NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: AFS 202

COURSE TITLE: PRINCIPLES OF FOOD SCIENCE AND TECHNOLOGY

COURSE GUIDE

AFS 202
PRINCIPLES OF FOOD SCIENCE AND TECHNOLOGY

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Working through this Course

This course involves that you would be required to spend a lot of time to read. The contents of the course are very dense and require you spending great time to study them. This accounts for the great effort put into their development in the attempt to make them very readable and comprehensible. Nevertheless, the effort required of you is still tremendous. I would advise that you avail yourself the opportunity of attending the tutorial sessions where you would have the opportunity of comparing knowledge with your peers.

Course Materials

You will be provided with the following materials:

Course guide
Study Units.

In addition, the course comes with a list of recommended textbooks which though are not compulsory for you to acquire or indeed read but are necessary as supplements to the course material.

Study Units

The following are the study units contained in this course:

Module 1

Unit 1	Principles of Food Science and Technology
Unit 2	Food and its Functions
Unit 3	The Role of Vitamins in Nutrition
Unit 4	The Role of Minerals in Nutrition
Unit 5	Food Poisoning

Module 2

Unit 1	Deterioration and Spoilage of Foods
Unit 2	Food Contamination and Adulteration
Unit 3	Food Processing and Preservation Operations I: Temperature Based Processes
Unit 4	Food Processing and Preservation Operations II: Use of Irradiation and Moisture Reduction
Unit 5	Food Processing and Preservation Operations III: Use of Additives, Modified Atmosphere and Fermentation

Module 3

The first unit under module one discusses the essential disciplines of Food Science and Technology, embracing Food Chemistry, Processing, Quality Control, Engineering, Preservation, Packaging Marketing and Storage.

The second unit introduces food groups, including cereals, legumes, starchy roots and tubers, sugar and preserves, meat, fish and eggs, fats and oils, fruits and vegetables, milk and milk products and beverages. The relationship of these groups to macro and micro nutrients are also discussed.

The third unit concentrates on the micronutrients that are called vitamins. These are divided into two major groups: The fat soluble and the water soluble. Among the fat soluble are vitamins A, D, E and K while the water soluble includes thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, cyanocobalamin, ascorbic acid, biotin, choline and inositol. The vitamins are derived mainly form food sources.

The fourth unit deals with the other group of micro nutrients called minerals. These are divided into two major groups: the major elements and the trace metals. Among the major elements are calcium, phosphorous and magnesium, stored in bones and teeth; sodium and potassium located in the intracellular fluids, controlling the ionic strength of the cellular fluids. The trace metals include iodine, iron, zinc, and fluorine. The deficiencies of these elements and trace metals result in severe growth loss and other specific symptoms.

The fifth unit discusses food poisoning. It identifies various factors responsible for food poisoning, types of organisms involved in food poisoning and the mode of control.

The first unit under module two identifies factors responsible for deterioration and spoilage of foods, namely: chemical, physical and biological factors. The impact of deterioration of foods on its quality and acceptability, as well as its control was reviewed.

The second unit discusses contamination and adulteration of foods. The causes of contamination, namely: bacterial, physical and chemical factors were reviewed. The unit also discusses mode of prevention of contamination in some field produce.

The third to fifth units discuss food processing and preservation operations, namely: I: Temperature Based Processes; II: Use of Irradiation and Moisture Reduction; III: Use of Additives, Modified Atmosphere and Fermentation. These units identify the advantages and disadvantages of each process as well as food items suitable for each procedure.

The first unit under module 3 concentrates on the structure and composition of major Nigerian/West African food crops, namely: Roots, tubers, cereals, legumes, meat and fish.

The second to fourth units reviews traditional food processing of various food commodities, namely: Roots, tubers, cereals, legumes, meat and fish in Nigeria. The review highlights the basic operations and problems involved in processing of commodities in each food group

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Assessment

There are two components of assessments for this course. The Tutor Marked Assignment (TMA) and the end of course examination.

Final Examination and Grading

The examination concludes the assessment for the course. It constitutes 70% of the whole course. You will be informed of the time for the examination. It may or not coincide with the University semester examination.

Summary

This course intends to provide you with some basic knowledge of Food Science and Technology dealing with food components and their functions. By the time you complete studying this course, you will be able to answer the following type of questions:

1. Define Food in terms of macro and micro nutrients. Suggest sources for the major macronutrient and micronutrients
2. Discuss the effects of food processing on the nutritive values of cereals and legumes
3. Differentiate between animal fats and vegetable fats. Why are vegetable fats essential in human foods?
4. Compare and contrast the functions of Vitamin A and Vitamin C.
5. (a) Name two vitamins that are derived only from animal sources.

(b) Name two vitamins that are available mainly in plants and cereals.

6. Discuss the role of minerals in enzyme activities
7. Classify foods into perishable and non perishable and show characteristics for each group.
8. List the advantages and disadvantages of Food Irradiation.
9. Discuss methods employed in achieving concentration of Moist Foods.
10. Discuss the different methods of food preservation by Freezing.
11. Differentiate between Pasteurization and Sterilization.
12. Enumerate the type of foods usually subjected to each method of Pasteurization and Sterilization.
13. Choose 2 farm produce and explain the techniques for the prevention of contamination during post harvest storage.
14. What are the advantages of Vacuum packaging and gas packaging commonly used in the beverage industries?

We wish you success in this course. In particular, we hope you will be able to appreciate the importance of energy, proteins, fats, the micro elements of vitamins and minerals. Food preservation, processing and packaging ensure the wholesomeness of foods against bacteria, moulds, fungi and other contaminants. Healthy foods are ready for storage, sales and marketing.

We sincerely hope you enjoy the course.

With the Best wishes.

MAIN COURSE

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MODULE 1

UNIT 1 PRINCIPLES OF FOOD SCIENCE TECHNOLOGY

CONTENTS

1.0 INTRODUCTION

Food is a complex biochemical material. It is anything eaten to satisfy appetite, meet physiological needs for growth, maintain all body processes and supply energy to maintain body temperature and activity. *Food, from the professional point of view, is any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink and any other substance which has been used in the manufacture, preparation or treatment of "food",* ***but does not include cosmetics or tobacco or substances used only as drugs.*** Because foods differ markedly in the amount of the nutrients they contain, they are classified on the basis of their composition and the source from which they are derived.

A normal healthy diet should not just consist of the three major nutrients, namely: fat, carbohydrates and protein, but should also provide a range of essential macro- and micronutrients, in the form of dietary fibre, minerals and vitamins.

Micronutrient: nutrient needed in tiny amounts; a substance that an organism requires for normal growth and development but only in very small quantities, e.g. a vitamin or mineral
Macronutrient: element needed in large amounts for normal growth and development.

For good health and vitality, a range of micronutrients is needed in sufficient but not excessive quantities, combined with the absence of toxic components, whether naturally present or as contaminants. Food Science and Technologists apply their scientific knowledge to ensure that food gets to all in the best possible state.

2.0 OBJECTIVES

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

define food science and technology
explain the different disciplines of food science and technology
distinguish between food science and technology (fst) and cooking, home-economics nutrition and food service
discuss Food situation and regulation in Nigeria.

3.0 MAIN CONTENT

3.1 What is Food Science?

Food Science is the study of the physical, biological, (including microbiological), and chemical makeup of food. Food Scientists and Technologists apply many scientific disciplines, including Chemistry, Engineering, Microbiology, Epidemiology, Nutrition, and Molecular Biology to the study of food to improve the safety, nutrition, wholesomeness, and availability of food. Depending on their area of specialization, Food Scientists develop ways to process, preserve, package, and/or store food, according to industry and government specifications and regulations. Consumers seldom think of the vast array of foods and the research and development that has resulted in the means to deliver tasty, nutritious, safe, and convenient foods.

What Food Science is not?

Food Science is Not Nutrition: While some food scientists may focus on making foods more nutritious or determining what components of food provides health benefits, Nutrition and Food Science are actually very different.

Food Science is not cooking: Although Food Scientists play a large part in making sure food tastes good, they are not chefs. They do, however, share a common objective: to prepare and present food that will deliver satisfaction to the consumer, and to do it in a safe, healthy, and cost-effective way.

Food Science is Not Food Service: Most of the employees we see on the front-lines of a restaurant are in the food service industry. The directors of food safety and those developing new food products for chain restaurants, however, are most likely Food Scientists.

3.1.1 Scope of Food Science and Technology

Food Science and Technology encompasses the following major areas of specialisations:

3.1.2 Food Chemistry

Food chemistry is the study of the composition of foods, their properties and how they interact with each other and the environment. It may also include Food Analysis which is subdivided into two main areas, qualitative and quantitative analysis. The former involves the determination of unknown constituents of a substance, and the latter concerns the determination of the relative amounts of such constituents.

The major chemical classes of food are: Proteins, carbohydrates and fats. Other components are minerals and vitamins.
The following is a brief summary of some reactions that can be induced in various food classes

Proteins and Polypeptides } hydrolysis → Polypeptides + Peptides + Amino Acids

Proteins and Polypeptides } proteinaces → Peptides (responsible for bitter taste)

Proteins and Polypeptides } peptidases → Simpler peptides + Amino acids (Responsible for both desirable and undesirable flavours)

Proteins } Anaerobic breakdown Foul smelling sulphur and

Peptides → nitrogen-containing products like Amino acids ethyl sulphides, amines, indole, ammonia etc. This is putrefaction

Glucose —Anaerobic Oxidation→ Carbon Dioxide + Water

Glucose —Alcoholic Fermentation→ Ethanol + Carbon Dioxide + Energy

Glucose —Lactic Acid Fermentation→ Carbon Dioxide + Water

Organic Acids —Aerobic Oxidation→ Carbon Dioxide + Water

This oxidation leads to loss of acidity and increased susceptibility to microbial attack and other alkaline deteriorative reactions.

Fats —Microbes→ Glycerol + Fatty Acids

A thorough understanding of these reactions is required to ensure that foods delivered to consumers are safe, wholesome, nutritious and tasty.

3.1.3 Food Microbiology

Food microbiology is the scientific study of microscopic organisms and their effects in food systems. Microscopic organisms commonly encountered in food systems are bacteria and fungi (comprising yeasts and moulds).

3.1.3.1 Bacteria

Bacteria are of major importance in the food industry. On the one hand, they cause food spoilage and food borne diseases, and so must be controlled. On the other hand, they improve food flavour and nutrition. On the helpful side, bacteria contribute to the fermentation (chemical breakdown) of many dairy products people eat every day. Yogurt, considered a healthful food, is produced by bacterial fermentation of milk. The bacteria produce lactic acid, which turns the milk sour, hampers the growth of disease-causing bacteria, and gives a desirable flavour to the resulting yogurt. Cheese also is produced by fermentation. First, bacteria ferment milk sugar to lactic acid. Then, cheese makers can introduce various microorganisms to produce the flavours they desire. The process is complicated and may take months or even years to complete, but it gives cheeses their characteristic flavours.

3.1.3.2 Fungi

Fungi are single-celled or multicellular organism without chlorophyll that reproduces by spores and lives by absorbing nutrients from organic matter. Thousands of different types of fungi grow on and absorb food from substances such as soil, wood, decaying organic matter, or living plants and other organisms. They range from tiny, single-celled organisms invisible to the naked eye to some of the largest living multicellular organisms. They are among the foremost decomposers of organic matter, breaking down plant and animal remains and wastes into their chemical components. As such, fungi play a critical role in the recycling of minerals and carbon. Fungi’s value to humankind is inestimable. Certain types of fungi, including several types of mould, have proven extremely valuable in the synthesis of antibiotics and hormones used in medicine and of enzymes used in certain manufacturing processes.

Black bread mould, *Aspergillus niger,* one of the most familiar molds, begins as a microscopic, airborne spore that germinates on contact with the moist surface of nonliving organic matter. It spreads rapidly, forming the mycelium (fungal body), which is made up of a fine network of filaments (hyphae). The mycelium produces other clusters of rootlike hyphae, called rhizoids, which penetrate the organic material, secreting enzymes and absorbing water and the digested sugars and starches.

Yeasts are small single-celled fungus that ferments sugars and other carbohydrates and reproduces by budding. Yeasts in general are widespread in nature, occurring in the soil and on plants. Most cultivated yeasts belong to the genus *Saccharomyces;* those known as brewer's yeasts are strains of *S. cerevisiae.* Today they are used industrially in a wide range of fermentation processes; medicinally, as a source of B-complex vitamins and thiamine and as a stage in the production of various antibiotics and steroid hormones; and as feed and foodstuffs. Pure yeast cultures are grown in a medium of sugars, nitrogen sources, minerals, and water. The final product may take the form of dried yeast cells, or the yeast may be pressed into cakes with some starchy material. When a batch of yeast for baking, medicinal, or food purposes is completed, the medium in which the yeast was grown is discarded. In the making of wines, beers, spirits, and industrial alcohol, however, the fermented medium is the desired product, and the yeast itself is discarded or used to make animal feeds.

3.1.4 Food Packaging

Packaging of food is essential to make sure the food remains wholesome during its journey from processor to consumer. Packaging contains food, makes it easier to handle, and protects it from environmental conditions, such as temperature extremes, during transport. It locks out microorganisms and chemicals that could contaminate the food, and helps prevent physical and chemical changes and maintain the nutritional qualities of food. The type of food and the processing method used often influence the choice of packaging. For example, since oxygen makes fats go rancid, oils are packaged in containers that are impermeable to oxygen. On the other hand, oxygen-permeable plastic wraps allow fruits and vegetables to “breathe” and ensure that meats will maintain a vibrant red colour. Metal and glass containers have traditionally been used in canning because these materials can withstand the high temperatures and changes in pressure that are involved in this processing method.

In addition to metal, glass is often used for packaging heat-sterilized foods. Glass is impermeable to oxygen and water and does not change the flavour of food. Another advantage of glass is that it is transparent, enabling the consumer to see the product inside. However, glass is not impact-resistant and is relatively heavy.

Plastic, by contrast, is lightweight and unbreakable, and it has become an extremely common material for use in food packaging. Most plastics used in food packaging are heat resistant so that they can go through high-temperature sterilization processes. Plastic is made into a wide variety of shapes, including bottles, jars, trays, and tubs, as well as thin films that are used as bags and wraps.

Paper alone is not frequently used in packaging, except for certain dry foods, such as flour and sugar. However, when paper is coated with plastic or other materials to make it stronger and impermeable to water, it can be more widely used. Paperboard is often used for cartons, and plastic-coated paperboard for packaging frozen foods. Cartons and containers for shipping are usually made of corrugated cardboard.

3.1.5 Food Processing and Preservation

Food Processing encompasses all the steps that food goes through from the time it is harvested to the time it gets to the retailer. Some processing methods convert raw materials into a different form or change the nature of the product, as in the manufacture of sugar from sugar beets, oil from corn or soybeans, or wara (unripened soft cheese) from milk. Processing may also involve an extremely complex set of techniques and ingredients to create ready-to-eat convenience foods.

Food Preservation refers specifically to the processing techniques that are used to keep food from spoiling. Spoilage is any change that makes food unfit for consumption, and includes chemical and physical changes, such as bruising and browning; infestation by insects or other pests; or growth of microorganisms, such as bacteria, yeast, and molds.

Food Processing and Preservation therefore is a branch of Food Technology that is concerned with the transformation of raw animal, vegetable, or marine materials into tasty, nutritious, and safe food products. It also provides a means of creating products that are convenient for consumers, like those that are ready to eat or require minimal preparation and cooking. Combining Food Processing and Preservation techniques with modern distribution networks makes seasonal crops available year-round.

3.2 Food Distribution and Marketing

After food is processed and packaged, it enters an extensive distribution network that brings food products from the manufacturer to various retail outlets across the country and even around the world. Modern, high-speed methods of transportation – trucks, trains, and planes – and reliable methods of environmental control – especially refrigeration – enable even perishable food to be transported great distances.

Distribution networks help satisfy consumer demand for variety, making available, even in remote areas, foods that are not locally grown or processed. In fact, although food distribution network is invisible to the average consumer, it plays a vital role in ensuring the availability of even the most basic foodstuffs.

