iodine, iron, fluoride and zinc.

2.5.2 Propellants and Sequestrant

Propellants help propel food from a container.

Sequestrants

A sequestrant is a food additive whose role is to improve the quality and stability of the food products. Sequestrants form chelate complexes with polyvalent metal ions, especially copper, iron and nickel, which serve as catalysts in the oxidation of the fats in the food. Sequestrants are a kind of preservative.

2.5.4 Antibiotics

- Antibiotics are being used in the food industry today to increase the shelf life of numerous food items, especially perishable food items including milk.
- Although not directly added during food processing, nonvegetarian food may contain a certain amount of antibiotics since antibiotics are frequently used in animal production.
- However, any antibiotic used for human therapeutic purposes or for animal feed additive are banned for use in the food industry. Tetracycline is a classic example.
- Antibiotics frequently used in food manufacturing are: Nisin, Natamycin, Subtilin, Tylosin Phytoncides

Self Assessment Exercise 3

5. ------------- are added to foods to increase their nutritional content
6. Nisin is an example of -----------

2.6 Summary

Food additives are numerous but we have looked at a few of them. they are very important in food processing but as earlier mentioned they must be used within recommended levels.

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MODULE 6: FOOD BEVERAGE MANUFACTURE

UNIT 1 DEFINITION AND CLASSIFICATION OF BEVERAGES

1.1 Introduction

Think back to the last 24 hours and recall some drinks you have taken other than water. I am sure some of the drinks include soft drinks, fruit juice, beer, kunu, soy milk etc. Beverages are an integral part of human diet, starting from new born. The cycle starts with the infant formulas to highly complex drink, rich in many key nutrients. Beverages are portable drinks other than water that humans can consume. They may be in the form of freshly squeezed juices to chemical-packed energy drinks.

In this unit, you shall learn the definition and classification of beverages. you will also learn the benefits of beverage consumption.

1.2 Learning Outcomes

By the end of this unit, you will be able to

1. Discuss the definition of beverages
2. Analyze the bases for classification of beverages
3. Evaluate the benefits of beverage consumption

1.3 Definition and Classification

1.3.1. Definition of beverages

Beverages can be defined as “any fluid which is consumed by drinking apart from water”. It consists of diverse group of food products, usually liquids that include the most basic drinks like tea or coffee to a wide range of commercially available fluids like fruit beverage, synthetic drinks, alcoholic beverage, milk, etc. Despite differences in their properties one common feature that exists in all beverages is their ability to act as thirst quencher. In simple words beverages can be defined as "liquid which is essentially designed or developed for human consumption". The beverages are rarely consumed for its food value but it is vital for life because of their high water content.

The term "beverages" has also been defined as all kinds of potable drinks which have thirst quenching refreshing stimulating, and nourishing properties. Beverages are consumed mainly to quench thirst, compensate loss of body fluid due to perspiration, feel fresh and active, as rituals, during social gatherings, and during and after eating, examples are fruit drinks, soft drinks, chocolate drinks, coffee, tea, beer, whiskey etc

1.3.2 Classification of beverages

Beverages may be classified in various ways. The classification criteria may depends on various factors as mentioned below:

- Natural and Synthetic (Ingredients used in manufacture)
- Carbonated and Non-carbonated (Degree of mechanical carbonation)
- Alcoholic and Non-alcoholic (presence or absence of alcohol)
- Hot and Cold (Temperature of serving)
- Stimulating and Non-stimulating (Based on physiological effect)

Self Assessment Exercise 1

1. Any liquid that is consumed including water is regarded as a beverage. True or false.
2. One of these is not a basis for classification of beverages

a. Natural and Synthetic
b. Carbonated and Non-carbonated
c. plain and sweetened
d. Hot and Cold

1.4 Classification of beverages Based on Ingredients used in Manufacture and Degree of Mechanical Carbonation

1.4.1 Natural and synthetic beverages

Natural beverages: The natural beverages are prepared from the naturally derived ingredients including fruit juices or milk or malt, sugar, acid, flavouring and colouring materials. The examples of this group are fruit based beverages, malt beverages and dairy beverages.

Synthetic beverages: Synthetic beverages are analogue of natural beverages and may contain ingredients which are prepared synthetically like flavouring and colouring materials. These are primarily developed to offer pleasure to consumers at affordable cost. The major group of synthetic beverages is soft drinks which contain flavoured sugar syrup as base material that may or may not be carbonated. The artificial sweetener based beverages also belong to the category of synthetic beverages as they contain artificial sweeteners mainly to reduce the calorific value.

1.4.2 Classification based on degree of mechanical carbonation

Carbonated beverages: Carbonated beverages are the one where carbon dioxide is dissolved in syrup or water. The presence of carbon dioxide creates bubbles upon release of pressure and fizzing in the beverage. The carbonated beverages are commonly referred as "Soft Drink". Cola or lemonade beverages are typical examples of carbonated beverages. The process of fermentation also produces carbon dioxide in certain beverages like beer. Carbonation is done for various reasons. Consumers find the fizzy sensation pleasant, and like the slightly different taste that dissolved carbonic acid provides. Soda water is another popular type of carbonated beverage which may also be flavoured.

Non-carbonated beverages: Majority of fruit and dairy based beverages falls into the category of non-carbonated beverages. The category also includes hot beverages and alcoholic beverages that do not contain carbon dioxide, examples include fruit drinks, squashes, coffee, tea etc

1.4.3 Classification Based on the Presence or Absence of Alcohol

Alcoholic beverages: Alcoholic beverages contain ethyl alcohol which can be consumed for its intoxicating and mind-altering effects. Alcoholic beverages are produced by the process of natural or controlled fermentation. On the basis of raw material used and process technology used in their manufacture alcoholic beverages may be classified into three major groups:

- **Beer**: Beer is the world‟s third most consumed beverage. Beer is prepared by fermenting the "wort" (soluble liquid of barley malt digest) with appropriate yeast to attain an alcohol level in the range of 4-8 percent. Apart from alcohol, beer is also characterized by the "effervescence" i.e. foam which is produced by carbon dioxide and bitterness. The bitterness and aroma in beer is contributed by the hops (*Humulus* *lupulus*) solids. There are many variants of beer but two are more popular. These are called as "Lager" beer which is fermented by bottom yeast i.e. *Saccharomyces pastorianus* at lower temperature (7-12 ^{O}C) for longer period, while the "Ale" is manufactured by using top fermenting yeast i.e. *Saccharomyces cerevisiae* at relatively higher temperature (18-25^{0}C).

- **Wine**: Wines are made from variety of fruits. Such as grapes, peach, plum or apricots. However, the most commonly used one is grapes, both green as well as red grapes. The grapes are macerated to release juice which is fermented naturally by wide range of yeasts including Saccharomyces spp., Pichia spp., Stellata spp. and certain lactic acid bacteria. The duration of fermentation is also longer as compared to beer and mostly fermented wine is aged (months to year) to develop desirable sensory characteristics . There are two major type of wines i.e. white wine (made from green grapes) and red wine (from red or blue grapes). The red wine contain anthocyanin (as colouring pigment) and subjected to secondary fermentation termed as "Malolactic fermentation" to mellow the flavour of wine. The alcohol content in wine ranges from 9-16% (v/v). Sparkling wines are characterized by "effervescence" produced by carbon dioxide and clarity, example: Champagne.
- **Spirit**: Spirit is a class of alcoholic beverages which are unsweetened and produced by distillation of fermented base. The fermented base may be molasses (by-product of sugar industry), fruit juices, cereal extract or sometime a combination of many fermentable substrates. Spirits are characterized by relatively higher alcohol content which may be as high as 20 percent.

1.4.4 Classification based on temperature of serving

Another criterion for classifying beverages is the temperature of serving. Certain beverages are consumed only hot i.e. temperature above 65-70^{0} C which are termed as "Hot beverage" while those served at chilled temperature are called as “cold beverages”. The examples of hot beverages are tea, coffee, chocolate and milk. However, iced tea and cold coffee are served chilled. Most of the fruit beverages, dairy drinks, alcoholic drinks and soft drinks are example of cold drinks.

Classification based on based on physiological effect

According to their physiological effect beverages are classified in to following three categories: nourishing, refreshing and stimulating beverages.

Nourishing beverages : These drinks are rich in carbohydrates, proteins, fats that impart them high food value. Examples are cocoa drinks, egg drinks, milk. Children and nursing mothers are suggested to take these drinks.

Refreshing beverages: This group of drinks include commercial carbonated drinks, fruit and vegetable juices. refreshing drinks are normally served cold.

Stimulating beverages: Consumption of some beverage stimulates the body systems mainly to nervous system and circulatory system. It is mainly due to the presence of certain chemical compounds like caffeine in coffee and tea, many phenolic compounds in herbal drinks and ethyl alcohol in alcoholic beverages. The chemical constituents present in these beverages influence the physiological processes as follows:-

- Increase in basic metabolic rate (BMR)
- Increase in blood circulation and heart beat
- Stimulation of central nervous system (CNS) and release of neuro transmitter
- Diuretic (increase in frequency of urination)
- Enhancement in secretion of gastric juice

Self Assessment Exercise 2

1. According to physiological function, beverages are classified into ----------, ------------ and ------------
2. which of the following is not a carbonated drink
    a. beer
    b. pepsi cola
    c. kunu
    d. fanta

1.5 Other Basis of Classification and Importance of Beverage Consumption

1.5.1 Other basis of classification

Herbal drinks: Herbal drinks are prepared by using the infusion of herbs in water. A wide variety of herbs may be used in preparation of such drinks. Many herbs like aloe vera, ginseng, garlic, ginger, lemongrass, scent leaf etc. may be used for as base material for herbal drinks.

Mood drinks and energy drinks: Energy drinks are those beverages which boost energy and mainly contain sugar and caffeine. In recent past there has been rapid growth in the demand of energy drinks. These drinks may also contain variety of stimulants and vitamins. Energy drinks provide carbohydrates and caffeine and some contain B vitamins, amino acids and among others.

Sports drinks:Sports beverages are also called as “electrolyte drinks” are basically designed to replenish the loss of fluid & electrolytes and provide quick energy during the exercise and sports activity. The monosaccharides such as dextrose, glucose syrup are added so that they can be transported easily into the muscle cells and produce energy apart from sucrose and maltodextrin.

1.5.2 Health importance of beverages

Beverages are essential for growth, development as well for carrying out various physiological processes that are critical for living a healthy life. In adult individuals 70 percent of body weight, 73 percent of lean muscle, 25 percent of adipose tissues, 22 percent of bone and 80 percent of blood consists of water. Consumption of beverages help in maintaining the water content in body and prevent dehydration.

- The water assists in digestion, assimilation and excretion of foods. It also helps in removing the toxic substances produced in body as a result of metabolisms such as urea, uric acid, ammonia etc. through kidney.
- Water in beverages help in regulating the temperature of body through the process of sweating.
- Beverages specially the fruit and vegetable based ones are source of micronutrients (vitamins and minerals) and anti-oxidants (carotenoids, flavonoids). milk beverages contain calcium which promotes strong bones and teeth.
- Certain beverages like tea and coffee contain alkaloids which stimulate the central nervous system.
- Consumption of alcoholic beverages specially wine is recommended for its heart healthy image due to the presence of flavonoids.
- Fermented dairy beverages are consumed because of the beneficial microflora present in them which assist in restoration and improvement of gastro-intestinal health.

Energy drinks provide carbohydrates and caffeine and some contain B vitamins, amino acids and among others.

Self Assessment Exercise 3

1. These drinks contain caffeine in them (there may be more than one answer).
    a. energy drink
    b. coffee
    c. soft drink
    d. fruit juice
2. State two importance of beverage consumption

2.6. Summary

Beverages are portable drinks other than water that humans can consume. their importance to our physiological functions cannot be overemphasized. beverages are classified based on different criteria which include ingredients used for manufacture, degree of mechanical carbonation, presence of alcohol etc

Beverages can function as stimulating, refreshing or nourishing drinks. beverages are very important to the body because they hydrate the body, provide some nutrients, contain some health promoting phytochemicals.

2.7 References/Further Readings

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2. Vernam, A.H. & Sutherland, J.P. (1999). *Beverages: Technology, Chemistry and Microbiology*. Chapman and Hall, London. Pp.127-190.

2.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise

1. A and B
2. See 1.5.2

Self Assessment Exercise 2

1. According to physiological function, beverages are classified into stimulating, refreshing and nourishing
2. C- Kunu

Self Assessment Exercise 1

1. false.

2. C-plain and sweetened

UNIT 2 MANUFACTURING OF SELECTED NON ALCOHOLIC BEVERAGES

2.1 Introduction

Non alcoholic beverage are potable drinks which may be nourishing, stimulating, refreshing may have thirst quenching properties. A non-alcoholic beverage is defined as a beverage that contains less than 0.5% alcohol by volume. Various types of non-alcoholic beverages are available as on today. Tea, coffee, fermented and non-fermented milk, fruit and vegetable beverages, herbal juices, soft drinks etc. Some non alcoholic beverages provide instant energy after exertion from sports/games or other activities. They prevent dehydration and help in maintaining blood volume in case of bleeding, heat stroke, vomiting, excess sweating or diarrhoea.

in the last unit, you studied the definition of beverages and the different criteria for classification. In this unit we will concentrate on all the basic non alcoholic drinks. You will learn about tea, coffee, juices, squashes, cordials, etc.

2.2 Learning outcomes

2.3 Cocoa, Tea and Coffee

2.3.1 Cocoa drink

Cocoa is a drink produced from the fruits of cocoa tree. Botanically, cocoa tree is also called *Theobroma cacao* and a tropical evergreen tree. The pods contain 20-50 seeds (cocoa beans) which could be broken open and cleaned by hand. The seeds are used to produce cocoa mass, cocoa powder and chocolate.

Processing of cocoa

Depoding : The cocoa pods are gathered in heaps and cut upon with sharp rounded knife. The cocoa beans are scooped out or removed from the mucilaginous pulp of the cocoa pod. The fresh bean from the cocoa pod has a strong bitter taste and must be fermented to develop its flavour and colour.

Fermentation : The cocoa beans are placed on fermenting heaps and fermented for 5-8 days to remove the pulp from the outside of the bean and to decrease the strong bitter taste. Oxidation begins almost at once causing the beans to become brown which is due to the oxidation to tannins.

Drying : The beans are then spread in the sun and dried to remove the moisture so that they are not spoilt during storage. the seeds are then sorted to remove bad ones.

Shelling or crushing: The sorted beans are crushed, then the shells are removed by fans and only the seed (pure core) is retained. The separation of the shells and the seeds must be optimal, as the more pieces of shell there are in the seed, the more difficult the grinding process will be. **Roasting:** The seeds obtained are roasted, i.e. their surface is heated to reduce the rate of humidity, eliminate the acidity formed during fermentation, facilitate shelling and crushing and enable the savours (“chocolate” flavour and aroma) to develop. The roasting process, which also sterilises the beans, is carried out at 98 - 120 °C for 90 - 95 minutes.

Grinding The roasted seeds are ground using a ball mill crusher or a grinding machine to obtain a cocoa mass or paste used to make cocoa butter or chocolate. 100 kg quantity of cocoa beans produces 80 kg of cocoa paste.

The pure cocoa paste obtained is pressed to extract cocoa butter and cocoa cakes. The butter obtained is filtered, centrifuged and deodorised by steam distillation. The cocoa butter is used to produce chocolate or cosmetics. The cocoa cake obtained on completion of pressing is crushed and ground to make cocoa powder. The cocoa powder is used to produce chocolate, pastries, milk-based drinks or cosmetics

2.3.2 Tea

Tea is defined as a universally drunk beverage made by infusing the leaves of and evergreen Asiatic shrub called " *Camellia Sinensis*". There are different types of tea:

- Black Tea

  Black tea is withered, fully oxidized and dried. Black tea commonly yields a hearty, amber-colored brew. Some of the most popular types of black teas are bold breakfast teas (e.g. English Breakfast, Irish Breakfast) and Darjeelings.

- Green Tea

  Green tea production endeavors to avoid the oxidation of the tea leaves, in order to retain its natural green color and fresh flavor. In Japan, the leaves are steamed, while other countries will pan-fire or dry it through other methods. This type of tea has a more delicate flavor than black tea and often brews up pale green or golden in color.

  Oolong Tea

- Oolong tea is produced mainly in China and Taiwan and is only partially oxidized. This type of tea can range from tasting similar to a fresh green tea, The flavor can vary widely, depending on where the tea leaves are grown and how the tea is made.

- White Tea

  Originally from China, white tea is simply withered and dried, causing a very light oxidation. Its flavor is most similar to that of green tea, but is usually more creamy, soft and sweet.

2.3.3. Manufacture of Tea

The processes in the manufacturing of tea depends on the type of tea. The major unit operations include

1. **Withering the leaf**:-On reaching the factory, which is usually close to the plantation, the plucked leaves are first weighed. They are then spread out evenly and thinly on special racks (slatted). At this stage, they lose 50% of their moisture by evaporation. This stage takes 24 hours,

depending on the surrounding temperature and the humidity in the air.

2. **Rolling the leaves**: - The leaves are put through rolling machines that break up the leaf cells,

thus releasing natural juices and bringing them into contact with air. At this stage, the finer leaves are separated from the larger coarser leaves and are then further separately processed.

3. Fermenting the leaves: - This isn"t really a true fermentation, but the oxidation stage. Tannin,

which is the astringent substance in the tea leaf, is oxidized and leads to development of aroma,

flavour and colour of the leaf. The leaves are spread out in a cool but humid room under controlled conditions, on racks for approximately 3 hours, during which they turn a coppery colour by the absorption of oxygen.

3. **Sorting and grading**

The dried tea is sorted into different grades passing it over series of vibrating screens of different mesh sizes producing a number of grades with evenly sizes particle.

4. **Packaging :** After sorting and grading, the next step in packing the tea. Teas are packed in air tight containers in order to avoid moisture absorption. tea is also packgaged in tea bags for easir infusion.

The unit operations for tea processing is shown in the figure below:

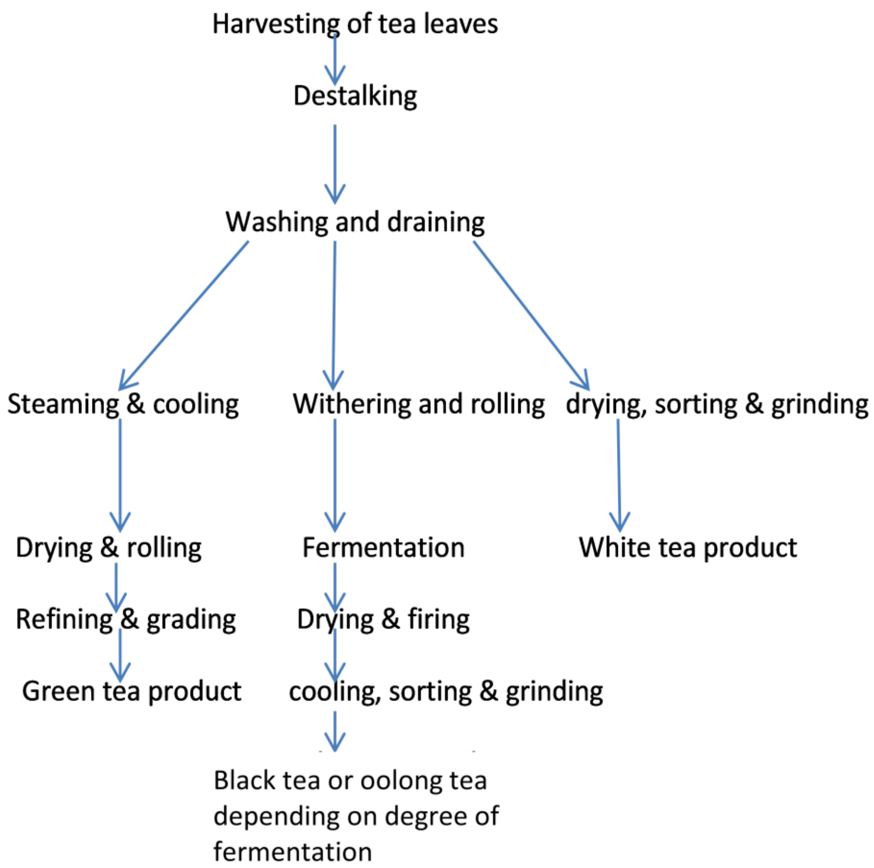

Fig 1: Processing of Tea

2.3.4 Coffee

Coffee is a brewed drink prepared from the roasted seeds of several species of an evergreen shrub of the genus Coffea. The two most common sources of coffee beans are *Coffee arabica* and *Coffee canephora*. Riped coffee "berries" are picked, processed and dried to yield the seeds inside. The seeds are then roasted to varying degrees, grounded and brewed to create coffee. Degrees of roasting of coffee beans imparts variable flavour to beans. Coffee is primarily used as stimulant due to high levels of caffeine found in it.

Self Assessment Exercise 1

1. The process of roasting of cocoa beans is for the following except
   a. reduce moisture content
   b. to eliminate the acidity formed during fermentation,
   c. oxidation of tannins
   d. and enable the formation of flavour and aroma
2. ------------ is not a type of tea
   a. short
   b. oolong
   c. green
   d. black

2.4 Fruit and Vegetable Based Beverages

2.4.1 Fruit juices

Fruit juices: Fruits juice is a natural product that contains few or no additives. Juices are extracted by crushing fruit berries; collecting concentrates and mixing them with water and sometimes sweetened. Percentage of water determines their nutritive value. Citrus products such as orange are familiar breakfast drinks, while pineapple, apple, lime, guava, lemon juice, raspberry, blackberry and currants are also very common at serving table. Coconut water, a highly nutritious and refreshing juice, is highly in modern trend. Fruits are highly perishable so the ability to extract juices and store them was of significant value. Some citrus fruits are highly acidic which require their mixing with water and sugars to make them palatable.

Vegetable juices: Vegetable juices such as tomato, carrot, cucumber juice are popular vegetable juices. They are usually served warm or cold. Some vegetable juices are mixed with some fruit juice to make it better in taste. Vegetable juices are rich in their mineral content, such as tomato juice, is high in sodium, and therefore, they must be consumed with care.

2.4.2 Cordials and squashes

Cordials: Fruit juice cordial is a sparkling clear sweetened fruit beverage from which all the pulp and other suspended materials have been completely eliminated. Cordial is prepared by mixing clarified fruit juice, with sugar syrup, acid and other ingredients.

Squash is a non-alcoholic concentrated syrup used in beverage making. It is usually made from fruit juice, water, and sugar or its substitute. These normally contain at least 25% fruit pulp mixed with sugar syrup. Squashes contain preservatives such as potassium sorbate or sulfites. They have good shelf life because of the preservatives and high sugar content. To increase their appeal modern squashes are added with food coloring and flavoring substances. Some traditional squashes contain herbal extracts, such as orange, and ginger. Squash is mixed with a water or carbonated water or alcoholic beverage to prepare a cocktail. They are diluted to taste, with water. Nonetheless, they are commonly kept in refrigerators.

2.4.3 Nectars

Nectars: Nectar is prepared from the tropical fruits pulp such as mango, litchi, guava, papaya, citrus fruits and pineapple by adding sugar, acid and other ingredients. These are non-carbonated soft drinks made by mashing fruit pulp. They normally contain 30 percent fruit pulp and are drunk immediately after opening. It is differentiated with any drink that has been labeled as fruit juice by the industry as it is not 100% fruit juice, and may or may not contain other ingredients such as water, sweeteners, and preservatives. There are no industry standards and so you can have a fruit nectar having fruit juice from anywhere in the range of 0- 100%. It differs from fruits juices as nectar is a natural drink prepared by crushing the pulp of a fresh fruit. It contains no preservatives and flavors whereas fruit juice is freshly squeezed from fruit pulp and is treated against deteriorated and spoilage, or processed into a concentrate where water is extracted from the juice.

Fruit nectar is a fruit juice containing a lower percentage of juice than pure fruit juice. When two or more fruit juices are mixed, the drink is called a nectar blend. While a fruit juice contains 100% fresh fruit juice that has been processed after extracting water from it, nectar contains lesser percentage of fruit juice and has other ingredients including preservatives and sugar.

Fig 2: Fruit juices

Self Assessment Exercise 2

1. A fruit beverage made from tropical fruits and contains about 30% of pure fruit juice is ----------

a. nectar

b. cordial

c. squash

d. mix

2. One of these fruits drinks contain only fruit juice

   a. nectar

   b. juice

   c. squash

   d. cordial

2.5 Milk Based Drinks

2.5.1 Yoghurt

Yogurt: Yogurt is a fermented dairy product made from the fermentation of lactic acid by two species of lactic acid bacteria, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus*..

2.5.2 Types of yoghurts

- **Balkan-style Yogurt**: Balkan-style yogurt is also known as set-style yogurt which has a thick texture and made in small and individual batches after pouring the warm cultured mix into containers following by incubation.
- **Greek-style Yogurt** This is also known as Mediterranean-style yogurt which is thicker and creamier, that made from partially condensed milk or by staining whey from plain yogurt. Due to its thick texture, it tends to hold up better upon heat than regular yogurt. This delicious yogurt, have a high amount of saturated fat. It is the richest source of vitamin A.
- **Stirred Curd Yogurt** European-style yogurt is characterized by its creamy and smooth texture. The method followed by incubating the yogurt mixture in a large vat instead of individual cups, then it cooled and stirring in order to obtain a creamy texture and added fruits (blueberries, strawberries, mango, and peach) and flavors . Yogurts of this style are slightly thinner than that of the Balkan-style and set yoghurt and can be used in cold beverages and desserts.
- French-style Yogurt This style of yogurt is known as custard-style yogurt made by direct culturing in the pot according to a French culture and process which characterized with a pudding-like texture. Sometimes French-style yogurts are decorated with fruit pieces (flavor comes from the fruit) which stirred into the mixture. It is the good source of vitamin A, iron and protein.
- **Probiotic Yogurt**: While some yogurts contain live and active cultures, some also contain cultures that have demonstrated health benefits beyond nutrition. Probiotics are live bacteria with known health benefits. Some manufacturers add probiotics to their yogurts. Most probiotic yogurts are considered as digestive aids or immune supporters.

- **Drinkable Yogurt**: Drinkable yogurts offer the benefits of yogurt without the need for a spoon. It is a great option for people on the go or for those who do not enjoy the texture of firmer yogurts. They are made by adding water and additional flavors to traditional yogurt. Drinkable yogurts contain same nutrients as natural yogurts, but it may be higher in sugar and calories.
- **Non-Dairy Yogurt** Non-dairy yogurts are a unique substitute for those whose have milk allergies and those who experience gastrointestinal problems as a result of consuming dairy-based yogurt products. They are also a good option for people that do not consume dairy products because of religious or personal beliefs. Yogurts made from soy milk can usually be found at a local grocer.

2.5.3 Other fermented milk products

There are several other fermented milk products in addition to yogurt.

- **Kefir** is an example of a non-yogurt, fermented milk product. Like yogurt, kefir contains live cultures. It is produced when “kefir grains,” which contain yeast and acid- forming bacteria, are added to milk and fermentation occurs. This produces a slightly carbonated, fermented milk drink. The nutritional benefits of kefir are similar to those of yogurt and health benefits may include improved gastrointestinal and immune function.
- **Butter milk**: The term buttermilk refers to a range of fermented milk drinks, common in warm climates. Buttermilk tartness due to the acid content in it. The increased acidity is primarily due to lactic acid produced by lactic acid bacteria during the fermentation of lactose. As the bacteria produce lactic acid, the pH of the milk decreases and casein, the primary milk protein, precipitates, causing the curdling or

clabbering of milk. Butter milk, rich is Ca , is easy to digest, has astringency and tastes sour.

Self Assessment Exercise 3

1. This type of yoghurt is produced by staining whey from plain yogurt.
   - **a.** butter milk
   - **b.** kefir
   - **c.** Greek yoghurt
   - **d.** stirred yoghurt
2. example of a non-diary yoghurt is ---------
   - a. Greek yoghurt
   - b. soy milk yoghurt
   - c. stirred yoghurt
   - d. spoonable yoghurt

2.6 Summary

Non alcoholic beverages are vary in their ingredients, compositions and processing methods. They also have various physiological functions. tea and coffee are regarded as stimulating drinks, fruits juices and fruit based beverages are refreshing while milk based beverages are nourishing.

Examples of non alcoholic beverages include tea, coffee, cocoa drink, fruit juices and fruit based beverages, milk and milk based beverages.

2.7 References/Further Readings

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2.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 3

1. C- Greek yoghurt
2. B- soymilk yoghurt

Self Assessment Exercise 2

1. A- nectar
2. B-Juice

Self Assessment Exercise 1

Self Assessment Exercise 1

1. C- oxidation of tannins
2. A- Short

MODULE 7: FOOD BY PRODUCT UTILIZATION

UNIT 1: **INTRODUCTION TO FOOD BY PRODUCT UTILIZATION**

1.1 Introduction

1.2 Learning Outcomes

- Define food waste and food by products.
- List at least four points of food waste generation.
- Describe five importance of food waste utilization

1.3 Concept of Food By-product/Waste

1. 3.1 Meaning of Food by product/waste

1. 3.2 Points of food by-product and wastes generation

1.4 Importance of food by products/waste utilization

1.4.1 Reduction of environmental pollution

1.4.2 Cost Reduction

1.4.3 Income Generation

1.5 Utilization of Food Waste from Food Processing

1.5.1 Types of food wasted from food processing operation

1.5.2 Food processing operations and associated waste

1.5.3 Utilization of food wastes/by product utilization

1.6 Summary

1.7 References/Further Readings

1.8 Possible Answers to Self-Assessment Exercise(s)

1.1 Introduction.

Your are already familiar with the benefits of food processing and how different raw materials are transformed into finished products via food processing. During food processing quite a number of by and waste products are generated.

Proper utilization and disposal of these wastes are very important for many reasons for instance for a clean environment. In this unit you will learn the different types of by products from food processing industries, importance of food by products/waste utilization and the importance of food by product utilization.

1.2 Learning Outcomes

By the end of this unit, you will be able to:

- Define food waste and food by products.
- List at least four points of food waste generation.
- Describe five importance of food waste utilization

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1.3 Concept of Food By-product/Waste

1. 3.1 Meaning of Food by product/waste

Food waste also refers to food intended for consumption that is discarded along the food supply chain, which cannot be consumed. Byproducts are generally secondary products derived from primary agro-food production processes and represent an interesting and cheaper source of potentially functional ingredients, such as animal feed, organic manure, ingredients for value added products etc. Many foods by products cannot be regarded as wastes but become an additional resource to augment existing natural materials. Recycling, reprocessing and eventual utilization of food processing by products offer potential of returning these products to beneficial uses rather than their discharge to the environment which cause detrimental environmental effects. in this discuss, the two words will be used interchangeably.

Food industries are currently focusing on solving the problems of waste management and recycling by valorization, i.e. utilization of the by-products and discarded materials and developing new value-added products from them for commercial applications. Valorization allows exploration of the possibility of reusing nutrients in the production of main products, and thus highlights the potential gains that can be achieved. Food production and processing in developing countries generate high levels of waste and byproducts, many of these biomaterials are a source of valuable compounds such as proteins, lipids, starch, micronutrients, bioactive compounds, and dietary fibers.

Fruit byproducts such as bagasse, peels, trimmings, stems, shells, bran, and seeds account for more than 50% of fresh fruit and have at times a nutritional or functional content higher than the final product. Food by products in meat processing industry include blood, bones, some internal organs, hide etc.

1. 3.2   Points of food by-product and wastes generation

Five system boundaries have been distinguished in the food supply chains (FSC) which are mainly responsible for generation of wastages.

i) Agricultural production: Wastage of agricultural resources due to environmental conditions, losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking), curing/ pre-treatments, on-farm temporary storage and sorting of crops etc.

ii) Postharvest handling and storage: including losses due to spillage and degradation during handling, storage and transportation between farm and distribution.

iii) Processing: including losses due to spillage and degradation during industrial or domestic processing, e.g. juice production, canning and bread baking. Losses may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling or during process interruptions and accidental spillage.

iv) Distribution: including losses and waste in the market system, at e.g. wholesale markets, supermarkets, retailers and wet markets.

v) Consumption: including losses and waste during consumption at the household level.

Self Assessment Exercise 1

1. Mention one difference and one similarity between food by-product and food waste
2. Food by-product/waste is generated in ------------ steps along the food supply chain.
   a. few
   b. all
   c. some
   d. most

1.4 Importance of food by products/waste utilization

1.4.1 Reduction of environmental pollution

Improper disposal of food by products leads to environmental pollution and degradation. A typical example of this is waste plastic materials from food industries. Plastics constitute serious environmental issues. The inappropriate disposal of food waste may lead to severe health and environmental issues such as greenhouse gas, which significantly contribute to climate change. Food waste also occupies landfill space, contaminates freshwater and increases carbon footprints. A food by product/waste dump is shown in Fig. 1

Fig 1: Picture of food by products

1.4.2 Cost Reduction

Cost of disposal of by products/waste may be enormous for the food industry. In some cases recycling such by products may be more cost effective.

1.4.3 Income Generation

Food by product utilization will yield additional income to the processor. This is because many by products can be sold to generate income, for example palm kernel cake from vegetable oil industry can be sold to livestock feed producers. Valuable products like enzymes, colouring materials can be extracted from such wastes.

Self Assessment Exercise 2

1. Evaluate briefly how food by product utilization would improve the environment

2. Two ways that a food processing unit can directly benefit from by-product utilization are ------ and ---------

1.5 Utilization of Food Waste from Food Processing

1.5.1 **Types of food wasted from food processing operation**

- food wastes – shavings, peelings, stones, animal by-products etc. in addition to wasted food
- Packaging waste - packaging of incoming materials and waste product packaging
- Waste water and liquid effluent
- gaseous wastes like carbon dioxide form brewery industry, steam, smoke from bakery industry.

Fig. 2: Smoke from a food processing plant

1.5.2 Food processing operations and associated waste

Food processing operations and associated waste is shown in the Table 1 below.