Some large supermarkets have the resources to buy food products directly from processors, transport the products, and store them in warehouses until they are needed at the store. However, for independent grocery stores and other small retailers, food wholesalers fulfill these roles. One type of wholesaler is a cooperative wholesaler, which is owned by the retailers that buy from them and usually sells only to these member-owners. In contrast, voluntary wholesalers are public companies that sell to any retailers without having membership requirements. Some food is sold directly to a retail store without going through a wholesaler first. This is common for foods such as bread and dairy products that must be delivered fresh every day or every few days. Smaller manufacturers often use food brokers as agents to arrange for their products to be sent to retailers or warehouses.

Through these various distribution channels, food makes its way to food retailers, such as restaurants, fast food outlets, supermarkets, convenience stores, specialty shops, drug stores, and some department stores. Minimarkets and open market selling are the predominant means of distributing foods in Nigeria.

3.2.1 What is Market?

Many different definitions and views of what marketing is have been presented. A Marketing Manager may think of a market in a more comprehensive way taking a broad look at the word market. Another may include a geographical place to demarcate a market. Yet, some can use demographic, sociological or psychological variables in defining their markets. Markets can also be seen in terms of units sold within a specific period of time. A common way of defining a market by the re-sellers is in terms of demand and supply. It is clear therefore that the term market depends largely on individual's perspective and judgement.

The earliest usage of market put market as a physical place where buyers and sellers gather to exchange goods and services. An economist sees market as all the combination of buyers and sellers involved in the purchase of goods and services. In other words, a market is seen here in terms of structure, conduct and performance relationship. This is best illustrated with demand and supply patterns. To the marketers, a market is seen as the set of all individuals and organisations who are actual and potential buyers of a product or service.

3.3 Food Situation in Nigeria

Most Nigerians are subsistence farmers, producing sorghum, millet, and cattle in the north, and maize, rice, and yams in the south. Cassava, legumes, and tomatoes are raised throughout Nigeria, as are poultry, goats, and sheep. Large amounts of plantains and sugar cane are also produced. Agriculture, including farming and herding, accounts for 26 percent of Nigeria's GDP and engages 3 percent of the economically active population.

Palm oil became an export crop to Europe in the early 19th century. Cocoa and groundnuts later grew in importance, surpassing palm oil as export crops in the early 1950's. Most crops are grown on small family farms. Large plantations were discouraged until the 1950's, but since then, they have been significant in the production of rubber, palm oil, and cocoa. Principal crops in 1999 (with annual output in tonnes) included: cassava (33.1 million); sorghum (7 million); millet (5.96 million); peanuts (3 million); and sugar cane (675,000). Palm oil, palm kernels, yams, and maize are also important. Livestock included 24.5 million goats, 19.6 million cattle and 14 million sheep.

However, food production is seasonal in Nigeria. Thus, during periods of harvest, a false impression of surplus is given. However, within a short time, they are exhausted through direct consumption, wastages, deterioration and spoilage. This is all the more so because adequate processing, preservation and storage facilities are not available during periods of plenty. In sharp contrast, constant food supply is ensured by extra-seasonal conservation and storage of food products in developed countries. In Nigeria where these facilities are not present, food consumption and industrial production patterns are markedly seasonal.

Food, by its very nature, is perishable. In a survey carried out in 1996, losses in food produce were as high as 25 – 65% in plantains, tomatoes, oranges, banana, leafy vegetables and citrus fruits. Apart from physical losses, nutritional losses were also recorded: as much as 15 – 20% of Vitamin C was reportedly lost during transportation between the farm gate and the eventual consumers. A 1994 survey conducted by the Central Bank of Nigeria reported losses in agricultural output in the following commodities: maize 6.852 million tonnes, cassava 22.3 million tonnes and beans 1.47 million tonnes. Other sources show losses in the following produce: maize 13%, rice 9%, sorghum 14%, millet 10%, cowpea 19%, groundnut 8%, soybean 5%, yam 16%, cassava 8%, cocoyam 10%, plantain 13%, other fruits 5%. These no doubt, represent massive losses in farm produce that ought to have been consumed and lost income if the commodities have been sold. This situation is further compounded by the fact that food availability has not been able to keep pace with the present rate of population growth.

Only when appropriate processing, storage and preservation techniques are developed and applied, will Nigeria break free from the shackles of poverty, which at present, is threatening to rock the nation to its foundation. The fact that fresh foods cannot be found at all times and in all places makes food processing essential if consumers are to remain satisfied.

One of the major problems facing the producer has always been that the crops he grows are generally ripe for harvesting during a single short period of the year. Yam, cassava, potatoes and other root crops have to be harvested when they are ready. Rice, millet and maize are ready for harvest after rains at the start of the dry season. A feasible solution to this problem is citing of specialised food processing plants close to the main producing areas.

These industrial factories can be set up to:

- Provide wholesome foods to the consumers
- See that the finished product meets all applicable government standard and regulations
- Ensure that food is produced under conditions acceptable to the governmental authorities.

As Nigeria embarks on her industrialisation effort, the products of its factories have to compete with imported goods so that her locally processed foods will be acceptable to consumers. The achievement of quality, therefore, cannot be accidental, in as much as it is the result of organised effort by the producer of the commodity.

In concise terms, the purpose of quality control is to provide information and the organisation necessary to achieve the production of good quality foods. To this end, the National Agency for Food Drug Administration and Control (NAFDAC) set up in Nigeria has established several quality standards for different products and has exposed a wide range of fake and adulterated products in recent times.

These standards and regulations established by NAFDAC are aimed at achieving the following:

i. Prevent adulteration
ii. Prevent manufacture and processing of foods under unsanitary conditions
iii. Control the use of chemicals and products as additives
iv. Create awareness and sensitise the populace to the need to avoid patronising fake and substandard products.

However, very little has been achieved in terms of implementation and enforcement among both multinational and cottage industries. In Nigeria, only few food industries have quality control services. The majority take advantage of the fact that the few existing regulations are not effectively monitored and enforced. Not to be overlooked is the bureaucratic bottlenecks associated with prosecution of defaulters and the slow pace of Nigeria's judiciary system. Nevertheless, NAFDAC is undaunted in its avowed war against fake, adulterated and substandard products. Nigeria's survival, with the upsurge of population (with a projected figure of 230 million by 2020) lies in a sustained massive and coordinated production of foodstuff. These must be coupled with modern and scientific methods of food processing and preservation to offset colossal waste of foodstuff.

Modernisation of native Nigerian technology is a must if the nation is to overcome her food problems. Appropriate technology is important because it permits the optimum utilisation of available resources and improvements in food products that are peculiarly Nigerian. It would therefore be necessary to develop improved processing methods as has been done of late for *garri* (fermented cassava meal), *ogi* (fermented corn meal) and *iru (Parkia biglobosa)*, otherwise, development pressures will make these indigenous products disappear and Nigeria would then have to depend almost exclusively on foreign products. This is already happening with lager beer, imported canned beverages and fruit drinks vis-à-vis native beverages like *Pito, Burukutu, Kunnu, Tsobo (zobo)* and *Sekete*.

4.0 CONCLUSION

Food Science and Technology (FST) involve many disciplines which ensure the processing, wholesomeness, safety, and marketing of foods. It also deals with the ultimate metabolism and utilization in body cells.

5.0 SUMMARY

In this unit we have learnt that:

- Food contains micro and macro nutrients.
- Food Science and Technology (FST) involve many disciplines including Chemistry, Engineering, Microbiology, Epidemiology, Nutrition, Toxicology and Molecular Biology.
- The sales, distribution and marketing of processed food are essential to make foods accessible.
- Food production and marketing are seasonal in Nigeria.
- Food quality control and the prevention of adulteration in the Nigerian Food Industries are regulated by NAFDAC.

SELF ASSESSMENT EXERCISE

Define Food Science and Technology. How is this discipline different from cooking or Home Economics?

6.0 TUTOR-MARKED ASSIGNMENT

Define Food in terms of macro and micro nutrients. Suggest sources for the major macronutrient and micronutrients.

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UNIT 2 FOOD COMPOSITION AND ITS FUNCTIONS

CONTENTS

1.0 INTRODUCTION

Foods that are commonly consumed by humans include: Cereals, and Cereal Products, Starchy roots and tubers. Legumes (Pulses) leafy vegetables, fruits, nuts and seeds, sugars, syrups, sweets and preserves, meat, poultry and other meat products, sea food, shell fish, eggs, and roe, milk, cream and cheese, fats and oils, herbs and spices, non alcoholic and non dairy beverages, alcoholic beverages, dietetic preparations, miscellaneous (salt, maggi cubes, iru, vinegar and fermented condiments).

This unit will enable you to gain an insight into quantity and quality of the food you eat. You will be able to identify many of the major and minor chemical components in your food. It will be possible, by the end of the unit, to determine whether your diet fulfills the natural requirements to keep you healthy.

2.0 OBJECTIVES

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

- define the major and minor constituents of food
- describe the food major groups
- classify human foods according to their functions
- describe the functions of each food major group
- differentiate between high and low energy foods
- enumerate the deficiency symptoms of low food intake
- explain the consequences of processing on the nutritive values of food major groups.

3.0 MAIN CONTENT

3.1 Food Groups Necessary in Human Diet

3.1.1 Bread and Cereal

Cereals common in sub-saharan Africa include corn, sorghum and millet. Corn differs from other cereals in that the yellow form contains carotenoids with *provitamin A* activity. Its other special feature is its low content of tryptophan. The niacin in corn is in a bound form that cannot be digested and absorbed by humans unless pre-treated with lime (calcium hydroxide) or by roasting. Most cereals contain little fat, although oats contain 7 percent. Wheat contains a type of dietary fibre (arabinoxylan hemicellulose) that is particularly valuable for treatment and prevention of constipation. It increases the bulk of the faeces and shortens the mouth-to-anus transit time. Bran is a concentrated source of the same dietary fibre.

Cereals are largely consumed as bread and to a lesser extent as cakes, crackers and breakfast cereals. They are also consumed in other forms in some countries; *e.g.*, boiled, crushed, or rolled, made into pasta, etc. Wheat and rice are the two major cereals for human consumption; wheat in Europe, North America, and northern India, and rice in East and Southeast Asia. The nutritional weakness of rice is its low thiamine and riboflavin (resulting in beriberi) content when it is milled to polished rice.

The bread-cereal group include all breads and cereals that are whole-grain or enriched. The protein content is not high in cereals, but these products can be a significant source of protein when they are consumed in large quantities. All cereals are very high in starch and are generally inexpensive sources of energy. The fat content of cereal products generally is very low unless the *germ* is included. Whole-grain products contribute significant quantities of fibre and such trace vitamins and minerals as pantothenic acid, vitamin E, zinc, copper, manganese and molybdenum.

3.1.2 Fruits and Vegetables

Fruits and vegetables have similar nutritive properties. Because 70 percent or more of their weight is water, they provide comparatively little energy or protein, however many contain vitamin C and carotene, two nutrients not found in cereals. Fresh fruits, particularly the citrus variety, and their juices are usually rich in vitamin C, which is easily destroyed when cooked. Fruits and vegetables also contain fibre, which adds bulk to the intestinal content and is useful in preventing constipation.

Most vegetables are important sources of minerals, vitamins and cellulose. Certain vegetables, such as potatoes, contribute appreciable quantities of starch. Large amounts of the minerals, calcium and iron are in vegetables, particularly beans, peas and broccoli. Vegetables also help meet the body's need for sodium, chloride, cobalt, copper, magnesium, manganese, phosphorus and potassium. Carotenes (the precursor of vitamin A) and ascorbic acid (vitamin C) are abundant in many vegetables. Vegetables are useful as sources of roughage. Citrus fruits are valuable sources of vitamin C and yellow-coloured fruits, such as peaches, contain carotene. Dried fruits contain ample amounts of iron. Figs and oranges are excellent sources of calcium. Like vegetables, fruits have high cellulose content.

3.1.3 Milk

The milk of each species of animal is a complete food for its young. One pint of cow's milk contributes about 90% of the calcium, 30 to 40% of the riboflavin, 25 to 30% of the protein, 10 to 20% of the calories and vitamins A and B, and up to 10% of the iron and vitamin D needed by an adult. The milks of mammals contain all essential nutrients. Human milk is the perfect food for infants, provided it comes from a *healthy, well-nourished mother* and the infant is full-term. Breast milk contains important antibodies, white cells and nutrients. In communities where hygiene is poor, breast-fed babies have fewer infections than formula-fed babies.

The milk group includes milk and milk products as well as cheese and ice cream. Milk is a complete protein food containing several protein complexes. It also contains important amounts of most nutrients, but it is very low in iron, ascorbic acid and niacin. Calcium and phosphorus levels in milk are very high. Vitamin A levels are high in whole milk, but this fat-soluble vitamin is removed in the production of skim milk. Riboflavin is present in significant quantities in milk unless the milk has been exposed to light.

Cow's milk is good food for human adults, but the cream (*i.e.* fat) contains 52 percent saturated fatty acids (longer than 10 carbon atoms in length) as compared to only 3 percent polyunsaturated fat. This fat raises the plasma cholesterol and is thought to be one of the dietary components that contribute to coronary heart disease, along with the same fat in concentrated forms (cream and butter). To circumvent this, the dairy industry has developed low-fat cow's milk (with 2 percent instead of almost 4 percent fat), very low-fat skim milk, or skim milk with extra non-fat milk solids (lactose, protein and calcium), which gives more body to the milk. Lactose, the characteristic sugar of milk, is a disaccharide made of the monosaccharides – glucose and galactose. While these monosaccharides are easily absorbed, lactose is not. Lactose passes to the large intestine, where it is fermented by the resident bacteria to produce gas and leading, sometimes, to diarrhoea.

In the late 1960’s, it was discovered that the adults of many ethnic groups couldn’t break down the lactose of large quantities of milk into galactose and glucose; they lose most of their intestinal lactase enzyme activity as they grow up (lactose intolerance). It is now recognised that such individuals share this deficiency with adults throughout the world, such as in Asia and Africa, and with most of the animal kingdom. People originating in northern Europe are the exception from the global viewpoint: they usually retain full intestinal lactase activity into adult life. People who have little of the enzyme lactase in their bodies can still take large amounts of milk if it has been allowed to go sour, if lactobacilli have split most of the lactose into lactic acid, or if the lactose has been treated with commercially available lactase.

The vitamin C present in milk is destroyed by heating (pasteurisation), which in many countries is required to prevent the milk from spreading bacterial and other infections. Cheese making is an ancient art formerly used on farms to convert surplus milk into a food that could be stored without refrigeration. Cheese is rich in protein and calcium and is a good source of vitamin A and riboflavin. Most cheeses, however, contain about 25 to 30% fat, which is mostly saturated, and they are usually high in salt (sodium).

3.1.4 Meat, Meat Substitutes, Fish and Eggs

Meats generally consist of about 20% protein, 20% fat and 60% water. The amount of fat present in a particular portion of meat varies greatly, not only with the kind of meat – pork, beef, lamb, etc. – but also with its quality. The "energy value" varies in direct proportion with the fat content. Meat is valuable for its protein, which is of high biological value. Meat also is an excellent source of B vitamins. Pork is the best source of thiamine, liver is next, and skeletal muscle, from any meat source, is third. Meat is also a good source of niacin, vitamin B_6, vitamin B_{12}, other vitamins of the B group, and the mineral nutrients iron, zinc, phosphorus, potassium, and magnesium. Liver is the storage organ for, and is very rich in, vitamins A and B_{12}. It is also an excellent source of riboflavin and folic acid.

The meat and meat substitutes group include beef, veal (calf's flesh), lamb, pork, organ meats such as liver, heart and kidney; poultry and eggs; fish and shellfish; and dried peas, beans and nuts. The meat group contains many valuable nutrients. One of its main nutrients is protein, but meat also contains cholesterol, which is believed to contribute to coronary artery disease. The minerals copper, iron and phosphorus occur in meats in significant amounts, particularly iron and copper in liver. Different meats vary in their vitamin content. Liver usually contains useful amounts of vitamin A, thiamine, riboflavin and niacin. All B vitamins occur in significant amounts in all meats.

The muscular tissue of fishes consists of 13-20% protein; varying amounts of fat, ranging from less than 1 to more than 20% and 60-82% water, varying inversely with fat content. Exact proportions of nutrients vary among different species. Furthermore, variations also exist within the same species due largely to seasonal and feeding variations. The fatty acids in fish are largely polyunsaturated. One of the major fatty acids, eicosapentaenoic acid, in large amounts reduces the tendency to thrombosis.