Category	Operations	Wastes
Raw material Preparation	Cleaning, Sorting, Grading, Peeling	Cleaning water effluent, peelings, hair, feathers, grit, blood, contaminated foodstuffs
Size Reduction	Chopping, cutting, slicing, dicing, Milling of Solid foods, pulping Emulsification and homogenization of liquids	Poor quality (too coarse / fine) product with loss of nutritional / sensory characteristics Dust Agglomerates. Waste off-cuts. Fat bearing effluents from colloidal products (e.g. dairy) Risk of pathogenic contamination in emulsification (e.g. dairy)
Mixing and forming	Mixing, forming malformed pieces.	Wrongly proportioned batches, poorly mixed ingredients
Separation and Concentration	Centrifugation, Filtration Expression, Solvent extraction Membrane concentration	Separated solids (e.g. after clarification of liquids press residues (e.g. fruit juice extraction)
Fermentation and use of enzymes	Fermentation, Enzyme technology	Spent biomass.

1.5.3 Utilization of food wastes/by product utilization

1. Livestock feeding: Many byproducts of food processing are rich in nutrients and serves as a more affordable feed or feed ingredients for livestocks. Examples include fruits and vegetable peels, soybean residue, brewers yeast waste, brewers spent grain etc. These are valuable feed ingredients for livestock such as poultry, pig, ruminants etc.
2. Compost manure. Food wastes are biodegradable and contain rich elements like nitrogen, phosphorus etc that could be used as organic manure to improve crop yield.
3. Production of value added products. Peels of fruits are very rich in fibre and so can be incorporated into foods to produce high fibre foods. Antioxidant rich phtochemicals are extracted from food by products especially from fruits and vegetable and used to produce functional foods. Functional foods are those foods that apart from providing the basic food nutrients also confer some health benefits.
4. Renewable energy source biogas, biofuel
5. Special products like vinegar, enzymes, antiodixants -, vinegar represents one of the most widely used seasonings in the world. In addition to being primarily used as food seasoning, vinegar plays an important role in the production of food products since it is applied in a wide variety of products, including sauces, ketchups and mayonnaise. Moreover, vinegar has long been used in the treatment of many common ailments with claims of anti-infective, antitumor, and hyperglycemic properties. Bromelain an enzyme used a meat tenderizer can be recovered from different wastes of pineapple including the core, peel, and stem. Antioxidants are the substances that are able to prevent or inhibit oxidation processes inhuman body and food products as ascorbic acid, phenolics and flavonoids.
6. **Bioadsorpents** for water treatment

Self Assessment Exercise 3

1. State four types of food waste from a food processing unit
2. State two points in a food processing operation where wastes can be generated, state the types of wastes from the stated points
3. These are ways to utilize food by products except
   a. dump in refuge dumps
   b. used as source of renewable energy
   c. used as animal feed
   d. used as compost

1.6 Summary

Food waste also refers to food intended for consumption that is discarded along the food supply chain, which cannot be consumed. Byproducts are generally secondary products derived from primary agro-food production processes. Food by products in a food processing industry includes fruit peels, seeds, bagasse, blood, bones, fat trimmings etc. By product utilization is very critical because of their negative environmental impact and added revenue to the industry if used to produce value added products like enzymes, vinegar, biofuel, bioadsorbents etc.

In this unit, you have learnt the definition of food waste and food by products, Points along the food supply chain that food by-product and wastes are generated, importance of food by products/waste utilization, typical wastes encountered in the food processing sector, food

processing operations and associated waste and Utilization of food wastes/by product utilization

1.6 References/Further Readings (This will come at the end of each unit)

1. EPA (2017). *Sustainable Management of Food [WWW Document]*. United States Environmental Protection Agency. Available online at: https://www.epa.gov/sustainable-management-food
2. O'Shea, N., Arendt, E., & Gallagher, E. (2012). Dietary fibre and phytochemical characteristics of fruit and vegetable by-products and their recent applications as novel ingredients in food products. *Innov. Food Sci. Emerg. Technol.*, 16, 1–10. doi: 10.1016/j.ifset.2012.06.002

1.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. Food by products can generally be recycled while food waste may not. one similiarity is that both of them are residual foods materials after food processing.
2. All

Self Assessment Exercise 2

1. utilization of food by products will reduce indiscriminate dumping of wastes that polute and deface the environment
2. cost reduction and income generation.

Self Assessment Exercise 3

1. gaseous, liquid and solid wastes

2. any of the points as shown in Table

3. a - dump in refuge dumps

UNIT TWO: UTILIZATION OF BY PRODUCTS FROM FRUIT AND VEGETABLE INDUSTRY

CONTENT

2.1 Introduction

Due to the increase in the world population and the consumer's awareness on the health benefits of consumption of fruits and vegetables, the demand for the fruits and vegetables has increased considerably. In many cases, the raw fruit and vegetables is not consumed directly by humans, but first undergoes processing to separate the desired value product from other constituents of the plant. Fruits and vegetables are processed into fruit drinks, fruit nectars, preserves, pickles, canned fruits and vegetables etc. During the processing of fruits and vegetables, large quantities of solid and liquid wastes are generated. There are many ways that these byproducts can be utilized and that is what we will be discussing in this unit.

In the last unit, we were able to learn the definition of food by products, Points along the food supply chain that food by-product and wastes are generated, importance of food by products/waste utilization, typical wastes encountered in the food processing sector, food processing operations and associated waste and **u**tilization of food wastes/by product utilization. In this unit we will go further to highlight how by produces from different fruits can be utilized.

2.2 Learning Outcomes

By the end of this unit, you will be able to

1. Evaluate four areas of by product utilization in the fruit industry
2. Analyze four areas of by product utilization in the vegetable industry
3. Discuss three major by products from citrus fruit processing

2.3 Utilization of By-Products from Pineapple and Mango Fruits

2. 3.1 Utilization of by-products from pineapple

The pineapple (*Ananas comosus*) is one of the most important fruits in the world and is the leading edible member of the family Bromeliaceae. This fruit juice is the third most preferred worldwide after orange and apple juices. Pineapple by-products are mainly the residual pulp, peels, stem and leaves. Peel is the major bio-waste generated during pineapple processing. Other wastes include, the core and the bagasse.

Pineapple waste can be used for :

1. **Biofuel production** : Sugars are present in large quantities in pineapple peel that can be used as nutrients in fermentation processes. For the production of biofuel. The peel can be used as a potential substrate for methane, ethanol and hydrogen generation . Pineapple peels have been found to be promising feed for biogas generation, since they are rich in carbohydrates and proteins .
2. **Production of beverages**: The second major bio-waste is the core and can be used for the production of pineapple juice concentrates, alcoholic, nonalcoholic beverages or vinegar. Pineapple wastes like the peels, core are used as flavouring agents in beverage production example in zobo drink.
3. **Enzyme extraction**: Bromelain is already commercially available enzyme, which is often derived from the pineapple stem. Due to its strong proteolytic activity, this enzyme has been used in numerous industrial applications such as a meat tenderizer, a bread dough improver, a fruit anti-browning agent, a beer clarifier, a tooth whitening agent, animal feed, and cosmetic substance and in textile industry. Bromelin can be extracted from different wastes of pineapple including stem,
4. **Value added foods**: Pineapple by-products contain significant amounts of dietary fiber especially insoluble dietary fiber. Fibers from pineapple by-products are considered high quality due to the physiological effects associated with both soluble

and insoluble fibers, and may be used in the development of food reduced in calories and dietary fiber enriched food products .

5. **Special products**: Pineapple waste has been used for the production of lactic and citric acids through submerged and solid state fermentation. The increase in demand for the natural flavours has triggered the research in production of natural vanillin from natural raw material through microbial biotransformation. Pineapple peel waste contains ferulic acid, a precursor for vanillic acid. Therefore vanillin can be synthesized from pineapple peels from a series of bio chemical reactions.
6. **Water treatment**: Pineapple peel wastes can also be used as a potential low-cost alternative adsorbent for waste water treatment.

2.3.2. Utilization of mango by products

1. **Dietary fibre:** mango peels are rich in dietary fiber made up of soluble and insoluble dietary fibre. The soluble dietary fiber content in both raw and ripe mangos peels are more than 35% of total dietary fiber. Insoluble dietary fiber relates to both water absorption and intestinal regulation whereas soluble dietary fiber associates with reduction of cholesterol in blood.
2. **Polyunsaturated fatty acids (PUFA)**: Mango seed kernel oil has been reported to be a good source of polyunsaturated fatty acids such as oleic and linoleic acids which have health benefits for example reduction of cholesterol and improvement of mental health.

Self-Assessment Exercise 1

1. The enzyme bromalin can be used for the following except
   a. fruit anti-browning agent,
   b. a beer clarifier,

c. a sweetener

d. a tooth whitening agent

2. polyunsaturated fatty acids can be extracted from the --------- of mango

a. kernel

b. pulp

c. pulp and kernel

d. peel and pulp

2.4 Utilization of By-Products from Citrus and Banana Fruits

2.4.1 Utilization of by-products from citrus fruits

Citrus fruits are highly consumed worldwide as fresh produce, juice and most often the peel is discarded as waste which contains a wide variety of secondary components with substantial antioxidant activity in comparison with other parts of the fruit. The peel is subdivided into the epicarp or flavedo (coloured peripheral surface) and mesocarp or albedo (white soft middle layer). Other by products are seeds, bagasse. Citrus fruits include oranges, lemon, lime, tangerine, grapefruit.

1. **Source of antioxidant rich compounds:** it contains several bioactive compounds, such as flavanones, polymethoxylated flavones, flavonols and phenolic acids; these compounds have a lot of uses as a natural antioxidants for pharmaceutical, biotechnological and food industries.
2. **Flavour enhancers**: Lime and lemon peel oils are widely used as aroma flavor enhancers for soft and alcoholic beverages and food. In pharmaceutical industries they are used as flavoring agents to mask unpleasant tastes of drugs. In perfumery, they

form the base of many compositions. Antimicrobial agents: lemon extracts have been used in food preservation as antimicrobial agents.

3. **Pectin extraction**: Pectin is a good thickening and gelling agent that is very important in jam production. It can also be used as texturizing agent, emulsifier and stabilizer

2.4.2 Utilization of by-products from Bananas

Bananas are one of the most popular fruits; peel is the main by-product, which represents approximately 30% of the whole fruit.

1. **Source of antioxidants**: Peels are rich in health promoting phytochemical compounds, with high antioxidant capacity such as phenolic compounds (gallocatechin), anthocyanin, carotenoids, catecholamines, sterols and triterpenes.
2. **Dietary fibre**: banana peels can be incorporated to products like bread, buiscuits, noodles and pastas to enrich their dietary fibre levels.
3. **Water treatment**: Peels have been reported to have heavy metal sorption capacity for removing chromium (III)and chromium (IV) from water.

Self-Assessment Exercise 2

1. An important gelling agent extracted from citrus peel is known as
   a. fibre
   b. antioxidant
   c. pectin

2. Write three ways that banana peels can be utilized

2.5. Utilization of by-products from potatoes and carrots

2.5..1 Utilization of by-products from potatoes

There is a large amount of potato peel is generated as potato is mostly consumed vegetable worldwide. Potato peel is rich in fibers. Fibers play an important role in human health and help in the prevention of diseases. The benefits of potato peels are listed below.

1. **Preservation of vegetable oil:** The addition of potato peels into vegetable oils can improve the hydrolytic stability of vegetable oil and slow thermal deterioration and stabilized the vegetable oil. The addition up to 200 ppm of potato peels extract had comparable stabilization efficiency with the synthetic antioxidants.
2. **Functional ingredient**: Peels have been used in making cookies, wheat bread, and bakery goods in order to improve the nutritional properties and health benefits of the products.

2.5.2. Utilization of by-products from carrots

Due to low yields associated with carrot juice production up to 50% of the raw material remains as pomace. This pomace is a solid waste is a rich source of carotenoids, fibers and phenolics compounds. Carrot pomace can be utitlized in the following ways:

1. **Valued added foods:** Carrot pomace can be added to foods such as bread, cake, dressings, pickle, fortified wheat bread, preparation of high fiber biscuits and production of functional drinks. Carrot pomace has been used for the production of carrot based condensed milk product.
2. **Dietary fibre**: The powder can be prepared by vacuum drying and it can be used as a good fiber source in many bakeries and other food products.

Self-Assessment Exercise 3

1. Fruits peels are very rich in ------------ which can be incorporated into cakes and breads

a. pectin

b. enzyme

c. fibre

d. gum

2. Give two reasons why carrot pomace should not be discarded after juice extraction

2.6 **Summary**

Food by products that are normally discarded can be transformed into value added products. We studied that pineapple peels and baggase can be used for production of important enzymes, vinegar. They are also good sources of dietary fibre. Citrus by products are good sources of antioxidants and pectin which is a good gelling agent in jams is extracted from the peels. The peels of potatoes are rich in antioxidants that can be used to preserve vegetable oils while carrot pomace contains very high levels of dietary fibre for the production of value added products like biscuit, bread etc.

2.7 References/Further Readings

1. Helkar, P.B, Sahoo A.K & Patil N.J. (2016). Food Industry By-Products used as a Functional Food Ingredients. *Int J Waste Resour*., 6, 248.
2. Galanakis, C.M. (2019). Valorization of Fruit Processing By-products. Academic Press Ltd

2.8 Possible Answers to Self-Assessment Exercises

Self-Assessment Exercise 1

1. C- sweetener

2. A – Kernel

Self-Assessment Exercise 2

1. D- Pectin
2. Source of antioxidants, source of dietary fibre and for water treatment.

Self-Assessment Exercise 3

1. dietary fibre
2. carrot pomace can be used to produce value added products and source of dietary fibre

UNIT THREE: UTILIZATION OF BY PRODUCTS FROM MEAT AND ANIMAL PROCESSSING

CONTENT

3.1 Introduction

The food processing industry can be divided into plant food processing and animal food processing. In the last unit, we have focused on the utilization of byproducts form plant product processing. We learnt that by products from pineapple, mango, citrus fruits, banana, potato and carrot can be utilized in various ways such as for the production of high fibre foods, antioxidants, flavor enhancers, pectin extraction. Special products like enzymes and vinegar can also be produced from by products from fruits and vegetables.

In this unit, we will look at how by products from the animal products processing industry can be utilized.

3.2 Learning outcomes

By the end of this unit you will be able to

1. Describe three major by products from meat processing industry
2. Evaluate four ways of utilizing blood from meat processing industry
3. Describe three ways of utilizing hide and skin from meat processing industry

3.3 Utilization of Animal By-Products

The animal product industry include such animal products as meat, poultry, milk etc. a lot of by products are generated during the processing of animal products examples include blood, bone, skin.

For this unit, we will be emphasizing by products utilization in meat processing industry

3.3.1 Utilization of blood

Meat by-products are produced by slaughter houses, meat processors, wholesalers and rendering plant. . Slaughter house waste consists of the portion of a slaughtered animal that cannot be sold as meat or used in meat-products. Such waste includes bones, tendons, skin, contents of the gastro-intestinal tract, blood and internal organs. Animal blood can be utilized in various ways such as:

1. **Value added foods**: Animal blood has a high level of protein and heme iron, and is an important edible by-product. Animal blood has long been used to make blood sausages, blood pudding, biscuits and bread. It has high protein content (17.0%), with a reasonably good balance of amino acids.
2. **Egg replacer**: Blood plasma also has an excellent foaming capacity and can be used to replace egg whites in the baking industry.
3. **Feed:** Blood is used in livestock feed in the form of blood meal. It is used as a protein supplement, a milk substitute, a lysine supplement or a vitamin stabilizer, and is an excellent source of most of the trace minerals.
4. **Medicine and pharmaceutics**: Blood can be separated into several fractions that have therapeutic properties. In the laboratory, many blood products are used as a nutrient for tissue culture media, as a necessary ingredient in blood agar, and as peptones for microbial use. Many blood components such as fibrinogen, fibrinolysin, serotonin, kalikreninsa, immunoglobulins and plasminogen are isolated for chemical or medical uses. Purified bovine albumin is used in testing for the Rh factor in human beings, and as a stabilizer for vaccines. It is also used in antibiotic sensitivity tests

3. 3.2 Utilization of hides and skins and bones

1. **Leather:** leather shoes, bags are made from the hides of cattle. Food

2. **Gelatin**: Both hides and bones contain large quantities of collagen. Gelatin is made from collagen. Gelatin is used in the food and pharmaceutical industries. Gelatin is added to a wide range of foods, as well as forming a major ingredient in jellies. Its main use is the production of jellied desserts, because of its “melt in the mouth” properties, but is also added to a range of meat products, in particular to meat pies. Gelatin is also widely used as a stabilizer for ice cream and other frozen desserts. High-bloom gelatin is added as a protective colloid to ice

cream, yoghurt and cream pies. Gelatin is an excellent emulsifier and stabilizing agent for many emulsions and foams. It is used in cosmetic products, and in printing for silk screen printing, photogravure printing etc.

3. **Livestock feed**: Bone meal is used as a source of calcim and phosphorus in livestock feed.

3.3.3 Utilization of glands and organs

1. **Food:** They are highly prized as food in many parts of the world including Nigeria. Those used as human foods include the brain, heart, kidneys, liver, lungs and spleen. They also include the tongue, the bovine pancreas and udder, the stomach and uterus of pigs, the rumen, reticulum, omasum and absomasum of sheep and cattle, and the testes and thymus of sheep and pigs. In Nigeria, these organs are used to prepare a delicacy called pepper soup. Animal organs and glands offer a wide variety of flavors and textures, and often have a high nutritional value.

2. **Sausage casing:** The intestine of animals are used to make sausage casing. To make them into sausage casing, they are removed from the abdomen. The ruffle fat is separated from the intestines, and the faeces stripped out.

3.3.4 Utilization of Animal fat

Animal fats are an important by-product of the meat packing industry. The major edible animal fats are lard (fat from pig) and tallow (fat from sheep or cattle). Lard is the fat rendered from the clean tissues of healthy pigs. Tallow is hard fat rendered from the fatty tissues of cattle or sheep.

1. **Food:** Traditionally, tallow and lard were used for deep frying (Weiss 1983). However, this use is declining in the fast-food industry, due to consumer health concerns. Animal fats contain cholesterol that has been implicated a number of health risks.
2. **Biodiesel**: Biodiesel fuel acquired from the oils and fats of meat and fish is a substitute for, or an additive to diesel fuel derived from petroleum.

Self Assessment Exercise 1

1. Which part of the blood can be used as an egg replacer
   a. plasma
   b. red blood cell
   c. white blood cell
   d. haemoglobin
2. An important product made from animal skin is
   a. foam
   b. leather
   c. hide
   d. fibre
3. the by-product from ----------- can be utilized for biodiesel
   a. animal fat
   b. animal blood
   c. animal liver
   d. animal heart

3.4 Utilization Of Poultry By-Products

3.4.1 Utilization of poultry by-products

These wastes, including animal excreta, mortalities, hair, feathers and processing wastes are convertible to useful resources.

1. **Biofuel:** Anerobic digestion of animal manure produces methane, an energy source for cooking, house heating etc.
2. **Feed**: Blood, discarded internal organs could be utilized as meals for feed supplementation.

Self Assessment Exercise 2

1. One of these is not a by-product of poultry processing
   a. mortalities
   b. feathers
   c. enzymes
   d. excreta
2. Animal excreta can be used to generate ---------------

3.5 Summary

The major by products from meat and poultry processing include blood, hides and skins, animal fat etc. these by products could be used for: feed/food, value added products, biofuels etc.

In this unit, you have learnt the various by products from animal product especially meat processing industry. The various by products like blood, hides and skins, animal fats need not be discarded but could be used for food and feed or converted to other useful products.

3.6 Glossary

- Bagasse - The dry pulpy residue left after the extraction of juice from a fruit, vegetable or root crop.
- Blood plasma - Blood plasma is a light amber-colored liquid component of blood in which blood cells are absent.
- Valorization - the conversion of food waste or by-products into higher value products that contribute back to the food supply chain.

3.7 References/Further Readings

1. Ockerman, H.W. & Hansen, C.L. (1999). Animal By-Product Processing & Utilization, CRC press, Florida, USA

2. Arvanitoyannis, I. S. & Ladas, D. (2008). Meat waste treatment methods and potential uses. *International Journal of Food Science and Technology*, 543–559.

3.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. a – plasma
2. b – leather
3. a – animal fat

Self Assessment Exercise 2

1. c- enzyme
2. biogas

MODULE 8 : FOOD DETERIORATION AND SPOILAGE

UNIT ONE: THE CONCEPT OF FOOD DETERIORATION AND SPOILAGE

Content

1.1 Introduction

Welcome to this module where we will be looking at a very important topic as far as food safety is concerned. We shall be learning about food deterioration and spoilage. In this unit, we shall discuss the concept of food deterioration and spoilage.

Food deterioration and food spoilage may be defined as a process or change which renders a product undesirable or unacceptable for consumption. Basically food deterioration can be regarded as the process to food spoilage. Depending on the level of deterioration, deteriorated food can still be edible and safe to eat example green leafy vegetable that has wilted is still good for consumption but when the same vegetable has decayed, we say it has spoiled and no longer fit for consumption. In the course, we shall use the two words interchangeably.

Many food products are perishable by nature and require protection from spoilage during their preparation, storage and distribution to give them desired shelf-life. Because food products are now often sold in areas of the world far distant from their production sites, the need for extended safe shelf-life for these products has also expanded.

In the production of food it's crucial that proper measures are taken to ensure the safety and stability of the product during its whole shelf-life. Shelf life of a food is the time during which it remains stable and retains its desired qualities.

We shall learn the causes of food spoilage, classification of foods based on their shelf-life and the conditions that promote food spoilage

1.2 Learning Outcomes

By the end of this unit, you will be able to

1. Mention five causes of food spoilage
2. Classify foods based on the ease of spoilage
3. Analyze five conditions that promote food spoilage

1.3 Causes of Food Spoilage and the Negative Impact of Food Spoilage

1.3.1 Causes of food spoilage

Some spoilage is inevitable, and a variety of factors cause deterioration of foods:

- Endogenous enzymes in plants oxidizing phenolic compounds (browning) or degrading pectins (softening) example browning reaction of yam slices.

- Insects infesting foods and rodents chewing on foods;
- Parasites, when visible for example in meat or fish, rendering food undesirable example is tape worms in pork
- Microbes (bacteria, molds, yeasts) growing on and metabolizing foods;
- Light causing degradation of pigments, fats, and proteins (off-flavors and odors) or stimulating pigment production (greening of potatoes).

- Temperature: both excessive heat and freezing physically affecting texture of foods and breaking emulsions; air, particularly oxygen, oxidizing lipids producing strong off-odors and flavors.
- Moisture: too little causing cracking, crumbling, or crystallization whereas excess causes sogginess, stickiness, or lumping.
- Physical injury due to bruising, pressure, freezing, drying and radiation.

These causes of food spoilage can be broadly divided into

1. Biological e.g. microorganisms , pests, insects.
2. Physical e.g. bruises, cracking, loss of moisture, light.
3. chemical eg enzymatic reactions, ripening, respiration.

These factors are interrelated, as certain temperatures and oxygen and moisture levels increase the activities of endogenous enzymes and of microbes. Rodent and insect damage may provide an entry point for microbial growth.

Early detection of spoilage would be advantageous in reducing food loss because there may be interventions that could halt or delay deterioration.

Spoiled bread caused by mould growth

Browning of cut yam.

Fig 3: Fruit cracking (mechanical damage)

1. 3.2 Negative impact of food spoilage

1. Unwholesome effects due to toxins and metabolites of pathogenic microorganisms. Food becomes unsafe for consumption. Spoiled canned food can have serious negative health implication and can lead to death.
2. Changes in organoleptic features like color change, texture problem, production of flavor and aroma compounds by spoilage organisms. Spoiled meat produces offensive odour and undesirable textural changes.
3. Loss of economic value due to lower quality foods.
4. Environmental degradation

Self-Assessment Exercise 1

1. Write four causes of food spoilage
2. --------------- is a negative impact of food spoilage
   a. loss of economic value
   b. production of undesirable odours
   c. illness
   d. all of the above

1.4 Classification of Foods Based On Shelf Life and Conditions for Food Spoilage

1.4.1 Classification of foods based on shelf life

Based on the ease or quickness with which a food item gets spoiled i.e. shelf life, all foods can be categorized into the following three groups:

Non-perishable foods: As the name suggests, these are the foods which do not spoil easily unless handled and stored carelessly and that can be stored a for several months.

Examples of non-perishable foods include cereals like rice, maize, sorghum, pulses (beans, peas, lentils) sugar, garri etc.

Semi-perishable foods: Like the non-perishable foods, semi-perishable foods can survive without any perceptible sign of spoilage for a few weeks or for a few months. Here, of course, temperature and humidity of the environment makes a big difference. Examples in this category include potatoes, yam, garlic, some fruits like citrus fruits, fats and oils.

Perishable foods: These are the foods which spoil easily within a day or two unless special methods are used to prevent such spoilage. All fresh animal foods such as milk and milk products, meat and meat products, fish, poultry, most fruits like bananas, mango, vegetables like spinach, tomatoes, fluted pumpkin etc are in this category.

Microbes require certain conditions for growth, and therefore management of the environment of foods can change these factors and delay spoilage:

1. **Nutrients:** Chemical composition of a food item generally influences the type of spoilage microbe as well the products liberated during growth Foods also provide enough water, nitrogen, minerals and vitamins to microorganisms.
2. **Time:** One bacterium can divide into two every 20 minutes. Food where bacteria rapidly multiple in are called perishable foods.
3. **Temperature**: Many, but not all, microbes grow slowly or not at all at low temperatures, and refrigeration can decrease growth rate of microbes.
4. **Water Activity/Moisture content:** Many microbes require a high water activity (a_w)/moisture content and therefore keeping foods such as grains and cereal products dry will help to preserve them. Water activity (a_W) is a measure of how much of that water is free, i.e., unbound, and thus available to microorganisms to use for growth. It is therefore

important with regard to food safety. A food may have high moisture content but low water activity example high sugar containing foods like jam. This is because the water is bound to the sugar and unavailable for microbial growth. The water activity is a value between 0 and 1. A value of 0 means there is absolutely no available water, this is very rare in food. A value of 1 means all water in the product is available, which is pure water. Most foods hover within a range of 0.2 and 0.99 for water activity.

Some microorganisms and water activity for their proliferation.

Microorganism	Water activity
Spoilage bacteria	0.90 – 0.91
Spoilage yeast	0.87 – 0.94
Clostridium botulinum	0.70 – 0.80
Salmonella	0.95 - 0.96
S. aureus	0.86 - 0.92

3. **Oxygen**: Some bacteria need oxygen to grow and multiply. These are called aerobic bacteria. Other bacteria grow well when there is no oxygen present, these are known as anaerobic bacteria. Managing the atmosphere during storage in packaging can retard or prevent the growth of some microbes.
4. **pH level**: An acidic or alkaline environment can promote of inhibit microbial growth. Most bacteria prefer a neutral pH (6.6 – 7.5). Moulds and yeasts can survive at pH levels of 1-1/5 (very acidic), food spoilage usually occurs by yeast and moulds. Common foods have been categorized according to their pH values

Table 1: pH of some common foods

Class	pH	Examples
High acid	< 4.5	Lemon, tomatoes
Medium acid	4.5 – 5.0	Bread, cheese
Low acid	5.0 – 7.0	Milk, Vegetables
Alkaline	> 7.0	Eggs

Self-Assessment Exercise 2

1. Based on the ease or quickness with which a food item gets spoiled i.e. shelf life, all foods can be categorized -------------, ----------------- and ---------------------
2. ----------- is a measure of how much water is available for microbial proliferation in a food.

1.5 Summary

Having learnt the dire consequences of food spoilage both to health and food quality, it is very important to map out strategies to reduce food spoilage. We do these by storing and preserving foods at conditions that will minimize the various causes of food spoilage.

We have learnt the definition of food deterioration and food spoilage and the different causes of food spoilage such as microorganisms, chemical reactions, temperature oxygen etc. we have also learnt the negative consequences of food spoilage such as unwholesome effects, change in quality etc. Based on ease of spoilage foods are divided into three: non-perishable, semi perishable and perishable foods.

The conditions for food spoilage were highlighted as nutrients, oxygen, time, temperature among others.

1.7 References/Further Readings

1. Kilcast, D. & Subramaniam, P (2011). Food and Beverage Stability and Shelf Life. Woodhead Publishing Series in Food Technology and Nutrition
2. Fung, Y. C. F. (2006). Rapid detection of microbial contaminants. In G. M. Sapers, J. R. Gorney, & A. E. Yousef (Eds.), Microbiology of Fresh Fruits and Vegetables (pp. 565–594). New York: Taylor and Francis Group

1.7 Possible Answers to Self-Assessment Exercise(s)

Self-Assessment Exercise 1

1. causes of food spoilage are microbial agents, enzymes, parasites, temperature, moisture among others
2. d – all of the above

UNIT TWO: AGENTS OF FOOD SPOILAGE

2.1 Introduction

2.2 Learning Outcomes

2.3 Bacteria As Agents Of Food Spoilage

2.3.1 What are Bacteria?

2.3.2 Important food spoilage bacteria – Brochothrix species and lactic acid bacteria

2.3.3. Important food spoilage bacteria – Pseudomonas

2.4 Yeasts and Moulds as Food Spoilage Organisms

2.4.1. Yeasts as spoilage organisms

2.4.2. Important spoilage yeasts

2.4.3 Moulds as Food Spoilage Organisms

2.4.4. Classification of Spoilage molds

2.4.5 Factors affecting microbial spoilage

2.5. Enzymes as Food Spoilage Agents

2.5.1. How enzymes cause food deterioration

2.5.2. Food Enzymes and Their Spoilage Actions

2.6 Summary

2.7 References/Further Readings

2.8 Possible Answers to Self-Assessment Exercise(s)

2.1 Introduction

In unit 1, you introduced food spoilage and learnt the causes of food spoilage. You also learnt the conditions for food spoilage. In this unit you shall go into details about the agents of food spoilage, give examples of foods that are spoiled by such agents and suggest strategies to reducing the effects.

In this unit, you will learn the foods that are more susceptible to each agent of food spoilage. For instance, tubers and some fruits are susceptible to enzymatic browning while fresh animal products like meat are more susceptible to bacterial spoilage.

2.2 Learning Objectives

1. Discuss three different types of microbial food spoilage agents
2. Discuss the two importance of yeasts and moulds in food spoilage.
3. Evaluate three effects of enzyme activities on foods.

2.3 Bacteria As Agents Of Food Spoilage

2.3.1 What are Bacteria?

- Bacteria are single celled micro-organisms (they cannot be seen by the naked eye) which are present naturally in the environment. Bacteria cause spoilage mainly through the process of putrefaction. Putrefaction refers to the series of anaerobic reactions through which amino acids detour to a mixture of amines, organic acids, and stiff-smelling sulfur compounds, such as mercaptans and hydrogen sulfde. This is a biochemical phenomenon as the presence of bacteria is exigent all through the process. Along with amino acids, indole, phenols, and ammonia are also formed due to protein putrefaction. Most of these chemicals have displeasing odor. Putrefaction is quite common in meats and other protein-rich foods at temperatures greater than 15 °C.

- The spoilage factors in heat-treated foods are especially spore-forming bacterial groups. Bacterial spores can survive even at high temperatures. Gram-positive bacteria can grow in an aerobic and anaerobic environment. They can also tend to grow in high temperatures up to 55°C. In this context, some groups of anaerobic bacteria produce hydrogen sulphide during growth in canned/hermetically sealed foods stored at high temperatures. Bacterial groups growing at ambient temperature can cause different spoilage such as rotting of canned products, premature swelling of cheese, production of butyric acid in canned vegetables and fruits. Bacteria that can grow at low temperatures can produce gas and bad odors in cold meat products, pickled and dried foods.
- Some bacteria are useful, e.g. in the production of yogurt, and some harmful. Some bacteria produce toxins which can lead to this also. Spores can also be produced by some bacteria leading to toxins being produced.

2.3.2 Important food spoilage bacteria – Brochothrix species and lactic acid bacteria

i. Brochothrix **spp.**

Brochothrix spp. is a common spoilage organism of meat and meat products stored at chilled temperatures. *B. thermosphacta and Brochothrix campestris are the two species assigned to the genus Brochothrix. B. thermosphacta* is the predominant spoilage organism in pork, lamb, and fish, particularly on fatty surfaces, chilled raw, and processed products stored aerobically or under modified atmospheres. It is a Gram-positive rod, nonsporing, nonmotile, and facultative anaerobe. There is no evidence to support that it is pathogenic.

ii. **Lactic acid bacteria** (LAB) are a group of Gram-positive bacteria, including species of Lactobacillus, Pediococcus, Leuconostoc and Oenococcus, some of which are useful in producing fermented foods such as yogurt and pickles. However, under low oxygen, low temperature, and acidic conditions, these bacteria become the predominant spoilage organisms on a variety of foods. Undesirable changes caused by LAB include greening of meat and gas formation in cheeses (blowing), pickles (bloater damage), and canned or packaged meat and vegetables. Off-flavors described as mousy, cheesy, malty, acidic, buttery or liver-like may be detected in wine, meats, milk, or juices spoiled by these bacteria. LAB may also produce large amounts of an exopolysaccharide that causes slime on meats and ropy spoilage in some beverages.

2.3.3. Important food spoilage bacteria – Pseudomonas

- **Pseudomonas** and related genera are aerobic, Gram-negative soil bacteria, some of which can degrade a wide variety of unusual compounds. They generally require a high water activity for growth (0.95 or higher) and are inhibited by pH values less than 5.4. Some species grow at refrigeration temperatures (psychrophilic) while other are adapted for growth at warmer, ambient temperatures. Four species of Pseudomonas (*P. fluorescens, P. fragi, P. lundensis, and P. viridiflava*), *Shewanella putrefaciens,* and *Xanthomonas campestris* are the main food spoilage organisms in this group.

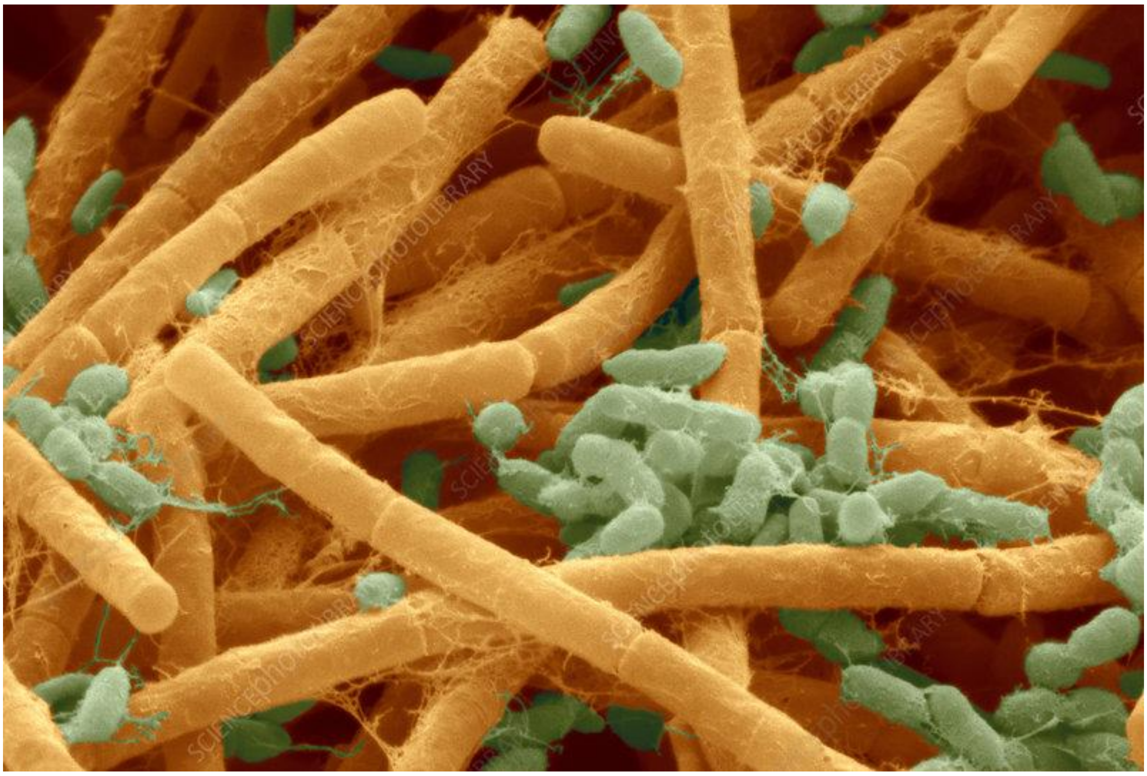


Plate 1. Food spoilage microorganisms

Self-Assessment Exercise 1

1. ---------------- is a common spoilage organism of meat and meat products stored at chilled temperatures

2. Pseudomomas species are generally inhibited by pH values of less than

a. 4.4

b. 5.0

c. 5.4

d. 4.0

2.4 Yeasts and Moulds as Food Spoilage Organisms

2.4.1. Yeasts as spoilage organisms

- **Yeasts** are a subset of a large group of organisms called fungi that also includes molds and mushrooms. They are generally single-celled organisms that are adapted for life in specialized, usually liquid, environments and, unlike some molds and mushrooms, do not produce toxic secondary metabolites. Yeasts can grow with or without oxygen (facultative) and are well known for their beneficial fermentations that produce bread and alcoholic drinks. They often colonize foods with a high sugar or salt content and contribute to spoilage of maple syrup, pickles, and sauerkraut.
- Fruits and juices with a low pH are another target, and there are some yeasts that grow on the surfaces of meat and cheese.

2.4.2. Important spoilage yeasts

There are four main groups of spoilage yeasts:

i. **Zygosaccharomyces** and related genera tolerate high sugar and high salt concentrations and are the usual spoilage organisms in foods such as honey, dried fruit, jams and soy sauce. They usually grow slowly, producing off-odors and flavors and carbon dioxide that may cause food containers to swell and burst. *Debaryomyces hansenii* can grow at salt concentrations as high as 24%, accounting for its frequent isolation from salt brines used for cured meats, cheeses, and olives. This group also includes the most important spoilage organisms in salad dressings.

ii. **Saccharomyces** spp. are best known for their role in production of bread and wine but some strains also spoil wines and other alcoholic beverages by producing gassiness, turbidity and off-flavors associated with hydrogen sulfide and acetic acid. Some species grow on fruits, including yogurt containing fruit, and some are resistant to heat processing.

iii. **Candida** and related genera are a heterogeneous group of yeasts, some of which also cause human infections. They are involved in spoilage of fruits, some vegetables and dairy products .

iv. **Dekkera/Brettanomyces** are principally involved in spoilage of fermented foods, including alcoholic beverages and some dairy products. They can produce volatile phenolic compounds responsible for off-flavors.

2.4.3 Moulds as Food Spoilage Organisms

- **Molds** are filamentous fungi that do not produce large fruiting bodies like mushrooms. Molds are very important for recycling dead plant and animal remains in nature but also attack a wide variety of foods and other materials useful to humans. They are well adapted for growth on and through solid substrates, generally produce airborne spores, and require oxygen for their metabolic processes.
- Most molds grow at a pH range of 3 to 8 and some can grow at very low water activity levels. on dried foods. Spores can tolerate harsh environmental conditions but most are sensitive to heat treatment. Different mold species have different optimal growth temperatures, with some able to grow in refrigerators. They have a diverse secondary metabolism producing a number of toxic and carcinogenic mycotoxins. Some spoilage molds are toxigenic while others are not

2.4.4. Classification of Spoilage molds

i. **Zygomycetes** are considered relatively primitive fungi but are widespread in nature, growing rapidly on simple carbon sources in soil and plant debris, and their spores are commonly present in indoor air. Generally they require high water activities for growth and are notorious for causing rots in a variety of stored fruits and vegetables, including sweet potatoes. Some common bread molds also are zygomycetes. Some Zygomycetes are also utilized for production of fermented soy products, enzymes, and organic chemicals. The most common spoilage species are Mucor and Rhizopus. Zygomycetes are not known for producing mycotoxins (toxins from moulds) but there are some reports of toxic compounds produced by a few species.

ii. **Penicillium** and related genera are present in soils and plant debris from both tropical and Antarctic conditions but tend to dominate spoilage in temperate regions. They are distinguished by their reproductive structures that produce chains of conidia. Although they can be useful to humans in producing antibiotics and blue cheese, many species are important spoilage organisms, and some produce potent mycotoxins (patulin, ochratoxin, citreoviridin, penitrem). Penicillium spp. cause visible rots on citrus, pear, and apple fruits and cause enormous losses in these crops. They also spoil other fruits and vegetables, including cereals. Some species can attack refrigerated and processed foods such as jams and margarine. A related genus, Byssochlamys, is the most important organism causing spoilage of pasteurized juices because of the high heat resistance of its spores. Aspergillus and related molds generally grow faster and are more resistant to high temperatures and low water activity than Penicillium spp. and tend to dominate spoilage in warmer climates. Many aspergilli produce mycotoxins: aflatoxins, ochratoxin, territrems, cyclopiazonic acid. Aspergilli spoil a wide variety of food and non-food items (paper, leather, etc.) but are probably best known for spoilage of grains, dried beans, peanuts, tree nuts, and some spices.

iii. **Other molds**, belonging to several genera, have been isolated from spoiled food. These generally are not major causes of spoilage but can be a problem for some foods. Fusarium spp. cause plant diseases and produce several important mycotoxins but are not important spoilage organisms. However, their mycotoxins may be present in harvested grains and pose a health risk.

Plate 2: Mold growth on an orange fruit

2.4.5. Factors affecting microbial spoilage

- Intrinsic e.g Endogenous enzymes, nutrient content, sensitivity of light, pH, water activity and oxidation-reduction potential

- and Extrinsic factors e,g. relative humidity, temperature, presence, and activities of other microbes, oxygen

Self-Assessment Exercise 2

1. List three molds that are spoilage agents
2. which of these is an extrinsic factor of food spoilage
   a. oxidation-reduction potential
   b. pH
   c. oxygen
   d. water activity

2.5. Enzymes as Food Spoilage Agents

2.5.1. How enzymes cause food deterioration

Enzymes are chemicals that are found in food. These chemicals have important uses in food. They can cause food to deteriorate in three main ways:

• Ripening – this will continue until the food becomes inedible, e.g. banana ripening;

• Browning – enzymes can react with air causing brown discolouration in certain foods, e.g. potatoes, yams and apples discolouring which lead to their deterioration.

• Oxidation – loss of certain nutrients, such as vitamins A, C and thiamin from food, e.g. over boiling of green vegetables. This is due to the reaction of certain food components with oxygen.

2.5.2. Food Enzymes and Their Spoilage Actions

Table 1: Food enzymes and their spoilage actions

Enzymes	Food	Spoilage action
Ascorbic acid oxidase	Vegetables	Destruction of vitamin C
Lipase	Milk, oils	Hydrolytic rancidity
Lipoxygenase	Vegetables	Destruction of vitamin A
Pectic enzymes	Fruits	Destruction of pectic substances (Softening)
Peroxidases	Fruits	Browning
Polyphenoloxidase	Fruits, vegetables	Browning, off flavour, vitamin loss
Proteases	Eggs crab, lobster Flour	Reduction of shelf life Over-tenderization Reduction in gluten network formation
Thiaminase	Meats, fish	Destruction of thiamine

Self-Assessment Exercise 3

1. Enzyme can cause food spoilage by all of the following except
a. wilting
b. oxidation
c. ripening
d. browning
2. the enzyme responsible for browning in yams is called -----------------

2.6 Summary

Food spoilage is mainly caused by the activities of microorganisms and enzyme activities. These various spoilage organisms and agents must be adequately controlled to ensure that food is wholesome for consumption.

You have learnt the different agents of food spoilage which are bacteria, yeasts, moulds and enzyme activities. The important bacterial species for food spoilage include *Brochothrix spp*, Lactic acid bacteria, Pseudomonas etc. the important yeast species in food spoilage include Zygosaccharomyces and Saccharomyces.

For molds, the important species are Zygomycetes and Penicillium. Intrinsic like endogenous enzymes, pH, nutrient content and extrinsic factors such as relative humidity, temperature etc influence microbial spoilage.

Enzyme activities cause ripening, browning and oxidation in foods which lead to food spoilage.

2.7 References/Further Reading

1. Kilcast, D. & Subramaniam, P (2011). Food and Beverage Stability and Shelf Life. Woodhead Publishing Series in Food Technology and Nutrition

2. Fung, Y. C. F. (2006). Rapid detection of microbial contaminants. In G. M. Sapers, J. R. Gorney, & A. E. Yousef (Eds.), Microbiology of Fresh Fruits and Vegetables (pp. 565–594). New York: Taylor and Francis Group

2.8 Possible answers to Self-Assessment Exercise

Self-Assessment Exercise 1

1. *Brochothrix* spp.
2. C – 5.4

Self-Assessment Exercise 2

1. See section 2.4.3. aboves
2. C – Oxygen

UNIT THREE: CONTAMINATION OF FOOD FROM NATURAL SOURCES

3..1 Introduction

3.2 Learning Outcomes

3.3 Types and Sources of Contaminants

3.3.1 Types of food contaminants

3.3.2. Sources of food contamination

3.4 Events That Cause Food Contamination

3.4.1. Food production and environmental factors

3.4.2 Food transport and food processing

3.4.3 Food storage and food preparation

3.5 Biological Contamination:

3.5.1 Bacterial contamination

3.5.2. The major bacteria and their risks

3.6 Pathogenic Agents and Illness

3.6.1 Botulism, Shigellosis and Campylobacteriosis

3.6.2 *Esherichia coli* infection, Salmonellosis and Listeriosis

3.7. Summary

3.8 References/Further Readings

3.9 Possible Answers to Self-Assessment Exercise(s)

3.1 Introduction

Food contamination is a matter of serious concern, as this poses serious health risks. Food contamination is the introduction or occurrence of a contaminant in food. A contaminant is any biological or chemical agent, foreign matter, or other substance unintentionally added to food that may compromise food safety or suitability. Among these contaminants are biological, chemical or physical agents in food with the potential to cause an adverse health effect. It may also be regarded as foods that are spoiled because they contain microorganisms that make them unfit for consumption.

In the last unit, you learnt the important microbial species in food spoilage. You also learnt the types of food they spoil and their spoilage activities. The role of different enzymes in food spoilage was also highlighted. In this unit, we shall discuss food contamination: the definition of food contamination, types of food contaminants, events that cause food contamination and food contamination caused by bacteria.

3.2 Learning Outcomes

By the end of this unit, you will be able to

1. Classify food contamination
2. Discuss five events that can cause food contamination
3. Evaluate the illnesses caused by four bacterial pathogens

3.3 Types and Sources of Contaminants

3.3.1 Types of food contaminants

Food contaminants are divided into three categories: biological, chemical, and physical or foreign material.

1. **Biological Contamination**: This occurs when bacteria, fungal, or other harmful microorganisms contaminate food. It is a common cause of food poisoning, food spoilage, and food-borne illness. Although all foods can harbor dangerous pathogens, some foods are more vulnerable to biological contamination than others.
2. **Chemical Contamination**: This refers to food that has been contaminated by some type of chemical substance. Common sources of chemical contamination include agrochemicals, kitchen equipment, unwashed fruits and vegetables, and food containers made from non-safe plastics.
3. **Physical Contamination**: This takes place when physical objects enter food. Common sources of physical contamination include metals, glass, hair, fingernails, pests, jewelry, and dirt.

3.3.2. Sources of food contamination

There are two sources of contaminants:

(1) Natural contaminants, which are unintentionally present in food. These include bacteria, molds, fungi, metals, hairs etc

(2) Those introduced intentionally such as food additives, veterinary drugs, and pesticides.

For this course we are going to concentrate on the natural contaminants

Self-Assessment Exercise 1

1. Discuss two types of food contamination

2. food contaminants which are unintentionally present in food are known as-----------------

3.4 Events that Cause Food Contamination

3.4.1. Food production and environmental factors

- **Food production**: The use of chemicals, fertilizers, manures etc. all have the potential to contaminate food as it is being grown.
- **Environmental factors**: Bacteria, parasites, fungal spores etc. travel in the wind, float in the water, hitch lifts with dust and reside snugly in the soil. They are a part of nature's web of life and will always be a possible source of contamination if not dealt with appropriately as part of a consistent and dedicated approach to food hygiene.

3.4.2 Food transport and food processing

- **Food transport**: Food contamination can take place during its transportation. Common sources of contamination include the vehicle exhausts of diesel and petrol or cross-contamination in the vehicle.
- **Food processing:** Whether in a large factory or in your own kitchen, food processing can be a major source of contamination. Areas used for processing need to be kept scrupulously clean or cross-contamination can easily occur, especially with meat products (natural bacteria residing in the intestines of animals are a major source of cross-contamination when mishandled).

3.4.3 Food storage and food preparation

- **Food storage**: Food that is stored incorrectly, for instance an uncooked chicken thigh resting next to some mango fruits, can be a source of transferring bacteria and other contaminants from one food to another.
- **Food preparation**: A great deal of food contamination occurs during the preparation stage. A sick person can pass on germs, ranging from flu to gastroenteritis. A chopping board used for meat that is not washed and then used for vegetables is another source of possible contamination. Unwashed hands, dirty kitchen spaces, insects and rodents in the kitchen etc. are all possible sources of food contamination.

Self-Assessment Exercise 2

1. Discuss four events that can cause food contamination
2. All these can cause contamination in the area of food preparation except
    a. unwashed hands
    b. kitchen pests
    c. proper storage
    d. a sick person

3.5 Biological Contamination:

3.5.1 Bacterial contamination

- Biological contamination generally realizes as contamination of food or environment with microorganisms and their derivatives such as toxins. In this regard, bacteria, viruses, fungi, and parasites are potential contaminants. They are found in food, walls, water, air, clothes, etc. The biological contamination also can occur via macroscopic organisms including rodents and insects. The biological contaminants cause human diseases via three mechanisms including infection, intoxication and immunologic responses.

- Bacteria are small microorganisms that can grow in an ideal condition. They split and multiply so quickly. Two classes of bacteria are important in food processing: Pathogenic bacteria and spoilage bacteria. Pathogenic bacteria or pathogens are harmful bacteria, called and are recognized as hazards in safety of food. Therefore the spread and incidence of them must be controlled in food.
- The spoilage bacteria may not be harmful but cause food deterioration and spoilage. The common sources for bacterial growth and further distribution are the air, human body, dust, pets and pests, row food (meat, milk, vegetable, etc.), soil, kitchen/factory instruments, food handlers and cloths/hands. The extrinsic factors that provide optimum conditions for bacteria to survive include food (especially protein), water (water activity), oxygen, temperature, and pH level. The control of these factors can result in well preservation of food.

3.5.2. The major bacteria and their risks

The major bacteria in food contamination and their risks are shown in Table 1.

table 1: Major bacteria and their risks

Major bacteria	**Risk contamination**
Clostridium botulinum	Intoxication, even death
Listeria monocytogenes	Infection
Salmonella spp. (*typhimurium, enteriditis*)	Infection

Major bacteria	**Risk contamination**
Enterohaemorrhagic *Escherichia coli*	Infection
Campylobacter jejuni	Infection
Yersinia enterocolitica	Infection
Listeria monocytogenes	Infection
Bacillus anthracis	Infection
Bacillus cereus	Intoxication
Staphylococcus aureus	Intoxication
Clostridium perfringens	Infection
Vibrio spp. (*vulnificus*, *parahaemolyticus*)	Infection
Brucella abortus, *B. suis*	Infection
Shigella spp. (*dysenteriae*)	Infection

Self-Assessment Exercise 3

1. The type of bacteria that is of great significance to food contamination are the ---------
   a. pathogenic bacteria
   b. facultative bacteria
   c. aerobic bacteria
   d. spoilage bacteria
2. *Clostridium botulinum* is a significant food contaminant because it can cause --------- and ----------------

3.6 Pathogenic Agents and Illness

- The consumption of food which is contaminated leads to food borne illness. Most food borne diseases are either infections or poisonings caused by bacteria, viruses or parasites and harmful toxins or chemicals respectively. Most common invisible agents for food contamination is bacteria Food borne pathogens can also be acquired through drinking water, consumption of food cooked with contaminated water, contact with animals or their environment or through person to person spread.
- .Bacteria are present everywhere and can grow wherever provided with favourable environmental conditions. Some of the common illness caused by pathogenic includes: Shigellosis, Salmonellosis, Listeriosis, Camplylobacteriosis, Botulism, *Esherichia coli* infection etc.

3.6.1 Botulism, Shigellosis and Campylobacteriosis

- **Botulism:** The disease is caused by bacteria Clostridium spp., like *Clostridium botulinum, Clostridiumdifficile, Clostridiumperfringens and Clostridiumtetani*. The ingestion of canned food items which are prepared at home causes the disease. The heat resistance spores are capable to survive in these foods. The growth of *Clostridium botulinum* results in formation of potent neurotoxin (in 7 different forms) which causes neuroparalytic syndrome in living beings. The disease may result in death. The organism can thrive in favourable growth conditions like temperature, acidity, oxygen, and water acidity. The conditions whenever found in food poses health risks and mortality rate.

- **Shigellosis**: The disease is common in children. The disease is caused by bacteria of the Shigella spp., like *Shigella sonnei*, *Shigella boydii*, *Shigella flexneri*, *Shigella dysenteriae*. The symptoms of disease involve abdominal pain, vomiting, fever, diarrhoea (watery and bloody), mucus and pus.
- **Campylobacteriosis**: This is caused by bacteria *Campylobacter jejuni* and is common worldwide. The disease is caused by bad food handling practices and poor hygiene. The victims of infection are mostly not priviledged or have access to safe drinking water and sanitary conditions.

3.6.2 *Esherichia coli* infection, Salmonellosis and Listeriosis

- ***Esherichia coli* infection**: *E. coli* is a marker for fecal contamination and is part of human, mammals and bird's gut. Many of the strains of *E. coli* are not hazardous but they may cause some intestinal disorders. The symptoms of all infections depend upon the strain which has caused the infection.
- **Salmonellosis**: The disease is caused by group of enteric bacteria which is gram negative. The bacteria is poisoning in most of the developing and developed country worldwide. The symptoms involves fever, headache, nausea, vomiting, abdominal pain, diarrhoea. The disease causing agents could be *Salmonella enteritidis*, *Salmonella typhi*, *Salmonella paratyphi*. The transmission of disease is usually from poultry, eggs, and meats. *Salmonella typhi*, *Salmonella paratyphiare* commonly

dangerous in developing nations and societies due to lack of access to safe drinking water and food.

- **Listeriosis**: The disease is usually caused by a spore forming bacteria called *Listeria monocytogene*. Although, there are many different species and strains of Listeria capable of causing listeriosis such as *Listeria ivanovii*, *Listeria inocua*, etc. The disease is common in people with immune-suppression. The source of disease could be milk, cheese, fish, and vegetables. The bacteria is capable to grow under cooling temperatures also.

Self-Assessment Exercise 4

1. Botulism is caused by ---------- bacteria while Listeriosis is caused by -------------
2. the bacteria that is a marker of faecal contamin is -------------
   a. *Salmonella typhi*
   b. *Campylobacter jejuni*
   c. *Shigella sonnei*,
   d. *Esherichia coli*

3.7 Summary

Contamination of food by microbial organisms, chemicals and physical contaminants can pose serious health risk to consumers. Serious efforts should therefore be made to eliminate these contaminants from foods.

To eliminate contaminants, one must understand the events along the food supply chain that can open the door for these contaminants. One must also appreciate the infections and illnesses that these contaminants can cause especially the bacterial agents.

In this unit, we discussed the definition of food contamination, the causes of food contamination and the events that could cause food contamination. We emphasized that food contamination could comprise the food safety status of foods and may lead to ill health. Major food contaminants are microorganisms, chemicals and physical contaminants. All the events along the food supply chain could cause food contamination.

3.8 References/Further Readings

1. Grumezescu, A.M & Holban, A.M (2017). Microbial Contamination and Food Degradation.

2. Nambiar, V (2004). A Textbook On Food Contamination And Safety. Anmol ublications Pvt. Limited

3.9 Possible Answers to Self-Assessment Exercise(s)

Self-Assessment Exercise 1

1. microbial, chemical and physical food contaminants
2. natural food contaminants

Self-Assessment Exercise 2

1. food production, environmental factors, food transport, food proessing, food storage and food preparation
2. C- proper storage

Self-Assessment Exercise 3

1. pathogenic bacteria
2. food intoxication and death

Self-Assessment Exercise 4

1. *Clostridium botulinum , Listeria ivanovii*
2. *Esherichia coli*

UNIT FOUR: CONTAMINATION OF FOOD VIRUSES, PARASITES, MYCOTOXINS

4.1 Introduction

The microbial food contaminants include bacteria, viruses, mycotoxins from certain fungi and parasites. Viruses are very tiny organisms (smaller the bacteria) that need a host cell to grow. Several negative health issues are caused by virus contaminated foods.

Parasites like worms can be consumed alongside inadequately cooked foods and these have been known to cause adverse health effects. Mycotoxins are secondary metabolites of some fungi and they pose serious health concerns especially in the developing countries. Mycotoxins are produced on grains and other foods that have not been adequately dried and stored.

In the previous unit, you learnt the definition of food contamination, types of food contaminants, events that cause food contamination and food contamination caused by bacteria. The different illnesses caused by food-borne bacteria were emphasized. These illnesses include Botulism, Shigellosis, Salmonellosis etc.

In this unit, we shall consider food contamination caused by viruses, parasites and mycotoxins. We shall also discuss methods of eliminating food contamination caused by microbiological agents.

4.2 Learning Outcomes

By the end of this unit, you will be able to

1. Discuss four viruses that are important food contaminants and the adverse effects they cause
2. Evaluate five mycotoxins and the fungi that produce them.
3. Discuss four measures to take to control microbial food contamination

4.3 Viruses and Parasites as Food contaminants

4.3.1 Definition of viruses

Viruses are very tiny organisms that can grow and survive only in a host cell. They are able to enter food and water due to poor hygienic conditions. Viruses can only multiply and grow inside a living cell. They are very resistant to heat, drying, freezing, radiation, etc., and are also able to survive for a long time in food or environment. Viruses can enter food during processing, transportation through person to person contact. The awareness about the importance of viruses as food contaminants would result in good hygiene practices done by consumers to minimize the transmission of viral illnesses. The Table below shows the major viruses and their health risks.

4.3.2 Major Viruses and their Risks

Major viruses	**Risk**
Hepatitis A virus	Fever, abdominal discomfort
Norwalk virus	Nausea, vomiting, diarrhea, abdominal pain (gastroenteritis), headache, low-grade fever
Rotavirus	Vomiting, watery diarrhea, fever, abdominal pain

4.3.3 Parasites as food contaminants

Parasite including worms and protozoa can enter food or water. They can also infect people through these ways. They need ambient environment and proper hosts to survive. Contamination of food occurs by fecal due to poor personal hygiene of food handler, improper disposal of human feces, improper sewage treatment and utilization of untreated sewage for crop culturing.

4.3.4 The major parasites and their risks.

Major parasites	**Risk contamination**
Giardia lamblia	Diarrhea, abdominal cramps, fatigue, nausea, flatulence (intestinal gas), weightloss
Entamoeba histolytica	Dysentery (severe, bloody diarrhea)
Ascaris lumbricoides	Intestinal, lung infection
Diphyllobothrium latum	Attaches to intestinal wall
Cryptosporidia	Respiratory, gastrointestinal illness
Trichinella spiralis	Intestinal wall, enter the blood (to feed on it) and lymphatic system
Toxoplasma gondii	Neurological disorders, particularly schizophrenia, bipolar disorder
Taenia solium	Attaches to intestinal wall
Anisakis spp.	Anisakiasis

Self-Assessment Exercise 1

1. List three major viruses that are food contaminants
2. All these are parasites except
   a. *Giardia lamblia*
   b. *Entamoeba histolytica*
   c. *Ascaris lumbricoides*
   d. Aspergillus flavus

4.4 Mycotoxin contamination problem

4.4.1 Definition of mycotoxins

- Mycotoxins are secondary metabolites that are produced by molds. Mycotoxins belong to biological contamination category. The majority of fungi can produce mycotoxins yet this potential is species specification. Several adverse effects on humans, animals, and crops originate from mycotoxins. The contamination of food with mycotoxins is a worldwide concern. Incidence of mycotoxins depends on temperature and humidity of a region that is prone to the fungal growth.
- The exposure to mycotoxins could take place by ingestion and or dermal and inhalation ways without involving the producer fungi. In fact these fungal toxins are a kind of abiotic hazard originated from biotic ones . The disease caused by mycotoxins is mycotoxicoses also resulted in different acute and chronic effects. Generally, the contaminants could enter the food unintentionally by agricultural production, environment, storage, transportation, sale and processing. The mycotoxin may contaminate the food during several stages of food chain from the soil to the plate. As a matter of fact mycotoxin contamination can occur in food by infection of crops not only when directly consumed by human but also consumed as feed. However ingested mycotoxin could result in its accumulation in body organs that enter food/feed through agricultural products, meat, milk or eggs. Various foods such as cereals, legumes, nuts, spices, fruits and also their products have a potent to be contaminated with mycotoxins.

4.4.2 Major mycotoxin and producer microorganism.

Mycotoxin name	**Producer microorganism**
Aflatoxins	*A. flavus, A. parasiticus*, *Aspergillus bombycis*, *Aspergillus ochraceoroseus*, *Aspergillus nomius*, and *Aspergillus pseudotamari*
Ochratoxins (ochratoxin A)	*Aspergillus ochraceus*, *Aspergillus carbonarius*, *Aspergillus melleus*, *Aspergillus sclerotiorum*, *Aspergillus sulphureus*, *Pichia verrucossum*
Trichothecenes	*Fusarium* spp.
Zearalenone	*Fusarium, F. culmorum*, *F. graminearum*, *F. sporotrichioides*
Fumonisins	*Fusarium proliferatum, Fusarium verticillioides*
Tremorgenic toxins	*Penicillium*
Ergot alkaloids	*Claviceps*
Moniliformin	*Fusarium* species (mainly *F. proliferatum*)

Self-Assessment Exercise 2

1. Toxic secondary metabolites that are produced by mold are known as -----
2. which of the following molds can produce aflatoxin
   a. *Fusarium* species
   b. *A. flavus*
   c. penicillium
   d. *Fusarium verticillioides*

4.5 Control of microbial food contamination

4.5.1 Control of microbial food contamination

Microbial contamination issue	Frequency/impact	How to improve
Contamination of raw materials	Fresh vegetable products implicated as sources of infection	• Inappropriate suppliers' processes or wrong storage may cause microbial contamination • Apply good agricultural systems and more hygienic performance in both crops and on farms •Establish effective cleaning/sanitizing programmes • Request a product inspection report from the suppliers that contains a self-evaluation document to ensure the materials were not contaminated by pathogens or toxins
Risk in food packaging •	Air combined with packaging in the food supply chain is one of the	Use appropriate air filters combined with production processes at all times that can control high-risk microbial aerosol generation • Use good hygienic practices in food

	major potential sources of pathogenic microorganisms	processing and supply a product inspection report form to ensure the products are not contaminated by pathogens or toxins
Risk in food refrigeration •	Inappropriate refrigeration systems can cause microbial contamination that can result in a big loss of food products	Refrigerate food products as that should produce a safe product by reducing the temperature of the meat and vegetables to a point where the rate of growth of spoilage microorganisms is slowed down and the growth of most pathogenic microorganisms is prevented • Supply a refrigeration inspection report
Risk in transportation and food service operations	Unsuitable and untimely transportation services can cause microbial contamination • Product handling at the end destination and/or at wrong temperatures can cause microbial contamination and food loss	Employ time and temperature control in all stages of transportation • Use good personal hygiene • Establish effective cleaning/sanitizing programmes • Supply product inspection report forms at the products destination for all products from the initial process to the ultimate end-products

Self-Assessment Exercise 3

1. Discuss three measures to take to prevent food contamination of raw materials for food processing
2. Discuss two measures to take to prevent cross contamination during food refrigeration

4.6 Summary

Viruses, protozoa, mycotoxins are agents of food contaminants. Viruses are important because they are very resistant to heat, drying, freezing, radiation, etc. they therefore require severe treatment to be eliminated. The best option for the reduction of viruses in food is to prevent their contamination.

Protozoa like worms can contaminate meat products like pork that are not given the proper heat treatment. Mycotoxins are toxins produced by certain fungi and cause serious health challenges. They attack grains such as groundnuts, cowpea, cereals and nuts. They thrive in hot and humid environments.

In this unit, we have looked out food contamination caused by viruses, protozoa and mycotoxins. We learnt that viruses are resistant to heat, drying and freezing treatments.

Parasites include worms and protozoas. They get into foods like pork through contact with faecal matter. Foods like pork should be properly cooked before consumption to eliminate worms.

Mycotoxins are toxins produced by some fungi. They can cause adverse health conditions. They attack improperly stored cereals, and legumes among other foods.

4.7 References/Further Reading

1. Grumezescu, A.M & Holban, A.M (2017). Microbial Contamination and Food Degradation.
2. Nambiar, V (2004). A Textbook On Food Contamination And Safety. Anmol ublications Pvt. Limited

4.8 Possible Answers to Self-Assessment Exercise(s)

Self-Assessment Exercise 1

1. Hepatitis A virus, Norwalk virus, Rotavirus
2. D – *Aspergillus flavus*

Self-Assessment Exercise 2

1. Mycotoxins
2. *A. flavus*

Self-Assessment Exercise 3

1. Inappropriate suppliers' processes or wrong storage may cause microbial contamination • Apply good agricultural systems and more hygienic performance in both crops and on farms Establish effective cleaning/sanitizing programmes etc.
2. use right temperarue for refridgeration, Supply a refrigeration inspection report

UNIT 5: PHYSICAL HAZARDS AND THEIR RISKS

Content

5.1 Introduction

Physical contaminants are either foreign material unintentionally introduced to food products eg metal fragments, hair, pieces of bottle or naturally occurring objects (e.g. bones in fish) that are hazardous to the consumer. A physical hazard contaminates a food product at any stage of production. Food processors should take adequate measures to avoid physical hazards in food.

In the last units, you learnt about the microbial and mycotoxins. You learnt the different organisms that cause contaminations either directly or by the production of mycotoxins. You also learnt strategies of food contamination reduction.

In this unit, we shall discuss the physical food contaminants, how the contaminate foods and strategies for their prevention and elimination.

4.2 Learning Outcomes

By the end of this unit, you will be able to:

1. Discuss four risks of physical food contaminants
2. Discuss four ways of preventing the physical contaminants from entering the processing line
3. Evaluate four strategies to eliminate those contaminants that have found their ways into the processing line.

5.3. Common Physical Hazards and their risks

5.3.1 Examples of physical hazards

i. Glass: light bulbs, glass containers and glass food containers
ii. Metal: fragments from equipment such as splinters, blades, needles, utensils, staples, etc.
iii. Plastics: material used for packaging, fragments of utensils used for cleaning equipment
iv. Stones: incorporated in field crops, such as peas and beans, during harvesting

v. Wood: splinters from wood structures and wooden pallets used to store or transport ingredients or food products

vi. Natural components of food: hard or sharp parts of a food (ex: shells in nut products) if consumers do not expect them

5.3.2 Physical hazards risk in food

1. Hard or sharp objects are potential physical hazards and can cause:

- cuts to the mouth or throat
- damage to the intestines
- damage to teeth or gums

2. The presence of physical hazards in food can trigger a food recall, affecting the brand name of your company and product.