Eggs have a deservedly high reputation as a food. The white is protein and the yolk is rich in both protein and vitamins A, D, E and B. Eggs also provide zinc, calcium and iron with little saturated fat and few calories; egg yolk, however, has high cholesterol content, which at elevated level in the bloodstream, can increase one's risk of coronary heart disease. Research has shown that consuming up to one egg a day is unlikely to increase the risk of coronary heart disease in healthy men and women. Eggs are better kept fresh in the refrigerator for 4 – 5 weeks whereas hardboiled egg will only last a week. Consumers are reminded that eggs age more in one day at room temperature than during one week in a refrigerator. All eggs should be cooked at low or medium heat and should be served when the white is completely coagulated and the yolk has begun thickening to prevent food poisoning. Eggs should not be cooked whole in the microwave oven (they'll explode).

3.1.5 Starchy Roots

Potatoes, cassava and yams are valuable and cheap sources of energy. Their nutritive value, in general, resembles that of cereals, but their protein content is lower. Protein deficiency may be common in tropical communities in which the staple food is cassava or yams. Potato, however, provides some protein – less than cereal does – but also contains some vitamin C. Sweet Potatoes contain the pigment beta-carotene, convertible in the body into vitamin A.

Although the quantity of protein in potatoes is only small (2%), its nutritive value appears to be high. Cassava contains half the protein of potatoes. There are toxic substances in some of the starchy root foods that have to be avoided or dealt with by careful preparation; *e.g.*, solanine in the green sprouts of potatoes and cyanide compound in the leaves and outer parts of the roots of cassava.

3.1.6 Legumes (Pulses)

Peas and beans resemble the cereals in nutritive value but have higher protein content and, since they are not subject to milling, are good sources of B vitamins. They are thus valuable supplements to cereal diets, especially in tropical or subtropical countries; moreover, they, particularly the soybean, are also valued for their taste. Soybean is especially rich in protein (about 38%) and is a major commercial source of edible oil. They are however known to be good sources of antinutrients, which, if not properly taken care of, could limit the uptake and utilisation of other essential nutrients.

3.1.7 Sugars, Preserves & Syrups

Sugars, mostly sucrose and high-fructose corn syrup, are added both in processing and at the table. Together sucrose and fructose provide 12% of the average total calories in adults and a little more in children. There are also naturally occurring sugars in foods (fructose, glucose, sucrose in fruits and some vegetables, and lactose in milk). Sugar contains no protein, no minerals, and no vitamins and thus has been called a source of "*empty calories*." Sugar is an excellent preservative because it adsorbs water and prevents the growth of microorganisms. Jams contain from 30 to 60% sugar, and honey and natural syrups (*e.g.* maple) are composed of more than 75 percent sugar.

3.1.8 Fat and Oil-Based Foods

Animal fats used by humans are butter, suet from beef, lard from pork, and fish oils. Important vegetable oils include oils from olive, peanut (groundnut),, coconut, cottonseed, sunflower seed, soybean, safflower, rape, sesame, mustard,, red palm and corn. All these are high in calories. Only butter (other than the previously mentioned fish-liver oils) contains any of the vitamins A and D, but red palm oil does contain carotene, which is converted to vitamin A in the body. Vitamins A and D in controlled amounts are added to margarines. Butter, margarine, other fats, oils, sugars, or unenriched refined-grain products are included in the diet to round out meals and satisfy the appetite. Fats, oils and sugars are added to other foods during preparation of the meal or at the table. These foods supply calories and can add to total nutrients in meals.

3.1.9 Beverages

Although most adults drink one to two litres of water a day, much of this is in the form of liquids such as coffee, tea, fruit juices, soft drinks, beer, wines, or spirits. In general, these are appreciated more for their taste or for their effects than for their nutritive value. Fruit juices are, of course, useful for their vitamin C content and good sources of potassium but low in sodium. Coffee and tea by themselves are of no nutritive value, except that coffee contains some niacin and tea contains fluoride and manganese, but they may be a vehicle for intakes of sugar, milk or lemon. Beer contains 2 to 6% alcohol, natural wines 10-13%, and most spirits up to 40 percent.

Since ethyl alcohol has an energy value of seven kilocalories per gram, very significant amounts of energy can be obtained from alcoholic drinks; in addition, beer and wine contain natural sugars as well. The only vitamin present in significant amounts in beer from a brewery is riboflavin. Wines are devoid of vitamins but sometimes contain large amounts of iron, probably acquired from iron vessels used in preparation, especially of cheap wine. It is possible for excess iron to be absorbed and stored in the liver where it may contribute to toxic manifestations.

3.2 Changing Food Habits and Related Problems

Traditional food habits in themselves have rarely been the cause of malnutrition and nutritional-deficiency diseases. The usual cause of such problems has been a simple lack of food, whether because of environmental conditions or of poverty. The poor in any society may be forced to consume less food or a more limited variety of foods than they require. If the staple is protein-low (e.g. cassava or plantain based), the poor who cannot afford legumes or animal products to supplement the staple may suffer from kwashiorkor; if the staple is maize, pellagra may become prevalent if other foods are not consumed along with the maize. Advances in agricultural and food-processing techniques have led to increased food supply and a nutritionally enriched diet. Nevertheless, modernisation and westernisation of traditional food habits have also had their deleterious effects. For example, the wide acceptance of refined rice (like *Uncle Bens*, *Arosso*, *Tomato* etc) at the expense of locally parboiled rice (like *Ofada*, *Abakaliki*, *Ekiti* etc) at the turn of the 20th century caused a scourge of beriberi (a niacin-deficiency disease) in many developing countries, resulting in thousands of deaths. The substitution of bottle-feeding for breast-feeding among poor families has also been implicated in a great deal of malnutrition and diarrhoeal diseases in Nigeria.

Changing food habits have had harmful effects in the affluent developed nations, as well. The proportion of energy obtained from carbohydrates has dropped significantly (often ranging from 35 to 50%), while that obtained from fats and protein – particularly animal protein – is on a steady rise. This represents gross inefficient use of agricultural resources; in addition, the increasing sedentary nature of jobs and dependence on fast – foods as replacement for normal healthy meals increases nutritional deficiency diseases, even among the educated. Furthermore, the increased intake of saturated fat and cholesterol, coupled with inadequate exercises has been related to an increased prevalence of cardiovascular disease in both developing and developed nations. In the developed countries, about 40% of the calories supplied by their diets are derived from fat and about 20% from sugar. There has also been notable increase in fat and sugar intake especially in developing countries. However, fat and sugar crowd out other foods. In a population that is largely sedentary, this tends to lead to obesity and deficiencies in iron, calcium, complex carbohydrates and fibres – which can, in turn, cause a host of health problems.

3.3 Food Composition

3.3.1 Proteins

Proteins are essential structural and functional components of all living organisms. They are large molecules with widely varied properties and many different functions. Proteins consist of many amino acids linked together by *peptide bonds*. Haemoglobin, for example, is a red blood cell protein involved in the transport of oxygen. Enzymes are proteins that catalyse the chemical reactions of cells. Collagen is a major structural protein in bones, tendons and skin. Antibodies, which are critical components of the immune system, and crystallins, found in the lens of the eye, are proteins. Many hormones are proteins.

The primary functions of protein are to build body tissue, regulate functions such as muscle contraction and blood pressure, synthesize enzymes and some hormones (such as insulin, that regulate communication among organs and cells) and other complex substances that govern body processes.

Structure and Composition of Proteins

There are about 20 common amino acids in most proteins. The name of the acids comes from the stem word amine, meaning "derived from ammonia." Amino acids join together in long chains, the amino group (-NH-) of one amino acid linking with the carboxyl group (-COO-) of another. The linkage is known as a peptide bond ($-COONH_2$), and a chain of amino acids is known as a polypeptide. Proteins are large, naturally occurring polypeptides. A few rare amino acids and several other kinds of chemical substances – metal ions, heme, prosthetic groups derived from vitamins, carbohydrates and lipids – are also frequently present. The amino acids differ in structure and properties; each has an amino group, a carboxylic acid group and an alky side chain (-R). The side chains differ in size, structure and properties. Some are composed of only carbon and hydrogen atoms and are *hydrophobic* (water hating). Others contain oxygen and nitrogen atoms and are *hydrophilic* (water loving); some ionise and have positive or negative electrostatic charges. Each protein has a specific number and sequence of amino acids, where peptide bonds connect the amino group of one to the carboxyl group of the next. The resulting linear sequences give each protein a specific size, a unique three-dimensional structure and in one way or another, account for its properties.

Protein and Nutrition

Plants, bacteria and most other microorganisms synthesize all of the amino acids required for protein synthesis. Humans and most animals, however, cannot synthesise all of the amino acids and must obtain some of them from their diet. Proteins are usually readily available from both animal and plant sources. Of the 20 amino acids that make up protein, eight are considered essential – that is, because the body cannot synthesise them, they must be supplied ready-made in foods. If these essential amino acids are not all present at the same time and in specific proportions, the other amino acids, in whole or in part, cannot be used for metabolising human protein. Therefore, a diet containing these essential amino acids is very important for sustaining growth and health. When any of the essential amino acids is lacking, the remaining ones are converted into energy-yielding compounds, resulting in the excretion of its nitrogen. However, when excess protein is eaten, which is often the case in countries with heavy meat diets, the extra protein is similarly broken down into energy-yielding compounds. Because protein is by far more scarce than carbohydrates and yields the same 4 calories per gram, the eating of meat beyond the tissue-building demands of the body becomes an inefficient way of procuring energy. Foods from animal sources contain complete proteins because they include all the essential amino acids. In most diets, a combination of plant and animal protein is recommended: 0.8 grams per kg of body weight is considered a safe daily allowance for normal adults.

Increased risks of gout (disease with inflammation of the smaller joints, especially of the toe), certain cancers and heart disease have been correlated with high protein diets. Kwashiorkor, a protein-deficiency disease that primarily affects children 1 to 4 years old who are weaned on starchy foods, is still endemic to parts of Africa, Asia, and South America.

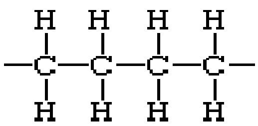
3.3.2 Fats

Fats or lipids are a family of chemical compounds stored by plants and animals as a source of energy. In most animals, fats are stored in special cells that tend to form pads of tissue under the skin and around certain organs and joints, the locations depending on the species. Stored fat, or adipose tissue, serves as a fuel reserve for metabolism. Fat protects the body from shocks, jolts and provides insulation. In plants, fats in the form of oil are found in the stems, seeds and fruit.

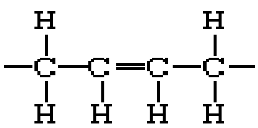
Fat is a concentrated source of energy, producing more than twice as much energy as equal amounts of carbohydrates and proteins. Being a compact fuel, fat is efficiently stored in the body for later use when carbohydrates are in short supply. Animals obviously need stored fat to tide them over dry or cold seasons, as do humans during times of scarce food supply. In industrial nations, however, with food always available and with machines replacing human labour, the accumulation of body fat has become a serious health concern. All fats are made up of units of glycerol and fatty acids. The kind of fatty acids eaten can affect a person's health. Saturated fatty acids found in butter, milk and other animal products can raise the level of cholesterol in the blood, thus leading to *arteriosclerosis*. Unsaturated fats found in vegetable oils can reduce high levels of blood cholesterol.

Dietary fats are broken down into fatty acids – the source of metabolic energy for muscle contraction – that pass into the blood to form the body's own triglycerides. The body's adipose tissue is in a constant state of build-up and breakdown, thus ensuring a continual supply of fatty acids. Fatty acids containing as many hydrogen atoms as possible on the carbon chain are called *saturated fatty acids* and are derived mostly from animal sources. *Unsaturated fatty acids* are those that have some of the hydrogen atoms missing; this group includes *monounsaturated fatty acids*, which have a single pair of hydrogen missing, and *polyunsaturated fatty acids*, which have more than one pair missing. Polyunsaturated fats are found mostly in seed oils. Saturated fats in the bloodstream have been found to raise the level of cholesterol, and polyunsaturated fat tends to lower it. Saturated fats are generally solid at room temperature; polyunsaturated fats are liquid.

The predominant substances in fats and oils are triglycerides, chemical compounds containing any three fatty acids combined with a molecule of glycerol. The fatty acids consist of a chain of carbon atoms with a carboxylic acid group (-COOH) at one end. The number of carbon atoms ranges from four to more than 22, but the most common chain length is 16 or 18. Because they are synthesised in the body from two-carbon units (acetyl coenzyme A), chain lengths are nearly always even numbers. Butyric acid is an example of a saturated fatty acid. The four valences of each carbon atom are attached to two hydrogen atoms and to the two adjacent carbons:



When adjacent carbon atoms are linked by a double bond, each has only one valence available for hydrogen:



When no double bonds are present, the fatty acid is said to be saturated; with the presence of one (monounsaturated) or more (polyunsaturated) double bonds, the fatty acid is said to be unsaturated.

Fats with a high percentage of saturated fatty acids tend to be solid at room temperature; *e.g.* butter and lard. Those with a high percentage of unsaturated fatty acids are usually liquid oils; *e.g.* sunflower, safflower and corn oils. In the shorthand notation for fatty acids, the number to the left of the colon is the number of carbon atoms, while the number to the right of the colon represents the number of double bonds; *e.g.* 4:0 has four carbon atoms and no double bonds (*i.e.* saturated). This is the shorthand notation for butyric acid.

A small group of fatty acids are essential in the diet. They occur in body structures, especially the different membranes inside and around cells, and cannot be synthesised in the body from other fats. Linoleic acid (18:2) is the most important of these fatty acids because it is convertible to the other essential fatty acids. Linoleic acid has two double bonds and is a polyunsaturated fatty acid. As well as being an essential fatty acid, it tends to lower the plasma cholesterol. Linoleic acid occurs in moderate to high proportions in many of the seed oils; *e.g.* corn, sunflower, cottonseed and safflower oils. Somemargarines (polyunsaturated margarines) use a blend of oils selected so that they have a moderately high linoleic acid content. Edible fats and oils contain smaller amounts of other lipids as well as triglycerides).

3.3.3 Carbohydrates

Carbohydrates, which include cellulose, starches, sugars and many other compounds, are the most abundant single class of organic substances found in nature. They are formed in green plants by a process known as photosynthesis, in which energy derived from sunlight is used for the assimilation of carbon dioxide from the air. Most naturally occurring sugars belong to the D-series, the most common being the aldohexoses, which have six carbon atoms and four asymmetric centres. Aldohexoses include glucose, mannose, galactose and the fruit sugar fructose. The aldopentose sugars ribose and deoxyribose – having 5 carbon atoms – are important constituents of nucleic acids.

Disaccharides and polysaccharides are formed from two or more monosaccharides joined by chemical bonds. Glucose linked to fructose, forms the disaccharide sucrose (cane sugar); glucose linked to galactose forms the disaccharide lactose (milk sugar); glucose linked to glucose forms the disaccharide maltose. Starch, glycogen and cellulose are all chains of glucose units, differing only in their modes of bonding and degree of chain branching. Some biologically important sugar derivatives are sugar alcohols, sugar acids, deoxy sugars, amino sugars, sugar phosphates, muramic and neuraminic acids.

Carbohydrates function as the main structural elements and storage products of energy in plants. The principal forms are starch in plants and glycogen in animal tissues. These are polymers of glucose; they are deposited in cells in the form of granules when a surplus of glucose is available. In times of metabolic need, the polymers are broken down by enzymatic action and become fuel. Plants store starch in roots, tubers and leafy parts mainly during photosynthetic activity; some plants, such as sugar beets and sugarcane, also store sucrose.

Carbohydrates and Nutrition

Carbohydrates are the most abundant food sources of energy. The two kinds of carbohydrates are *starches* and *sugars*. Starches are found mainly in grains, legumes and pulses, roots and tubers and some rhizomes, while sugars are found in plants and fruits the most important being sucrose (obtained from sugarcane or the sugar beet). The carbohydrates containing the most nutrients are the complex carbohydrates, such as unrefined grains, tubers, vegetables and fruits, which also provide protein, vitamins, minerals and fats. Less beneficial sources are foods made from refined sugar, such as confectionery and soft drinks, which are high in calories but low in nutrients and fill the body with what nutritionists call *empty calories.*

A large part of the human diet consists of carbohydrates in the form of starch and sucrose. Both must first be broken down to their component sugars by digestive enzymes before absorption into the bloodstream can take place. In humans, carbohydrates are used by the cells in the form of glucose, the body's main fuel. After absorption from the small intestine, glucose is processed in the liver, which stores some as *glycogen,* a starch-like substance, and passes the rest into the bloodstream. In combination with fatty acids, glucose forms *triglycerides* – fat compounds that can easily be broken down into combustible ketones. Glucose and triglycerides are carried by the bloodstream to the muscles and organs to be oxidised. Excess quantities are stored as fat in the adipose and other tissues, to be retrieved and burned at times of low carbohydrate intake.

4.0 CONCLUSION

Cereals, roots and tubers supply energy and vitamin B complex, legumes and leafy vegetables supply proteins and carotenoids or pro-vitamin A, while meat, fish and eggs supply proteins. Animal fats contain mainly saturated fatty acids, whereas vegetable oils contain poly-unsaturated fatty acids which are essential to humans. Food therefore is composed of major nutrients such as proteins, Fats and Carbohydrates. It also consists of minor but essential nutrients such as vitamins and minerals.

5.0 SUMMARY

In this unit we have learnt that:

Foods can be classified into 17 major groups e.g. Cereals, Roots, Meat and Meat Products etc.
Food contains different compositions depending on the group that it belongs to
Cereals include Rice, Corn, Millet, Sorghum which supply low tryptophan needed for body build up of Niacin. Polished rice is also low in thiamine. Cereals however supply fibre.
Legumes, Meat, and Milk supply high proteins but also legumes contain anti-nutrients.
Fruits and vegetables contain 70% water but supply high vitamin C (Ascorbic acid)
Milk and milk products are rich in proteins, while infants survive on breast milk which contains antibodies which prevents infections.

SELF ASSESSMENT EXERCISE

1. Define major and minor constituents of food.
2. Classify Foods in terms of their composition, i.e. those that are rich in proteins, fats and carbohydrates and those that are rather rich in vitamins and minerals.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss the effects of food processing on the nutritive values of cereals and legumes.
2. Differentiate between animal fats and vegetable fats. Why are vegetable fats essential in human foods?

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UNIT 3 THE ROLE OF VITAMINS IN NUTRITION

CONTENTS

1.0 INTRODUCTION

Vitamins are organic compounds that function mainly in enzyme systems to enhance the metabolism of proteins, carbohydrates, and fats. They are not synthesised in the body hence must be obtained, therefore, from outside sources as food. Exceptions to this definition include vitamin D, which is synthesised in the body to a limited extent, and vitamins B_{12} and K, which are synthesised by bacterial flora in the intestinal tract. Without these substances, the breakdown and assimilation of foods could not occur. Certain vitamins participate in the formation of blood cells, hormones, nervous-system chemicals, and genetic materials. Vitamins and minerals function as "*cofactors*" in the metabolism of products in the body. Most aspects of body metabolism proceed with the aid of specific enzymes, but if additional catalysts were not present – for example, the cofactor vitamins and minerals – the reactions would proceed so slowly that they would be ineffective.

Vitamins are classified into two groups, the fat-soluble and the water-soluble vitamins. Fat-soluble vitamins include vitamins A, D, E, and K. The water-soluble vitamins include vitamin C and the B-vitamin complex.

2.0 OBJECTIVES

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

- define a vitamin
- list the fat soluble vitamins
- list the water soluble vitamins
- discuss dietary sources of the vitamins
- explain the deficiency symptoms of three named vitamins.

3.0 MAIN CONTENT

3.1 Vitamins

3.1.1 Fat Soluble Vitamins

3.1.1.1 Vitamin A (Retinol)

Vitamin A is found in animal foods, especially in liver of land animals or fish. It exists in a variety of forms, including retinol, which is currently considered the most active form. Most of the world's population, however, derive most or all of their vitamin A from plant foods, many of which contain the yellow-orange pigment carotene. Carotene, a pigment in some plants, can be converted in the human body to vitamin A. One molecule of β-carotene can be cleaved by an intestinal enzyme into two molecules of vitamin A. The pigment β-carotene occurs in fruits such as apricots, peaches, melons, mangoes and pumpkins. It is also a companion of chlorophyll, the green pigment in leaves, so that green vegetables are good sources. Enough vitamin A is stored in the liver of a well-nourished adult to last about two years of deprivation.

Vitamin A has many important functions in the body that relate to the maintenance of membrane integrity, especially of epithelial cells and mucous membranes. It is also essential for bone growth, reproduction and embryonic development. Vitamin A deficiency results in *night blindness*, in which the ability of the eye to see in dim light is impaired, permanent blindness and extremely dry skin *Hypervitaminosis A*, which results from excessive intake over a long period of time, is most common in children. Symptoms consist of irritability, vomiting, loss of appetite, headache, dry and scaling of skin.

3.1.1.2 Vitamin D

Dairy products, eggs and cod liver oil are good sources of vitamin D. The active forms of vitamin D are *ergocalciferol* (vitamin D_2) and *cholecalciferol* (vitamin D_3), both of which arise in the body from ingested precursors by exposure of the skin to ultraviolet light. Vitamin D primarily regulates calcium metabolism by determining the movement of calcium from intestines to blood and from blood to bone. It interacts with parathyroid hormone and calcitonin in controlling calcium levels. Thus, vitamin D is today more legitimately considered a hormone rather than a vitamin. In tropical countries, where exposure to sunlight is high, vitamin D deficiency is rare. Ultraviolet irradiation of food products increases their vitamin D content.

Whether formed in the skin from a derivative of cholesterol or taken from the diet (*e.g.*, in fatty fish and dairy products), vitamin D is changed in the liver to 25-hydroxyvitamin D. This is further changed in the kidney by an enzyme (regulated by parathormone) to 1,25-dihydroxyvitamin D (1,25-$(OH)_2$ vitamin D), the active form. The best-known action of activated vitamin D at the cellular level is to turn on synthesis of calcium transport protein in the cells lining the small intestine.

A deficiency of vitamin D results in failure to absorb calcium and phosphorus, causing faulty formation of bone. In children, the syndrome is known as *rickets* and is manifested by deformities of the rib cage and skull and bowlegs. Adult rickets, or *osteomalacia*, is characterised by generalised bone decalcification and, eventually, gross bone deformities. Symptoms of *hypervitaminosis D* consist of weakness, fatigue, lassitude, headache, nausea, vomiting and diarrhoea. Urinary symptoms occur when calcium deposits build up in the kidneys (kidney stones).

3.1.1.3 Vitamin E

Vitamin E, chemically known as *alpha tocopherol*, is the most active of the group of tocopherols. It is present in seed oils, especially wheat-germ oil, margarine, seeds and green leafy vegetables. Vitamin E protects fatty acids and cell membranes from oxidation. Few vitamins have been implicated for more diseases than has vitamin E, including such diverse disorders as coronary artery disease, muscular dystrophy, habitual abortion and schizophrenia (mental disease marked by a breakdown in the relation between thoughts, feelings and actions, and often with delusions and retreat from social life). Thus far, vitamin E is considered to have possible value in decreasing the risk of cancer. It is relatively non-toxic.

3.1.1.4 Vitamin K

Vitamin K, found mainly in green leafy vegetables egg yolk, liver and fish oils, is essential for synthesis by the liver of several factors necessary for the clotting of blood. Although the alphabetical letters for most vitamins are arbitrary, the letter *K* came from the German *Koagulationsvitamin.* One vitamin (K_1) occurs in some plant foods; others (the vitamin K_2 group) are formed by bacteria in the large intestine Chemically, *phylloquinone* is the natural plant source of vitamin K, and a synthetic derivative, *menadione,* is used therapeutically. Although deficiency of vitamin K rarely occurs, when it does the result is uncontrolled bleeding. It is used medically in treating specific deficiencies that occur during anticoagulant therapy, in haemorrhagic disease of the newborn, and in *hepatocellular* (liver related) diseases.

3.2 Water Soluble Vitamins

3.2.1 Thiamine (B1)

Thiamine, the first B vitamin to be identified chemically in 1926, consists of a complex organic molecule containing a pyrimidine and a thiazole nucleus. In the body, it functions as a coenzyme in the form of thiamine pyrophosphate and is important in alcohol, some amino acids and carbohydrate intermediary metabolism. Alcoholics are at special risk of thiamine deficiency because the more alcohol a person drinks, the less thiamine-containing food he consumes. Alcohol requires thiamine for its metabolism, and body’s reservoir of thiamine is smaller than for any other vitamin. It only takes about 30 days without thiamine intake before signs of deficiency appear, provided the calorie intake is maintained. The symptoms of thiamine deficiency are known as *beriberi*, a syndrome consisting primarily of peripheral neuritis marked by sensory and motor paralysis of the limbs and, finally, heart failure. Thiamine deficiency is prevalent during damage and most often occurs in nutritionally deficient alcoholics. Thiamine is found in whole-grain cereals, meats, yeasts, and nuts.

When thiamine is deficient, the two most prominent biochemical abnormalities are *the accumulation of pyruvic acid,* because the enzyme that processes pyruvic acid for entry into the tricarboxylic acid cycle cannot function without thiamine, and *disturbances in areas of the nervous system*, a system highly dependent on glucose as fuel and thus requiring thiamine as an essential coenzyme for three steps in glucose metabolism. Thiamine deficiency can lead to *beriberi*, *Wernicke's encephalopathy* in association with *Korsakoff's* syndrome, or a *peripheral neuropathy* (a disorder of the peripheral nervous system).

Beriberi is a high-output cardiac failure associated with general dilatation of small blood vessels in response to accumulation of pyruvic and lactic acids. It was formerly common in rice-eating peoples of East Asia but is now rare. In Wernicke's encephalopathy, the abnormalities are in the central part of the brain. There is progressive mental deterioration, disorientation, and a characteristic paralysis of eye movements. Like beriberi, it responds dramatically to injection of thiamine, but unlike beriberi, there may be a residual abnormality of memory. Thiamine deficiency is one of many causes of peripheral neuropathy, generally involving an impairment of the sensory, motor and reflex functions of the limbs. However, other B-vitamin deficiencies and a number of toxins can produce a similar effect. Response to nutrient therapy always takes weeks and it is advisable to treat the disease with multiple B vitamins. Good sources of thiamine are cereals, yeast, meat (pork, liver, poultry), nuts, beans, potatoes, egg yolk, milk, peanut butter, enriched and whole grain bread.

3.2.2 Riboflavin (B_2)

Riboflavin is a fluorescent yellow-green water-soluble vitamin colour which plays a vital role in intermediary metabolism. It has a complex organic ring structure to which the sugar ribose is joined. In the body, riboflavin is conjugated by phosphate to yield riboflavin 5'-phosphate (FMN) and by Adenine Dinucleotide to yield Flavin Adenine Dinucleotide (FAD). Both serve as coenzymes for a wide variety of respiratory proteins. Riboflavin deficiency in humans is characterised by growth failure in children, nerve degradation (particularly of the eyes), sore throat; seborrheic dermatitis of the face (and body mass) and anaemia. The only established use of riboflavin is in the therapy or prevention of deficiency disease. Food sources include: dairy products (milk, cheese), meat (liver, kidney, poultry), fish, wheat, yeast, enriched and whole grain breads.

3.2.3 Niacin (B_3)

Niacin is a water-soluble vitamin that is made in the human liver by the conversion of the amino acid tryptophan. If the protein intake is low, pre-formed niacin must be provided in the diet; if the protein intake is generous, the body makes its niacin from the tryptophan. Some animals (such as cats) do not have this ability. Two forms of niacin exist: nicotinic acid and nicotinamide. In the body, niacin is present in Nicotinamide Adenine Dinucleotide (NAD) and Nicotinamide Adenine Dinucleotide Phosphate (NADP), whichserve as coenzymes in conjunction with protein in tissue respiration and also as dehydrogenases.

Pellagra, caused by niacin deficiency, is characterised by a cutaneous eruption, which at first resembles sunburn because it affects the areas of the body exposed to sunlight. The tongue becomes red and swollen, with excessive salivary secretion. Diarrhoea also occurs along with nausea and vomiting. Later, central-nervous-system symptoms appear with headache, dizziness, insomnia, depression and even overt psychosis with hallucinations and other mental disturbances.

Nicotinic acid (in doses about 200 times the RDA) is used in medicine as a drug that lowers the cholesterol level in the plasma. This is an example of a pharmacological action of a nutrient. Because nicotinic acid in large doses lowers blood lipids, it has been extensively used in the therapy and prevention of arteriosclerotic vascular disease. It is also used in the treatment of pellagra. Toxicity may occur in the form of liver damage with large doses over a prolonged period. Food sources of niacin are meat, poultry, dark green vegetables, cereals, whole grain or enriched breads.

3.2.4 Pyridoxine (B_6)

Pyridoxine, found mostly in whole-grain cereals, vegetables and meats, is a substituted pyridine ring structure that exists in three forms, all of which may be converted in the body to pyridoxal-5-phosphate (PLP), the active coenzyme form. PLP functions in human metabolism in the conversion processes of amino acids, including decarboxylation, transamination and racemization.

Pyridoxine in megadoses (100 and more times the RDA of around two milligrams per day) has been taken to ameliorate the effects of premenstrual syndrome (prescribed or self-medication), but its efficacy has not been established. Symptoms of deficiency in humans consist of seborrhoea-like skin lesions of the face, increased irritability, convulsive seizures (particularly in children), kidney stones and neuritis (inflammation of nerves) resulting in degeneration of peripheral nerves. On the other hand, prolonged dosage of 500 milligrams and above of vitamin B_6 over a period of time causes damage to peripheral nerves, with a loss of sensation in legs and hands.

3.2.5 Pantothenic Acid

Pantothenic acid was first identified in 1933 as a factor necessary to cure certain skin lesions in chicks. It is found mainly in milk products, liver, eggs, grains and legumes. Pantothenic acid is converted to coenzyme A, which serves a vital role for a variety of reactions involving transfer of 2-carbon fragments (acetyl groups). It is also essential for the production of metabolic products crucial to all living organisms.

Pantothenic acid has no specific curative indications but is included in multivitamin preparations.

3.2.6 Folic Acid

The name comes from Latin *folia* ("leaf"). This vitamin is found in animal organs, legumes, whole-grain cereals, as well as vegetables. Chemically, folic acid is pteroylglutamic acid. In the body, folic acid is converted to folinic acid (5-formyl-tetrahydrofolic acid), the coenzyme form, which accepts 1-carbon units important in the metabolism of many body compounds.

The main function of folic acid is in the synthesis of DNA, thus in folic acid deficiency, replication of DNA and cell division are slowed or stopped; nucleic acid synthesis will also not take place. Cells that rapidly turn over, such as blood cells and epithelial cells lining the intestine are affected first. The requirement for folic acid is notably increased in pregnancy. It is sensitive to heat and is mostly destroyed when vegetables are over-boiled. Folic acid deficiency can occur in late pregnancy, when the requirement is double that in other adults. It is also fairly common in patients with diseases in which cell division is increased; *e.g.*, in blood diseases or cancer. The most common cause of vitamin B_{12} deficiency is pernicious anaemia, in which absorption of the vitamin is defective because of the failure of the stomach to secrete a special protein (intrinsic factor) that assists absorption of vitamin B_{12} in the lower intestine. Dietary deficiency occurs in vegetarians, who eat no animal food. It takes five or more years of such a diet before symptoms appear because the stores of vitamin B_{12} in the liver (about 1.5 milligrams are enough to last about five years with the daily requirement as small as one microgramme).

Deficiency in humans results in various anaemias and diarrhoea. Deficiency can also be induced by antivitamins such as methotrexate, which is used in cancer chemotherapy. Folic acid is present in many common foods like vegetables and liver – but can be destroyed by excessive cooking. Deficiency is relatively rare unless caused by an antivitamin or pregnancy.

3.2.7 Cyanocobalamin (B_{12})

Vitamin B_{12}, the last of the vitamins to be isolated in 1948, is chemically the most complex of all the vitamins. It has the highest molecular weight (1,355) compared with any vitamin, and is absorbed by a complex mechanism. It has a central ringed structure called a corrin nucleus, linked to an amino propanol esterified by a nucleotide, and also an atom of cobalt to which is attached a cyanide group. Few vitamins are as important metabolically as B_{12}, because it is involved in many of the synthetic steps required in the manufacture of nucleoproteins and proteins. Almost all organisms need this vitamin but only in very small amounts.