Self Assessment Exercise 1

1. State four physical hazards
2. Hard or sharp objects are potential physical hazards and can cause ------ and -----------

5.4. Preventing and Eliminating Common Physical Hazards

5.4.1 Prevention of physical hazards

There are many ways food processors can prevent physical hazards in food products.

i. Inspect raw materials and food ingredients for field contaminants, such as stones in cereals that were not found during receiving

ii. Handle food according to Good Manufacturing Practices (GMPs). For instance avoid inclusion of physical hazards such as jewelry or false fingernails in food products by using proper personnel practices.

- Eliminate potential sources of physical hazards in processing and storage areas, e.g. use protective acrylic bulbs or lamp covers to prevent contamination by breakable glass.
- Install an effective detection and elimination system for physical hazards. Use metal detectors or magnets to detect metal fragments in the production line while filters or screens to remove foreign objects at the receiving point.

iii. Establish an effective maintenance program for the equipment in your facility to avoid sources of physical hazards such as foreign materials that can come from worn out equipment.

5. 4.2 Detecting and Eliminating Physical Hazards

There are several methods available to detect foreign bodies on food processing production lines:

a. Magnets can be used to attract and remove metal from products.

b. Metal detectors can detect metal in food and should be set up to reject products if metal is detected. Equipment should be properly maintained to ensure it is always accurate and doesn't produce false positives.

c. X-Ray machines can be used to identify hazards such as stones, bones and hard plastics, as well as metal.

d. Food radar systems transmit low-power microwaves through food products to identify foreign bodies such as metals, plastics, bones or kernels in food.

e. Assess every step of your operation for potential sources of contamination.

Self Assessment Exercise 2

1. GMP means ------------------
   a. Great manufacturing production
   b. great monitoring process
   c. good monitoring production
   d. good manufacturing practices
2. Tick the hazards that X-Ray machined can detect
   a. stone
   b. hard plastic
   c. metals

5.5 Summary

As physical hazard contaminates a food product at any stage of production, food processors should take adequate measures to avoid physical hazards in food. Metals and broken glass fragments in foods can cause serious health problems.

A food processor must ensure to prevent physical hazards by inspecting raw materials and food ingredients for field contaminants, such as stones in cereals that were not found during receiving and also follow Good Manufacturing Practices (GMPs).

In this unit, you have learnt about the physical food contaminants. Examples are stones, pieces of metal, broken bottle fragments, hair strands, twigs etc. some of the physical contaminants like metals and broken bottles are potential hazards and must be eliminated.

Preventive measures must be put in place to eliminate such hazards. Such measures include proper inspection of raw materials and strict adherence to GMPs. Use of screens, magnets, and metal detectors is important to detect foreign bodies on food processing production lines.

5.6 Glossary

Bacterial rods and cocci - Bacteria are categorized based on their shapes into three classes: cocci (spherical-shaped), bacillus (rod-shaped).

Facultative Anaerobe - Facultative anaerobes are bacteria that can grow in both the presence or absence of oxygen.

Gram Positive Bacteria - In bacteriology, gram-positive bacteria are bacteria that give a positive result in the Gram stain test, which is traditionally used to quickly classify bacteria into two broad categories according to their type of cell wall.

Gram Negative Bacteria - In bacteriology, gram-negative bacteria are bacteria that give a negative result in the Gram stain test, which is traditionally used to quickly classify bacteria into two broad categories according to their type of cell wall.

5.7 References/Further Readings

1. Source and Surveillance (1991). *Food Contaminants***,** Purchase, R & Creaser C. (eds). Woodhead Publushing Series in Food Science, Technology, Nutrition

2. Di Stefano V, & Avellone G. (2014). Food contaminants. *Journal of Food Studies*. 3, 88-102

5.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. stone, hair, glass, plastic, leaves, twigs, any foreign physical material that can get into food.
2. break the teeth, cut interstine, cut the tongue, may lead to death etc

Self Assessment Exercise 2

1. GMP means good manufacturing practices
2. Tick all of them

MODULE 9: POST HARVEST CHANGES IN FOODS

UNIT 1: TRANSPIRATION

1.1 Introduction

1.2 Learning Outcomes

1.3 Physiological Changes Associated with Post Harvest

1. 3.1 Respiration

1. 3.2. Classification of fruits based on respiration rate

1.4 Transpiration

1.4.1 Definition of Transpiration

1.4.2 Factors affecting rate of transpiration – Environmental factors

1.4.3 Factors affecting rate of transpiration Biological factors

1.4.4 Control of transpiration

1.5 Ripening and Senescence

Unit 1: introduction to post harvest changes in fruits and vegetables

1.1 Introduction

Fruits and vegetables are living tissues and they should be alive in order to maintain their keeping qualities. Like all living entities, they respire, consuming oxygen and liberating carbon dioxide. The principle task of the respiratory process is production of energy needed for various metabolic activities. They rely on organic matter that generally is replenished during growth.

Upon removal from the mother plant, the fruits and vegetables are cut off from their normal supplies of water, minerals and organic matter, provided to them from other parts of the plant. The produce, however, remains capable of continuing a wide range of metabolic activities, breaking down stored organic matter in order to meet energy requirements. Some of these physiological activities lead to deterioration of the produce. Biological factors include rate of respiration, sprouting, rooting, changes in color, changes in flavor, changes in texture, changes in nutrition, ethylene production, water loss, and pathological deterioration.

You are welcome to this new module where we shall be discussing post harvest changes in foods with particular reference to fruits and vegetables. We have earlier studied food deterioration and spoilage and have noted that over time some chemical changes within a food render food unsafe for consumption.

In this unit, we shall discover that fruits and vegetables begin to deteriorate as soon as they are harvested and should be handled with care to reduce such deteriorative changes. You will learn the factors that cause, classification of fruits based on respiration rate, how to control post harvest changes.

1.2 Learning Objectives

By the end of this unit, you will be able to

1. Discuss the three factors that affect post harvest changes in fruits and vegetables
2. Discuss the two classes of fruits based on their rate of respiration.
3. Analyze five ways to control ripening in fruits

1.3 Physiological Changes Associated with Post Harvest

Some physiological activities may are highly desirable for the attainment of the optimum eating qualities: example, ripening of fruits like banana, mango, papaya, pineapple, etc and maintenance of vigor of the tissue and provide a kind of defense against attack by spoilage organisms. Physiological changes associated with post harvest

- Respiration
- Transpiration
- Ripening

1. 3.1 Respiration

Respiration is the most important physiological activity and has a direct bearing on produce quality. Respiration is the complex process of oxidation of organic matter (starch, sugars, acids, fats, proteins, etc.) to simpler molecules, such as CO_2 and H_2O with the concurrent production of energy and other intermediate products. The undesirable consequences of respiration include:

1. Loss of food value (stored organic matter is degraded).
2. Hastening of senescence (process of aging).
3. Loss of saleable weight.
4. Reduced quality (usually after a ripening process for fruits).

The desirable effects of respiration include

1. It provides the energy for numerous metabolic processes.
2. It provides valuable intermediates.
3. It maintains tissue vigor.

1. 3.2. Classification of fruits based on respiration rate

Fruits are classified as climacteric and non-climacteric based on their respiration and ethylene production rates during development, maturity, ripening and senescence.

Climacteric fruits: They are those fruits which exhibit a large and sudden increase in the respiration and ethylene production rates almost coincident with their ripening. Examples of climacteric fruits include: Avocado, banana, apple, guava, jackfruit, mango, papaya, passion fruit, peach, plantain, plum soursop, tomato, watermelon. In climacteric fruits ethylene evolution can reach up to 30-500 ppm/kg/h (parts per million) during ripening at 20-25^{o}C.

Non-climacteric fruits do not show the sudden increase, and commonly emit a considerably reduced level of ethylene. Examples of non-climacteric fruits include fruits such as oranges, lemons, strawberries, grapes, pineapples, and cucumbers, among others, ethylene production levels usually range from 0.1 to 0.5 ppm/kg/h, during ripening at 20-2^{o}5C.

Climacteric fruits respond to external ethylene treatment by an early induction and increased levels of ethylene and CO_2 levels, and an accelerated ripening, in a concentration-dependent manner. Non-climacteric fruits, on the other hand, show increased respiration and ethylene production in response to external ethylene treatment without showing acceleration in the time required for ripening.

Self Assessment Exercise 1

1. List five (5) undesirable effect of respiration
2. Fruits can be classified into ------ and ----- based on their rate of respiration during development, maturity and ripening.

1.4 Transpiration

1.4.1 Definition of Transpiration

- Transpiration is the second most important factor with respect to quality loss during storage and transportation. Transpiration means loss of water from the produce due to evaporation. Any moist material will lose moisture when exposed to air that is not saturated. Moisture loss from produce occurs through evaporation and vapor diffusion. This lost water is immediately replenished when the organ is attached to plants. However, when a plant is harvested, no water replacement occurs, which results in a loss of saleable weight. Moisture loss of 3–4% can make the produce unsellable.

- Actual moisture loss that a commodity can withstand varies from 3% in leafy tissues to 5% for common vegetables to 10% for onions. The moisture loss can seriously influence the product quality with adverse effect on appearance, texture and flavor. Wilting, shriveling, shrinkage, drying, dehydration, desiccation, etc. are results of transpiration activity.

1.4.2 Factors affecting rate of transpiration – Environmental factors

Environmental factors

- Temperature: the higher the temperature the higher the rate of transpiration
- Relative humidity: the lower the relative humidity (a measure of the amount of water vapour in the air) the higher rate of water loss from the produce
- Wind speed: the higher the wind speed the more water will be evaporated from the surface of the fruit or vegetable.

1.4.3 Factors affecting rate of transpiration Biological factors

Biological factors

- **Fruit Size**: Fruit transpiration decreases with increasing fruit size.
- **Surface Area/Weight Ratio**: The commodity transpiration rate is directly proportional to its surface area. For commodities of similar shape, the surface area/weight ratio decreases as the commodity increases in size

- **Stage of Development/Maturity Stage**: The maturity stage may influence the transpiration rate of the commodity. As commodities develop, the transpiration rate may change in response to their increased size and decreased surface area/weight ratio as well as other factors.
- **Injuries,** Wounds, and Cracks Tissue wounds caused by disease or mechanical injury may increase the transpiration rate of commodities. In addition to causing increased transpiration, tissue wounds may be a route for penetration of pathogenic microorganisms into fruits and vegetables. The presence of cracks in commodities is usually associated with increased transpiration.
- **Presence of Leaves, Stems, Flowers, or Calyx attached to Commodities:** The transpiration rate in commodities may increase when the commodity is attached to plant parts (leaves, stems, peduncles, flowers, etc.) that have a high transpiration rate.
- **Cultivars:** The transpiration rate may vary among cultivars of the same crop. This difference may be due to differences in permeance of the epidermis or to differences in surface area/weight ratio as a result of differences in size or shape.

1.4.4 Control of transpiration

i. Storage at low temperature and high relative humidity
ii. Use of Surface Coatings Surface coatings (waxes, edible films, etc.) are used reduce water losses from fruits and vegetables.

Self Assessment Exercise 2

1. The factors that affect transpiration can broadly be divided into two --------- and ---------------
2. The condition most likely to control transpiration process is
   a. high relative humidity and high temperature
   b. low relative humidity and high temperature
   c. low relative humidity and low temperature
   d. high relative humidity and low temperature

1.5 Ripening and Senescence

1.5.1. What is ripening?

- Ripening, a term reserved for fruit, is generally considered to begin during the later stages of maturation and to be the first stage of senescence. Senescence is defined as the period when anabolic (synthetic) biochemical processes give way to catabolic (degradative) processes, leading to ageing and finally death of the tissue. Fruit ripening is probably one of the more complex developmental processes by which a plant organ suffers profound physiological and biochemical transformations. During early phases of growth and development, fleshy fruits are green, accumulate water and nutrients, and are covered by thick epidermal layers providing protection for seed.
- After fruit development has been completed, ripening evolves a series of transformations characterized by changes in color, texture, aroma, nutrients, etc. making the fruit attractive for predators to facilitate seed dispersal, and also nutritious for human consumption. Distinct structural, physiological, and biochemical mechanisms may operate during ripening in the different types of fruits..

1.5.2. Changes during ripening

- **Colour:** Due to degradation of the green chlorophyll and increase in the carotenoid content, mainly lycopene, most colours of fruits change from green to red or yellow upon ripening.
- **Softening** Pectin can be degraded by pectinases that may get activated upon ripening of fruits, this makes the fruits softer and more attractive for seed dispersal. However, oversoftening produces important economic losses, since it reduces transportability, storage time, and postharvest shelf-life. Pectin present in fruits and vegetables provides mechanical rigidity.
- **Flavor and Aroma**: Aroma plays an important part in the development of optimal eating quality in most fruit. Aroma occurs because of the many volatile organic compounds (often known as volatiles) that are synthesized during the ripening phase.
- **Organic acids**: Usually organic acids decline during ripening as they are used in respiration or converted to sugars. This is why an unripe fruit tastes more tarty than a ripe fruit of the same type.
- **Carbohydrate metabolism:** The largest quantitative change associated with ripening is usually the breakdown of carbohydrate polymers, such as the near total conversion of starch to sugars. This alters both the taste and the texture of the fruit. The increase in sugar renders the fruit much sweeter and therefore more acceptable. The breakdown of polymeric carbohydrates, especially pectic substances and hemicelluloses, weakens cell walls and the cohesive forces binding cells together. In the initial stages, the texture becomes more palatable, but eventually the plant structures disintegrate.

1.5.4 Control of ripening

Ripening can be controlled by:

- Modified Atmosphere Packaging: Modified Atmosphere Packaging (MAP) can be defined as "the enclosure of food products in a barrier film in which the gaseous environment has been changed or modified to slow respiration rates, reduce microbiological growth and retard enzymatic spoilage with the intent of extending shelf life"
- Good harvesting practices: fruits should be harvested at peak maturity. Avoid bruises as much as possible. Maintain good hygiene during and after harvest.

Self Assessment Exercise 3

1. During ripening of a fruit all these happen except
    a. it becomes less tarty
    b. it becomes more acidic
    c. it becomes sweeter
    d. it becomes softer.
2. the purpose of modified atmosphere packaging include all these except
    a. increase transpiration
    b. reduce respiration
    c. reduce ripening
    d. reduce enzyme activities

1.6 Summary

Post harvest changes are physiological changes that set in as soon as a fruit or vegetable is harvested. These changes could lead to deteriorative changes and so have to be controlled to extend the shelf life of the commodity.

Rate of respiration, transipiration and ripening are the physiological activities that continue after harvest and may lead to sprouting, rooting, changes in color, changes in flavor, changes in texture, changes in nutrition, ethylene production, water loss, and pathological deterioration

In this unit, you learnt that some physiological activities trigger deteriorative changes in harvested fruits and vegetables. These activities are respiration, transpiration and ripening.

You also learnt that fruits are classified as climateric and non-climateric fruits based on their rate of respiration. Climacteric fruits like mango, banana show a sudden increase in the respiration and ethylene production rates almost coincident with their ripening. Non-climateric fruits like orange, lemon, cucumber,do not show such sudden increase.

Ripening can be controlled by modified atmospheric storage and good harvest practices.

1.7 References/Further Reading

1. Yahaya SM, Mardiyya AY. (2019). Review of Post-Harvest Losses of Fruits and Vegetables. *Biomed J Sci & Tech Res* 13(4). DOI: 10.26717/ BJSTR.2019.13.002448

1.8 Possible Answers to Self Assessment Exercises

Self Assessment Exercise 1

1. Any factor listed in 1.3.1
2. Climacteric and non climacteric fruit

Self Assessment Exercise 2

1. environmental and biological factors
2. D – high relative humidity and low temperature

Self Assessment Exercise 3

1. b – becomes more acidic
2. a – increase transpiration

UNIT TWO: CAUSES OF POST HARVEST LOSSES AND CONTROL OF POST HARVEST CHANGES

2.1 Introduction

Post harvest changes in fruits and vegetables lead to deterioration and loss of commodities which reduces their economic value. Many factors contribute to these post harvest losses. Such factors include mechanical injury, microbial and physical losses.

In the last unit, you learnt that some physiological activities trigger deteriorative changes in harvested fruits and vegetables. These activities are respiration, transpiration and ripening. You also learned that fruits are classified as climacteric and non-climacteric fruits based on their rate of respiration. The last unit also discussed effect of ripening on quality of fruits and methods of controlling ripening.

In this unit we shall discuss other factors that facilitate post harvest losses of fruits and vegetables and ways of reducing the losses.

2.2 Learning Outcomes

By the end of this unit, you will be able to:

1. Evaluate at least three major causes of post harvest loses.

2. Discuss at least four measures to take to reduce post harvest losses.

3. Discuss the optimal temperature and relative humidity for storage of at least three produces

2.3 Primary Causes of Post Harvest Losses

2.3.1 Mechanical and Physio-biochemical losses

- **Mechanical losses:** Besides causing damage, bruising and cracking make the vegetable more prone to attack by organisms and significantly increase the rate of water loss and gaseous exchange. Mechanical damage of fruits and vegetables are caused by careless handling during harvesting, packing, transportation, storage etc. Some insects and birds are also responsible for the mechanical injury in fruits and vegetables. Several times the damage cause by mechanical injury on fruits and vegetables as a result of pressure thrust during transportation, though many times invisible, but causes rupturing of inner tissues and cells. Such produce is degraded faster during the natural ageing process.

- **Physio-biochemical losses:** In fresh vegetables transpiration and respiration and sprouting of tuber and bulb vegetables lead to direct food loss. The loss is accounted towards senescence process and represents major components of post-harvest losses. Post-harvest rooting in tuber-vegetables, seed germination, greening of potatoes leading to production of harmful compounds and toughening and sponginess in carrot and radish that represent physiological loss, lower down the quality of vegetables.

2.3.2 Microbial and Physical losses

- **Microbial losses:** A significant portion of losses of vegetables during post harvest is attributed to diseases caused by fungi and bacteria. Succulent nature of the vegetables makes them easy to invade by the organisms. Fruits and vegetables are also prone to damage by microbial attack. The microbial spoilage is mainly caused by fungi, bacteria, yeast and moulds. However, a significant portion of losses of fruits and vegetables during post-harvest period is attributed to diseases caused by fungi and bacteria. The succulent nature of fruits and vegetables makes them easily invaded by these organisms. The most common pathogens causing rots in vegetables and fruits are fungi such as *Alternaria, Botrytis, Diplodia, Monilinia, Phomopsis, Rhizopus, Penicillium,* *Fusarium*, etc. Among bacteria *Ervinia, Pseudomonas*, etc. cause extensive damage.

- **Physical losses:** Excessive or insufficient heat during processing, improper cold storage temperature and relative humidity and undesirable gaseous composition of controlled atmosphere storage lead to physical damage due to tissue break down.

Self Assessment Exercise 1

1. State four causes of post harvest losses
2. Tick the agents of microbial spoilage of fruits
   a. fungi,
   b. bacteria,
   c. yeast
   d. moulds.

2.5 **Control of Post Harvest Losses**

2.4.1 Cultural operations and pre-cooling

- **Cultural operations:** Cultural operations, which ensure normal development of vegetables and avoid infection from decayed organisms, help to prolong shelf life. For root crops such as carrot and radish, preparation of the soil to a fine tilth of porous is necessary to avoid root forking. Regular irrigation during development of bulb, tuber and fruit vegetables is of vital importance.
- **Pre-Cooling**: Pre-cooling prevents premature ripening and ageing of the fresh produce. Therefore, it is important to remove field heat of the harvested

vegetables, especially when the harvesting is done during hot weather. Cooling, therefore, conserves weight of the fresh produce which gives an added advantage during the extended storage period. In fruits like tomato pre-cooling during storage can reduce Physiological loss in of weight from 6 to 2.9 per cent. Therefore, effective pre-cooling can be accomplished by:

1. placing the produce in refrigerated trucks with forced humidified air circulation,
2. placing ice in packages,
3. placing ice in water and then passing through a spray of cool water – hydro-cooling
4. passing through vacuum cooling

2.4.2 Pre harvest, harvest and packaging practices

- **Pre-harvest treatments:** Post-harvest applications of metabolic inhibitors such as maleic hydrazide reduces sprouting of onions and potatos during storage and those of growth promoters such as benzyladenine prolongs the shelf-life of leafy vegetable. Ethylene induces early maturity.
- **Harvesting:** Consumers always prefer fresh, tender and disease and insect free vegetables of attractive appearance. Vegetables should be harvested as and when they attain maximum size and yet are tender. Vegetables other than root crops should not directly be placed on the soil.
- **Washing and grading:** Root and tuber crops are often washed to remove adhering_soil. Besides cleanliness, water used for washing improves vegetable appearance and prevent wilting. Vegetables are graded according to shape, colour, size, maturity and general appearance as well. In sorting the vegetables into

different grades, all characters that influence appearance and quality of the produce should be considered.

- **Packaging:** Cheap packaging techniques and material such as polyethylene films, paper board boxes lined with polyethylene_and other materials can effectively prolong the shelf-life of vegetables.

2.4.3 Curing and low temperature storage

- **Curing:** Curing of onions in crates of **40°C for 16 hours** is found to reduce rot losses in storage. In other crops such as potato, garlic, sweet potato cassava, yam and others curing effectively reduces post-harvest decay and water losses.
- **Low temperature storage:** Refrigeration or low temperature storage can most effectively extent shelf life of vegetables and reduce post harvest losses by arresting metabolic break down and fungal deterioration of the commodity. The most suitable condition for fresh fruits and vegetables in storage is the lowest temperature, which does not cause chilling injury to the fresh produce. Any variation from the desired condition is detrimental. Relative humidity of the store rooms also has a considerable bearing on the keeping quality of the fresh produce. it should be noted that the temperature and relative humidity requirements differ for different fruits and vegetables.

2.4.4 Controlled atmosphere storage and chemical treatments

- **Controlled atmosphere (CA) storage:** In CA storage higher CO_2 and lesser O_2 are maintained. It retards respiratory activity, delay softening, yellowing, quality changes and other deteriorative processes.
- **Post harvest chemical treatments:** Wide range of chemicals have been used to control microorganisms (fungicides. antibiotics), ethylene level (ethylene absorbents)

water loss (antitranspirants) and senescence (growth substances) desiccants (calcium chloride, fumed silicas) for dehydrated products also gave added advantage.

Self Assessment Exercise 2

1. State four ways to control post harvest losses

2. The use of control atmosphere strorage has the following advantages except

   a. reduces respiration

   b. reduces senescence

   c. increases ripening

   d. increases post harvest shelf life

2.5 Temperature and relative humidity in storage life of vegetables

2.5.1 **Effect of temperature and relative humidity on the storage life of vegetables**

The Table below shows the effect of temperature and relative humidity on the storage life of vegetables.

By manipulating the temperature and relative humidity condition of a storage area, the storage life of these fruits and vegetables can be extended.

Vegetable	**Temperature (oC)**	**RH (%)**	**Storage life (Weeks)**
Cabbage	0.0 to 1.7	92 to 95	4-6

Ginger	7 to 10 0.0	75	16-24
Onion bulbs	0.0	70 to 75	20-24
Tomato ripe	7.2	90	1
Banana (a) For ripening (b)) Ripened fruit	 15.50-21.00 fruit 11.10-12.70	 80-85 85-90	 1-2 3
Papaya	8.30- 10.00	80- 85	1-2
Lemon	7.20- 8.80	85- 90	8-12
Guava	8.30- 10.00	80-85 4	4
Mango	7.20-8.80	85-90	4-7

Self Assessment Exercise 3

3. The condition most likely to control transpiration process is
    e. high relative humidity and high temperature
    f. low relative humidity and high temperature
    g. low relative humidity and low temperature
    h. high relative humidity and low temperature
4. By storing ripe tomatoes at 7.2^{O}C at 90% relative humidity, their shelf life can be extended to ------------ week(s)
    a. one
    b. two
    c. three
    d. four

2.6 Summary

As soon as fruits and vegetables are harvested, post harvest changes that lead to deterioration begins. Those changes are caused by physiological activities such as respiration, transpiration and ripening. Apart from these physiological activities, other factors that quicken post harvest deterioration and spoilage include: mechanical injury, microbial activities among others.

Some measures must be put in place to reduce post harvest loses. Such measures include pre-cooling, curing, low temperature storage etc.

In this unit we discussed factors that facilitate post harvest losses of fruits and vegetables and ways of reducing the losses. Such factors include mechanical injury, physio-biochemical losses, and microbial losses. To reduce these loses, one must apply good cultural practices like reducing infections caused by decayed organisms and proper tilling of ground. Pre-cooling of produce must be done, also curing and storage at low temperature must be undertaken.

Different produce have different optimal storage conditions that must be taken into account to minimize losses for example onion bulbs $0^{o}C$ at RH of 70-75 for storage for up to 24 weeks.

2.7 References/Further Readings

1. Yahaya SM, Mardiyya AY. (2019). Review of Post-Harvest Losses of Fruits and Vegetables. Biomed J Sci & Tech Res 13(4). DOI: 10.26717/ BJSTR.2019.13.002448

2. Thompson, J.F., Mitchell, F.G & Robert F. Kasmire, R.F. (2002). *Cooling horticultural commodities in Postharvest technology of horticultural crops*, Third Edition, University of California, Agriculture and Natural Resources. pp 97-112.

3. Thompson, J. (1998). *Commercial Cooling of Fruits and Vegetables*. University of California, ANR Publications #21567

2.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. see section 2.3
2. Tick all

Self Assessment Exercise 2

1. See section 2.4

2. C- increases ripening

Self Assessment Exercise 3

1. d.- high relative humidity and low temperature
2. a - one

UNIT THREE: PRECOOLING: AN IMPORTANT POST HARVEST PRACTICE

3.1 Introduction

Pre-cooling is the key component in the preservation of quality for perishable fresh produce in post-harvest systems. It is likely the most important of all the operations used in the maintenance of desirable, fresh and salable produce. Precooling is defined as the removal of field heat from freshly harvested produce in order to slow down metabolism and reduce deterioration prior to transport or storage.

One of the most important factors affecting the postharvest life and quality of fruits and vegetables is temperature. Quality loss after harvest occurs as a result of physiological and biological processes, the rates of which are influenced primarily by product temperature. As the maintenance of market quality is of vital importance to the success of the horticultural industry, it is necessary not only to cool the product but to cool it as quickly as possible after harvest. Pre-cooling rapidly lowers the temperature of freshly harvested produce and is done immediately following harvest to minimize spoilage.

In the last unit, you learnt the primary causes of post harvest losses. The causes include mechanical injury, microbial activities and physio-biochemical losses. You also learnt measures to control post harvest losses and the effect of temperature and relative humidity of storage area on shelf life of fresh produce. In this unit you will learn, the importance of cooling as a post harvest practice.

3.2 Learning Outcomes

By the end of this unit, you will be able to

1. Analyze at least three advantages of pre-cooling
2. Discuss at least four pre-cooling methods
3. Discuss a minimum of two advantages of each method mentioned above.

3.3 Benefits and Importance of Pre-Cooling

3.3.1 Proper pre-cooling preserves product quality by

1. inhibiting the growth of decay producing microorganisms
2. restricting enzymatic and respiratory activity
3. inhibiting water loss
4. reducing ethylene production

3. 3.2 Importance of pre-cooling

1. Removal of field heat from fresh produce

   Field heat can cause rapid deterioration of some horticultural crops and therefore it is desirable to remove this heat as quickly as possible after harvesting. When it comes to produce quality, every minute counts and that pre-cooling is among the most cost-effective and efficient quality preservation methods available to commercial crop produces

2. Reduces respiration rate

   The rate of deterioration after harvest is closely related to the respiration rate of the harvested product, therefore the reduction of respiration rate is essential to preserving market quality. Since the rate of respiration is influenced by temperature, precooling to remove the field heat before storage will reduce the respiration rate and hence deterioration will decline accordingly

3. Reduces metabolism rate

   The increase in the rate of deterioration is related to the metabolic processes of the crop. Within the plants temperature range, the rate of deterioration increases logarithmically with increasing temperature. Metabolic rates double for each 100^{o}C rise in temperature. From these reports, it can be seen that the quicker the temperature is reduced the less losses that can occur. Hence, pre-cooling is essential in order to reduce metabolic changes such as enzyme activity, and to slow the maturation of perishable produce.

4. Reduction in ethylene production

   The reduction in temperature has the added advantage of reducing the production and sensitivity of the produce to ethylene that accelerates ripening and senescence. Therefore, the faster and more promptly the field heat and hence temperature is reduced after harvest, the quicker these deteriorative processes are retarded and hence the more of the initial quality can be maintained.

Self Assessment Exercise 1

1. Pick the option that is not a benefit of pre-cooling
   a. reduces flavour development
   b. inhibiting the growth of decay producing microorganisms
   c. restricting enzymatic activity
   d. inhibiting water loss
2. Give two reasons why ethylene production from harvested fruits needs to be reduced.

3.4 Methods For Pre-Cooling Produce

3.4.1 Room Cooling

There are seven principal methods of pre-cooling fresh produce:

1) Room cooling

2) Forced-air cooling

3) Hydro-cooling

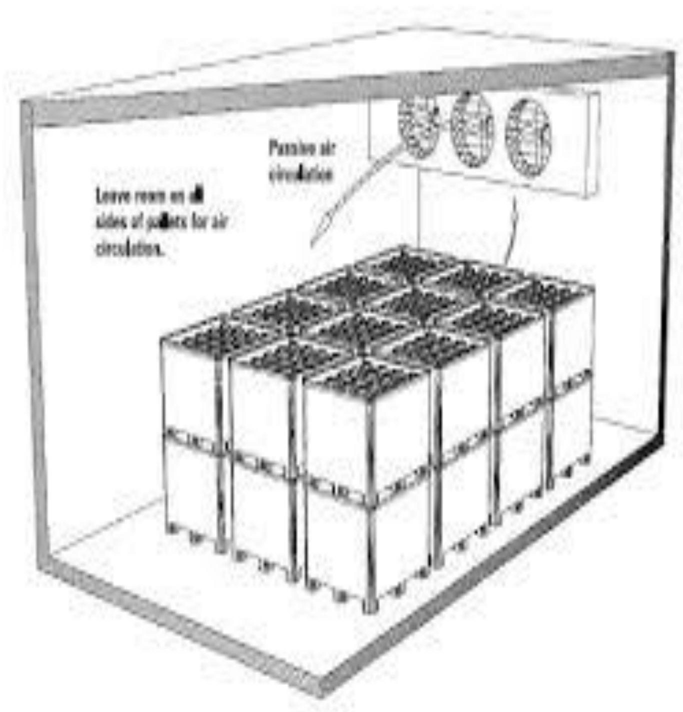
4) Ice cooling

5) Vacuum cooling

6) Cryogenic cooling

7) Evaporative cooling

Room cooling: This widely used method involves the placing of produce in boxes (wooden, fiberboard or plastic), bulk containers or various other packages into a cold room, where they are exposed to cold air. It is used for produce sensitive to free moisture or surface moisture. Because this type of cooling is slow, room cooling is only appropriate for very small amounts of produce or produce that does not deteriorate rapidly. Room cooling has become increasingly difficult as more commodities are being handled in larger quantities and are packaged immediately after harvest due to better mechanization. These difficulties coupled with its slow and variable cooling extend the cold chain and therefore reduce the product life in subsequent storage.

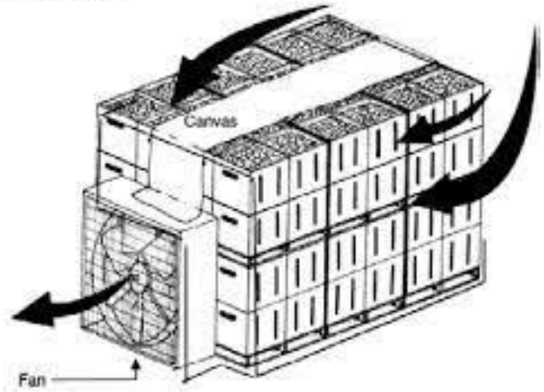


Room cooling

3.4.2 Forced air cooling and Hydro cooling

Forced air cooling: Fans are used in conjunction with a cooling room to pull cool air through packages of produce. Although the cooling rate depends on the air temperature and the rate of air flow, this method is usually 75–90% faster than room cooling.

Figure 2. Forced-air Tunnel



Hydro-cooling: Dumping produce into cold water, or running cold water over produce, is an efficient way to remove heat, and can serve as a means of cleaning at the same time. In addition, hydro-cooling reduces water loss and wilting. Use of a disinfectant in the water is recommended to reduce the spread of diseases. Hydro-cooling is not appropriate for berries, potatoes to be stored, sweet potatoes, bulb onions, garlic, or other commodities that cannot tolerate wetting.

Hydro-cooling

3.4.3 Top icing and vacuum cooling

Top or liquid icing: Icing is particularly effective on dense products and palletized packages that are difficult to cool with forced air. In top icing, crushed ice is added to the container over the top of the produce by hand or machine. For liquid icing, a slurry of water and ice is injected into produce packages through vents or handholds without removing the packages from pallets and opening their tops. Icing methods work well with high-respiration commodities such as sweet corn and broccoli.

Top icing pre-cooling

Vacuum cooling: Produce is enclosed in a chamber in which a vacuum is created. As the vacuum pressure increases, water within the plant evaporates and removes heat from the tissues. This system works best for leafy crops, such as lettuce, which have a high surface-to-volume ratio. To reduce water loss, water is sometimes sprayed on the produce prior to placing it in the chamber. This process is called hydrovac cooling. The primary drawback to this method is the cost of the vacuum chamber system.

3.4.4 Cryogenic and evaporative cooling

Cryogenic cooling: The use of the latent heat of evaporation of liquid nitrogen or solid CO2 (dry ice) can produce `boiling' temperatures of -196 and -780 C, respectively. This is the basis of cryogenic precooling. In cryogenic cooling, the produce is cooled by conveying it through a tunnel in which the liquid nitrogen or solid CO2 evaporates. However, at the above temperatures the produce will freeze and thus be ruined as a fresh market product. This problem is prevented by careful control of the evaporation rate and conveyor speed. Cryogenic cooling is relatively cheap to install but expensive to runThe high cost of liquid nitrogen, dry ice and other suitable non-toxic refrigerants make this process most suitable for relatively expensive products.

Evaporative Cooling: Evaporative cooling is an inexpensive and effective method of lowering produce temperature. It is most effective in areas where humidity is low. Dry air is drawn through moist padding or a fine mist of water, then through vented containers of produce. As water changes from liquid to vapor, it absorbs heat from the air, thereby lowering the produce temperature. The incoming air should be less than 65 percent relative humidity for effective evaporative cooling. It will only reduce temperature, 10-15°F. This method would be suitable for warm-season crops requiring warmer storage temperatures, such as tomatoes, peppers, cucumbers or eggplant.

Self Assessment Exercise 2

1. Mention two disadvantaged of hydro cooling
2. the use of the principles of latent heat of vaporization for precooling is known as
   a. top cooling
   b. cryogenic precooling
   c. hydrocooling
   d. forced air cooling

3.5 Summary

Pre-cooling is defined as the removal of field heat from freshly harvested produce in order to slow down metabolism and reduce deterioration prior to transport or storage. It is likely the most important of all the operations used in the maintenance of desirable, fresh and salable produce.

Pre cooling reduces field heat, rates of respiration, metabolism and ethylene production. Methods of pre-cooling includes room cooling, forced air cooling, hydro cooling etc. to maintain optimal post harvest quality, producers must ensure that fruits and vegetables are appropriately pre-cooled.

In this unit, you have learnt that proper pre-cooling preserves product quality by inhibiting the growth of decay producing microorganisms, restricting enzymatic and respiratory activity, inhibiting water loss and reducing ethylene production. Pre-cooling reduces respiration rate, metabolism rate and removes field heat from produce.

There are many types of pre-cooling including room cooling, forced-air cooling, Hydro-cooling, Ice cooling among others.

3.6 Glossary

3.7 References/Further Readings

1. Thompson, J.F., Mitchell, F.G & Robert F. Kasmire, R.F. (2002). *Cooling horticultural commodities in Postharvest technology of horticultural crops*, Third Edition, University of California, Agriculture and Natural Resources. pp 97-112.

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3.8 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. Pick the option that is not a benefit of pre-cooling
   a. reduces flavour development
2. to inhibit ripening and senescence

Self Assessment Exercise 2

1. May lead to contamination and make some fruits and vegetables soggy
2. The use of the principles of latent heat of vaporization for precooling is known as
   b. cryogenic precooling

MODULE 10: STURCTURE AND COMPOSITION OF SOME WEST AFRICAN FOODS

UNIT 1: CLASSIFICATION OF WEST AFRICAN FOODS

1.1 Introduction

1.2 Learning Outcomes

1.3 Physiological Changes Associated with Post Harvest

1. 3.1 Respiration

1. 3.2. Classification of fruits based on respiration rate

1.4 Transpiration

1.4.1 Definition of Transpiration

1.4.2 Factors affecting rate of transpiration – Environmental factors

1.4.3 Factors affecting rate of transpiration Biological factors

1.4.4 Control of transpiration

1.5 Ripening and Senescence

1.5.1. What is ripening?

1.5.2. Changes during ripening

1.5.5 Control of ripening

1.6. Summary

1.7 References/Further Readings

1.8 Possible Answers to Self-Assessment Exercise(s)

1.1 **Introduction**

Think of what you have eaten in the last 24 hours, list the components of the meals as much as you can remember. You would realize that your meals were made up of diversity of foods. You may have a eaten a tuber food, fruits and vegetables, cereals, meat, fish etc.

West African region is blessed with a large array of foods. The many food types in West Africa can be classified into seven basic food groups. This classification is based on similarity in nutrient composition of the foods.

Welcome to this module. In this module we shall be discussing the structure and composition of some typical West African foods. We will start from classification of typical west African foods. The knowledge of the composition and structure of some of our foods is very important for adequate nutrition, in food storage, in food processing and in food transportation.

In unit one, you will learn the classification of West African foods and the major constituents of each class. You will also learn examples of foods in each food class.

1. 2. Learning Outcomes

1. Evaluate West African foods according on similarity in nutrient composition.

2. Discuss the basic nutrients of at least three classes

3. State at least five examples from each class.

1.3 Major Classification of West African

1.3.1 Classifications of West African foods

West African foods can be classified into the following:

1. The milk group - comprising all dairy products, such as powdered milk, skim milk, fresh milk, buttermilk, condensed milk, ice-cream, and yoghurt;

2. The meat group - including diverse food items such as beef, veal, lamb, pork, other meats, eggs, fish, beans, peas, ground-nuts, and other nuts and seeds;

3. The cereal and grain group - including wheat, rice, maize, guinea-corn (sorghum), millet, and potatoes;

4. Roots, Starchy Fruits, and Tubers

5. The fruit and vegetable group - including all fruits and vegetables commonly consumed

1. 3.2 The milk group

Group One – (Milk and Milk Products): This group is made up of all dairy products, including fresh milk, skim milk, buttermilk, condensed milk, powdered milk, local and foreign cheeses, butter, yoghurt, and ice-cream.

Individuals with varying degrees of lactose intolerance have a choice of cheeses, buttermilk, and yoghurt. However, for those who must watch their weight, the use of ice-cream and other milk-containing beverages should be restricted.

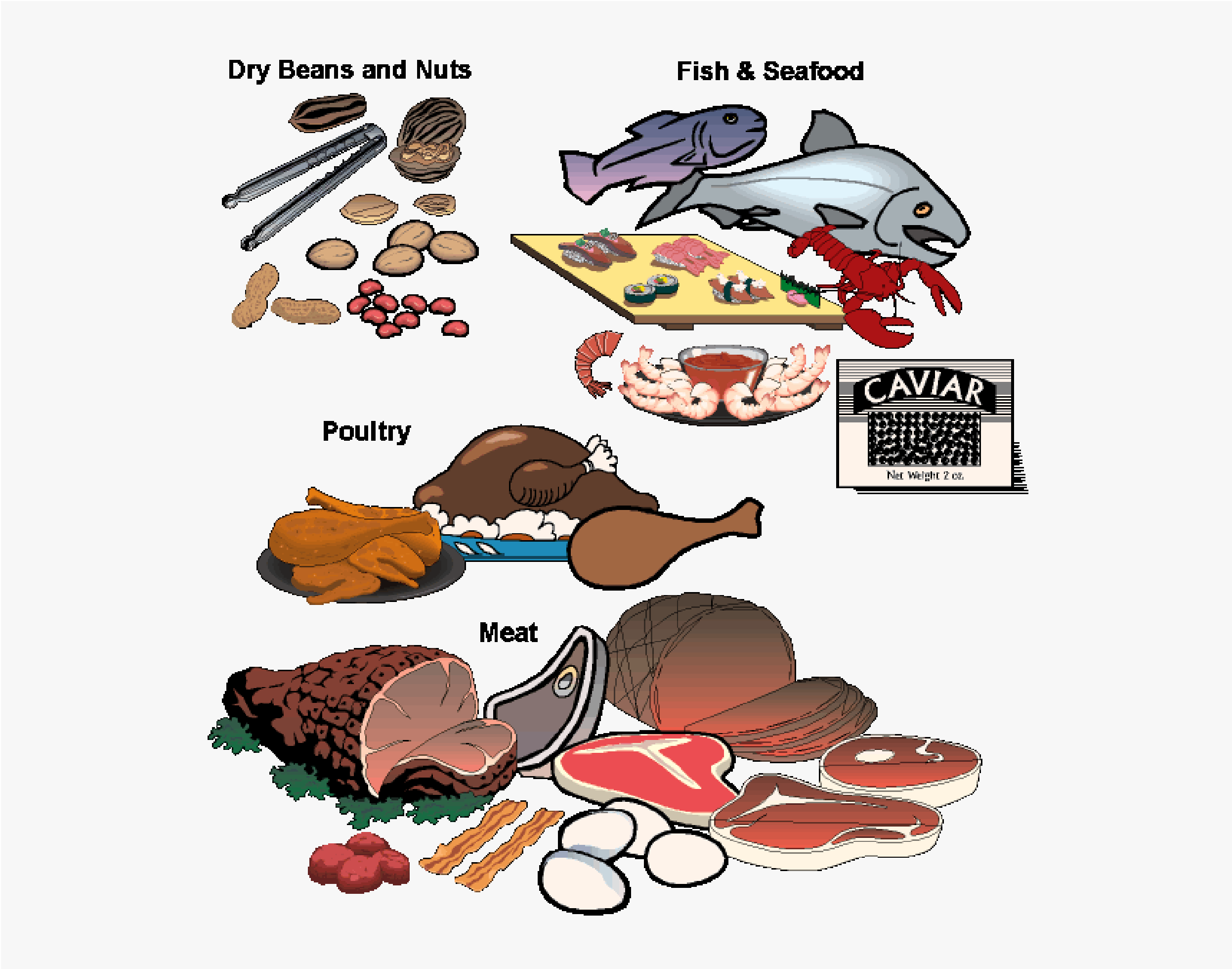
1.3.3 The meat group

Group Two – (Meats, Fish, Nuts, and Beans). This group includes meats; poultry; fish; snails; shrimp; termites; grubs; edible insects, such as caterpillars, locusts, crickets, and grasshoppers; crabs and other sea products; eggs; legumes (pulses); seeds; and nuts.

Although the nutritional contributions of the members of the group vary, they all provide valuable amounts of energy, protein, iron, and B-complex vitamins. The various cuts of meat do compare favourably with the amounts of protein available in poultry or fish. While legumes contain only about 30 per cent of the amount of protein available in animal protein foods of equivalent weight, other valuable components of the various foods in this group compare quite favourably with meats, particularly in light of the high cost and the variable prices of the latter. Furthermore, since large amounts are consumed, legumes are perhaps the most important sources of proteins in many African diets, partly because they are relatively cheap, palatable, and keep fairly well.

A greater use of legumes, nuts, poultry, and fish would help to reduce the intake of saturated fat that is quite abundant in meats (beef is 20-30 per cent saturated fat, compared with poultry and fish, which contain 6 per cent and 2-8 per cent respectively).

Milk and milk products



Meat, fish, nut and bean group

Self Assessment Exercise 1

1. One of these is not a produt from milk
    a. cheese
    b. ice-cream
    c. margarine
    d. butter
2. legumes are classified under the meat group because legumes are rich in ---------
    a. protein
    b. carbohydrates
    c. vitamins
    d. water

1.4 Cereals, Tubers, Fruits and Vegetables

1.4.1 Cereals and grains

Group Three – (Cereals and Grains): The separation of cereals and grains from the tubers, roots, and starchy fruits is based on the differences in their ease of storage and protein content. Although they are of plant origin, the group-three foods contribute not only carbohydrates but also the B-complex vitamins, iron, magnesium, and generous amounts of protein and energy to the diet. Members of this group include bread and other wheat products such as Semovita, rice, maize, guineacorn, and millet. It is believed that there is hardly any village in Africa where one cereal or another is not used as a staple. As a group, cereals constitute the most important food for peoples all over the world, with approximately half of the people in the world depending heavily on rice. The survival of the peoples of the Sahel regions has been attributed to the use of cereals, limited only in Iysine and the sulphur-containing amino acids .

1.4.2 The Roots and Tubers

Group Four – (Roots, Starchy Fruits, and Tubers). The members of this group include yams, sweet potatoes, cassava, plantains, and breadfruit They are the common staples in the wetter, more humid regions of Africa , but they are readily perishable and cannot be stored for long periods of time. Because of storage limitations, they are seasonal foods . As a group, they are mainly starchy foods and major sources of readily available energy, with high caloric densities. They supply about 385 kilocalories per 100 grams of dry matter and very low amounts of other nutrients. Thus, they are limited in their contribution to the provision of a balanced diet.

In general, the group-three foods (cereals and grains) and group-four foods (roots, starchy fruits, and tubers) constitute the largest portion of the typical Nigerian diet. These two groups of foods, especially the latter, because of their limited contributions to a balanced diet are usually consumed alongside typical African sauces and soups like *egwusi* soup, bitter leaf soup, *ewedu* soup, tomato sauce etc. these African sauces provide additional nutrients to the diet.

Cereal group

Tubers group

1.4.3 Fruits and Vegetables

Group Five – (Fruits and Vegetables). This group provides nutritionally important quantities of the water-soluble vitamins, especially folic and ascorbic acids, carotene (the precursor of vitamin A), and minerals. Furthermore, many members of this group make substantial contributions of roughage to the diet in the form of cellulose. Fruits have low protein content, while the protein content of vegetables, often ignored, may be significant. The common fruits include mangoes, pawpaws, guavas, coconuts, oranges, grapefruit, tangerines, bananas, pineapples, imported apples, African pears, cashew fruits, avocado pears, and watermelon. The common vegetables include tomatoes, spinach, mushrooms, pumpkins, onions, okra, collard greens, bitter leaf, water leaf, carrots, tomatoes, cabbage, fluted pumpkins leaf, and lettuce.

Some fruits and vegetables sold in Nigeria.

Self Assessment Exercise 2

1. A major similarity between the cereal and tuber group of foods is -----
2. Tick all the tuber crops in the option below
   a. cassava
   b. yam
   c. sweet potatoes
   d. beet root
3. The major component of vegetables is ----------
   a. carbohydrates
   b. vitamins
   c. water
   d. protein

1.5 Summary

West Africa is blessed with a great variety of foods. These foods can be classified into five groups namely: milk and milk products, meat, fish and grains; cereal groups; tubers and fruits and vegetables. Each group provide important nutrients for quality life to the consumers and contribute to the survival of people in west African region including Nigeria. The variety of foods available should be appropriately harnessed for adequate nutritional intake of the populace.

In this unit, the foods available in west African were classified into five groups namely: milk and milk products, meat, fish and grains; cereal groups; tubers and fruits and vegetables. Examples of foods in the first class include raw milk, yoghurt, ice cream. For the second class, examples include muscle meat, fish, cowpea, nuts etc and for the third class rice, maize, sorghum. Examples of foods in the fourth and fifth classes are yam, cassava, potatoes and water melon, oranges, carrots respectively.

The nutritional significance of each class was highlighted. The first two groups are important for their protein content while the second and third groups provide significant amounts of carbohydrates.

1.5 References/Further Readings

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1.6 Possible Answers to Self-Assessment Exercise(s)

Self Assessment Exercise 1

1. C- margarine
2. A- protein

Self Assessment Exercise 2

1. they are rich in carbohydrates/starch
2. Tick all. All are tuber crops

3. C- water

UNIT TWO: STRUCTURE AND COMPOSITION OF THE MILK AND MILK PRODUCT GROUP

2.1 Introduction

Milk is a white liquid produced by the mammary glands of mammals for feeding their young. It is secreted as a natural process in the mammary glands after parturition of the newborn. Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/capita per day, 8 g of protein/capita per day and 7.3 g of fat/capita per day.

Milk can be fermented to get such products as cheese and yoghurt. Milk is also used to produce ice creams, butter fat etc.

In the last unit, you learnt the classification of West African foods based on similarity in nutrients. You also learnt the basic nutrient composition of each class as well as some typical examples from each class. In this unit, we will go further to discuss the milk and milk product class in detail. You shall learn the typical examples of foods in this group and their detailed nutrient composition

2.2 Learning Outcomes

By the end of this unit, you will be able to:

1. Discuss at least five unfermented milk products.
2. Discuss the nutritional significance of fresh milk.
3. Evaluate two fermented milk products.

2.3 Composition of Milk

2.3.1 Nutritional significance of milk

Milk provides only 3 percent of dietary energy supply in Asia and Africa compared with 8–9 percent in Europe and Oceania; 6–7 percent of dietary protein supply in Asia and Africa compared with 19 percent in Europe; and 6–8 percent of dietary fat supply in Asia and Africa, compared with 11–14 percent in Europe, Oceania and America.

Water is the main component in all milks, ranging from an average of 68 percent in reindeer milk to 91 percent in donkey milk. The main carbohydrate is lactose, which is involved in the intestinal absorption of calcium, magnesium and phosphorus, and the utilization of vitamin D. Lactose also provides a ready source of energy for the neonate, providing 30 percent of the energy in bovine milk, nearly 40 percent in human milk and 53–66 percent in equine milks. The proximate composition of milk is shown below.

Table 1: Proximate composition of cow and goat milk (per 100g)

	Cow	Goat
Energy (KJ)	262	270
Energy (kcal)	62	66
Water (g)	87.3	87.7
Protein (g)	3.3	3.4
Fat (g)	3.3	3.9
Lactose (g)	4.7	4.4
Ash (g)	0.7	0.8
Calcium (mg)	112	118
Iron (mg)	0.1	0.3
Magnesium (mg)	11	14

Phosphorus (mg)	91	100.4
Potassium (mg)	145	202

Self Assessment Exercise 1

1. Milk is an important source of one of these minerals
   a. phosphorus
   b. iron
   c. calcium
   d. sodium
2. milk consumption provides 6–7 percent of dietary protein supply in -------- region of the world/
   a. Oceanic
   b. Europe
   c. America
   d. Africa

2.4 Products from Unfermented Milk

2.4.1 Liquid and skim milk

Liquid Milk as Beverage

The most widely available milk for human consumption is in the liquid form. Raw milk is milk that is collected directly from the animals. Raw milk is normally heat treated to kill disease causing microorganisms and to prolong its shelf life. This heat treatment is called pasteurization. Pasteurization is a process of heat-treating every particle of milk to remove harmful organisms and allows the prolonged shelf life of milk.

Skim milk

Skim milk has as much fat removed as possible and has about half the calories of whole milk. It is the best choice for adults, and is the only type of milk that should be consumed by people on strict low-fat diets.

2.4.2 Cream and Butter

Cream

Cream is the fatty part of milk, and creams of different fat contents can be prepared by the separation of milk fat from the nonfat solids portion of milk. Cream is a richly fl avoured product, which makes it desirable for use in applications such as desserts, cakes, and some chocolate confectionery. The fat content of cream products varies from about 10–50%.

Butter

Butter is defined as a fatty product derived exclusively from milk. A 100 g portion of butter must contain a minimum of 80 g fat and a maximum of 16 g water and 2 g nonfat milk solids.

Self Assessment Exercise 2

3. Which of the following is not a non-fermented milk product
   a. *Nono*
   b. skim milk
   c. butter
   d. cream
4. A milk product whereby most of the fat has been removed is known as
   a. *Nono*
   b. skim milk
   c. butter

2.5 Fermented Milk Products

2.5.1. Yoghurt

Yoghurt

Yoghurt is a milk product fermented by Lactic Acid Bacteria. It represents the most popular milk product worldwide. Yoghurt is produced from preheated milk with the addition of materials such as flavourings or colourants that make it more attractive than other milk products to consumers. Nowadays, the health promoting properties of yoghurt are widely produced and well accepted by consumers. Yogurt is a good source of several micronutrients and may help to improve diet quality and maintain metabolic well-being as part of a healthy, energy-balanced dietary pattern. The micronutrient composition in yoghurt is more concentrated than in milk. Yoghurt consumption is significantly associated with lower levels of circulating triglycerides, glucose, and lower systolic blood pressure and insulin resistance.

2.5.2 Nono: Nigerian indigenous yoghurt

Nono is a spontaneously lactic acid fermented milk that originates from the northern parts of Nigeria. *Nono* is a fermented food drink derivatives gotten from cow milk. Traditionally, nono is prepared by inoculating freshly drawn cow milk with a little of the leftover as starter and then is allowed to ferment for twenty four hours at room temperature. During fermentation, some of the lactose is converted to the lactic acid. At the end of the fermentation period, the milk butter is removed by churning for further use and the remaining sour milk, *nono* is a delicious and refreshing beverage. Most of the organisms involved in the fermentation process are usually of three main groups; bacteria, yeast, and mould. Of these, *Lactobacilli*(*L. acidophilus and L.bulgaris*), *Lactococci species* (*L. cremoni, and L.lactis*), *Streptococcus thermophilus, Leuconostoc species and Saccharomyces species* seems to be the most prominent, each giving the product a characteristic flavour.

Nono has yoghurt-like taste (sharp acid taste), and is therefore usually taken with sugar, and fura which is made up of millet flour compressed in balls and cooked for about twenty to forty minutes.

2.5.3 Cheese

Cheese: Cheese making is an art of science and technology to convert raw materials with the action of selected microorganisms to produce cheese, a highly nutritious food. Milk is the raw material and main ingredient in cheese manufacturing.

The main step in cheese-making, the coagulation of the casein component, is achieved using one of the following methods, or a combination of these methods: a) limited proteolysis using enzymes; b) acidification by adding acids or a starter culture; and c) acidification combined with heating to about 90 °C. The majority of cheeses are produced by enzymatic (rennet) coagulation; rennet from the stomachs of young calves, kids, lambs and buffalo was traditionally used.

Wara

Wara is Nigerians indigenous cheese-type product. *Wara* is prepared by coagulating fresh cow milk with Sodom apple (*Calotropis procera*) leaf extract. *Wara* processing involves the use of rudimentary equipment, in many cases, starter cultures are not used and the processing conditions are not normally standardized. The manufacture of *wara* is widespread in Nigeria and a similar cheese called 'Wogachi' is made in the northern provinces of Benin republic, a French speaking country to the west of Nigeria. *Wara* is very rich in protein, containing about 20% protein.

Fig 1: *Wara*

2.5.3. Nutritional composition of some milk products

Table 1: Nutritional composition of some milk products

	Product							
Component (%)	WMP	SMP	Cheese	Butter	Casein	MPC	WP	BMP
Fat	26.50	1.00	35.00	84.00	0.00	0.00	1.00	8.30
Protein	25.10	33.00	24.50	0.59	89.00	90.50	15.15	41.72
Lactose	39.80	54.00	1.39	0.79	0.56	Trace	77.15	40.32
Minerals	5.90	8.00	2.15	0.12	0.80	Trace	4.32	4.66
Water	2.70	4.00	35.26	14.50	9.64	9.50	2.38	5.00

BMP, butter milk powder; MPC, milk protein concentrate; SMP, skim milk powder; WMP, whole milk powder; WP, whey powder.

Self Assessment Exercise 3

5. Nono is to yoghurt what wara is to -------------
6. During fermentation of milk ----------- acid is produced
   e. lactose acid
   f. lactate acid
   g. lactic acid
   h. malic acid

2.6 Summary

Milk and milk products like yoghurt and cheese provide significant amounts of important nutrients like protein to the body. Milk can be consumed fresh, or inform of skimmed milk or cream. Milk can be fermented to produce yoghurt or cheese. *Nono* and *wara* are examples of local yoghurt and cheese in Nigeria.

In this unit, you learnt about the foods that belong to the milk and milk product class. The foods include fresh milk, skimmed milk, cream. Milk can be fermented to produce yoghurt and cheese. *Nono* and *wara* are examples of fermented milk products in Nigeria.

Milk and milk products are good sources of high quality protein and calcium.

2.7 References/Further Reading

1. Early, R. (1998). *The Technology of Dairy Products*, 2nd Ed., Thomson Science.

2. Chandan, R.C. (2008). Dairy processing and quality assurance: An overview, in: Chandan, R.C., Kilara, A.& Shah, N.P., Eds., *Dairy Processing and Quality Assurance*, Wiley-Blackwell, pp 1–40.

2.8 Possible Answers to Self Assessment Exercises

Self Assessment Exercise 1

1. C- calcium
2. D- Africa

Self Assessment Exercise 2

1. **A- Nono**
2. B- Skim milk

Self Assessment Exercise 3

1. Cheese
2. C- Lactic acid

UNIT THREE: STRUCTUREAND COMPOSITION OF MEAT, FISH, EGG AND LEGUMES

3.1 Introduction

Meat is known as a source of complete protein because it contains all the essential amino acids. Essential amino acids are those amino acids that the human body cannot produce so they must be provided in adequate amounts from our diets.

Fish is an excellent source of protein due to its quality and quantity. They contain around 20 % of protein. The biological value of fish protein is 80. Fish is rich in lysine and methionine hence, it has supplementary value with cereals and pulses.

Egg protein is of such a high quality that its biological value has been taken as 100 and it acts as a standard for evaluating the biological value of other food proteins. All the essential amino acids required in human diet are present in egg proteins. The amount of proteins in legumes varies greatly depending on the species, and ranges between 20 and 35%.

In the last unit, you learnt the foods that belong to the milk and milk product groups. You also learnt the nutritional value of milk. You learnt that milk products can be derived either from unfermented milk or fermented milk. Products from unfermented milk include, skimmed mikl, cream and butter. Milk products from fermented milk are yoghurt and cheese.

In this unit, you will learn the structure of meat, fish and legumes. You will get to understand the nutritional importance of each.

3.2. Learning Outcomes

By the end of this unit, you will be able to:

1. Discuss the nutritional content of meat and fish

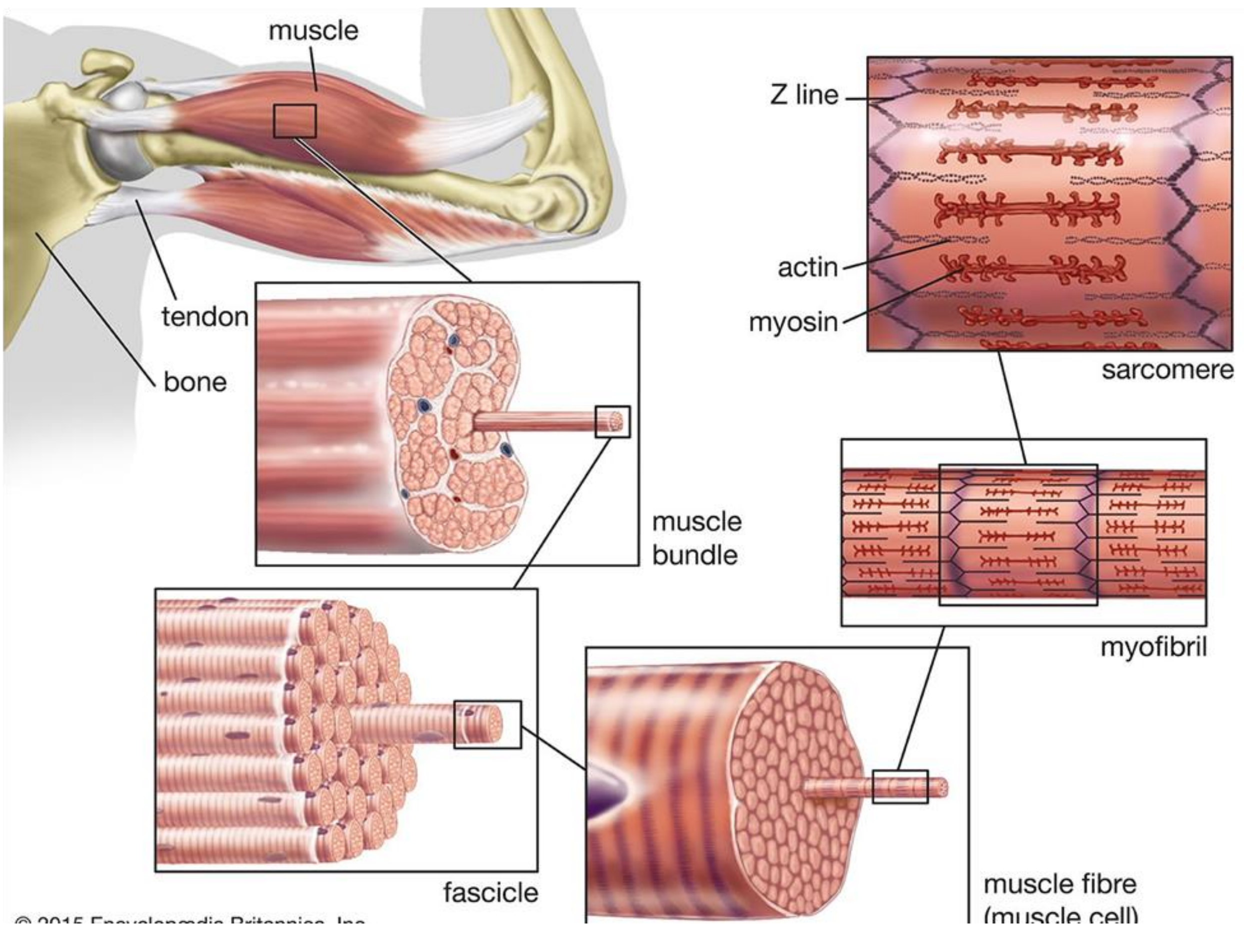
2. Explain nutritional composition of eggs

3. Discuss at least three reasons why legumes are very important food crop for the developing countries

3.3 Structure and Composition of Meat and Fish

3.3.1. Structure of meat

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



Structure of muscle meat

3.3.2 Nutritional composition of meat

The Table below shows the composition of meat. Most meat contains about 29% protein. The protein of meat is of good quality because it contains all the essential amino acids. Meat contains a fair amount of saturated fat which has been linked to some cardio-vascular diseases. Meat must be taken in moderation especially by adults.

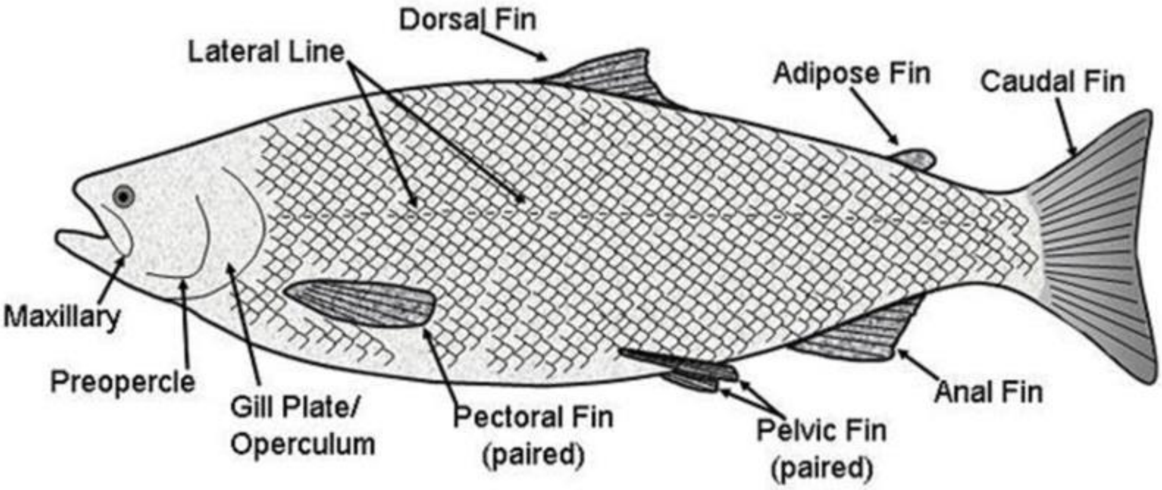
Muscle meat also contains important vitamins and minerals like vitamin B_{12}, zinc, phosphorus and iron.

Nutritional composition of meat

	Protein (g)	Saturated fat g)	Fat (g)	Energy (kcal)	Vit. B12 (mcg)	Na (mg)	Zn (mg)	P (mg)	Fe (mg
Chicken breast, raw	24.2	0.2	8.5	178	0.39	71	0.9	199	1.2
Chicken, raw	22.8	0.6	1.9	113	0.70	78	1.4	202	0.7
Beef, loin, raw	20.9	1.5	3.2	115	2	59	3.7	142	1.6
Pork, loin, raw	21.9	1.7	4.9	134	1.1	55	1.9	220	0.7
Duck meat, skinless, raw	19.4	1.8	6.6	130	2.8	90	1.8	201	2.5

3.3.3 Structure and Composition of Fish

The structure of a typical fish is shown below.



1.3.4 Composition of Fish

The composition of fish varies to a large extent and depends on its fat content. Nutritive value of various fish is given in Table.

Fish contains less amount of fat compared to meat and poultry. The lipid content of both fish and prawns is very low and varies within a very narrow range of 1-2.8 %. Crab contains nearly 10 % fat.

Moisture (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (mg)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Thiamin (mg)	Riboflavin (mg)

Cat fish	77.1	86	21.4	-	-	10	230	-	-	
Mackerel	77.3	93	18.9	1.7	0.5	429	305	4.5	-	-
Sardine	78.1	101	21.0	1.9	-	90	360	2.5	-	-
Prawn	77.4	89	19.1	1.0	0.8	323	278	5.3	0.01	0.10
Crab	65.3	169	11.2	9.8	9.1	1606	253	-	-	-

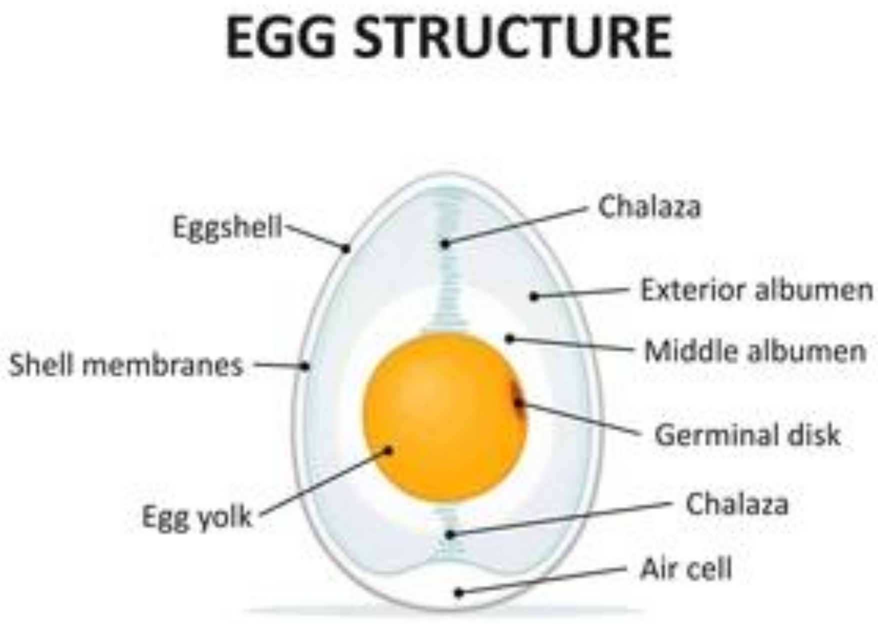
Self Assessment Exercise 1

1. which among these types of meat contains the highest protein
   a. Chicken
   b. beef
   c. pork
   d. Duck meat
2. Fish contains more fat than crab. True or false

3. 4 Structure and Composition of an Egg

3.4.1 Structure of an egg

There are four main components of hen's egg: a. Shell b. Shell membranes c. Albumen or white d. Yolk. The structure of a typical egg is shown below.