The ability to absorb this vitamin depends on the production by the stomach of an intrinsic factor, a glycoprotein. Cases of B_{12} deficiency often involve patients with defective production of this intrinsic factor. Failure of absorption (pernicious anaemia) is more common than dietary deficiency. Vitamin B_{12} is found only in animal foods, so that *vegans* (pure vegetarians) are at risk of deficiency over the course of several years. The requirement of vitamin B_{12} (with vitamin D) is the smallest of all the vitamins, only two micrograms per day. What is stored in the liver is enough to last for five years of deprivation. Vitamin B_{12} participates with folic acid in DNA synthesis so its deficiency leads to a similar anaemia.

The symptoms of deficiency are identical to the classical syndrome of pernicious anaemia: ineffective manufacture of red blood cells; faulty myelin synthesis, leading to paralysing neuritis (inflammation of nerves) and a failure to maintain the epithelium of the intestinal tract. Marked anaemia and generalised debility, which eventually develop, are always fatal unless treated. Cyanocobalamin has only one established use, the treatment of this deficiency disease, but is included nevertheless in many multivitamin preparations. Food sources are mainly of animal origin, namely: milk, eggs, meat, poultry, fish, liver, kidney and heart.

3.2.8 Ascorbic Acid (Vitamin C)

Ascorbic acid is a plant sugar in the acid form, hexuronic acid. It is the opposite of vitamin B_{12} in that it is found in almost all plant foods, notably citrus fruits, green leafy vegetables and tomatoes, but not in meat. It is a powerful antioxidant and is required for the formation of collagen; *i.e.,* in wound healing. Unlike vitamins of the B complex, ascorbic acid does not act as a cofactor. In the body, ascorbic acid is reduced to dehydroascorbic acid and is involved in oxidation-reduction reactions. Vitamin C functions mainly in the formation and maintenance of intercellular ground substance and collagen in teeth, bone and connective tissue of blood vessels.

Symptoms of deficiency are manifested mainly in bone and blood vessels: teeth loosen because dentin is absorbed and the gums become spongy and bleed easily; haemorrhages in other tissues also occur easily with the slightest trauma. Vitamin C is used to prevent and treat scurvy and many other disorders, including various dental problems. Intake of very large amounts for long periods of time can be harmful, even though vitamin C is well tolerated, as it may contribute to the formation of kidney stones in the urinary tract. A daily intake of sufficient fresh orange juice provides enough vitamin C for most purposes.

3.2.9 Biotin, Choline and Inositol

Biotin, a complex organic acid containing sulphur, is a coenzyme for several carboxylation reactions involving carbon dioxide fixation. It is synthesized by intestinal bacteria and is widespread in food products like meats, vegetables and legumes. A natural deficiency in humans is unknown, even in individuals on extremely deficient diets.
Choline, a simple amino alcohol, is a component of lecithin and of acetylcholine, the latter of which is one of the most important neurotransmitters. Unlike most vitamins, choline can be synthesised in the body, provided that methionine intake is sufficient. It is present in large amounts in egg yolk, milk and seafood. Human deficiency rarely occurs.

Inositol is an isomer of glucose, the common sugar of human diets. It is a component of certain phospholipids. No coenzyme function has been established, but inositol promotes the growth of yeast.

4.0 CONCLUSION

Vitamins are micronutrients present in the body system regulating the metabolism of proteins, fats and carbohydrates. They are mainly obtained from dietary sources although some of them can be synthesized in the body system (e.g. vitamin D) and by bacterial flora in the intestine (e.g. vitamins B_{12} and K).

5.0 SUMMARY

Fat-soluble vitamins are usually absorbed with foods that contain fat. They are broken down by bile in the liver, and the emulsified molecules pass through the lymphatic system and veins to be distributed through the arteries. Excess amounts are stored in the body's fat and in the liver and kidneys. Because fat-soluble vitamins can be stored, they do not have to be consumed every day.

With the exception of vitamin C (ascorbic acid), water-soluble vitamins belong mainly to what has been termed the B complex of vitamins. The better-known B vitamins are thiamine (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6), pantothenic acid, lecithin, choline, inositol, and paraaminobenzoic acid (PABA). Two other members are folic acid and cyanocobalamin (B_{12}). Yeast and liver are natural sources of most of these vitamins.

SELF ASSESSMENT EXERCISE

List the water soluble vitamins and fat soluble vitamins.

6.0 TUTOR-MARKED ASSIGNMENT

1. Compare and contrast the functions of Vitamin A and Vitamin C.
2. (a) Name two vitamins that are derived only from animal sources.
   (b) Name two vitamins that are available mainly in plants and cereals.

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UNIT 4 THE ROLE OF MINERALS IN HUMAN

CONTENTS

1.0 INTRODUCTION

Unlike sodium and potassium which are staple elements of the diet and are present in ample amounts in all food of vegetable and animal origins, certain minerals are additional dietary requirements. Although most are present in the average diet, these minerals may not always be ingested in quantities sufficient to satisfy metabolic needs, especially during growth, stress, trauma, blood loss and in some diseases. Minerals are classified as major or trace depending on the body's requirements. Major minerals are: calcium, magnesium, chlorine, phosphorus, potassium, sulphur, sodium and potassium. Trace elements are other inorganic substances that appear in the body in minute amounts and are essential for good health. Little is known about how they function, and most knowledge about them comes from how their absence, especially in animals, affects health. Trace elements appear in sufficient amounts in most foods. They include chromium, copper, fluorine, iodine, iron, selenium and zinc.

2.0 OBJECTIVES

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

- classify minerals in the body into major and trace elements
- discuss main metabolic functions of each mineral element through the deficiency symptoms
- identify major dietary sources of these mineral elements
- discuss the advantages of eating foods containing dietary fibre.

3.0 MAIN CONTENT

3.1 Mineral Elements

3.1.1 Major Elements

3.1.1.1 Calcium

The body's requirements for calcium are generally met by eating or drinking dairy products, especially milk and cheese as well as dried legumes and vegetables. Most calcium (about 90%) is stored in bone, with a constant exchange occurring among blood, tissue and bone. The intake is balanced by losses in urine and faeces. The blood levels of calcium and its intestinal absorption, deposition, or mobilisation from bone are all controlled by a complex interplay of vitamin D, parathyroid hormone and calcitonin. Contrary to some long-held beliefs, high intakes of protein and phosphorus do not lead to a loss of calcium. Excessive dietary fibre, however, can hinder its absorption.

Calcium promotes bone rigidity and is important in maintaining the integrity of intracellular cement and cellular membranes. It also regulates nervous excitability and muscle contraction and may be protective against high blood pressure. During periods of growth, pregnancy and lactation, calcium intake should be increased. Diseases of calcium metabolism include vitamin D deficiency, hypervitaminosis D, hypo- and hyper-parathyroidism, and some forms of renal disease.

Calcium depletion is difficult to recognise because 99 percent of the calcium in the body is in the bones. A 1 % reduction of bone calcium is impossible to detect. This amount, though small, is quite large (it amounts to about 10 – 12 g). *Osteoporosis*, a calcium deficiency disease, is manifested by reduced bone mass for a particular length or volume of bone. This implies less mineral [calcium phosphate] and bone protein, and by extension, reduced or impaired bone mobility. Osteoporosis is common in postmenopausal women in industrial societies. It causes bone pain and a tendency to fractures. It clearly has multiple causes, including lack of exercise as well as the possibility of insufficient dietary calcium.

3.1.1.2 Phosphorus

Phosphorus plays important roles in conjunction with calcium in bone and teeth formation, acid-base balance maintenance, haemostasis of calcium and in reactions involving carbohydrates, lipids and proteins. The chemical energy of the body is stored in "high energy phosphate" compounds (ATP's). Elemental phosphorus is extremely poisonous, but phosphorus ingested as phosphates in the diets based on milk, cheese, yoghurt, fish, poultry, meats and grains, is not toxic. Deficiency is manifested in general body weakness and loss of calcium.

3.1.1.3 Magnesium

Magnesium is an essential element in human metabolism and functions in the activities of muscles and nerves, enzyme activation, protein synthesis and many other reactions. Magnesium is also important for maintaining the electrical potential in nerve and muscle cells. It is found mainly in whole grains and green, leafy vegetables. Magnesium deficiency results in growth failure, behaviour problems and occasional spasms. Magnesium deficiency may also occur in cases of alcoholism, diabetes mellitus, pancreatitis and renal diseases. Prolonged deficiency can cause changes in heart and skeletal muscle. Excessive retention of magnesium can occur in renal disease and results in muscle weakness and hypertension. A deficiency in magnesium among malnourished people, especially alcoholics, leads to tremors and convulsions.

3.1.1.4 Sodium

Sodium, which is present in small and usually sufficient quantities in most natural foods, is found in liberal amounts in salted prepared and cooked foods. It functions mainly in the maintenance of acid-base and body water balance, and nerve function regulation. Its depletion occurs, usually with accompanying water loss, as a result of massive loss of fluids as in severe cases of diarrhoea, vomiting and excessive urination. The patient ends up being weak and exhausted. Sodium depletion (usually accompanied by chloride depletion) occurs in a number of disease states. Deficiency results in muscle cramps, reduced appetite and mental apathy. Too much sodium causes *oedema*, an over accumulation of extra cellular fluid. Evidence now exists that excess dietary salt contributes to high blood pressure.

3.1.1.5 Potassium

Potassium occurs naturally in bananas, leafy vegetables, potatoes, milk and meats. It functions mainly in maintenance of acid-base and fluid balance and nerve transmission Depletion occurs in situations similar to sodium and may become obvious if sodium and water, but not potassium, are replaced. Potassium loss is especially likely to occur with diarrhoea or overuse of purgatives, with regular use of diuretic drugs (drugs causing increased output of urine), with corticosteroid treatment. In potassium depletion the serum-potassium level is low, there is weakness of voluntary muscles and intestinal peristalsis may stop. Under these conditions, the electrocardiograph shows low T waves. Deficiency results in muscle cramps, mental confusion, loss of appetite, and irregular cardiac rhythm

3.2 Trace Metals

3.2.1 Iodine

Iodine is found naturally in salt-water fishes, shellfish, dairy products and vegetables. The one important function of iodine is associated with the synthesis of thyroxine and the function of the thyroid gland. Persons living in coastal regions usually receive an adequate supply of iodine because of the high content in seafood. In geographic regions located far inland, however, a lack of iodine in food is apt to occur, causing goitre, so a small amount of iodine is often added by manufacturers of table salt (iodised salt). Elemental iodine is highly poisonous, and its only use in medicine is as an antiseptic.

Iodine is necessary for the synthesis of the hormones of the thyroid gland. In the absence of adequate iodine, the thyroid enlarges because of increased secretion of pituitary thyrotrophin. Where the frequency of endemic goitre is high, babies are often born with cretinism (a cause of mental defect and dwarfism), in addition, a large percentage of apparently normal people in the community develop abnormalities such as learning disabilities, deafness, a higher rate of stillbirths and malformed babies. Iodised salt is effective only in developed communities. For remote, isolated communities the best method of prevention is an injection of two millilitres of iodised oil to all women of childbearing age.

3.2.2 Iron

Iron is a vital component of haemoglobin and also of certain respiratory enzymes. The main function of iron is in the formation of haemoglobin, the red pigment of the blood that carries oxygen from the lungs to other tissues. Foods high in iron content include meat (liver and heart), Lean meats, eggs, whole grains, wheat germ, legumes and most green vegetables. Increased requirements for iron occur during the growth period, pregnancy, excessive menses and other instances of blood loss. An average diet containing 10 to 15 mg a day is adequate for most people. Iron deficiency, resulting in anaemia, can be treated by large amounts of iron in order to gain positive absorption.

Iron deficiency is common throughout the world, much more so in women than in men. Bleeding depletes the body of iron because each millilitre of blood contains 0.5 milligram of iron. When iron stores are empty, there is anaemia (reduced red blood cell count) with small cells containing less haemoglobin than normal (microcytic, hypochromic anaemia).

3.2.3 Zinc

Zinc, found mainly in lean meat, whole-grain breads and cereals, dried beans and seafood serves as a cofactor of dehydrogenases and carbonic anhydrase. Zinc loss occurs during such stress situations as surgical operations and its replacement aids in wound healing. Dietary programmes often promote zinc loss, while the use of concentrated zinc supplements can lead to calcium deficiency. Features of zinc deficiency in humans have been protean: various combinations of loss of taste, retarded growth, delayed wound healing, baldness, pustular skin lesions, growth failure, small sex glands, impotence in males, infertility in females, delayed wound healing, mental lethargy and reduced immunity to infections. Over ingestion of zinc or inhalation of its vapours can cause depression, vomiting and headache.

3.2.4 Fluorine

Fluorine is concentrated in the dental enamel and in bones as fluoride. It functions in bone structure maintenance and increases the resistance of the enamel to erosion by acid. The chronic toxic dose of fluoride starts at intakes of about five milligrams per day; the first sign is mottling of the teeth. Above 10 milligrams per day bony outgrowths may occur (skeletal fluorosis). The only foods that contain appreciable amounts of fluoride are tea and fish. In communities and countries where the drinking water is not fluoridated many obtain some fluoride from toothpastes, a few give fluoride tablets to children prophylactically, and dentists apply fluoride solution directly to their patients' teeth periodically. Deficiency results in osteoporosis and tooth decay.

3.2.5 Other Trace Minerals

Selenium, found mainly in seafoods, meat and grains, prevents breakdown of fats and other body chemicals. However, its deficiency is manifested in various forms of anaemia. *Copper* occurs naturally in meats and drinking water. It aids red blood cell formation. Deficiency results in anaemia and impaired bone and nervous tissue development. *Chromium* occurs naturally in legumes, cereals, organ meats, fats, vegetable oils, meats and whole grains. It functions mainly in glucose metabolism. Deficiency results in adult onset diabetes.

3.3 Dietary Fibre

Dietary Fibre can be defined as food material, particularly plant material, that is not hydrolysed by enzymes secreted by the human digestive tract but may be digested by microflora in the gut. It refers to the remains of plant cell walls, a complex mixture of carbohydrates that resist digestion in the intestinal tract and are therefore apparently of no nutritional value in the diet. Dietary fibre, also known as bulk and roughage, is essential in the diet even though it provides no nutrients. Human nutritionists have thus disregarded dietary fibre for many years.

Over the past two decades, however, there has been a widespread appreciation of the importance of dietary fibre for health. With the development of precise methods for measuring the different compounds present, the term *non-starch polysaccharide* (NSP) is preferred to the less-precise term dietary fibre. These include cellulose, hemicelluloses, pectins, fructans (e.g. inulin), gums and lignins. They are all polysaccharides (*i.e.,* unavailable carbohydrates) except lignin, which occurs with cellulose in the structure of plants. The various types of NSP can be divided into two broad groups: those that are insoluble (celluloses, some hemicelluloses and lignin) and those that are soluble in water (beta-glucans, pectins, gums, mucilages and some hemicelluloses), forming viscous gels. However, the Codex definition recognises that there are other materials that are not hydrolysed within the human digestive tract, the principal class being the resistant starches (oligosaccharides based on galactose, maltose and other sugars) and lignin. There are three forms of resistant starches: (a) protected starch molecules, (b) unswollen granules, e.g. potato starch and (c) retrograded starch. These materials (a – c) are resistant to digestion in the upper reaches of the alimentary canal and arrive intact in the colon where they are digested by the microflora of the gut, a definining characteristic of dietary fibre.

The increased bulk of high-fibre foods give them greater satiety value (that is, they make a person feel “full up”), which is beneficial in preventing obesity. More importantly, a diet low in fibre leads to constipation and the development of high pressures in the intestinal tract. This has been linked with the development of *diverticular* disease of the colon, hiatus hernia, *haemorrhoids* (piles), and varicose veins. All of these conditions are more common in people with a low intake of NSP, and high-fibre diets are protective.

High-fibre diets lower blood cholesterol thereby reducing the risk of heart disease. Bile salts are formed in the liver from cholesterol; normally some 30g are secreted daily in the bile. Most of this is reabsorbed and recycled. Fibre will bind a proportion of the bile salts (and cholesterol itself, which is also secreted in the bile), so that they are excreted in the faeces rather than being reabsorbed, thus causing more cholesterol to be used for bile salt synthesis.