3.4.2 Nutritional composition of an egg

An egg contains about six grams of protein. All the essential amino acids required in human diet are present in egg proteins. An egg also provides five to six grams of easily digestible fat, wherein the proportion of much desired unsaturated fatty acids (especially oleic acid) is more as compared to most other livestock products

Egg yolk lipid is composed of mostly triglyceride (65%), good amount of phospholipid (8%) and controversial cholesterol (5%). Egg is an important source of fat soluble vitamins (A,D,E and K) and water soluble vitamins of B-complex group. However, it does not contain vitamin C. Egg is very good source of important minerals such as iron, phosphorus, potassium and trace elements which are necessary for the formation of blood, bone and soft- tissues.

Self Assessment Exercise 2

1. Another name for egg white is ---------
   a. albumen
   b. Shell
   c. Shell membranes
   d. Yolk
2. Answer true or false. All the essential amino acids required in human diet are present in egg proteins.

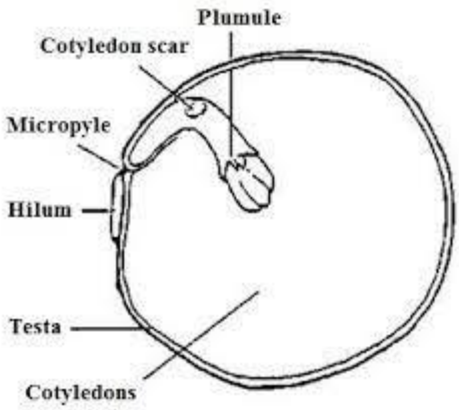
3.5 Structure and Composition of Legumes

3.5.1 Structure of a typical legume

Pulses or legumes all have a similar structure, but differ in color, shape, size, and thickness of the seed coat. Mature seeds have three major components: the seed coat, the cotyledons, and the embryo.

The seed coat or hull accounts for 7-15% of the whole seed mass. Cotyledons are about 85% of the seed mass, and the embryo constitutes the remaining 1-4%. The external structures of the seed are the testa (i.e., seed coat), hilum, micropyle, and raphe. The testa is the outer most part of the seed and covers almost all of the seed surface. The hilum is an oval scar on the seed coat where the seed was attached to the stalk. The micropyle is a small opening in the seed coat next to the hilum.

When the seed coat is removed from grain, the remaining part is the embryonic structure. The embryonic structure consists of two cotyledons (or seed leaves) and a short axis above and below them. The two cotyledons are not physically attached to each other except at the axis and a weak protection provided by the seed coat. Thus the seed is unusually vulnerable to breakage.



Structure of a legume

3.5.2 Nutritional Composition of Legumes

The chemical composition of the legumes varies between the different types of seeds. The amount of proteins in legumes varies greatly depending on the species, and ranges between 20 and 35%. The protein content is considered high compared with cereals and is rich in the amino acid lysine and sulfur amino acids such as methionine, both of which are limited in most plant foods. Examples of legumes include cowpea, pigeon pea, mung beans, soy beans, groundnuts, lentils etc.

Legumes are also rich in dietary fiber, and it is the soluble fiber fraction that is relevant (approximately 16–20%). This type of fiber plays a leading role because it facilitates water adsorption in the intestine. Thus, the intestinal bolus increases, facilitating intestinal movement and preventing constipation.

Legumes are also low in fat, with values from 1 to 4%, except for oilseeds that show mean values of 18% for soybeans and 50% for peanuts. The nutritive value of some legumes are shown in the Table below

Composition	Soybeans (*Glycine max* L. Merr)	Mungbeans (*Vigna radiata* L.)	Cowpeas (*Vigna unguiculata* L.)	Pigeon peas (*Cajanus cajan* L.)	Red kidney beans (*Phaseolus vulgaris* L.)	Jack beans (*Canavalia ensiformis* L.)
Enery (kcal)	335	345	339.1	336	336	389
Moisture (g)	8	10	10	9.6	12.0	–
Protein (g)	38.0	22.2	22.0	22.4	23.1	30.36
Fat (g)	18.0	1.2	1.4	1.7	1.7	2.9
Carbohydrate (g)	31.3	62.9	59.1	51.2	62.7	54
Fiber (g)[a]	3.8	4.4	4.5	5.5	–	–
Ash (g)[a]	5.1	3.3	3.3	3.7	4.2	–
Calsium (mg)	227	125	77	125	80	153
Phosphor (mg)	585	320	449	275	410	298
Iron (mg)	8	6.7	6.5	4	5.8	10.1
Vitamin A (SI)	110	157	30	150	30	–
Vitamin B_1 (mg)	1.07	0.6	0.92	0.48	0.64	8.5
Vitamin C (mg)	–	6	2	5	–	–
Folat (µg)[a]	250	490	545	343	310	–

Self Assessment Exercise 3

1. legumes are important in the diet of people in the developing countries because ------
2. legumes are lacking in this amino acid
   a. lysine
   b. tryptophan
   c. alanine
   d. methionine

3.6 Summary

The foods in this class are very good sources of proteins. They provide about 20% protein. The meat, fish and eggs are sources of good quality proteins that contain all the essential amino acids. Legumes contain proteins that may lack in one or more of the essential amino acids so their protein is inferior to that from animal sources.

In this unit, you learnt the structure and composition of meat, fish, egg and legumes. Most foods in this group contain about 20% protein or more. Meat, fish and eggs provide good quality proteins containing all the essential amino acids. Legumes on the other hands contain protein deficient in some essential amino acids.

Meat contain a fair amount of saturated fats which have negative effect on health. Eggs also contain some cholesterol which has been implicated in the risk for cardio-vascular diseases. Fish contains less fat than meat. Legumes contain little fat except for such legumes as soy beans and groundnuts.

3.7 References/Further Reading

1. Early, R. (1998). *The Technology of Dairy Products*, 2nd Ed., Thomson Science.

2. Chandan, R.C. (2008). Dairy processing and quality assurance: An overview, in: Chandan, R.C., Kilara, A.& Shah, N.P., Eds., *Dairy Processing and Quality Assurance*, Wiley-Blackwell, pp 1–40.

3.8 Possible answers to self assessment exercises

Self Assessment Exercise 1

1. A- Chicken
2. False

Self Assessment Exercise 2

1. A-Albumen
2. True

Self Assessment Exercise 3

1. Legumes are sources of low cost protein
2. D- Methionine

MODULE 11: STRUCTURE AND COMPOSITION OF CEREALS, TUBERS, FRUITS AND VEGETABLES

UNIT 1: STRUCTURE AND COMPOSITION OF CEREALS

1.9 Possible Answers to Self-Assessment Exercise(s)

1.1 Introduction

Eighty percent of dry matter of cereals is carbohydrates. The two forms of carbohydrates present are insoluble fibre (cellulose) and soluble carbohydrate. Cereals contain 6-12 percent protein, which are deficient in lysine. Among cereals, protein is of better quality than others. Fats are present to the extent of 1-2 percent in wheat and rice and 3 percent in maize. Most cereals are poor sources of calcium and iron. Whole grain cereals are important source of B vitamins in the diet. Important cereals in West Africa and Nigeria include the millet, sorghum, maize, rice. Wheat based products like bread are popular in West Africa but most of the wheat flour is imported.

In the last unit, you learnt the unit; you learnt the structure and composition of the meat, fish, poultry and legume food class. You were able to state the nutritional content of meat, fish, egg and legumes. It was noted that all of the members of this class had high protein content in common.

In this unit, we shall discuss another important food class: the cereals. You shall learn that the foods that belong to this class include maize, rice, sorghum e.t.c. You shall be able to draw the structure of the cereal grains, discuss their nutritional composition and explain their food applications.

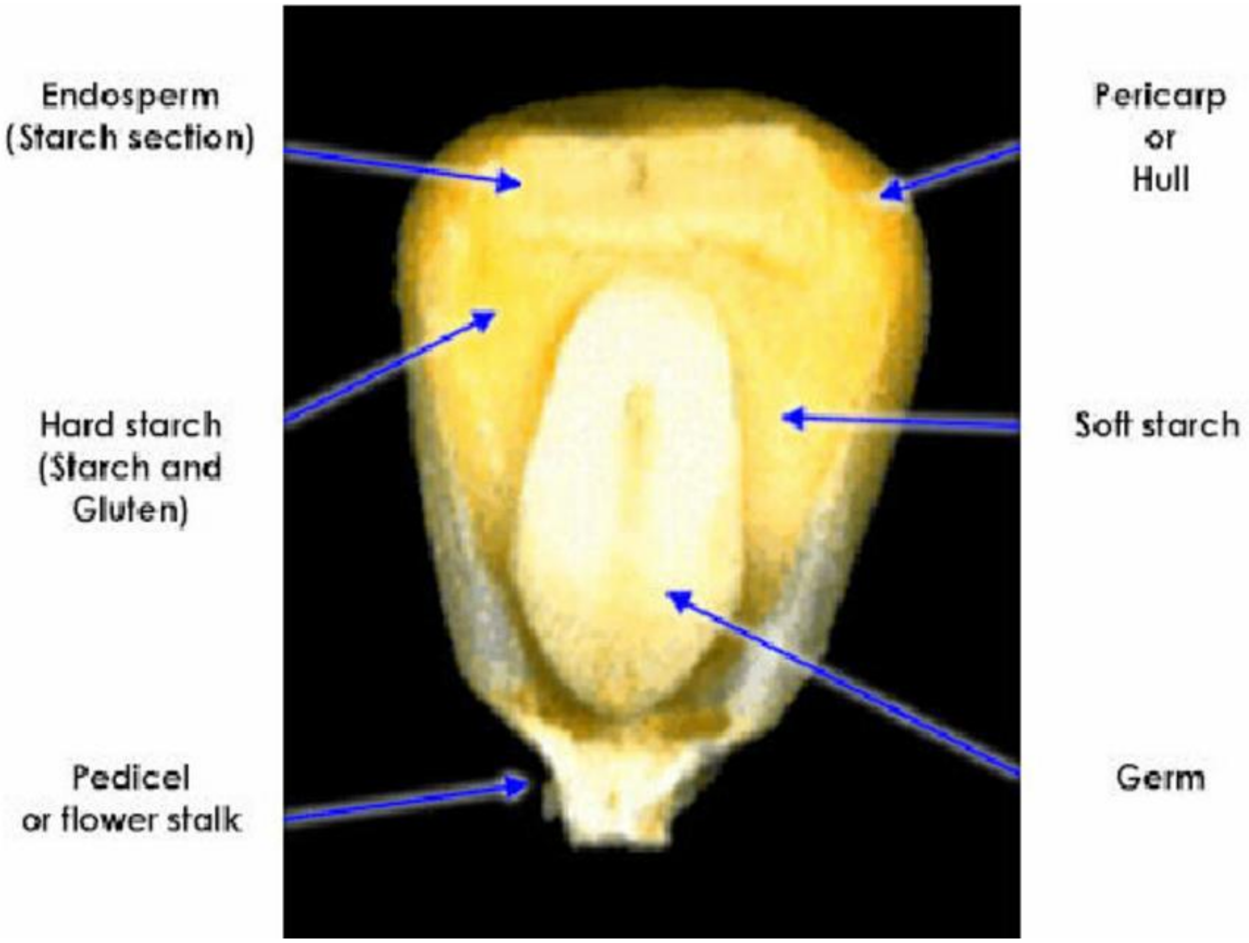
1.2 Learning Outcomes

- Discuss the structure of at least two cereal grains
    - Discuss the nutritional composition of two cereal grains
    - Evaluate for four food applications of cereals

1.3. Structure and Composition of Maize Grain

1. 3.1 Structure of Maize

The maize grain largely consists of endosperm that is rich in starch (71%). Both the embryo and endosperm contain proteins but the germ proteins are superior in quality as well as quantity.



Structure of a maize grain

1.3.2 Nutritional composition of maize

Maize is the most widely-grown staple food crop in sub-Saharan Africa (SSA) occupying more than 33 million ha each year. Maize kernel is an edible and nutritive part of the plant. The composition of maize kernel is presented in the Table below. It also contains vitamin C, vitamin E, vitamin K, vitamin B1 (thiamine), vitamin B2 (niacin), vitamin B3 (riboflavin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine. Potassium is a major nutrient present which has a good significance because an average human diet is deficient in it. Roasted maize kernels are also used as coffee substitute (Breadley, 1992). Maize germ contains about 45–50% of oil that is used in cooking, salads and is obtained from wet milling process.

Composition per 100 g of edible portion of maize is shown in the Table below

Composition per 100 g of edible portion of maize

Constituent	Amount
Carbohydrate	71.88 g
Protein	8.84g
Fat	4.57 g
Fiber	2.15 g
Ash	2.33 g
Moisture	10.23 g
Phosphorus	348 mg
Sodium	15.9 mg
Sulfur	114 mg
Riboflavin	0.10 mg
Calcium	10 mg

Iron	2.3 mg
Potassium	286 mg
Thiamine	0.42 mg
Vitamin C	0.12 mg
Magnesium	139 mg
Copper	0.14 mg

Self Assessment Exercise 1

1. The germ of maize contains more protein than the endosperm. True or False
2. Maize contains more than 10 % protein. True or False

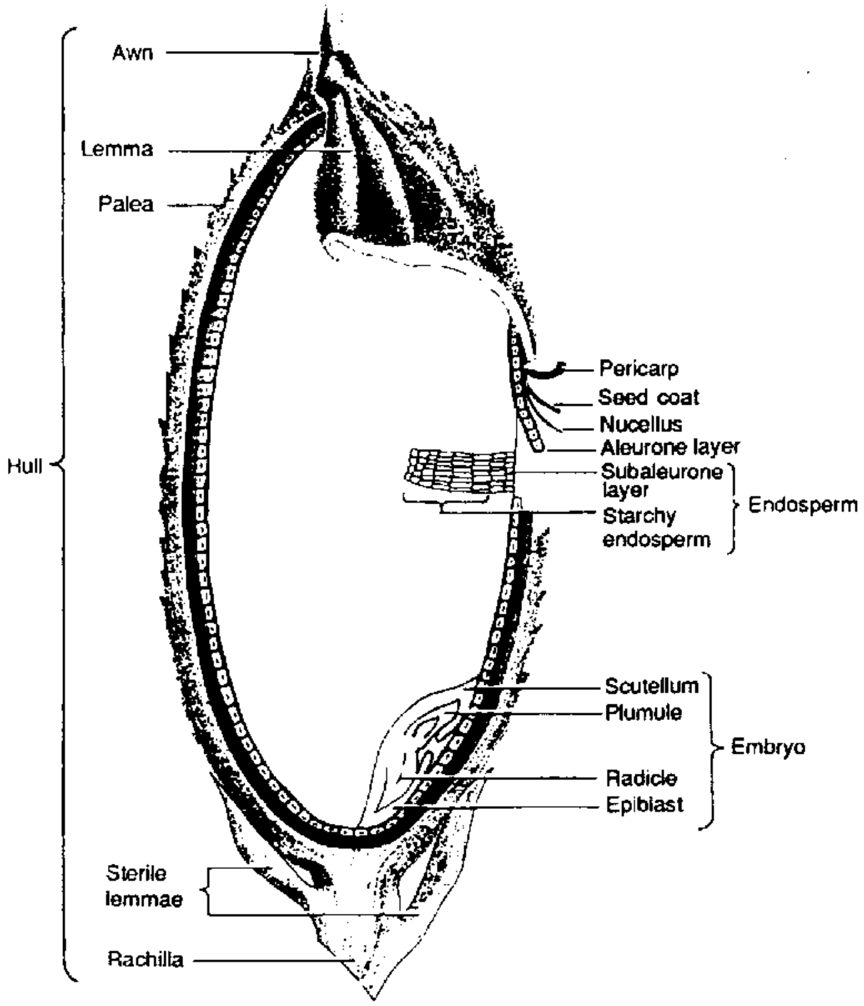
1.4 Structure and Composition of Rice

1.4.1 Structure of Rice Grain

The mature rice grain is harvested as a covered grain (rough rice or paddy), in which the caryopsis (brown rice) is enclosed by a tough siliceous hull (husk). The caryopsis is enveloped by the hull, composed of two “modified” leaves (lemmae): the palea (dorsal) and the larger lemma (ventral)

Inside the hull and covering the endosperm and embryo of the mature rice grain are three distinct layers of crushed cells that make up the caryopsis coat: the pericarp, seed coat (tegmen), and nucellus. The aleurone layer, the outermost layer of the endosperm, differs in both morphology and function from the starchy endosperm. The embryo (germ) is extremely small and located at the ventral side at the base of the grain. The starchy endosperm is divided into two regions: (1) The subaleurone layer, i.e., the two outermost cells located just beneath the aleurone layer; and (2) the central region consisting of the rest of the starchy endosperm.

Dehulling separates the hull (husk) from the brown rice or caryopsis. The ability of the palea and lemma to hook together without gaps differs among rice. Although a tight hull may provide storage protection to the grain, it may make such rice varieties more difficult to dehull. Abrasive milling removes the outer maternal tissues, producing milled or polished or white rice, and the by-products rice bran and polish. The bran contains more of the pericarp, seed coat, nucellus, aleurone layer, and germ than the polish, which contains relatively more starchy endosperm. The bran is darker than the polish. Usually 10% by weight of brown rice is removed during milling



Structure of a rice grain

1.4.2 Composition of rice grain

Brown rice contains slightly higher protein than milled or polished riche. This is because of the higher protein level in the bran. Crude fat, crude ash, crude fiber, and total dietary fiber are also higher in brown than milled rice, being concentrated in the bran fraction. Brown rice contains higher vitamins and minerals than milled or polished rice. The higher fat content of brown rice makes is more susceptible to rancidity which affects the taste and odour negatively. The Tables below show the nutritional composition of rice fractions.

Nutritional composition of different rice fractions

Rice fraction	Crude protein (g N x 5. 95)	Crude fat (g)	Crude fibre (g)	Crude ash (g)	Available carbohydrates (g)	Neutral detergent fibre (g)	Energy content		Density (g/ml)	Bulk density (g/ml)
							(kJ)	(hcal)		
Rough rice	5.8-7.7	1.5-2.3	7.2-10.4	2.9-5.2	64-73	16.4-19.2	1580	378	1.17-1.23	0.56-0.64
Brown rice	7.1-8.3	1.6-2.8	0.6-1.0	1.0-1.5	73-87	2.9-3.9	1520-1 610	363-385	1.31	0.68
Milled rice	6.3-7.1	0.3-0.5	0.2-0.5	0.3-0.8	77-89	0.7-2.3	1460-1 560	349-373	1.44-1.46	0.78-0.85
Rice bran	11.3-14.9	15.0-19.7	7.0-11.4	6.6-9.9	34-62	24-29	670-1 990	399-476	1.16-1.29	0.20-0.40
Rice hull	2.0-2.8	0.3-0.8	34.5-45.9	13.2-21.0	22-34	66-74	1110-1 390	265-332	0.67-0.74	0.10-0.16

The table below shows the vitamin and mineral content of different rice fractions. One could observe that brown rice is higher than milled rice in most of the vitamins and minerals. This is because most of these nutrients are concentrated in the bran which is removed during milling.

Vitamin and mineral content of rough rice and its milling fractions at 14 percent moisture

Rice fraction	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	α - Tocopherol (mg)	Calcium (mg)	Phosphorus (g)	Phytin P (g)	Iron (mg)	Zinc (mg)
Rough rice	0.26-0.33	0.06-0.11	2.9-5.6	0.90-2.00	10-80	0.17-0.39	0.18-0.21	1.4-6.0	1.7-3.1
Brown rice	0.29-0.61	0.04-0.14	3.5-5.3	0.90-2.50	10-50	0.17-0.43	0.13-0.27	0.2-5.2	0.6-2.8
Milled rice	0.02-0.11	0.02-0.06	1.3-2.4	0.25-0.30	10-30	0.08-0.15	0.02-0.07	0.2-2.8	0.6-2.3
Rice bran	1.20-2.40	0.18-0.43	26.7-49.9	2.60-13.3	30-120	1.1-2.5	0.9-2.2	8.6-43.0	4.3-25.8

Rice hull	0.09-0.21	0.05-0.07	1.6-4.2	0	60-130	0.03-0.07	0	3.9-9.5	0.9-4.0

Assessment Exercise 2

1. Dehulling separates the hull from the ----------

a. brown rice or caryopsis

b. endosperm

c. husk

d. protein layer

2. Brown rice contains more of the following than polished rice except

   a. vitamin

   b. minerals

   c. carbohydrates

   d. protein

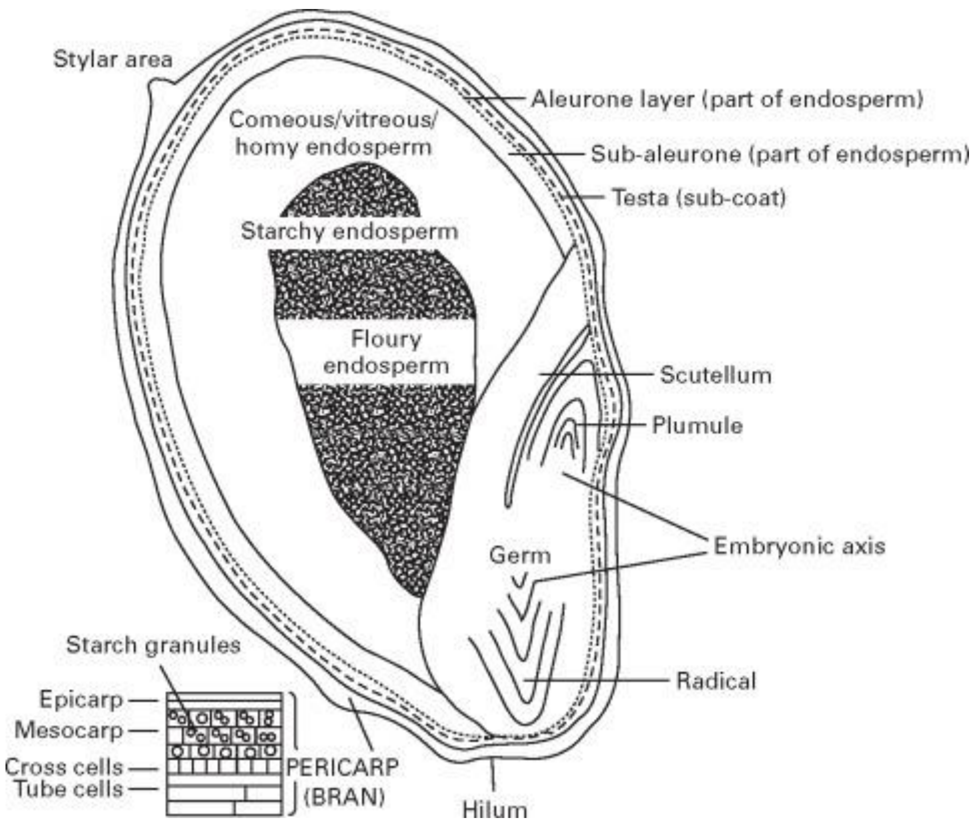
1.5 Structure and Composition of Sorghum

1.5.1 Structure of sorghum

Sorghum [*Sorghum bicolour* (L.) Moench] is an indigenous crop to Africa, and remain a basic staple food for many rural communities

Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley and it serves as the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America.

The figure below shows the structure of a sorghum grain. Sorghum like any other cereal grain has an endosperm which is comprises majorly of starch.



Structure of a sorghum grain

1.5.2 Nutritional composition of sorghum

The composition of sorghum grain and its parts is generally similar to that of corn, except for lower oil content. The grain contains 8 to 12% protein, 65 to 76% starch with approximately 2% fibre. The germ, a rich source of oil (28% of the germ) also has high levels of protein (19%) and ash (10%). Sorghum grain is known for its hardness compared to other food grains. The hardness of the grain is due to higher content of protein prolamin (3.6 to 5.1%). The lysine content ranges from 1.06 to 3.64%.

Nutritional composition of sorghum grain

Parameters	Grain colour		
	Brown/Red	White	Pale yellow
Thousand grain weight, grams	36,94	29,39	25,17
Protein %	9,95	9,42	10,06
Starch %	60,93	63,40	63,32
Fat %	3,32	2,82	3,35
Tannin %	0,35	0,16	0,23
Ash %	1,44	1,40	1,22
Fibre %	1,83	1,97	1,62
Calcium, mg/kg	113,59	95,67	77,27
Iron, mg/kg	51,78	47,55	43,03
Zinc, mg/kg	26,21	22,25	22,67

Self Assessment Exercise 3

1. The endosperm of sorghum is majorly made up of ------------

2. Sorghum is a good source of -------------------------

1.6 Food Applications of Cereals

1.6.1 Main meals

- **Tuwo:** Tuwo is a local delicacy of the Northern part of Nigeria; it is made from almost all types of cereals which include wheat, millet, fonio, rice, maize and sorghum as the case may be and the choice of the producer. Tuwo is a solid food which is made in forms of balls or swallow and eaten with sauce.
- **Sorghum Ball Production "Fura":** *Fura* is a staple food for the Fulanis and Hausas. The single most important cereal grain for fura production is sorghum or its twin grain millet. In tropical Africa, cereal grains are milled and used to produce thick porridges which are known by various names in different parts of

the continent. In West Africa particularly in Nigeria, Ghana and Burkina Faso, one such thick porridge is called ‘fura’

- **Gruel Production:** Maize and Sorghum have been used for gruel production or as breakfast meals which are in turn produced into pap, “ogi”, “akamu” etc and are taken with any other desired snacks for adequate nourishment.

1.6.2 Local beverages

- **Burukutu beer**: *Burukutu* is a traditional cereal-based fermented beverage.
- **Local beverages:** The local beverage is known as Techoukoutou in Benin or Togo, Dolo in Burkina-Faso, Pito in Ghana, Burukutu or Otika in Nigeria, Bilibili in Tchad, Mtama in Tanzania, Kigage in Rwanda. The manufacturing processes are very variable and dependent on the geographical location.
- **Kunu** or Kunun-zaki is a nonalcoholic, non-carbonated and refreshing cereal beverage popular in Northern Nigeria and is becoming widely consumed in the South. It serves as breakfast drink, appetizer and weaning food. *Kunu*, is a nutritious non-alcoholic drink that is produced from various cereal grains such as millet, sorghum, maize and rice.

Self Assessment Exercise 4

1. Which of these is not a local food made from cereals
   a. kunu
   b. okpa
   c. fura
   d. tuwo
2. one of the following sentences is not true about *kunu*
   a. It is an alcoholic beverage
   b. it is a non alcoholic beverage
   c. it is made from cereals
   d. it could be part of weaning food

1.7 Summary

The cereals are a very important food group for the developing countries. The provide cheap sources of protein and other nutrients and they are well adapted for the tropical climate.

The major nutrient of the cereals is carbohydrates. In most homes in West Africa the cereals are consumed with legumes to provide better protein balance. For example the combination of rice and beans is very popular in Nigeria, also maize is cooked with beans, cereal based pap is commonly consumed with *akara* balls.

In this unit, your learnt the structure and composition of foods in the cereal class. The cereal class include maize, rice, sorghum, millet. You learnt their structures and their nutritional compositions.

It was highlighted in this unit that the cereal provides mostly carbohydrates in form of starch and a fair amount of protein. Rice loses some of its nutrients like protein and vitamins during milling as the bran layer which is removed during milled contains most of the protein and vitamins. Food application of cereals include for the production of local foods and beverages like kunu, burukutu, fura among others.

1.8 References/Further Reading

1. Owens, G. (2001). *Cereals Processing Technology*, 1st Edition. Woodhead Publishing in Food Science and Technology

2. Wang, J., Sun, B., & Tsao, R (2019). *Bioactive Factors and Processing Technology for Cereal Foods***.** Springer, Singapore

1.8 Possible answers to self assessment exercises

Self Assessment Exercise 1

1. True
2. False

Self Assessment Exercise 2

1. A-brown rice or caryopsis
2. C- Carbohdrates

3. **Self Assessment Exercise 3**

1. Carbohydrates

2. Carbohydrates

Self Assessment Exercise 4

1. B - Okpa
2. A- It is an alcoholic beverage

UNIT 2: STRUCTURE AND COMPOSITION OF ROOTS AND TUBERS

2.1 Introduction

Root and tuber crops, including yam, cassava, potato and sweet potato are the most important food crops for direct human consumption in Africa. They are grown in varied agro-ecologies and production systems ranging from highland densely populated regions to lowland drier areas prone to droughts or floods. These four crops account for about 95% of the total root and tuber crops production in Africa and produce more than 240 million tons annually on 23 million hectares. Roots and tuber like the cereals contain high carbohydrate content but unlike the cereals they contain higher moisture content.

In the last unit, you learnt the structure and composition of the cereal food group. Your were able to state their nutritional and you noted that all of them had high carbohydrate and moderate protein content in common.

In this unit, we shall discuss another important food class: the roots and tubers. You shall learn that the foods that belong to this class include yam, cassava, potatoes etc. You shall be able to draw the structure of the different root and tuber crop, discuss their nutritional composition and explain their food applications.

2.0 Learning Outcomes

By the end of this unit, your will be able to:

1. Discuss at least three characteristic of food crops in the roots and tuber class

2. Evaluate the nutritional composition of two tuber crops.
3. Discuss three food applications of roots and tubers.

2.3 Structure and Composition of Cassava Tubers

2.3.1 Structure of cassava

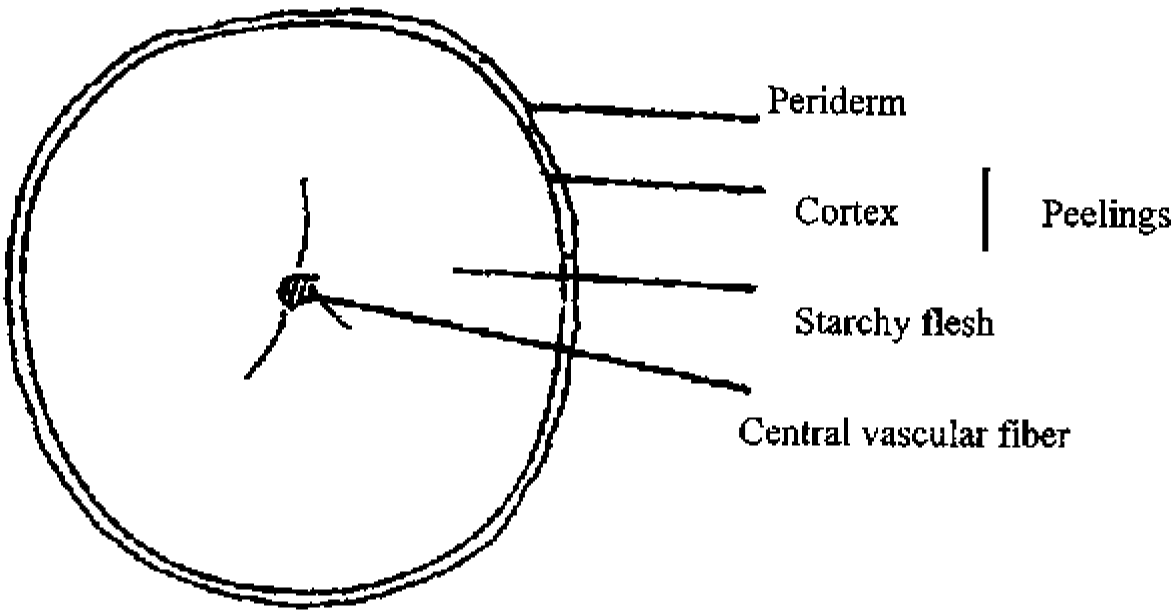
Cassava is one of the world's most important food crops, with annual global production at approximately 276 million metric tons (MT) in 2013. The top producing countries globally in 2013 were: Nigeria (accounting for ~19% of the total), Thailand (~11%), Indonesia (~9%), Brazil (~8%) and Democratic Republic of Congo (~6%).

The root crop is a source of livelihood for at least 300 million people. Virtually all cassava (90%) produced in Africa is used as a staple food for human consumption, providing calories for ~500 million people and constituting ~37% of the population's dietary energy requirements.

The edible portion of cassava is a starchy root, which matures to harvest within 8 to 24 months of planting, depending on cultivar and climate. A mature cassava root may be anything from 15 to 100 cm in length and from 0.5 to 2.0 kg in weight, subject to variety and growing conditions. The root is circular in cross-section . It is generally fattest at the proximal end and tapers gently towards the distal end. Transversely a cassava root consists of three principal areas.

- **The periderm**. Comprises the outermost layer of the root. It is composed mostly of dead cork cells, which seal the surface of the root. The periderm is only a few layers of cells thick and as the root continues to increase in diameter, the outermost portions of it are sloughed off and replaced by new cork formations from the inside layers of the periderm.

- **The cortex**. A layer 1 to 2 mm thick located immediately beneath the periderm.
- **The starchy flesh**. The central portion of the root, consisting mainly of parenchyma cells packed with starch grains.