High-fibre diet also reduces the risk of gallstone formation, since a high-fibre diet results in more bile salts and less cholesterol being present in the bile – it is the insolubility of cholesterol when its concentration in bile is high that causes the formation of gallstones. Bile salts have been implicated in the development of cancer of the large intestine. However, if the salts are bound to dietary fibre rather than being free in solution, they will not be able to interact with the intestinal wall in such a way to promote the development of tumours.

Dietary fibre has two further important effects in reducing the risk of cancer. All diets contain a number of potentially carcinogenic (cancer-causing) compounds; many of these will bind to dietary fibre, and so will be unavailable for absorption into the body, and unable to interact with intestinal cells. Furthermore, the intestinal bacteria ferment a proportion of the dietary fibre, and some of the products of this bacterial metabolism (especially butyric acid) have anti-proliferative action (that is, they help prevent cells from multiplying), and so will provide further protection against the development of intestinal cancer.
The food sources of fibre are fruits, vegetables, cereals (especially whole grain), whole-grain bread, wheat bran and products made from nuts and legumes. A diet overly abundant in fibre, however, can cut down on the absorption of important trace minerals during digestion.

4.0 CONCLUSION

Minerals are micro nutrients which can be classified into major elements and trace in organic components which are present in foods required for good health.

5.0 SUMMARY

In this unit we have learnt that:

- Calcium and phosphorus are minerals required for bone and teeth formation. A small amount of calcium is however required in the serum which regulates nervous excitability and muscle contraction.
- Enzymes require magnesium for activation of the activities of muscle and nerves. Similarly Zinc is required as a cofactor in the dehydrogenases and carbonic anhydrases required in intermediary metabolism.
- Both sodium and potassium are elements found in small quantities for the maintenance of acid-base and body water balance, and nerve function regulation. Both minerals are involved in hypertension.
- Blood contains haemoglobin which requires iron as a cofactor. Lack of iron result in hypochromic and microcytic anaemia.
- Fluorine derived from water or dental sources, aid in the formation of strong teeth and bones.
- Eating foods containing fibre e.g. from leafy vegetables cereals and legumes promote many advantages even though fibre itself is not a nutrient.

SELF ASSESSMENT EXERCISE

Classify the mineral micronutrients according to their physiological functions in the body.

6.0 TUTOR-MARKED ASSIGNMENT

Discuss the role of minerals in enzyme activities.

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UNIT 5 FOOD POISONING

CONTENTS

1.0 INTRODUCTION

Food Poisoning, in the broadest sense, refers to any condition in which a food causes a toxic reaction, whether as a result of *a toxin naturally present in the food* (for example, green or sprouting potatoes, partially cooked red kidney beans, many mushrooms and so on); *a toxin acquired by the food as a result of natural accident* (such as contamination of fish or shellfish with toxins from dinoflagellate organisms in plankton); *fungal spoilage leading to the production of mycotoxins in the food*; or *contamination of the food with toxins during agricultural processing* (for example, pesticide residues) or *food processing* (such as accidental contamination with industrial chemicals). It may also result from *ingestion of heavy metals* (intoxication) such as copper and mercury.

However, ***the term is generally reserved for gastrointestinal disease resulting from bacterial (or sometimes viral) contamination of foods***. Food poisoning (or intoxication) is generally characterised by the symptoms of nausea, vomiting, loss of appetite (anorexia), fever, abdominal pain or discomfort (gastroenteritis) and diarrhoea, in varying degrees.

By far the most important cause of food poisoning is contamination of foods with bacteria that do not cause any obvious spoilage, so that the food is still apparently fit to eat, but may contain hazardous amounts of toxins, or sufficient numbers of bacteria to cause infection in people eating the food. While in some cases the symptoms develop within a few hours of eating the contaminated food, in other cases there may be a delay of several days or even weeks before there are any signs of infection. Obviously in such cases, it is difficult to ascertain which food caused the infection.

2.0 OBJECTIVES

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

- define food poisoning, botulism and cross contamination
- enumerate the types of botulism
- explain main sources of mineral poisoning
- enlist the symptoms of bacteria and mineral poisoning
- propose measures for the control of food poisoning.

3.0 MAIN CONTENT

3.1 Causes and Management of Food Poisoning

3.1.1 Causes of Food Poisoning

Direct or indirect contamination of food may cause infections in man. The transmission of these diseases by food depends on the following conditions:

- The presence of a food that supports the growth of the microorganism
- The inoculation of the food with a sufficient number of microorganisms, which may come from a patient with clinical disease, a carrier, or from contaminated environment (water, sewage etc)

Contamination at suitable temperatures for a period long enough to permit the growth of the organism or the elaboration of the toxin

The absence of suitable treatment or processing of the food to inactivate the organism or the toxin

Ingestion of food by the host.

This series of events usually occurs in a setting where there is a reservoir of organism in man, animals, or the environment; where knowledge and practice of food hygiene and personal hygiene is inadequate to prevent transmission of the organism; and where sanitation facilities are insufficient to prevent contamination of the environment with human excreta and its transfer to food.

Contamination of food leading to food poisoning can occur as a result of the way in which the food is handled and prepared. The major causes are:

3.1.1.1 Inadequate Cooking

Inadequate cooking of contaminated raw food and inadequate reheating of pre-cooked food, so that the temperature is not sufficiently high to kill the bacteria.

3.1.1.2 Food Storage Conditions

Keeping cooked food at temperatures that favour the growth of bacteria. *Bacillus cereus* is a special problem because it forms spores that are relatively resistant to heat, and these spores are commonly found on cereal grains. If cooked rice is kept warm, as often occurs in take-away restaurants, the spores germinate and the organism multiplies, producing its toxin.

3.1.1.3 Cross - Contamination between Raw and Cooked Food

Cross-contamination is commonly a problem in domestic food preparation, but may also occur, sometimes with dramatic effects, in industrial food processing. In one incident in 1994, some 224,000 people were infected with *Salmonella* as a result of pasteurised ice cream being carried in tankers that had previously been used to transport unpasteurised egg contaminated with *Salmonella enteritidis*.

3.1.1.4 Poor Personal Hygiene in Food Handlers

3.1.1.5 Ingestion of Toxins

The ingestion of naturally occurring poisons present in mushrooms, toadstools, fish and shellfish and other contaminants. Mushroom poisoning from mushrooms, such as *Amanita phalloides* or muscaria, result in sweating, cramps, diarrhoea, confusion and sometimes convulsions. Patients usually recover within 24 hours. If the infecting mushroom is *Amanita phalloides*, however, liver damage is common, leading to jaundice. Remissions may occur, but the mortality rate is about 60 percent or higher. Fish poisoning can result from Pacific types such as sea bass, Caribbean types such as *Cavallas*, Scrombroid types such as *Mackerel*, and Tetraodon types such as *Puffers*. Symptoms include numbness of the limbs, joint aches, chills and fever. Muscle weakness and paralysis can also occur, and death may result within 24 hours. Mussels and clams may ingest a poisonous dinoflagellate (red tide) from June to October that produces a toxin not destroyed by cooking. Symptoms include nausea, vomiting and abdominal cramps and death can occur as a result of respiratory failure.

3.1.1.6 Ingestion of Heavy Metals

Ingestion of heavy metals, such as lead and mercury, can cause acute nausea, vomiting and diarrhoea and may cause respiratory or nervous system damage over the long term. The severity of the symptoms depends on the irritant and the dose, as well as the resistance of the patient. Treatment includes bed rest, fluids and blood or plasma expanders in severe cases where shock is anticipated.

3.2 Types of Food Poisoning Organisms

Food poisoning organisms can be classified into four groups, depending on the mechanism involved in causing disease:

3.2.1 Organisms that Produce Toxin in the Food

The main examples of such food poisoning organisms are *Clostridium botulinum*, *Staphylococcus aureus* and some strains of *Bacillus cereus*. Here the problem is one of intoxication rather than infection, as occurs with the other classes of food poisoning organism. This means that if the food contains a significant amount of the toxin then subsequent cooking will not reduce the risk of food poisoning.

Clostridium botulinum **Food Borne Poisoning**

Botulism is poisoning caused mainly by eating food containing *Clostridium botulinum*, a poisonous bacterium. There are three main kinds of botulism. *Food-borne botulism* caused by eating foods that contain the botulism toxin; *wound botulism*, caused by toxin produced from a wound infected with *Clostridium botulinum*; *infant botulism*, caused by consuming the spores of the botulinum bacteria, which then grow in the intestines and release toxin. All forms of botulism are fatal and are medical emergencies.

Food-borne botulism is especially dangerous because eating a batch of contaminated food can poison a large number of people. The food-borne organism, which is derived from the soil, grows in many meats and vegetables. Its spores are killed by boiling for 30 minutes, while the toxins may be destroyed by moist heat at 80° C (176° F) for the same period. Because the spores grow best in the absence of oxygen, improperly processed foods in sealed containers offer a perfect environment for their development.

If food contaminated by the bacterium *Clostridium botulinum* is improperly canned or bottled, the bacteria are able to produce a toxin (botulin), which produces the disease botulism. Within 8 to 36 hours of ingestion of the contaminated food, the botulin toxin paralyses nerves regulating muscle function, resulting in respiratory failure, as the muscles that control breathing weaken. In addition, the toxin affects the central nervous system and interrupts nerve impulses, but the mind continues to function normally (symptoms usually appear 18 to 36 hours after ingestion). Disability progresses from difficulty in walking and swallowing, along with impaired vision and speech, to occasional convulsions, and ultimately to paralysis of the respiratory muscles, suffocation, and death, all within a few hours or days, depending on the amount of toxin ingested.

The most direct way to confirm diagnosis is to demonstrate the presence botulinum toxin in the patient's serum or stool by injecting serum or stool into mice and looking for signs of botulism. The bacteria can also be isolated from the stool of persons with food-borne and infant botulism.

Botulism antitoxin may be effective if administered early. Surgical opening of the trachea and use of a respirator may be life saving. Physicians may try to remove contaminated food still in the gut by inducing vomiting or by using enemas. The respiratory failure and paralysis that occur with severe botulism may require a patient to be on a ventilator for weeks. Research into the use of botulism in biological warfare has produced a toxoid, an inactivated poison for use in a vaccine, to induce immunity.

***Staphylococcus* Food Borne Poisoning**

The most common species of Staphylococcus is *Staphylococcus aureus* (also known as *Staphylococcus pyogenes*), which is found on the skin, mouth, external ear and in the nostrils of many healthy individuals. Another species of staphylococcus, *Staphylococcus epidermidis (Staphylococcus albus),* is very widespread but is not normally pathogenic. However, either of these bacteria can cause serious infections under the right conditions. For example, they may infect wounds or give rise to *endocarditis* (inflammation of the heart membrane) if the host's immune system is weak. They may also cause pneumonia and internal abscesses. Although they do not form spores, staphylococci can survive for several weeks in dry conditions. Some strains can withstand high temperatures; they do not often grow outside the body, but may do so in meat, milk or dirty water.

The various species of *Staphylococcus* bacteria multiply rapidly at room temperature and may directly infect the gastrointestinal tract. This is due largely to careless food handling: workers may sneeze or cough on food or may have infected pimples or wounds on the hands or face and transmit the bacteria to the food. *Staphylococcus aureus* infections are characterised by the presence of pus and formation of abscesses.

This form of staphylococcus is responsible for skin pustules (pimple containing pus), boils and carbuncles (severe skin abscess), impetigo (contagious skin infection forming pimples and sores), infections of wounds and burns, breast abscesses, whitlow, osteomyelitis, bronchopneumonia, septicaemia (blood-poisoning), acute endocarditis, food poisoning and scalded skin syndrome. Symptoms of nausea, vomiting and diarrhoea develop 1 to 8 hours after exposure to the *Staphylococcus* bacteria. Treatment is usually a combination of fluid and electrolyte replacement; deaths are rare. Much more rarely, *Staphylococcus aureus* give rise to more serious infections when the resistance of a tissue or the host is reduced.

3.2.2 Organisms that Multiply in the Intestinal Tract and Produce Toxins that Causes the Symptoms

Such organisms may multiply in the intestinal cavity (for example, some strains of *Bacillus Cereus* and *Clostridium perfringens*), in which case the onset of symptoms is relatively rapid after eating the contaminated food, and the infection lasts generally for only a day or so. Other organisms, including the various pathogenic strains of *Escherichia coli,* species of *Aeromonas* and *Vibrio cholerae* (causing cholera) invade and multiply inside the cells of the intestinal wall, secreting toxins. The onset of symptoms from such organisms is typically one to two days and the symptoms may last for several days.

Escherichia coli Food Borne Poisoning

E. coli infection is a potentially fatal form of food poisoning caused by certain strains of the bacterium *Escherichia coli.* Some 5 million *E. coli* bacteria normally inhabit the human and animal intestinal tract, and are vital to processing vitamins in the diet. However, a number of strains are pathogenic and cause gastroenteritis. Some strains, known as entero-pathogenic strains, are associated with undercooked meat, and are a common cause of diarrhoea in infants, but rarely produce gastroenteritis in adults. Other "entero-toxicogenic" strains are the main cause of "travellers' diarrhoea". A relatively large number of organisms (100 million or more) are normally required to cause such infections, which are generally associated with food and water contaminated by faeces.

Entero-invasive strains of the bacterium invade cells of the intestines, causing dysentery, with bloody diarrhoea. These are highly virulent strains, and ingestion of just a few organisms may cause infection. Outbreaks of such infection have been associated with undercooked hamburgers and unpasteurised milk. The entero-haemorrhagic strains are also highly virulent, causing both bloody diarrhoea and possibly fatal systemic infection. In particular, the strain *E. coli* 0157:H7, which also exists in animals and humans, is thought to be a virally infected, highly toxic strain of the *E. coli* bacterium. Ingestion of as few as 10 organisms may cause intestinal haemorrhaging and possible kidney failure. The fatality rate from the infection is 50 per cent in children and the elderly. The main source of infection is undercooked beef that has been contaminated, often in abattoirs, with faeces containing the bacterium. Infection through nursing of victims can also occur. Once infected, people in confined areas can pass on the infection.

Certain rare strains of the bacteria *Escherichia coli* cause food poisoning in young children, the elderly, and people with impaired immune systems. *E. coli* 0157:H7 normally found in the intestines and faecal matter of humans and animals, can survive in meat if the meat is not cooked past 155°F. Outbreaks are due mainly to contaminated cooked meats bought from local retail butchers. These incidences underscore the need for improved food regulations, preparation and hygiene as bacteria from meat surfaces are incorporated during grinding and cutting, and subsequent insufficient cooking.

Symptoms appear after four to nine days, and include bloody diarrhoea, cramping pain and fever. Complications include septicaemia, kidney failure and brain damage. There is no cure for *E. coli* infection. Patients recover once the infection has run its course, although digestive and renal problems may persist. Prevention is by maintaining high standards of food hygiene. This includes always washing the hands before handling food, scalding the utensils used to prepare meat and keeping raw meat separate from other foods and kitchen surface areas during preparation. Meat should be thoroughly cooked to 70° C (160° F).

***Vibrio Cholerae* Infection**

Vibrio cholerae cause cholera, a severe infectious disease endemic to tropical countries and occasionally spreading to temperate climates. The major means of infection is through the use of contaminated water in cold drinks and in the preparation of foods such as fruits and vegetables. In addition, ready-to-eat foods may be contaminated by storage in contaminated containers or by sprinkling with contaminated water. The symptoms of cholera are diarrhoea and the loss of water and salts in the stool. In severe cholera, the patient develops violent diarrhoea with characteristic “rice-water stools”, vomiting, thirst, muscle cramps and sometimes, circulatory collapse. Death can occur as quickly as a few hours after the onset of symptoms. The mortality rate is more than 50% in untreated cases, but falls to less than 1% with effective treatment.

Prevention of the disease is therefore a matter of sanitation. Treatment consists mainly of intravenous or oral replacement of fluids and salts containing the correct mixture of sodium, potassium, chloride, bicarbonate and glucose. A vaccine made from dead bacteria is commercially available and offers partial protection for a period of three to six months after immunization.

3.2.3 Organisms that Invade the Body, but: (a) Generally Remain in the Region of the Intestinal Tract (b) Cause Widespread Systemic Infection

Organisms like species of *Campylobacter*, *Salmonella*, *Shigella* and *Yersinia* remain in the intestinal tract. The onset of symptoms is relatively slow (up to several days after eating the contaminated food) and the infection may persist for weeks. Organisms that invade and cause systemic infections in the body include *Listeria monocytogenes*, *Salmonella typhi* (causing typhoid fever) and *Salmonella paratyphi*. The onset of symptoms may occur many days after consuming the contaminated food and symptoms may persist for many weeks.