Structure of cassava tuber

2.3.2 Composition and Uses of Cassava

Cassava contains about 1% protein and some 30-35% of amyloses and amylopectins on a dry weight basis; it is thus a predominantly starchy food. As a human food it has been criticized for its low and poor quality protein content, but the plant produces more weight of carbohydrate per unit area than other staple food crop under comparable agro-climatic conditions. The edible starchy flesh comprises some 80% to 90% of the root and includes:

Table 1: Nutritional composition of cassava tuber

water	62%	fibre	1-2%

carbohydrate	35%	minerals	1%
protein	1-2%	fat	3%

Cassava roots and leaves contain cyanides in two different forms: i) the glycosides; linamarin and lotaustraline which are considered "bound" and ii) the non-glycosides; hydrogen cyanide (HCN) and cyanohydride which are considered "free". Free cyanide comprises 8%-12% of the total tuber cyanide. This cyanide can, under some circumstances, lead to human toxicity problems and cassava for food use has to be processed to remove cyanide-containing substances

2.3.3.Uses of Cassava

The figure below illustrates some of the food applications of cassava tubers

Cassava tubers can also be used for the production of

- Bio ethanol
- Cassava starch is used as binders and thickeners in food and pharmaceutical industries
- Glucose syrup
- High quality cassava flour is used as composite flour in the bakery industry

Self Assessment Exercise 1

1 Inadequately processed cassava tubers may contain a toxic principle called ------

2 Write two industrial uses of cassava tubers

2.4 Types, Structure and Composition of Yams

2.4.1. Types of Yams

It has been estimated that 96% of the world production of yam comes from West Africa, the main producers being; Nigeria with 71% of world production; Côte d'Ivoire 8.1%; Benin 4.3% and Ghana 3.5%.

In the humid tropical countries of West Africa yams are one of the most highly regarded food products and are closely integrated into the social, cultural, economic and religious aspects of life. The ritual, ceremony and superstition often surrounding yam cultivation and utilisation in West Africa is a strong indication of the antiquity of use of this crop.

There are many varieties of yam species widespread throughout the humid tropics but the edible yams are derived mainly from about ten. The most economically important species are:

- **White yam (***Dioscorea rotundata* **Poir)**. Originated in Africa and is the most widely grown and preferred yam species. The tuber is roughly cylindrical in shape, the skin is smooth and brown and the flesh usually white and firm. A large number of white yam cultivars exist with differences in their production and post-harvest characteristics.

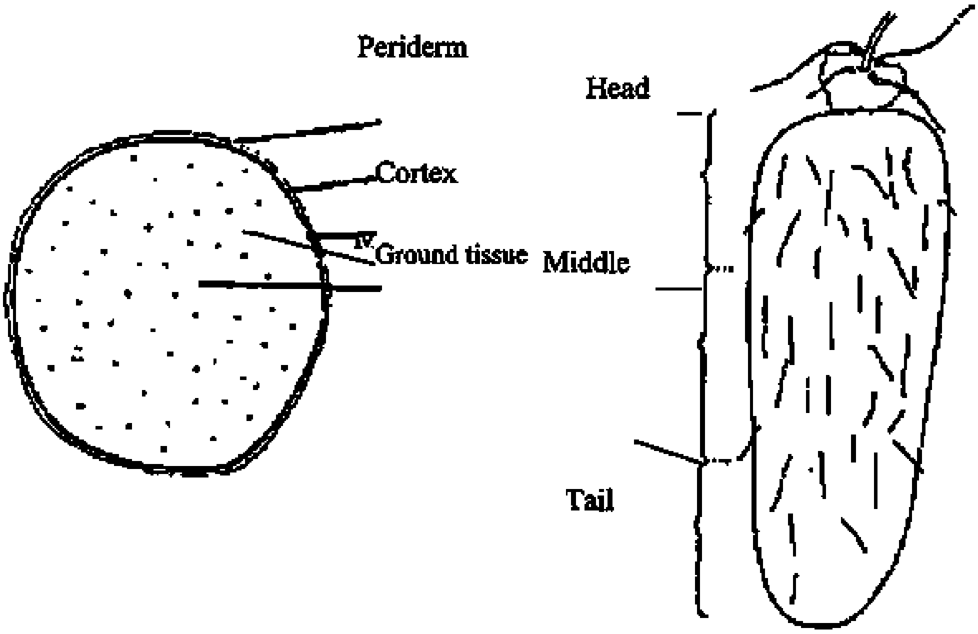
- **Yellow yam (*Dioscorea cayenensis* Lam.)**. Derives its common name from its yellow flesh, which is caused by the presence of carotenoids. It is also native to West Africa and very similar to the white yam in appearance. Apart from some morphological differences (the tuber skin is firm and less extensively grooved), the yellow yam has a longer period of vegetation and a shorter dormancy than white yam.
- **Water yam (*Dioscorea alata* L.)** Originates from South East Asia, it is the species most widely spread throughout the world and in Africa is second only to white yam in popularity. The tuber shape is generally cylindrical, but can be extremely variable. Tuber flesh is white and "watery" in texture.
- **Bitter yam (*Dioscorea dumetorum*)**. Also called trifoliate yam because of its leaves. Originates in Africa where wild cultivars also exist. One marked characteristic of the bitter yam is the bitter flavour of its tubers. Another undesired characteristic is that the flesh hardens if not cooked soon after harvest. Some wild cultivars are highly poisonous.
- Structure of yam

2.4.2 Structure of yam tuber

A transverse section of a mature yam tuber shows it to be composed of four concentric layers:

- **Corky periderm**. The outer portion of the yam tuber; it is a thick layer of cork cells, often cracked, but which provides an effective barrier against water loss and invasion by pathogens.

- ·**Cortex**. A layer located immediately beneath the cork, comprising thin-walled cells with very little stored starch.
- **Meristematic layer**. Elongated thin-walled cells under the cortex. Sprouts are initiated from this layer.
- **Ground tissue**. The central portion of the tuber, composed of thick-walled starchy cells, with vascular bundles ramifying throughout the mass.



Structure of a yam tuber

2.4.3 Nutritional Composition of Yam

Like cassava, yam tuber is mainly made up of water and carbohydrates. Yam is poor in protein and other nutrients. The table below shows the nutritional composition of yam.

Nutritional composition of yam

Variety	Moisture content	Carbohydrate	Fats	Crude Protein
D. alata	65 – 73	22 – 29	0.1 - 0.3	1.1 -2.8

D. rotunda **D**. cayenensis	58 – 80	15 – 23	0.1 - 0.2	1.1 -2.0
D. esculenta	67 – 81	17 – 25	0.1 - 0.3	1.3 - 1.9
D. bulbifera	63 – 67	27 – 33	0.1	1.1 - 1.5

2.4.4 Uses of Yam

- Yam tubers are eaten directly after peeling after boiling, frying or roasting accompanied with palm oil or sauce. Boiled yam can be pounded into yam fufu which when accompanied with local soup is relished in different parts of Nigeria.
- Yam flour is reconstituted in boiling water, to form a stiff dough which is dark in colour. This is called *amala* among the Yorubas of Nigeria.
- Instant yam flour this is precooked yam cubes that are rapidly reconsistuted in boiling water to form dough resembling the traditional pounded yam.

Self Assessment Exercise 2

1. The botanical name for water yam is ----------

   a *Dioscorea alata*

   b. *Dioscorea dumetorum*

   c. *Dioscorea cayenensis*

   d. *Dioscorea rotundata*

2. State two food uses of yam

2.5 COMPSOTION OF SWEET POTATO

2.5.1 Types of sweet potato

Sweet potato is a crop with a significantly unrealised potential. It is capable of producing high yields of dry matter per unit area of land and labour and this potential can be achieved under a wide range of agro-climates and farming systems.

There are many cultivars of sweet potato each with its own characteristics of size, shape, colour, storage life, levels of nutrition and suitability for processing. A single plant may produce 40 to 50 tubers ranging in length from a few to 30cm; they may be spindle-shaped or spherical and weigh from 100g to 1 kg. Tubers may have a smooth or irregular surface and the skin and the flesh may range from almost pure white through cream, yellow, orange and pink, to a very deep purple.

Picture of sweet potato tubers

2.5.2 Nutritional Composition of Sweet Potato

Like other tubers, sweet potatoes are mainly made of water and carbohydrates as shown in the Table below.

Nutritional composition of Sweet Potato (*Ipomea batatas* L.)

Constituent	Percent or (mg/100g)
Moisture	50 – 81
Protein	1.0 - 2.4
Fat	1.8 - 6.4
Starch	8.0 – 29
Non-starch Carbohydrates	0.5 - 7.5
Reducing Sugar	0.5 - 7.5
Ash	0.9 - 1.4
Carotene (average)	4 mg /100 g
Thiamine	0.10 mg /100 g
Ascorbic Acid	25g /100 g
Riboflavin	0.06 mg /100 g

Uses of sweet potatoes

Sweet potatoes tubers can be fried, boiled or roasted and eaten with sauces.

Self Assessment Exercise 3

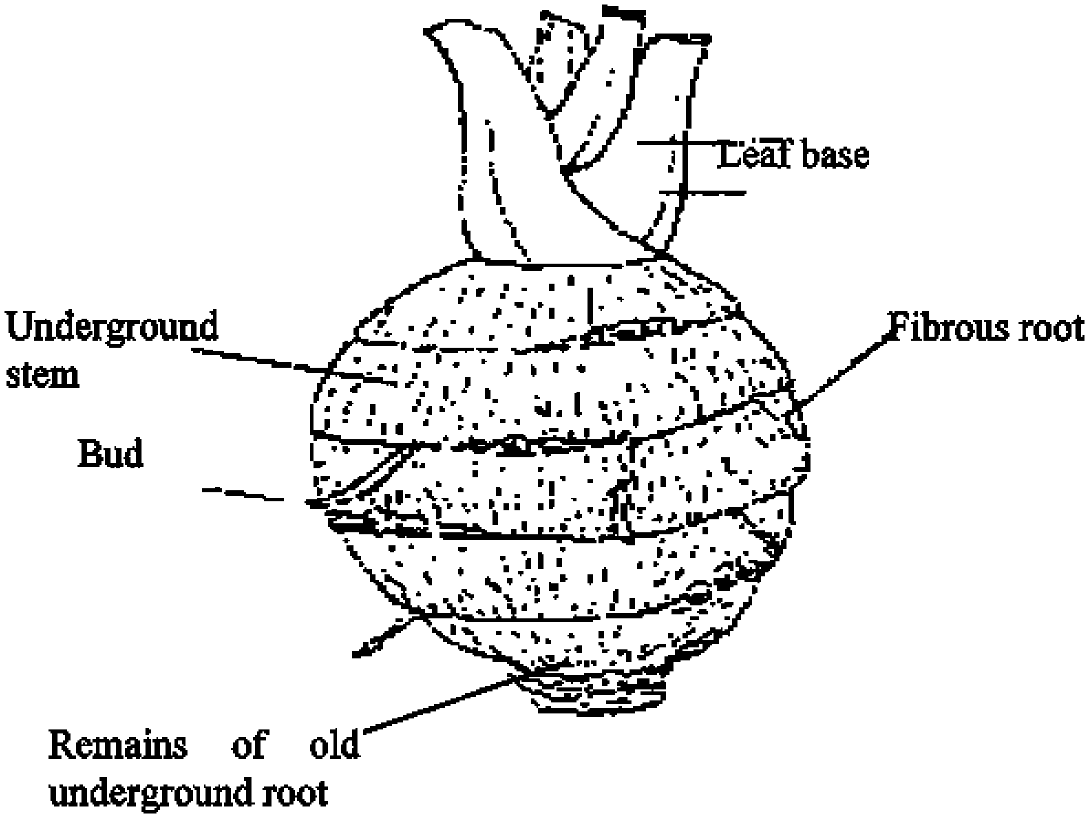
1. Sweet potatoes have low protein content. True or false
2. Write two uses of sweet potatoes

.

2.6 Structure And Composition Of Edible Aroids

2.6.1 Types and structure of edible aroids

Colocasia esculenta (commonly known as **taro**) and *Xanthosoma sagittifolium* (**Tania**) are the most important of the edible aroids.



Structure of C. esculenta

2.6.2 Nutritional Composition of Cocoyam

The nutritional composition of Taro and Tania (% wb)

Constituent	Taro	Tania
Moisture	63 - 85	70 - 77
Carbohydrates	13 - 29	17 - 26
Protein	1.2 - 3.0	1.3 - 3.7
Fat	0.16 - 1.18	0.2- 0.4
Crude fibre	6.60 - 1.18	0.6 - 1.9
Ash	0.60 -1.3	0.6 -1 .3

2.6.3 Food Uses of Cocoyam

Thus, most traditional cooking methods employ heat by boiling, baking, roasting, or frying, either alone or in combination with other ingredients to obtain delicacies.

In the south eastern part of Nigeria, cocoyam are prepare into dried chips known as *achicha*. *Achicha* is made after boiling cocoyam corms overnight, peeling and cutting them into cubes, sun drying and finally smoking over a fire place in the kitchen. Due to extensive sun drying and smoking *achicha* chips have a very long shelf life and are normally consumed during the planting season when other tubers are scarce. It is normally eaten mixed with cooked beans or pigeon pea.

Self Assessment Exercise 4

3. All the tubers have high ---------- content
   1. protein
   2. carbohydrates
   3. fats
   4. mineral
4. The two common species of cocoyam are --------- and -----------

2.7 Summary

Roots and tuber are very important components of the diets of many people in west Africa. In fact, there is hardly a day in most parts of West Africa that this class is not incorporated into the diet. In the southern part of Nigeria for example, many people claim that do without eating cassava or yam fufu in a day. Roots and tubers have the challenge of high moisture content which makes them very perishable especially the cassava tubers. Local technologies like sun drying and fermentation has been developed as a means of prolonging their shelf lives

In this unit, your learnt about the roots and tubers food class. They are characterized by high moisture, high carbohydrate and low protein contents. Example of roots and tubers grown in West Africa are cassava, yam, potatoes etc.

You learnt their structures and nutritional composition and also their food application. Cassava for example is fermented into fermented cassava that is cooked and pounded into fufu or fermented and fried to produce garri. High quality cassava flour is incorporated into wheat flour for bread baking.

2.8 References/Further Readings

1. Sharma, H.K., Njintang, N.Y., Rekha S. Singhal,R.S. & Kaushal, P (2016). Tropical Roots and Tubers: Production, Processing and Technology. John Wiley & Sons, Ltd

2. Bradshaw, J. (2010). Root and Tuber Crops. Springer Science & Business Media

2.9 Possible Answers to Self-Assessment Exercises

Self Assessment Exercise 1

1. Cyanide
2. high qulity cassava flour, sugar syrup, bioethanol

Self Assessment Exercise 2

1. A - *Dioscorea alata*
2. instant yam flour, amala, can be boiled, roasted or fried

Self Assessment Exercise 3

1. True
2. potato flour, can be boiled, roasted or fried and eaten

Self Assessment Exercise 4

1. carbohydrates

2. Tania and taro

UNIT 3: STRUCTURE AND COMPOSITION OF FRUITS AND VEGETABLES

3.6 Sumamry

3.7 Glossary

3.8 References/Further Reading(S)

3.9 Possible Answers to Self Assessment Exercises

3.1 Introduction

Fruits and vegetables provide people with a range of compounds, many of which have more than one role, being involved both with immediate good health and with protection against disease that can develop over a long period of time, such as cancer, heart conditions, stroke, hypertention, birth defects, cataracts and diabetes. Fruits and vegetables are generally acceptable as good sources of nutrient and supplement for food in a world faced with scarcity .They are known to be excellent source of nutrients such as minerals and vitamins

West Africa is blessed with a wide array of fruits which include pineapple, bananas, paw paw, mango, cashew, oranges, lemon, African bush mango and vegetables which include

In the last unit, you learnt the unit, you learnt that the foods that belong to this class include yam, cassava, potatoes etc. In this unit, we shall discuss another important food class: the fruits and vegetables. You shall learn that the foods that belong to this class include oranges, guava, tomatoes, green leafy vegetables etc.

3.3 **Learning Outcomes**

By the end of this unit, your will be able to:

1. Discuss at least three characteristic of food crops in the fruits and vegetable class
2. Evaluate the nutritional composition of two fruits and two vegetables.
3. Discuss three food applications of fruits and vegetables

3.3 Structure of Typical Fruits

3.3.1 Structure of mango fruit

As noted earlier West Africa is blessed with a wide range of fruits like mango, paw paw, pineapple, oranges etc. for the purpose of the structure of fruits we are going discuss pineapple and mango.

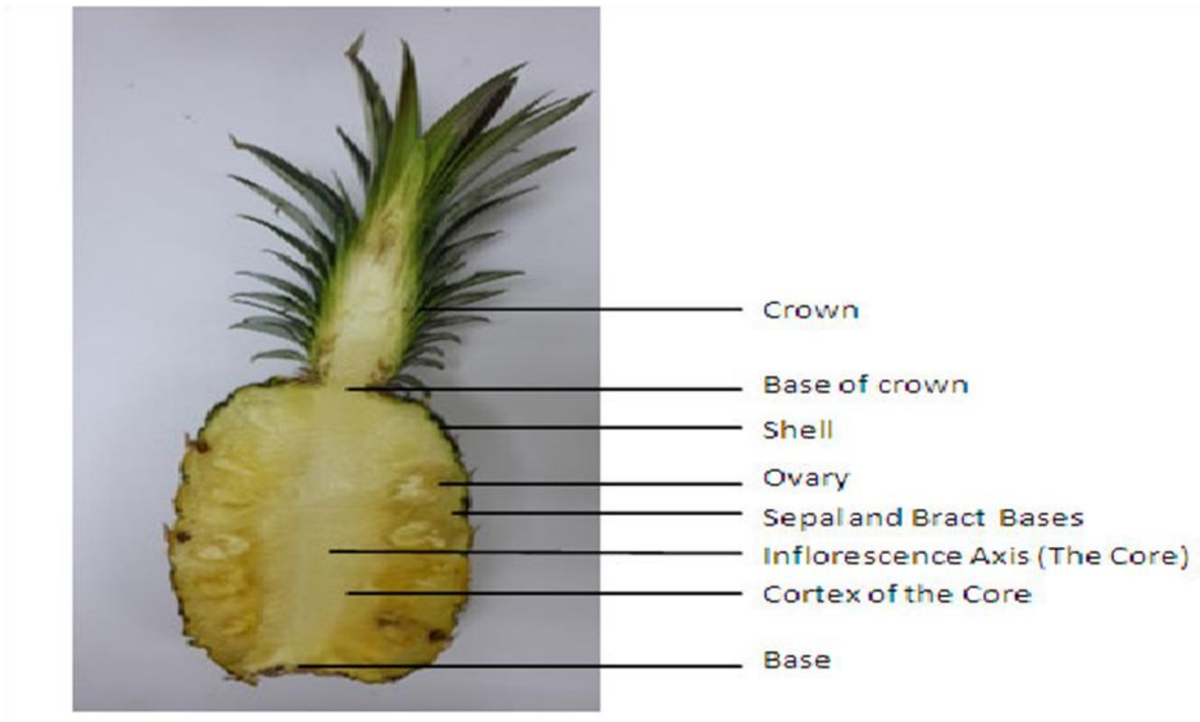
The mango fruit is roughly oval in shape, with uneven sides. The fruit is a drupe, with an outer flesh surrounding a stone. The flesh is soft and bright yellow-orange in color. The skin of the fruit is yellow-green to red.

In mango, the pericarp is well differentiated into an outer thin epicarp, a middle fleshy edible mesocarp and an inner endocarp which is stony and hard.

structure of the mango fruit

3.3.2 Structure of pineapple

Pineapple is the third most commercial important tropical fruit. The pineapple fruit is a compound fruit that develops through the fusion of many individual fruitlets. These small fleshy fruitlets are fused together around the fibrous central stem referred to as the core. Each fruitlet develops from a hermaphrodite flower, which is self-sterile although it has both male and female parts. Pineapple (*Ananas comosus* L., Family-Bromeliaceae) is an important tropical fruit that is consumed in many parts of the world as fresh and processed product. In recent years, it has become one of the most demanded exotic fruits.



Structure of a pineapple fruit

3.3.3 Nutritional composition of fruits

Fruits are found to be rich in vitamins, especially vitamin C, minerals. The main sugars in fruits are glucose and fructose and sucrose. Some fruit are low in carbohydrate and consequently low in calorie. However, higher values for carbohydrate have been reported in various fruits like bananas. The protein constituents of fruits are low. The moisture content of fresh fruits at maturity is generally high. Moisture content of fruits determines how fresh the fruits were at harvest, or for how long they have been stored before analysis.

Fruits and vegetables as sources of dietary fibre normalizes blood glucose levels. Fibre slows the rate at which food leaves the stomach and by delaying the absorption of glucose following a meal. Fibres also increase insulin sensitivity. As a result, high intake of fiber plays a role in the prevention and treatment of type 2 diabetes. Main contribution of fruits and their products to nutrition is their supply of vitamins most, especially the ascorbic acid (vitamin C). While Guava is among the richest sources of vitamin C, bananas are rich in potassium.

Nutritional composition of some tropical fruits (100g)

	Guava	Pineapple	Mango	Oranges	Avocado
Moisture	86.10	86.50	81.71	86.75	74.27
Energy (Kcal)	51	49	65	47	161
Protein	0.82	0.39	0.51	.94	1.98
Fat	0,60	12.39	0.27	0.12	15.32
Carbohydrates	11.88	1.20	17.00	11.75	7.39
Fibre	5.4	1.20	1.8	2.4	5.0
Ash	0.60	0.29	0.5	0.44	1.04
Vit C (mg)	183.5	15.4	27.7	53.2	7.9
Vit A (Mcg	792	23	389	205	612

RE)					
Potassium (mg)	284	113	156	181	599
Magnesium (mg)	10	14	9	10	39
Calcium (mg)	20	7	10	40	11
Iron (mg)	0.31	0.37	0.13	0.10	

Self Assessment Exercise 1

1. One of these is not a tropical fruit
   a. mango
   b. bananas
   c. oranges
   d. apple
2. which of these fruits contains the highest amount of vitamin C
   a. guava
   b. oranges
   c. mango
   d. pineapple

3.4 Nutritional composition of green leafy vegetables.

Green leafy vegetables Green leafy vegetables constitute an indispensible constituent of human diet in Africa, generally and West Africa in particular. Generally they are consumed as cooked complements of major staples like cassava, cocoyam, guinea corn, yam, maize, millet, rice, unripe plantain and banana. Indeed, most of the meals based on these staples are considered incomplete without a generous serving of cooked vegetables. These vegetables grow abundantly in rainy season when they are much more readily available than in the dry season. There are a lot of green leafy vegetables in Nigeria ecosystem. These could provide adequate quantities of micronutrient in the diet.

3.4.1 Nutritional composition of fluted pumpkin and water leaf

Fluted pumpkin: (*Telferia occidentails*) The leaves of this crop are important food vegetables for many people, especially in the mid-western parts of Nigeria. The local names include “Ugu” in Igbo and “Iroko” in Yoruba . The leaves are highly cherished as cooked vegetables and the seeds are used in soups.

The leaf was found to contain in (g/100) 30.5% dry weight, 2.5% crude protein, 3.0 ± 0.15% crude lipid, 8.3 ± 0.50% crude fiber and 8.4 ± 0.50% total ash. The potassium, calcium, magnesium and iron contents of ash were 594,144, 100 and 120mg/100g dry net respectively.

Water leaf: Water leaf vegetables are rich sources of vitamins A, C and minerals such as iron, calcium, phosphorus, sodium, potassium. Water leaves have great nutritional value. They contain very high amount of zinc, important in many enzyme functions and keeping the skin fresh.

3.4.2 Nutritional composition of bitter leaf and water leaf

Bitter leaf has high protein (33.3%) fat (2.1%), crude fiber (29.2%), ash (11.7%), minerals (sodium, calcium, magnesium, zinc and iron, phytate (10.54mg/100g) and tannin (0.6%) content, and it contains

3.4.3 Nutritional content of common West African Vegetables

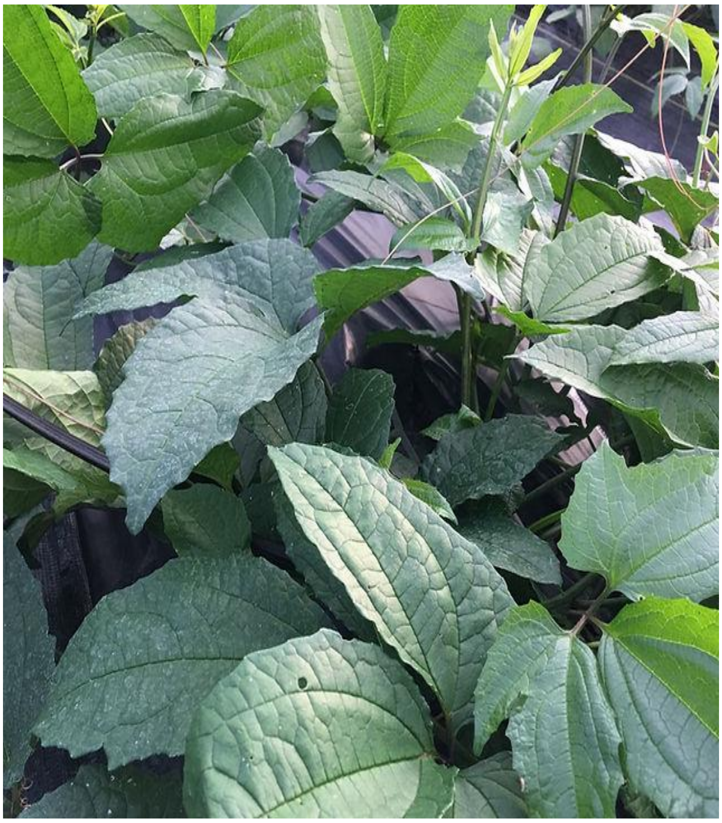
Vegetables	Moisture	Carbohydrate	Protein	fat	Fibre	Ash	Vitamin C
Aramanthus hybridus	84	7.0	4.6	0.2	1.8	2.9	40.5
Bitter leaf	21.6	64.4	22.2	2.7	10.9	10.00	34.5
Indian spinach *Basella alba*	93.4	2.9	1.6	0.3	0.6	11.00	62
Water leaf	90.8	4.4	2.4	0.4	1.4	2.00	280
Fluted pumpkin	86.0	Trace	4.3	0.8	2.3	6.00	340

Amaranthus hybridus

Bitter leaf

Water leaf

Basella alba



Fluted pumpkin leaves

Egg plant leaves

Self Assessment Exercise 2

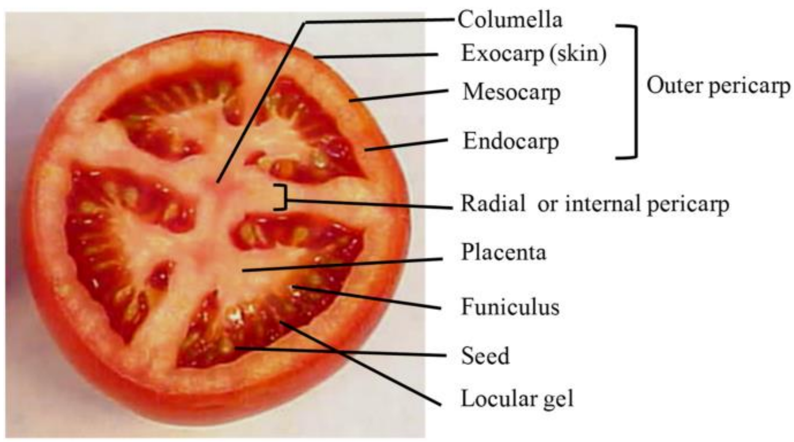
1. Vegetables are added to dishes because they are rich in ----- and ---------
    a. protein and fat
    b. protein and vitamin
    c. fat and fibre
    d. vitamin and minerals
2. One of these the following is not an indigenious vegetable of West Africa
    a. Brocolli
    b. fluted pumpkin
    c. eggplant leaves
    d. bitter leaves

3.5 Structure and composition of Tomatoes, cucumber and eggplant

3.5.1 Structure of tomatoes

Tomato (*Lycopersicon esculentum* Mill.) has been noted as one of the most important nutritious vegetable crops consumed by man. It belongs to the family solanaceae, and cultivated in almost all home gardens and also in the field for its adaptability to wide range of soils. It is widely cultivated in tropical, sub-tropical and temperate climates, and ranks the third in terms of world vegetable production. It is rich in vitamin A and vitamin C, carbohydrates, proteins, fats, fibres and potassium.

The seeds are located inside of the locular cavities and are enclosed in gelatinous membranes. Tomatoes can be either bilocular or multilocular. Most cultivated varieties except cherry tomatoes have four or five locules. The locules are surrounded by the pericarp. The pericarp includes the inner wall, columella; the radial wall, septa; and the outer wall. The pericarp and the placenta comprise the fleshy tissue of the tomato. The structure of tomato is shown below.



Structure of tomatoes

3.5.2 Nutritional composition of tomatoes

Tomatoes are rich in vitamin A and potassium. Tomatoes contain lycopene which is an antioxidant that has a lot of health benefits. The nutritional composition of tomatoes is shown below.

The Table below shows the detailed nutritional composition of tomatoes

Phytochemicals	Value/100 g (unit)	Phytochemicals	Value/100 g (unit)
Energy	74 kJ (18 kcal)	Potassium	237 mg (5 %)
Carbohydrates	3.9 g	Lycopene	2,573 µg
Sugars	2.6 g	Vitamin A equiv.	42 µg (5 %)
Dietary fiber	1.2 g	β-Carotene	449 µg (4 %)
Fat	0.2 g	Lutein/zeaxanthin	123 µg
Protein	0.9 g	Thiamine	0.037 mg (3 %)
Water	94.5 g	Niacin	0.594 mg (4 %)
Magnesium	11 mg (3 %)	Vitamin B_6	0.08 mg (6 %)
Manganese	0.114 mg (5 %)	Vitamin C	14 mg (17 %)
Phosphorus	24 mg (3 %)	Vitamin E	0.54 mg (4 %)
		Vitamin K	7.9 µg (8 %)

3.5.3 Composition of Cucumber and carrot and egg plant

Cucumber (*Cucumis sativus*) is ~96 % water and contains minerals, vitamins, provitamin A, 11 % K, 2 % K, and 10 % NaCl. The chemical composition of the cucumber is presented in the Table below.

Nutritional composition of cucumber

Phytochemicals	Value/100 g (unit)	Phytochemicals	Value/100 g (unit)
Energy	15 kcal	Vitamins	
Water	95.23 g	Vitamin C, total ascorbic acid	2.8 mg
Protein	0.65 g	Thiamin	0.027 mg
Total lipid (fat)	0.11 g	Riboflavin	0.033 mg
Carbohydrates, by difference	3.63 g	Niacin	0.098 mg
Fiber, total dietary	0.5 g	Vitamin B_6	0.040 mg
Sugars, total	1.67 g	Folate, DFE	7 µg
Minerals		Vitamin B_{12}	0.00 µg
Calcium	16 mg	Vitamin A, RAE	5 µg
Iron	0.28 mg	Vitamin A, IU	105 IU
Magnesium	13 mg	Vitamin E (α-tocopherol)	0.03 mg
Phosphorus	24 mg	Vitamin D (D_2 + D_3)	0.0 µg
Potassium	147 mg	Vitamin D	0 IU
Sodium	2 mg	Vitamin K	16.4 µg
Zinc	0.20 mg		
Lipids			
Fatty acids, total saturated	0.037 g	Fatty acids, total polyunsaturated	0.032 g
Fatty acids, total monounsaturated	0.005 g	Cholesterol	0 mg

Source: Butnariua and Butu (2014)

3.5.4 Composition of carrot

Carrot (*Daucus carota)* contains the highest amount of β-carotene among all vegetables. Its consumption increases resistance to ultraviolet rays, giving the skin a smooth and healthy coloring. Carrot contains vitamins, levulose and dextrose, salts, minerals (Fe up to 7 % and K 235 mg%), carotene, asparagine, daucarine, and pectin.

Nutritional composition of carrot

Component	Value/100 g (unit)	Phytochemicals	Value/100 g (unit)
Energy	41 kcal	Vitamins	
Water	88.29 g	Vitamins C	5.9 mg
Protein	0.93 g	Thiamin	0.066 mg

Total lipids (fat)	0.24 g	Riboflavin	0.058 mg
Carbohydrate	9.58 g	Niacin	0.983 mg
Total dietary fibre	2.8 g	Vitamin B6	19 µg
Sugar, total	4.74 g	Folate, DFE	19 µg
Mineral		Vitamin B12	0.00 µg
Calcium	33 mg	Vitamin A, RAE	835 µg
Iron	0.30	**Vitamin A, IU**	**16706 IU**
Magnesium	12	Vitamin E	0.66 mg
Phosphorus	35	Vitamin D	0.0 µg
Potassium	320	Vitamin D	0 IU
Sodium	69	Vitamin K	13.2 µg
Zinc	0.24		

3.5.5 Composition of egg plant

Eggplant (*Solanum melongena)* contains starch, minerals, and vitamins. A serving of 100 g eggplant has 20 kcal. The chemical composition of eggplant is presented in Table below.

Nutrient (Unit)	Amount	Nutrient (Unit)	Amount
Proximates		Vitamins	
Sugars, total (g)	3.53	Vitamin K (Phylloquinone) (µg)	3.5
Fibre, total dietary (g)	3	Vitamin E (α-tocopherol) (mg)	0.3
Carbohydrate, (g)	5.88	Vitamin A, IU (IU)	23
Total lipid (fat) (g)	0.18	Vitamin A, RAE (µg)	1
Protein (g)	0.98	Folate, DFE (µg)	22
Energy (kcal)	25	Vitamin B6 (mg)	0.084
Water (g)	92.3	Niacin (mg)	0.649
Minerals		Riboflavin (mg)	0.037
Zinc, Zn (mg)	0.16	Thiamin (mg)	0.039
Sodium, Na (mg)	2	Vitamin C (mg)	2.2
Potassium, K (mg)	229	Lipids	
Phosphorus, P (mg)	24	Cholesterol (mg)	0
Magnesium, Mg (mg)	14	Fatty acids, total polysaturated (g)	0.076
Iron, Fe (mg)	0.23	Fatty acids, total monosaturated (g)	0.016
Calcium, Ca (mg)	9	Fatty acids, total saturated (g)	0.034

Source: Butnariua and Butu (2014)

3.5.6 Food applications of fruits and vegetables

- Many fruits and vegetables are eaten raw eg carrot, tomatoes, egg plant, egg plant leaves etc. Fruits and vegetable can also be cooked before consumption.
- Vegetables are added to many dishes as sources of vitamins and to improve eye appeal in form of garnishing
- Fruits and vegetables are added to salads
- They are used to produce juices and drinks e.g. orange juice, ugu drink
- Fruits are used as natural flavourants in drinks, cakes etc.
- Fruits are used to make jams and other preserves
- Pectin extracted from fruits is an important food thickening and gelling agent.

Self Assessment Exercise 3

3. Carrot contains the highest amount of ------------ among all common vegetables
4. State four food uses of fruits and vegetables

3.6

3.6 Summary

West African is blessed with a variety of fruits and vegetables which are important sources of vitamins and minerals. the common fruits are mango, pineapple, paw-paw, guava, oranges etc. the common vegetables include fluted pumpkin leaves, spinach, carrot, tomatoes etc.

Fruits and vegetable contain high amount of water and are low in carbohydrates and proteins. tomatoes contain an important phytochemical called lycopene which has many health benefits such as reducing the risk of developing chronic illnesses

Fruits and vegetable contain significant amounts of vitamins and minerals but low protein and carbohydrate contents. fruits and vegetables are used in the preparation of several soups and sauces, in salads, many are eaten raw or cooked. fruits and vegetables are used in the production of juices and beverages. fruits are utilized in the production of jams and preserves. Pectin an important food thickener is extracted from fruit peels.

3.7 Glossary

Antioxidant – antioxidants are those

lycopene

3.8 References/Further Reading(S)

1. Butnariua, M and Butum, A. (2014). Chemical Composition of Vegetables and their Products. *Handbook of Food Chemistry* DOI 10.1007/978-3-642-41609-5_17-1

2. Tindall, H.D.(1983). *Vegetables in the Tropics*. London. McMilian Press, 86.

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3.9 Possible Answers to Self Assessment Exercises

Self Assessment Exercise 3

1. β- carotene or pro vitamin A
2. source of vitamins, garnishing, for jams, extraction of pectins, as flavourants etc

Self Assessment Exercise 2

1. D- vitamins and minerals
2. A- Broccoli

Self Assessment Exercise 1

1. D- apple
2. A- Guava

MODULE 12: FACTORS THAT AFFECT SENSORY PROPERTIES AND CHOICE OF FOODS

UNIT 1: FACTORS THAT AFFECT FOOD CHOICE

1.1 Introduction

1.2 Learning Outcomes

- Discuss the sensory attributes of food
- Explain the different aspects of appearance
- Discuss the five basic tastes

1.3 Appearance as a Sensory Attribute

1.3.1. Definition of Appearance

1.3.2 Attributes of Appearance

1.4 Odour/Aroma/Fragnance as Sensory Attributes

1.4.1 Definition of odour/aroma/fragnance

1.4.2 Words that describe odour

1.5. Taste and Flavor as Sensory Properties

1.5.1. Definition of Taste

1.5.2. Definition of Flavor

1.6 Texture as a Sensory Property

1.6.1 Definition of texture

1.6.2 . Some textural characteristics

1.7 Sound as a Sensory Property

1.7.1 Definition of sound

1.8 Summary

1.9 References/Further Readings (This will come at the end of each unit)

2.0 Possible Answers to Self-Assessment Exercise(s)

1.1 Introduction

Sensory properties of foods are those properties that can be perceived with our five senses. These senses are: sight; smell; hearing; taste and touch. A combination of these senses enables one to evaluate a food. The properties of food than can be perceived with our senses include: colour, appearance, taste, aroma, flavor, consistency, texture, etc.

Colour, aroma and taste, are major factors affecting quality perception and consumer's acceptance of food. Colour and appearance are the initial quality attributes attracting us; nevertheless, the flavour (the overall combination of oral and nasal stimulation) may have the largest impact on acceptability and desire to consume it again.

1.2 Learning Outcomes

By the end of this unit, you will be able to:

1. Discuss the sensory attributes of food
2. Explain the different aspects of appearance
3. Discuss the five basic tastes

1.3 Appearance as a sensory attribute

1.3.1. Definition of Appearance

Imagine going to purchase tomatoes for your jollof rice and you see in the market blue coloured tomatoes. what would be your reaction? I know that if that was your first time of seeing blue tomatoes, you will be shocked and will most likely not purchase it. This is because you have grown up thinking tomatoes as red. This shows the role of colour and appearance in our food choice or food acceptability.

Appearance of a food means how that food appears in the eyes. Often if a food does not look appetizing, then you will not eat it. Colour and appearance aspects of products should not be overlooked because these features may render the product acceptable / unacceptable.

The appearance is an attribute which a decision is taken to purchase or consume a food product.

1.3.2 Attributes of Appearance

Color: A phenomenon that involves both physical and psychological components: the perception by the visual system of light of wavelengths 400 to 500 nm (blue), 500 to 600 nm (green and yellow), and 600 to 800 nm (red). Many foods are identified by their colours and if the food does not have the expected colour it could be rejected even though the food may still be wholesome. An example of this is that orange is associated with orange fruit, therefore any drink labeled orange drink is expected to have an orange colour even though not all orange fruits have the deep orange colour.

Deterioration of food is often accompanied by a colour change so helps consumers to somewhat assess freshness of foods eg a dark brown meat cut is perceived as spoiled meat.

Size and shape: Length, thickness, width, particle size, geometric shape (square, circular, etc.), distribution of pieces, e.g., of vegetables, pasta, prepared foods, etc.; size and shape are indications of quality of products.

Surface texture The dullness or shininess of a surface, the roughness, evenness; surface characteristics i.e wet, dry, soft, hard, crisp, tough are indicators of quality.

Clarity The haze or opacity of transparent liquids or solids, the presence or absence of particles of visible size are important indicators of quality.

Self-Assessment Exercises 1

1. Appearance is perceived by sense organ of --------------------
2. Discuss three attributes of appearance

1.4 Odour/Aroma/Fragnance as Sensory Attributes

1.4.2 Definition of odour/aroma/fragnance

The above quality parameters are perceived by the nose. The role of olfactory perception is greater in overall flavour than the taste. Food products are smelled for aroma perception immediately after the opening of closure/ package and earlier than the taste.

The odor of a product is detected when its volatiles enter the nasal passage and are perceived by the olfactory system. We talk of odor when the volatiles are sniffed through the nose (voluntarily or otherwise). Aroma is the odor of a food product, and fragrance is the odor of a perfume or cosmetic.

The amount of volatiles that escape from a product is affected by the temperature and by the nature of the compounds.

Volatility is also influenced by the condition of a surface: at a given temperature, more volatiles escape from a soft, porous, and humid surface than from a hard, smooth, and dry one.

1.4.2 Words that describe odour

Table 1: Words that describe odour with examples

Words	Example
Aromatic	Onions
Floral	Hibiscus flavour
Perfumed	Some food flavours
Rotten	Rotten meat
Acrid	Vinegar
Pungent	Pepper
Bland	Unsweetened

Rancid	Deteriorated oil
Tart	Yoghurt
Spicy	Spiced foods
Savoury	Mono sodium glutamate

Self-Assessment Exercises 2

1. The similarity between aroma and fragnance is ---------

    a. they are related to food
    b. they both mean sweet smelling
    c. they interchangeable
    d. they are both perceived with the nose

2. Pepper is to pungent odour as ---------- is to aromatic

1.5. Taste and Flavor as Sensory Properties

1.5.1. Definition of Taste

The tongue can detect five basic tastes: bitter; salt; sour; sweet; umami. Taste may be described by association with a particular food, e.g. meaty, minty or fruity. qunine like substances

Bitterness: It may be due to alkaloids, glycosides, other classes of organic compounds as well as inorganic salts. Naringin the bitter principle of grapefruit is a glycoside of rutinose and is not toxic, while amygdalin, a glycoside present in bitter almonds contains gentiobiose and cyanide group, and it toxic. Quinine, strychnine, nicotine, etc., are bitter alkaloids. Caffeine, a constituent of coffee and tea, is bitter. Phenolic compounds like tannin and some flavonoids combine bitterness with astringency.

Salty: Sodium chloride is the only salt that has a pure salty taste. Besides imparting flavor to food, it is also an essential nutrient. Other salts have different tastes, e.g., some iodides and bromides are bitter while some salts of lead and beryllium are sweet.

Sweet: Sugar is used more to impart sweetness than flavor to food. Fructose present in honey is the sweetest sugar followed by sucrose and glucose, whereas lactose in milk is slightly sweet and gives less flavour. Natural sweet compounds are generally polyhydroxy (containing many hydroxyl groups) compounds with a straight-chain structure, such as sugars and the hexahydroxy cyclic alcohols, mannitol and sorbitol. Diverse compounds, such as saccharin, some peptides and cylcamates are also sweet.

Sourness: Sourness of food is due to the presence of organic acids of which citric, tartaric and malic are the most common. Acetic acid produced by fermentation of alcohol is common in processed fruits. Ascorbic acid is abundantly present in fruits and vegetables. Oxalic acid found in spinach and phosphoric acid and its salts are often used in the food industry. Remarkably, the hydrogen ion is mainly responsible for sour taste. Except for oxalic acid, all other acids are weak acids and the degree of sourness is not proportionately related to the hydrogen ion concentration.

1.5.2. Definition of Flavor

Flavour is a sensory phenomenon which is a combination of the sensations of taste, odour or aroma, heat and cold, and texture or “mouthfeel”. The appearance of food is important, but it is the flavor that ultimately determines its quality and acceptability.

Flavour can be classified into:

- Natural Flavours: Herbs, Spices, Aromatic seeds, Fruits, Vegetables
- Processed flavours: Fermented, Baked, Toasted, Roasted, Cara-melized
- Added flavours: These are two types: natural extracted flavours eg addition of herbs and spices and synthetic flavours.

Self-Assessment Exercises 3

1. All these are taste perceptions except
   a. hard
   b. sweet
   c. sour
   d. bitter
2. Flavour is perceived by
   a. the tongue only
   b. the tongue and eye
   c. the tongue and nose
   d. the nose only

1.6 Texture as a Sensory Property

1.6.1 Definition of texture

Texture can be assessed through touch. When food is placed in the mouth, the surface of the tongue and other sensitive skin reacts to the feel of the surface of the food. The sensation is also known as mouth-feel. Different sensations are felt as the food is chewed. The resistance to chewing also affects texture, e.g. chewiness, springiness. The viscosity is also a factor, e.g. runny, thick. The mouth also detects temperature, which plays an important stimulus, e.g. cold ice cream, warm bread, hot soup.

Texture of food is based on multi parameters; some parameters are governed when food is placed inside the mouth while most of them are perceived when food gets deformed during mastication and detected through several senses. There is no single and specific receptor which governs the evaluation of texture of food instead there are many receptors and tissues come in to action.

1.6.2 . Some textural characteristics

Textural characteristics	Definition	
Hardness	Force required to compress a food between the molar (solid) teeth or between the tongue and palate (semi solid)	Palm kernel, coconut have high degree of hardiness
Cohesiveness	The extent to which a food can be deformed before it ruptures and is dependent upon the strength of the internal bonds.	Chewing gum is very cohesive
Tenderness, chewiness or toughness	Is defined as the energy required to masticate a solid food product to a state of read for swallow and involves compressing, shearing etc.	Chocolates are very tender
Brittleness, crunchiness, crumbliness	These are due to the high degree of hardness and low degree of cohesiveness	Biscuits are very brittle.

1. All these are aspects of textural perception except

a. temperature

b. springiness

c. viscosity

d. colour

2. The extent to which a food can be deformed before it ruptures is known as -------------

Self-Assessment Exercises 4

-

1.7 Sound as a Sensory Property

1.7.1 Definition of sound

The sounds of food being prepared, cooked, served and eaten all help to influence our preferences. You can tell a lot about the texture of a food— crispy, crunchy, and crackly—from the mastication sounds heard while biting and chewing. plantain chips that does not make the crunchy sound will be poorly accepted.

1.8 Summary

The five senses help us to evaluate food quality. Each food is expected to have a particular kind of colour, taste, texture and even sound for maximum acceptability.

The sensory attributed of foods are colour, taste, texture, odour and sound. all these parameters are perceived by our five senses to give us an interpretation of the perceived quality of the food.

1.9 References/Further Readings

1. Murray, J.M. & IBaxter, L.A (2003). sensory Evaluation :Food Acceptability and Sensory Evaluation ,in Encyclopedia of Food Sciences and Nutrition (Second Edition),

2. Schutz H.G. and Wahl O.L. (1981). Consumer perception of the relative importance of appearance, flavor and texture to food acceptance. In: Criteria of food acceptance. (eds. J. Solms and R.L. Hall). Zurich: Foster Verlag AG/ Foster publishing Ltd.

2.0 Possible Answers to Self-Assessment Exercise(s) within the content

Self-Assessment Exercises 1

1. Eye

2. Appearance is a sensory property perceived by the eyes and includes colour, shape, surface texture, clarity etc

Self-Assessment Exercises 2

1. They are perceived by the nose

2. onions

Self-Assessment Exercises 3

1. nose

2. hard

Self-Assessment Exercises 4

1. colour

2. cohesiveness

UNIT 2: FACTORS THAT AFFECT THE SENSORY PROPERTIES OF FOODS

2.1 Introduction

Sensory properties are those properties of foods that can be perceived and assessed by the five senses. examples are colour and taste which are perceived by the eye and tongue respectively. in the previous unit, we discussed the definitions of the sensory properties and how they are perceived.

In this unit you shall understand that these properties are affected by different factors. the redness of a tomato for example can be affected by a lot of factors which include the variety, the agronomic factors, stage of maturity before harvest, storage conditions etc.

2.2 Learning Outcomes

By the end of this unit, you will be able to

1. Evaluate the pre-harvest factors that affect sensory properties of crop produce
2. Discuss at least three the pre-harvest factors that affect sensory properties of crop produce
3. Discuss at least four factors that affect the quality characteristics of meat

2.3 Factors that Affect Sensory Properties

Factors that affect sensory properties of food materials can be divided into pre harvest and post harvest factors for plant crops and into pre slaughter and post slaughter factors for meat.

2.3.1 Pre harvest factors

These factors include variety, soil nutrient, cultural practives, environmental conditions etc

Variety: Different varieties of a particular produce have different genetic makeup. it is the genetic makeup that is expressed as the firmness, size, colour, taste of the produce. Certain varieties of orange or tomatoes have more carotenoid content than the others making the orange to express more of the orange colour or the tomato to express more lycopene resulting in more intense red colour.

Soil nutrient: Soil nutrients affect the quality of the produce. It has been shown that tomatoes receiving enhanced NPK nutrition (150%) had fruits with better quality, color and market acceptability than the ones receiving standard NPK nutrition (100%). Many studies have shown P and K nutrition has positive effects on fruit sugar and acid content. High P application was shown to produce higher sugar content in tomatoes when compared to low P conditions. Supply of K had been found to increase acid content of tomatoes. Many studies

have reported moderate N supply will improve tomato flavor, but excess N can harm the fruit favor. Heavy N and K fertilization can also have detrimental effects on fruit favor.
Application of different types of fertilizers had significant effect on some semsory properties of bananas. The total bunch weight, total fruit weight, hand weight and number of fingers and fruits per hand and total soluble sugar were influenced. .

Other cultural practices in the farm: Cultural practices like crop density, root and trunk pruning, weeding practices, plough depth, land preparation methods, watering practices and planting date will all influence the final quality of the crop.

2.3.2 Effect of Post Harvest Practices

Stage of maturity at harvest: The maturity stage of crops at harvest has great effect on their ripeness, firmness, taste etc. Tomato being a climacteric fruit can be harvested at the matured green state allowing ripening and senescence to occur during the postharvest period of the fruit. Fully ripened tomatoes are susceptible to mechanical injuries during harvesting resulting in shorter shelf life. harvesting of crops before the peak maturity would negatively affect ripening and firmness.

Pre-cooling: Field heat is usually high and undesirable at harvesting stage of many fruits and vegetables and should be removed as quickly as possible before any postharvest handling activity. Excessive field heat gives rise to an undesirable increase in metabolic activity and immediate cooling after harvest is therefore important. Precooling minimizes the effect of microbial activity, metabolic activity, respiration rate, and ethylene production, whilst reducing the ripening rate, water loss, and decay, thereby preserving quality and extending shelf life of harvested tomatoes. Excess water loss would negatively affect firmness and appearance of fruits and vegetables. Excessive ripening produce over ripe fruits that have low acceptability.

Packaging

Packaging is also one of the important aspects to consider in addressing postharvest losses in fruits and vegetables. It is enclosing food produce or product to protect it from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources. using unsuitable packaging can cause fruit damage resulting in low quality, acceptability and losses. Some common packaging materials used in most developing countries include wooden crates, cardboard boxes, woven palm baskets, plastic crates, nylon sacks, jute sacks, and polythene bags. Most of the abovementioned packaging materials do not give all the protection needed by the commodity.

Whilst the majority of these packaging materials like the nylon sacks do not allow good aeration within the packaged commodity causing a build-up of heat due to respiration, others like the woven basket have rough surfaces and edges which cause mechanical injuries to the produce. The wooden crate and the woven palm basket are some of the common packaging materials used in many developing countries especially those in Africa for packaging fruits and vegetables like tomatoes. The major shortcoming of the wooden crate is in its height which creates a lot of compressive forces on fruits located at the base of the crate.. These undesirable compressive forces cause internal injuries which finally result in reduced postharvest quality of the tomatoes The palm woven baskets used by tomato handlers have sharp edges lining the inside which puncture or bruise the fruit when they are used. It has also been recommended by that woven palm baskets should be woven with the smooth side of the material turned inward.

Storage: Fruits and vegetables and some tubers has very high moisture content and therefore is very difficult to store at ambient temperatures for a long time. Meanwhile, storage in the value chain is usually required to ensure uninterrupted supply of raw materials for processors.

Storage maintains the quality and helps provide continuity of product supply throughout the seasons.

For short-term storage (up to a week), tomato fruits for example can be stored at ambient conditions if there is enough ventilation to reduce the accumulation of heat from respiration. For longer-term storage, ripe tomatoes can be stored at temperatures of about 10–15°C and 85–95% relative humidity

Very low temperature storage too is detrimental to the shelf life and quality of many tropical fruits like tomatoes. For instance, refrigerating a tomato will reduce its flavour, a quality trait of tomatoes which is largely determined by the total soluble solids (TSS) and pH of the fruit

Transportation: In most developing countries, the production sites for many tomato producers are far from the marketing centres and also inaccessible by road. Transporting harvested tomatoes to the market on such bad road network and the lack of proper transportation like refrigerated vans become a big challenge for both producers and distributors. This challenge therefore causes unnecessary delays in getting the produce to the market. Meanwhile, any delay between harvest and consumption of crops may result in loss of sensory qualities like colour, firmness, sweetness etc.

During transportation, the produce should be immobilised by proper packaging and stacking to avoid excessive movement or vibration. Vibration and impact during transportation as a result of undulations on roads are one of the major causes mechanical damage and reduced sensory properties.

Food processing: Food processing may be used to intentionally or unintentionally change food properties. High temperature processing would change the colour of green leafy vegetables. the taste, flavour and aroma are all affected by high temperature processing.

Fermentation of milk changes the textrual, taste, flavour, colour characteristics of milk. cutting of yam during processing could bring about undesierable browning reacations that will affect the colour of the product.

- **Self-Assessment Exercises 1**

1. State three (3) pre harvest factors that can affect sensory qualities of tomatoes. 2. Briefly analyze the relationship between pre-cooling and sensory properties of fruits.

2.4 Factors that Affect Sensory Qualities of Meat and Other Animal Products

2.4.1 Animal factors

Animal species: Different species of animals differ in the sensory properties. Goat meat (chevron) has a more chewable texture than sheep meat (mutton). This is because of the different ways fat is deposited in the muscles. bigger animals like cow have tougher meat than smaller animals like pig, sheep and goat.

Breed of animal: Among animals of same species, the breeds affect some sensory qualities. Some breeds of cows produce more tender, juicy and flavourfull meat as a result of marbling. In chicken, layers are known to have tougher meat than broilers.

Sex/Age: Sex of the animal determines the rate and extent of fat deposition, growth rate as well as development of some odourous compounds in the body related to sexual maturity which affect the quality of meat. In general, males have less intramuscular fat than females, whereas castrated aimals of any sex have more intermusculare than the uncasterated ones. Male animals have superior carcass leanness and hence preferred by fresh meat processor and the consumers who prefer lean meat. Age at slaughter is highly related to meat tenderness. tenderness decreases as age of animal increases.

2.4.3 Managemental Factors

System of rearing: Free range animals have the potential to have access to variety of feed stuffs prior to slaughter that may affect the flavour of the meat. Meat from grass fed cattle is of lower quality and less tender than grain fed cattle. In intensive system, if the animals are overcrowded, there may be limited access to feed and water and animals exhibit undesirable social behaviours such as fighting, chewing and inability to rest properly. In these situations, animals' growth rate will be affected and meat obtained from them will be lower in overall fatness and may have a higher incidence of quality problems related to stress during slaughter. Free range animals have more muscle pigments than their stall-fed counterparts.

Feeding: Feeding of high energy carbohydrate diets leads to faster growth and fat deposition in all livestock. Feeding of meat animals with fish meal, certain strains of clove and other legumes may produce meat with abnormal flavour (taint).

Pre-slaughter handling: Pre-slaughter handling of meat animals includes the process of loading at farm, the journey to the abattoir lairage and subsequent handling upto the point of slaughter. During completion of these processes animals are subjected to wide variety of 'stressors', which adversely affect the meat quality.

Pale soft exudative (PSE) and dark firm dry(DFD)meats are very important meat quality problems that continuous to bedevil the meat industry. Acute or short term stress such as the use of electric goads, fighting among animal just before sticking, and overcrowding in the lairage cause PSE. Exposing animals to chronic or long time stress such long hours of transportation, food and water deprivation and overcrowding of animals in the lairage can cause DFD carcasses.

PSE and DFD meats are unattractive and more likely to face discrimination by consumers. Pale soft exudative meat looks pale, lean, has soft texture and low water holding capacity. DFD meats are dark in colour with dry appearance.

2.4.4 Effect Of Processing Conditions on Sensory Properties Of Meat

Low temperature: Holding of meat at low temperature results in improvement in tenderness, juiciness and flavour of meat. This phenomenon is called 'ageing' or 'conditioning'. This is an important event which determines the palatability of meat particularly beef.

High temperature: Boiling, roasting or grilling of meat affect some sensory properties. the colour red colour is reduced, the meat becomes tougher and less juicy. Roasting can improve the aroma, flavour and taste of meat because of volatile compounds produced as a result of the high temperature.

- **Self-Assessment Exercises 2**

1. Discuss two animal factors that affect the flavour of meat
2. Mention two managerial conditions that affect colour of meat
3. Briefly discuss how high temperature can affect the texture of meat

2.5 Summary

The acceptability of any food is largely dependent on its sensory properties. it is there fore important for food processors to make sure that foods are maintained at optimal conditions to improve sensory properties.

Pre and post harvest practices during farming of crop produce affect sensory qualities. for example variety of crop, soil nutrient, post harvest practices as well as food processing conditions are all critical factors that affect sensory qualities.

In the same way, pre and post slaughter practices of animals will affect meat quality. these factors include the breed, age, sex, feed of animals as well as pre slaughter condition of the animals. Low temperature and high temperature conditions during storage and processing all have impact on sensory quality of meat.

2.5 References/Further Readings

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2. Gustavo, B.C.V., Juan, F.M. J., Stella, M., Maria, S.T., Aurelio, L.M. &and W. C. Jorge, W.C. (2003) “Handling and preservation of fruits and vegetables by combined methods for rural areas,” *Technical Manual FAO Agricultural Services Bulletin* 149, FAO, Rome, Italy, 2003.

2.6 Possible Answers to SAEs

Self-Assessment Exercises 1

1. variety, soil nutrient, cultural practices,
2. Pre-cooling helps to reduce post harvest degradation therefore maintaining sensory properties of crops.

Self-Assessment Exercises 2

1. Type of animal – Different animals have different sensory properties, goat meat is different from beef. breed- animals of the same type but different breeds have different meat quality, sex- male animals have more lean meat than memal, age.- the younger the animal the more tender the meat.
2. Rearing condition, feed and pre slaughter conditions
3. High temperature processing reduces the red colour of meat, makes the meat tougher and may improve taste and flavour.

UNIT THREE: FACTORS AFFECTING FOOD AND EQUIPMENT CHOICE

3.1 Introduction

3.2 Learning Outcomes

- Discuss the factors that affect food choice
- Explain the effect of cost on food choice
- Explain the effect of culture/ethnicity on food choice

3.3 Factors that Affect Food Choice

3.3.1 The factors that affect food choice include:

3.4 Effect of cost on food choice

3.4.1. Effect of the cost of the food

3.4.2. Cost of transportation

1.4.3. Cost of food preparation

3.5 The Role of Culture/Ethnicity in Food Choice

3.5.1 Definition of ethnic group and ethnic food

3.5.2. Definition of culture

3.5.3 Effect of ethnicity and culture on food choice

3.5.4 Influence of ethnicity on nutritional intake

3.6 Summary

3.7 Glossary

3.8 References/Further Readings (This will come at the end of each unit)

3.9 Possible Answers to Self-Assessment Exercise(s)

3.1 Introduction

Is there any food you know that people from other cultures or religion consume but you will not even taste it? Food choice is defined as a set of conscious or unconscious decisions made by an individual at the point of purchase of food, at the point of its consumption or at any point between.

In the last this unit, you learnt about the factors that affect the sensory properties of foods. In this unit we shall be highlighting the factors that individuals differ in their food choices. Why is it that in a buffet party where a variety of dishes are presented, one would notice that the choices of people differ? We shall also discuss the factors that affect the choice of food processing equipment.

3.2 Learning Outcomes

By the end of this unit, you will be able to

1. Discuss the factors that affect food choice
2. Explain the effect of cost on food choice
3. Explain the effect of culture/ethnicity on food choice

3.3 Factors that Affect Food Choice

3.3.1 The factors that affect food choice include:

- Physical such as access, cooking skills and time
- Economic such as cost, income, availability
- Social such as social status, social class
- Educational such as nutritional knowledge
- Biological such as hunger, appetite, and taste
- Psychological such as mood, stress and guilt
- Cultural/ethnicity,
- Religion

For this unit, we will concentrate on the effect of cost and culture/ethnicity on food choice.

- Self-Assessment Exercises 1

1. All these are part of the economic component of food choice except
   a. food cost
   b. food availability
   c. food nutrients
   d. income
2. Which of the following affect food choice (There may be more than one answer)
   a. religion
   b. hunger
   c. education
   d. mood

3.4 Effect of Cost on Food Choice

3.4.1 The role of cost of the food itself

No matter how appealing or nutritious a food is, one cannot purchase it unless he can afford it. Cost of food is a major determinant to food choice. Many people in the developing countries cannot afford the cost of meat and other animal products because their cost is beyond their income. These poor people are more vulnerable to suffer from malnutrition. Income of a person determines if he or she can afford to buy a particular food.

3.4.2 Cost of transportation

A food may be cheap in some locations but the cost of transportation to those locations makes it the food inaccessible to consumers. In Nigeria, certain foods are cheap in remote rural areas but the cost of transportation to those rural areas is too high because of the remoteness and inaccessibility of the areas. It is important that government provides rural infrastructures like good roads to enable local farmers bring out their produce to the urban areas.

3.4.3 Cost of food preparation

Cost of food preparation is also an important factor for instance the high cost of cooking gas in Nigeria has resulted in household going for those foods that take shorter time to be cooked even though that such foods may be nutritionally inferior. certain types of foods need special equipment for preparation for example one must have an oven to make bread and many can not afford it so the either buy already

prepared ones are go without it.

Self-Assessment Exercises 2

1. State three ways that cost could affect food choice
2. Describe how high cost of food preparation may lead to malnutrition

3.5 The Role of Culture/Ethnicity in Food Choice

3.5.1 Definition of ethnic group and ethnic food

1. Ethnic groups are groups of people who share common blood ties, land ties or racial and religious similarities example the Hausas, the Yorubas and the Igbos in Nigeria.
2. Ethnic foods are foods that are typical of a given racial, national or religious culture examples *tuwo* for the Hausas, *amala* for the yorubas and pounded yam for the Igbos.

3.5.2. Definition of culture

- Culture consists of the values, beliefs, systems of language, communication, and practices that people share in common and that can be used to define them.
- Culture can be defined as all the ways of life including arts, beliefs and institutions of a population that are passed down from generation to generation.
- Culture has been called "the way of life for an entire society." As such, it includes codes of manners, dress, food language, religion, rituals, art. etc
- Culture and ethnicity are somewhat related. While ethnicity is the division of groups of people depending on their ancestry, culture or other special characteristics of the society in which he/she is born into, culture, on the other hand, is a social phenomenon which explains the characteristics of a particular society.

3.5.3 Effect of ethnicity and culture on food choice

- Ethnicity and culture affect the outlook and attitudes of people towards life and people, health and even food choices. These factors among others are instilled into individuals of these groups at an early age and are difficult to change.

- For instance, while the Yorubas cherish amala, a dark brown food made from dried yam chips, an Igbo person may abhor it not because it is toxic but because it is not part of his ethnic foods.
- Cooking methods, serving and even cooking equipment and utensils are affected by ethnicity. The Hausas in Nigeria would typically prepare kunu a local beverage from cereals such as sorghum or maize, the Igbos would normally grind maize and transform to *fufu* from the same cereal. Some ethnic groups eat certain foods with their fingers eg fufu. Ethnicity could even influence cooking and serving utensils for foods. People from Igbo ethnic group in Nigeria will normally serve a delicacy known as “Nkwobi” with traditional wooden plates.

3.5.4 Influence of ethnicity on nutritional intake

- Ethnicity can have a positive or negative effect on nutritional intake. For instance ethnicity promote the consumption of nutrient rich foods by encouraging dietary diversity ie meals that are cooked from diverse food groups. In many of our cultures and ethnic groups a starchy food is eaten in combination with legumes and vegetables for example rice, beans and tomatoe sauce.
- Culture and ethnicity may also have a negative effect on nutritional intake. Some cultures prohibit the consumption of certain foods e.gs. Certain people in the South East of Nigeria forbid the consumption of snails. Some culture forbid children from eating eggs because they fear it will lead the child to steal. This kind of influence of culture/ethnicity deprives people from consuming the much need nutrients and may lead to malnutrition.

Self-Assessment Exercises 3

1. Discuss two ways that culture can influence food choice
2. Discuss one positive effect of culture on food choice

3.6 Factors affecting choice of food processing equipment

3.6.1 Available capital, cost of maintenance and ease of replacement

The availability of cash with the promoter or management governs the quality and quantity of all categories of service equipment required for food processing operations.

Equipment made of very fine material that is long-lasting, involves less maintenance cost, and requires less storage area, will always be more expensive.

The maintenance cost of any equipment should be minimum. It calls for constant maintenance by cleaning, polishing, laundering, and so on. the availability of spare parts and maintenance personnel should also be considered.

3.6.2 Target customers, location of the food processing plang

The type of target consumers determines the quality of equipment required. The upmarket client expects service equipment of high standard for the value of money he or she pays. Whereas, middle and lower-middle clients do not expect high-quality service equipment but want the dishes at a reasonable price.

The location determines the profile of customers and level of service quality. for example if you are in a place with very poor electricity supply, it will not make much sense going for equipment that depend on electricity.

3.6.3 Available space, operation cost and existing food laws

One must consider available space before purchase of an equipment. Gigantic equipment with little space will not be practicable.

The cost of handling a new equipment under consideration should be less compared to theexisting equipment. As mentioned earlier, the energy, labor, and maintenance cost of the machine should be less compared to the machine one desires to replace.

There are food laws and regulations governing food processing. A food processor must know these laws and adhere by them. For instance all metals in contact with food must be made of stainless steel.

Self Assessment Exerise 4

1. ------------- and -------------- are factors affecting choice of food processing equipment.

2. A food processor must always purchase very costly equipment. True or False

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3. 7 Summary

The kind of food people eat , the manner the cook it and even the way food is served is referred to food choice. many factors including cost, culture/ethnicity, hunger, mood, religion all interact to affect an individual's food choice.

cost and culture/ethnicity have important roles to play in food choice. these can have positive or negative impact on nutritional intake of individuals.

3.8 Glossary

Dietary diversity - *Dietary diversity* is *defined* as a number of food groups consumed over a reference period

Fructose – A type of sugar found in honey and many fruits

Glycoside - any molecule containing a carbohydrate moiety (sugar) bound to some other non- sugar part

Lairage - A place where sheep or cattle may be rested during transit to a market or abattoir.

Marbling in meat - refers to white flecks and streaks of fat within the lean sections of *meat*.

Malnutrition - *Malnutrition* refers to deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients

malnutrition -

dietary diversity

3.9 References/Further Readings

1. Simeone, M. & Scarpato, D. (2020). Sustainable Consumption: How Does Social Media Affect Food Choices? J. Clean. Prod. 277.
2. Leng, G.; Adan, R.A.; Belot, M.; Brunstrom, J.M.; de Graaf, K.; Dickson, S.L.; Hare, T.; Maier, S.; Menzies, J.; Preissl, H. The determinants of food choice. Proc. Nutr. Soc. **2017**, 76, 316–327.

3.10 Possible Answers to SAEs

Answers to SAEs 1

1. C- Food Nutrients
2. all the options are correct

Answers to SAEs 2

1. cost of food itself, cost of transportation and cost of preparation
2. high cost of cooking fuel or equipment will cause people to always cook food that cook fast or require cheper equipment. such foods may be inferior in terms of nutritional content

Answers to SAEs 3

1. Culture means a people way of life including what those people eat. some culture forbid eating of a particular food.
2. culture can promote consumption of nutritious foods

Answers to SAEs 4

1. See section 3.6
2. False