Salmonella Food Borne Infection

Salmonella is a genus of infectious bacteria, named after the American veterinarian Daniel Elmer Salmon, who first isolated it in 1885. The organism is transmitted through contaminated poultry, eggs and certain other foods. Three species are recognised: *Salmonella typhi, S. cholerasius* and *S. enteritidis*, which have more than 1,400 antigenically distinct serotypes. *S. typhi* cause typhoid fever. *S. typhimurium,* a serotype of *S. enteritidis,* causes salmonella gastroenteritis, a type of food poisoning characterised by abdominal pain, fever, nausea and vomiting, and diarrhoea. The incubation period is 8 to 48 hours, and an attack may last from three to seven days. Mild cases usually are treated with anti-diarrhoeal remedies while more severe cases require antibiotics. *S. enteritidis* occurs in most flocks of hens, thus undercooked chicken or eggs are the usual source of infection. Careful cleaning and thorough cooking of food prevent salmonella infections.

Typhoid Fever

Typhoid fever is an acute infectious disease caused by the typhoid bacillus *Salmonella typhi.* The bacillus is transmitted by milk, water, or solid food contaminated by faeces of typhoid victims or of carriers (healthy people who harbour typhoid bacilli without presenting symptoms). The incubation period of typhoid fever lasts one to three weeks. The bacteria collect in the small intestine, from where they enter the bloodstream. This induces the first symptoms, chills followed by high fever and prostration. Victims may also experience headache, cough, vomiting and diarrhoea. The disease spontaneously subsides after several weeks in most instances, but in about 20% of untreated cases the disease progresses to pneumonia, intestinal haemorrhage and even death.

Compulsory inspection of milk and water supplies, and the pasteurisation of milk in particular, have greatly reduced the incidence of the typhoid bacilli. Of equal importance in the control of typhoid fever has been the recognition of carriers (who can then be prevented from handling food), and improvement of sewerage facilities. Another important factor in the control of typhoid fever is typhoid inoculation of people exposed to the disease, such as hospital employees and travellers to areas with poor sanitary facilities.

3.2.4 Other Microbial Infection

Clostridium perfringens, found mainly in poultry products, cause mild form of food poisoning. Symptoms include abdominal pain, nausea, diarrhoea and vomiting. Symptoms last only a day and starts about 8 – 22 hours after ingestion.

In *Shigella* infection, no specific food is dominant. It is however found in chicken spread, fruit and fish salad. It is characterised by sudden appearance of abdominal pains, cramps, diarrhoea, fever and vomiting; blood, pus and mucous may be found in stools of about $^{1}/_{3}$ of infected patients.

3.3 Control of Food Poisoning

Around the world there are enormous variations in climate, eating habits, cooking methods, food storage and preservation, and public health advice. Recommended food hygiene practices must therefore take these conditions into consideration. Food Hygiene refers to the totality of practices in food handling that help keep food clean and safe to eat in order to avoid food poisoning. People's attitude to the importance of food hygiene will depend upon their awareness, education and the standard of living they can afford. Food hygiene regulations have been brought into force in many countries around the world to protect the public and reduce the number of outbreaks of food poisoning. These regulations must be followed by anyone responsible for handling food in the food business.

3.3.1 Food Hygiene at Home and the Catering Industry

Food hygiene advice falls into three main sections: personal hygiene, cleanliness of the food area and food hygiene practice.

Personal Hygiene

Prevention of food poisoning starts with personal hygiene. Food poisoning bacteria can be found on human skin, hair, and clothes, and in ears, noses, mouths and faeces. If people touch affected parts of their bodies during the preparation of food, they can transfer the bacteria to the food. This is why hands must always be washed **before** working with food, **especially after visiting the toilet**. The bacterium *Staphylococcus aureus* is found in the human nose, infected wounds and boils, so cuts and grazes must be covered to avoid food contamination. Clean, protective clothing such as aprons or overalls should also be worn during food preparation.

In food businesses, food handlers should not work with food if they are suffering from or are carriers of food-poisoning infections as they can accidentally contaminate foodstuffs. Many food factories insist that workers' hair and beards are covered with hats and nets. Food handlers should not smoke, chew tobacco, or spit in food-preparation areas.

At home, be sure to wash your hands in hot soapy water before preparing each dish. Always wash after using the bathroom, dealing with a child’s hygienic needs (such as changing a diaper or wiping a nose), or handling any animal (including household pets). Wash fruits and vegetables in lukewarm water to get rid of insects and pesticide residue. In many cases, skinning, peeling and boiling are the best ways to cleanse foodstuff. With lettuce or cabbage, remove and throw away the outermost leaves.

Cleanliness of the Food Area

Areas where food is stored and prepared must be kept clean and free from pests and pets. Dirt, soil and food residues can harbour bacteria and pests. Detergents should be added to hot water, and the solution used to wipe down and clean surfaces, equipment, floors and walls. In addition, all utensils, cutting boards and countertops should be washed with hot soapy water after preparing each dish – especially after handling raw meat, poultry or seafood. Food waste should be regularly removed from the food preparation area. Bacteria grow rapidly in warm conditions, especially at the normal human body temperature of 37°C.

The danger zone is anywhere between 5°C and 63°C. Temperature control is important, so cold food must be stored correctly then cooked at a temperature high enough to kill bacteria. Although the refrigerator can inhibit the growth of dangerous bacteria, the temperature should not be greater than 4°C. The freezer should be –17°C.

Food Hygiene Practice

The most serious cross contamination occurs between raw foods and cooked foods, so they should not be stored together or prepared using the same equipment. Keep raw meat, poultry or seafood separate from other food **at all times** (when shopping, storing and preparing). Do not let the juices flow or drip onto each other or unto other food. Never put cooked food unto a dish that formerly held raw meat, fish or poultry, unless that dish has been washed thoroughly with hot soapy water.

It is also important to cook all food items thoroughly. If internal heat of food exceeds 70°C, even briefly, almost all bacteria, viruses and parasites will be killed. Poultry should be cooked even more than that, up to 80°C. Reheated foods should be brought to a temperature of 75°C or it should be hot and steaming. Avoid eating poultry that is still pink inside, eggs with runny yolks or whites, or fish that is not yet opaque and that you cannot readily flake apart with a fork.

When dining out, make sure the restaurant you visit satisfies the health standards required by law. Always order well-cooked meat when eating out. With take-away meals, make sure it is eaten within 2 hours from the time of purchase. If more time elapses, reheat the food to a temperature not less than 75°C.

If you are in doubt as to whether some food item is good or spoiled, play safe and throw it out. **Throw away any questionable food.** Granted, it is unwise to waste good food, still, getting sick from bad food may prove even more costly.

3.3.2 Health Education

Health education programmes are concerned with turning knowledge to action. The actions include:

- Changing food habits to incorporate the boiling of drinking water, cooking all food and avoiding raw meat and fish.
- Taking specific precautions including the adequate cooking of food and the avoidance of foods and food preparation methods that have caused outbreaks in the past.
- Avoiding long delays in consuming prepared food and following approved food sanitation methods and procedures.
- Giving positive support to community activities such as improvement of water supply and the construction and use of latrines
- Accepting expert advice on food hygiene and control of enteric diseases.
- Health education methods include both person-to-person contacts and the use of mass information media. The methods must be carefully chosen to match the educational level of the target group and effective use should be made of community leaders in the educational effort. The educational programme should be designed specifically for the community. The task is difficult since a number of anti-health factors exist. These include ignorance, superstition, lethargy and povertyaswell as opposition from vested interests.

4.0 CONCLUSION

Food poisoning may occur as a consequence of non control of environmental temperature leading to growth of spores from microorganisms including Clostridium and staphylococcus species. Mineral poisoning from heavy metals may also occur from contaminations and cross-contaminations.

5.0 SUMMARY

In this unit we have learnt that:

Food poisoning may result from poor environmental and personal hygiene, storage conditions and contaminations.
The most deadly and pathogenic microorganisms include 3 types of clostridium botulinum and staphylococcus aureus.
Mineral poisoning may occur from heavy metals such as lead and mercury from contaminations.
Other microorganisms that cause food poisoning include:

- *Escherichia coli* especially in children and the elderly.
- *Vibrio cholerae* which causes cholera.
- Salmonella transmitted through contaminated poultry, eggs and certain foods.
- *Salmonella typhi* which causes typhoid fever is transmitted by milk, water or solid food contaminated by faeces of carriers.

The recommended control pressures against food poisoning include:

- Good hygiene in the handling, processing and storage of foods.
- Application of low Temperature: Refrigeration at less than 4^0C and deep-freezers at less than 17^0C.
- Application of proper Health Education by applying methods from contacts and information media.

SELF ASSESSMENT EXERCISE

Enumerate the pathogenic microorganisms involving *Clostridium botulinum* and *Staphylococcus aureus* species.

6.0 TUTOR-MARKED ASSIGNMENT

What are the major sources of food poisoning and how can they be controlled?

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MODULE 2

UNIT 1 DETERIORATION AND SPOILAGE OF FOODS

CONTENTS

1.0 INTRODUCTION

All foods (agricultural & aquatic products) undergo varying degrees of deterioration after harvest and during storage, leading to losses in nutritional value, safety, esthetic appeal (colour, texture, flavour). Fruit, vegetables and root crops are very perishable and, if care is not taken in their harvesting, handling and transport, they will soon decay and become unfit for human consumption. Estimates of production losses in developing countries are hard to judge, but some authorities put losses of sweet potatoes, plantain, tomatoes, bananas and citrus fruit as high as 50 percent of what is grown. Reduction in these losses, particularly if they can be avoided economically, would be of great significance to growers and consumers alike.

All fruits, vegetables and root crops are living plant parts containing 65 to 95 percent water and they continue their life processes after harvest. The post-harvest life of produce depends on the rate at which stored food reserves are used up and the rate of water loss. The changes that occur not only lead to reduced quality but can also make the product more susceptible to contamination with microorganisms. Although the microorganisms involved in produce deterioration may be of public health significance, their effects on human health are often limited since the physiological deterioration of the product often makes the product unfit for consumption. However, the potential for the growth of harmful microorganisms along with the loss of product quality make it important to not only understand the factors involved in product deterioration, but also the steps needed to maintain the best possible quality for the life of the product.

Food by nature is subject to deterioration either by chemical or microbial means. The shelf-life will be influenced by factors such as:

i. nature of the product (nutritional composition)
ii. packaging
iii. temperature

In order to optimise the storage quality and extend shelf-life of fresh and value-added products, a clear understanding of the role of the following factors in food spoilage is important:

i. chemical components in the food
ii. environmental conditions
iii. initial microbial load
iv. nature and types of micro-organisms present

Table 1 identifies some of the major causes of post harvest losses and poor quality for the various groups of fruits and vegetables.

Table 1: Causes of Post Harvest Losses and Poor Quality for the Various Groups of Fruits and Vegetables

Product Group	Principle Causes Of Postharvest Losses And Poor Quality
Root Vegetable (carrots, beets, onions, garlic, potato, sweet potato)	• Mechanical injuries • Improper curing • Sprouting • Water Loss • Decay • Chilling injury
Leafy Vegetables (lettuce, chard, spinach, cabbage, green onions)	• Water loss • Loss of green color • Mechanical injuries • Relatively high respiration rates • Decay
Flower Vegetables (artichokes, cauliflower, broccoli)	• Mechanical injuries • Discoloration • Water loss • Abscission of florets
Immature Fruit Vegetables (cucumbers, squash, eggplant, peppers, okra, snap beans)	• Decay • Overmaturity at harvest • Water loss • Bruising and other mechanical injuries • Chilling injury
Mature Fruit Produce (tomatoes, melons, bananas, mangoes, apples, grapes, stone fruit)	• Decay • Bruising • Over-ripeness at harvest • Water loss • Chilling injury • Compositional changes

Deterioration, or undesirable quality changes, may be the result of biological, microbiological, biochemical/physiological, or physical changes in the product. Factors identified as causes of deterioration usually encourage the conditions that lead to quality losses. These factors are usually the result of inadequate training of product handlers, inadequate or non-existent storage structures, unsuitable or inadequate technologies for handling and storing product, ineffective quality control, and adverse/extreme environmental conditions. In addition, time is an important factor in the spoilage of produce.

Table 2: Factors Responsible for the Deterioration and Spoilage of Foods

Deterioration Factor	Cause
Biological	
• Pests (insects, rodents, birds)	Inadequate GMPs
• Microbiological	Inadequate controls
• Physiological	
Respiration	Heat
Ethylene production	Environment (temp, gas atm.)
Growth, development	Time, environment
Maturation, ripening, senescence	Time, environment
Transpiration and water loss	Packaging, RH, air velocity
Disorders, injury	Chilling, heat, freezing, gas comp.
Chemical/Biochemical	
• Enzymic	Environment, handling/bruising
• Oxidation	Oxygen
• Non-enzymic changes	Packaging, composition, heat
• Light oxidation	Packaging
Physical	
• Bruising, crushing	Handling, packaging
• Wilting	Relative humidity, packaging
• Texture changes	Environment, packaging
• Moisture change	Relative humidity, packaging, environment
Time	

2.0 OBJECTIVES

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

- identify the major sources of food deterioration
- discuss the role of temperature, packaging and composition of food in food spoilage
- explain the influence of initial microbial load and the nature and types of micro-organisms present
- discuss the extrinsic and intrinsic factors of food that affect deterioration
- relate to other forms of deterioration arising from insect infestation and rodent attacks.

3.0 MAIN CONTENT

3.1 Causes of Deterioration and Spoilage

Foods are frequently classified on the basis of their stability as non-perishable, semi-perishable and perishable.

1. Hermetically sealed and heat processed (e.g. canned) foods are generally regarded as non-perishable. However, they may become perishable under certain circumstances when an opportunity for recontamination is afforded following processing. Such an opportunity may arise if the can seams are faulty, or if there is excessive corrosion resulting in internal gas formation and eventual bursting of the can. Spoilage may also take place when the canned food is stored at unusually high temperatures: thermophilic spore-forming bacteria may multiply, causing undesirable changes such as flat sour spoilage.

2. Low moisture content foods such as dried fruit and vegetables are classified as semi-perishable. Frozen foods, though basically perishable, may be classified as semi-perishable provided that they are properly stored at freezer temperatures.

3. The majority of foods (e.g. meat and fish, milk, eggs and most fresh fruits and vegetables) are classified as perishable unless they have been processed in some way. Often, the only form of processing which such foods receive is to be packaged and kept under controlled temperature conditions.

3.1.1 Chemical factors

Deterioration may result from chemical reactions (via endogenous enzymes) or through interactions involving one or more of the macronutrients present in food and food products. Enzymes are proteins that occur naturally in plant tissues and catalyze a number of important biochemical reactions. Some enzyme-catalyzed reactions are beneficial while others result in quality deterioration. Examples of reactions involving endogenous enzymes include:

i. the post-harvest senescence and spoilage of fruit and vegetables;
ii. oxidation of phenolic substances in plant tissues by phenolase (leading to browning);
iii. sugar - starch conversion in plant tissues by amylases;
iv. post-harvest demethylation of pectic substances (i.e. breakdown of structural material) in plant tissues (leading to softening of plant

tissues during ripening, and firming of plant tissues during processing).

v. development of off-flavors through the breakdown of lipid components; and loss of color and undesirable browning.

vi. catalyze fermentation of sugars, breakdown of ascorbic acid, and many other deterioration reactions. Bruising, ripening, cutting, temperature, and presence of co-factors (e.g. Fe and Mg) increase the rate of degradative enzyme activity.

3.2 Physical Factors

One major undesirable physical change in food powders is the absorption of moisture as a consequence of an inadequate barrier provided by the package; this results in caking. It can occur either as a result of a poor selection of packaging material in the first place, or failure of the package integrity during storage. In general, moisture absorption is associated with increased cohesiveness.

Anti-caking agents are very fine powders of an inert chemical substance that are added to powders with much larger particle size in order to inhibit caking and improve flowability. Studies in onion powders showed that at ambient temperature, caking does not occur at water activities of less than about 0.4.
At higher activities, however, ($a_w > 0.45$) the observed time to caking is inversely proportional to water activity, and at these levels anti-caking agents are completely ineffective. It appears that while they reduce inter-particle attraction and interfere with the continuity of liquid bridges, they are unable to cover moisture sorption sites.

3.3 Biological Factors

3.3.1 Microbiological

The presence of pests and/or their droppings is cause for alarm. They can result in product that is unsightly and can produce a significant food safety hazard. Pests can spread disease-causing organisms to produce. They also cause damage to the surfaces of fruits and vegetables Pests such as insects, rodents and birds, are often identified as causes of biological deterioration of produce. They also cause damage to the surface of fruits and vegetables leading to greater susceptibility to invasion by microorganisms that can cause product spoilage and/or disease to consumers. Proper sanitation in all produce handling and storage areas is the most effective weapon against these pests.
Micro-organisms can make both desirable and undesirable changes to the quality of foods depending on whether or not they are introduced as

an essential part of the food preservation process or arise unintentionally and subsequently grow to produce food spoilage.

The two major groups of micro-organisms found in foods are bacteria and fungi, the latter consisting of yeasts and moulds. Bacteria are generally the fastest growing, so that in conditions favourable to both, bacteria will usually outgrow fungi. Spoilage micro-organisms including bacteria, fungi, and viruses are major causes of food deterioration. These organisms may cause softening, off-colour, and off-flavour in produce. Some micro-organisms, called pathogens, will result in illness of those consuming the product if present in sufficient quantity in the foods. In general, fruits and vegetables offer considerable resistance to microbial activity. However, the softening that usually accompanies aging of products and mechanical injuries increase the susceptibility of produce to micro-organisms.

The species of micro-organisms which cause the spoilage of particular foods are influenced by two factors: a) the nature of the foods and b) their surroundings. These factors are referred to as intrinsic and extrinsic parameters. The intrinsic parameters are an inherent part of the food: pH, a_w, nutrient content, antimicrobial constituents and biological structures. The extrinsic parameters of foods are those properties of the storage environment that affect both the foods and their microorganisms. The growth rate of the micro-organisms responsible for spoilage primarily depends on these extrinsic parameters: temperature, relative humidity and gas compositions of the surrounding atmosphere.

3.3.2 Insect Pests

Warm humid environments promote insect growth, although most insects will not breed if the temperature exceeds about 35 C° or falls below 10 C°. Also many insects cannot reproduce satisfactorily unless the moisture content of their food is greater than about 11%. The main categories of foods subject to pest attack are cereal grains and products derived from cereal grains, other seeds used as food (especially legumes), dairy products such as cheese and milk powders, dried fruits, dried and smoked meats and nuts.

As well as their possible health significance, the presence of insects and insect excrete in packaged foods may render products unsaleable, causing considerable economic loss, as well as reduction in nutritional quality, production of off-flavours and acceleration of decay processes due to creation of higher temperatures and moisture levels. Early stages of infestation are often difficult to detect; however, infestation can generally be spotted not only by the presence of the insects themselves but also by the products of their activities such as webbing, clumped-together food particles and holes in packaging materials.

Unless plastic films are laminated with foil or paper, insects are able to penetrate most of them quite easily, the rate of penetration usually being directly related to film thickness. In general, thicker films are more resistant than thinner films, and oriented films tend to be more effective than cast films. The looseness of the film has also been reported to be an important factor, loose films being more easily penetrated than tightly fitted films.

Generally, the penetration varies depending on the basic resin from which the film is made, on the combination of materials, on the package structure, and of the species and stage of insects involved. The relative resistance to insect penetration of some flexible packaging materials is as follows:

> *excellent resistance:* polycarbonate; poly-ethylene-terephthalate;
> *good resistance:* cellulose acetate; polyamide; polyethylene (0.254 mm); polypropylene (biaxially oriented); poly-vinyl-chloride (unplasticised);
> *fair resistance:* acrylonitrile; poly-tetra-fluoro-ethylene; polyethylene (0.123 mm);
> *poor resistance:* regenerated cellulose; corrugated paper board; kraft paper; polyethylene (0.0254 - 0.100 mm); paper/foil/polyethylene laminate pouch; poly-vinylchloride (plasticised).

3.3.3 Rodents

Rats and mice carry disease-producing organisms on their feet and/or in their intestinal tracts and are known to harbour salmonella of serotypes frequently associated with food-borne infections in humans. In addition to the public health consequences of rodent populations in close proximity to humans, these animals also compete intensively with humans for food.

Rats and mice gnaw to reach sources of food and drink and to keep their teeth short. Their incisor teeth are so strong that rats have been known to gnaw through lead pipes and unhardened concrete, as well as sacks, wood and flexible packaging materials.
Proper sanitation in food processing and storage areas is the most effective weapon in the fight against rodents, since all packaging materials apart from metal and glass containers can be attacked by rats and mice.

3.4 Effect of Deterioration on Food Quality

Chemical, physical and biological changes which occur during handling, processing and storage of foods lead to deterioration in sensory and nutritional quality of foods.

3.4.1 Sensory Quality

i. ***Lipid Oxidation***

Lipid oxidation rate and course of reaction is influenced by light, local oxygen concentration, high temperature, the presence of catalysts (generally transition metals such as iron and copper) and water activity. Control of these factors can significantly reduce the extent of lipid oxidation in foods.

ii. ***Non-enzymatic browning***

Non-enzymatic browning is one of the major causes of deterioration which occurs during storage of dried and concentrated foods. The non-enzymatic browning, or Maillard reaction, can be divided into three stages: a) early Maillard reactions which are chemically well-defined steps without browning; b) advanced Maillard reactions which lead to the formation of volatile or soluble substances; and c) final Maillard reactions leading to insoluble brown polymers.

iii. ***Colour changes***

Chlorophylls. Almost any type of food processing or storage causes some deterioration of the chlorophyll pigments. Phenophytinisation (with consequent formation of a dull olive-brown phenophytin) is the major change; this reaction is accelerated by heat and is acid catalysed. Other reactions are also possible. For example, dehydrated products such as green peas and beans packed in clear glass containers undergo photo-oxidation and loss of desirable colour.

Anthocyanins. These are a group of more than 150 reddish water-soluble pigments that are very widespread in the plant kingdom. The rate of anthocyanin destruction is pH dependent, being greater at higher pH values. Of interest from a packaging point of view is the ability of some anthocyanins to form complexes with metals such as Al, Fe, Cu and Sn. These complexes generally result in a change in the colour of the pigment (for example, red sour cherries react with tin to form a purple complex) and are therefore undesirable. Since metal packaging materials such as cans could be sources of these metals, they are usually coated with special organic linings to avoid these undesirable reactions.

Carotenoids. The carotenoids are a group of mainly lipid soluble compounds responsible for many of the yellow and red colours of plant and animal products. The main cause of carotenoid degradation in foods is oxidation. The mechanism of oxidation in processed foods is complex and depends on many factors. The pigments may auto-oxidise by reaction with atmospheric oxygen at rates dependent on light, heat and the presence of pro- and antioxidants.

iv. ***Flavour changes***

In fruit and vegetables, enzymatically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours. In addition, these types of reactions can lead to significant off-flavours. Enzyme-induced oxidative breakdown of unsaturated fatty acids occurs extensively in plant tissues and this yield characteristic aromas associated with some ripening fruits and disrupted tissues. The permeability of packaging materials is of importance in retaining desirable volatile components within packages, or in permitting undesirable components to permeate through the package from the ambient atmosphere.

3.4.2 Nutritional Quality

The four major factors which affect nutrient degradation to varying extents are light, oxygen concentration, temperature and water activity. However, due to the diverse nature of the various nutrients, chemical heterogeneity within each class of compounds and complex interactions of the above variables, generalizations about nutrient degradation in foods will inevitably be broad ones.

Ascorbic acid is the most sensitive vitamin in foods, its stability varying markedly as a function of environmental conditions such as pH and the concentration of trace metal ions and oxygen. The nature of the packaging material can significantly affect the stability of ascorbic acid in foods. The effectiveness of the material as a barrier to moisture and oxygen as well as the chemical nature of the surface exposed to the food are important factors. For example, problems of ascorbic acid instability in aseptically packaged fruit juices have been encountered because of oxygen permeability of the package and the oxygen dependence of the ascorbic acid degradation reaction.

Also, because of the preferential oxidation of metallic tin, citrus juices packaged in cans with a tin contact surface exhibit greater stability of ascorbic acid than those in enamelled cans or glass containers. The aerobic and anaerobic degradation reactions of ascorbic acid in reduced-moisture foods have been shown to be highly sensitive to water activity, the reaction rate increasing in an exponential fashion over the water activity range of 0.1-0.8.

4.0 CONCLUSION

Food deterioration can occur as a result of the activities of enzymes, bacteria or fungi. The mixture of the food composition and packaging materials also influence food deterioration. In addition, environmental, temperature and storage conditions play major roles in food deterioration.

5.0 SUMMARY

Major causes of food deterioration include the following:

growth and activities of micro-organisms, principally bacteria, yeasts and moulds
activities of natural food enzymes
insects, parasites and rodents
temperature, both heat and cold
moisture and dryness
air and in particular oxygen
light
time

Extrinsic factors controlling the rate of food DETERIORATION reactions are mainly:

Effect of temperature;
Effect of water activity (a_w);
Effect of gas atmosphere;
Effect of light.

SELF ASSESSMENT EXERCISE

Explain the biochemical phenomenon surrounding, these observations:

i. Peeled yams turn brown on standing.
ii. Bread that is toasted turned brown after toasting.
iii. Green okra turns white on storage without refrigeration.

6.0 TUTOR-MARKED ASSIGNMENT

Classify foods into perishable and non perishable and show characteristics for each group.

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UNIT 2 FOOD CONTAMINATION AND ADULTERATION

CONTENTS

1.0 INTRODUCTION

Foods can become contaminated by micro-organisms (bacteria and viruses) from many different sources during the food preparation and storage process. Cross contamination of food is a common factor in the cause of food borne illness. Preventing cross contamination is one step to help eliminate food borne illness. It is important to protect food from risk of contamination to prevent food poisoning and the entry of foreign objects.

Adulteration is the act of making any commodity impure by admixture of other or baser ingredients deliberately. This admixture may corrupt the nature of the original to the extent of destroying its identity, or it may merely lower the value or effectiveness of the finished product. Adulteration of foods and beverages has been performed with the aim of increasing profits for the manufacturer or merchant. Adulteration is also designed to defraud consumers; however it can also pose a health threat.

2.0 OBJECTIVES

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

- identify the major sources and types of food contamination
- differentiate between food contamination and adulteration
- identify causes and prevention of cross contamination of foods
- explain control of contamination in various agricultural produce.

3.0 MAIN CONTENT

3.1 Food Contamination

3.1.1 Causes of Food Contamination

There are three main ways in which food can become contaminated, namely: bacterial, physical and chemical contamination.

3.1.1.1 Bacterial Contamination

If food is consumed that has been contaminated by certain, harmful bacteria (pathogenic bacteria) or their toxins (poisons produced by some of these bacteria), food poisoning may result. Bacteria are responsible for most food poisoning cases. Symptoms of food poisoning may include vomiting, diarrhoea, fever and abdominal pain. The symptoms may take some time to occur depending on the type of bacteria (incubation period). In general, the bacteria must grow in the food to produce sufficient numbers to infect the body, multiply within the intestine and cause illness. Alternatively, toxins may be produced in the foodstuff or within the intestine, to produce symptoms very soon after ingestion. It is important to remember that foods contaminated with pathogenic bacteria will look, taste and smell perfectly normal. Steps must therefore be taken to prevent pathogenic bacteria getting onto food and multiplying to levels that will cause food poisoning.

Control of Bacterial Contamination

i. Prevent cross-contamination

Cross-contamination occurs when bacteria are transferred onto food either directly (e.g. when raw and cooked food come into direct contact, sneezing or coughing onto food) or indirectly (e.g. via a vehicle such as from dirty utensils, pests, hands etc.)

ii. Separate raw and cooked foods

Prepared and cooked foods should be stored separate to raw foods and unprepared vegetables to reduce the risk of cross-contamination. If this is not possible, raw food and unprepared vegetables should always be stored at the base of the refrigerator.

iii. Keep stored foods covered.
iv. Prevent animals and insects entering the food room.
v. Keep food preparation areas and utensils clean.
vi. Wash hands frequently, particularly after using the toilet, handling raw foods, handling refuse, blowing your nose, combing your hair and after smoking.
vii. Keep cuts, boils etc., covered with a waterproof dressing (preferably coloured).
viii. Do not handle food if suffering from symptoms of diarrhoea or vomiting and notify your supervisor immediately.

To multiply, bacteria require food, warmth, moisture and time. By removing one or more of these criteria the growth of bacteria can be slowed or even stopped. Therefore foods should

i. be stored at safe temperatures (either cold below 8°C or hot above 63°C);
ii. be cooked thoroughly;
iii. not be prepared too far in advance;
iv. not be kept at room temperature for any longer than necessary,
v. be heated thoroughly and stirred during heating;
vi. be cooled food within 1½ hours and refrigerate;

Foods that are dry should be kept dry and prevented from becoming moist.

3.1.1.2 Physical Contamination

Physical contamination can occur at any stage of the food chain and therefore all reasonable precautions must be taken to prevent this type of contamination.

Examples of physical contamination include:

i. Pieces of machinery which can fall into food during manufacture. Most manufacturers protect against this type of contamination by installing metal detectors on the production lines which reject food if anything metallic is present.
ii. Stones, pips, bones, twigs, pieces of shell.

iii. Foreign objects can enter food during handling so care must be taken to adhere to good food handling practices (e.g. do not wear jewellery or smoke in a food room).

3.1.1.3 Chemical Contamination

Chemicals, including pesticides, bleach and other cleaning materials can contaminate food if not used carefully. For example, store cleaning fluids separate to foods to prevent tainting and contamination if there is a spillage.

Toxicity of Heavy Metals

The toxicity of heavy metals increases sharply in the order zinc, cadmium, mercury. The toxicity of zinc is low. In drinking water zinc can be detected by taste only when it reaches a concentration of 15 parts per million (ppm); water containing 40 parts per million zinc has a definite metallic taste. Vomiting is induced when the zinc content exceeds 800 parts per million. Cases of fatal poisoning have resulted through the ingestion of zinc chloride or sulfide, but these are rare. Both zinc and zinc salts are well tolerated by the human skin. Excessive inhalation of zinc compounds can cause such toxic manifestations as fever, excessive salivation, and a cough that may cause vomiting; but the effects are not permanent.

Compared with those of zinc, the toxic hazards of cadmium are quite high. It is soluble in the organic acids found in food and forms salts that are converted into cadmium chloride by the gastric juices. Even small quantities can cause poisoning, with the symptoms of increased salivation, persistent vomiting, abdominal pain, and diarrhoea. Fatal cases have been reported. Cadmium has its most serious effect as a respiratory poison: a number of fatalities have resulted from breathing the fumes or dusts that arise when cadmium is heated. Symptoms are difficult or laboured breathing, a severe cough, and violent gastrointestinal disturbance.

Mercury and its compounds are highly toxic. They can be handled safely, but stringent precautions must be taken to prevent absorption by inhalation, by ingestion, and through the skin. The main result of acute poisoning is damage to kidneys.

3.2 Cross – Contamination

Cross contamination is the contamination of a food product from another source. There are three (3) main ways cross contamination can occur:

Food to food
Equipment/Utensil to food
People to food

3.2.1 Food to Food

Food can become contaminated by bacteria from other foods. This type of cross contamination is especially dangerous if raw foods come into contact with cooked foods. Here are some examples of food to food cross contamination:

In a refrigerator, meat drippings from raw meat stored on a top shelf might drip onto cooked vegetables placed on a lower shelf.
Raw chicken placed on a grill touching a steak that is being cooked.

3.2.2 People to Food

People can also be a source of cross contamination to foods. Some examples are:

Handling foods after using the toilet without properly washing your hands.
Touching raw meats and then preparing vegetables without washing hands between tasks.
Using an apron to wipe your hands between handling different foods, or wiping a counter with a towel then using the towel to dry hands.

3.2.3 Equipment to Food

Contamination can also be passed from kitchen equipment and utensils to food. This type of contamination occurs because the equipment or utensils were not properly cleaned and sanitized between each use. Some examples are:

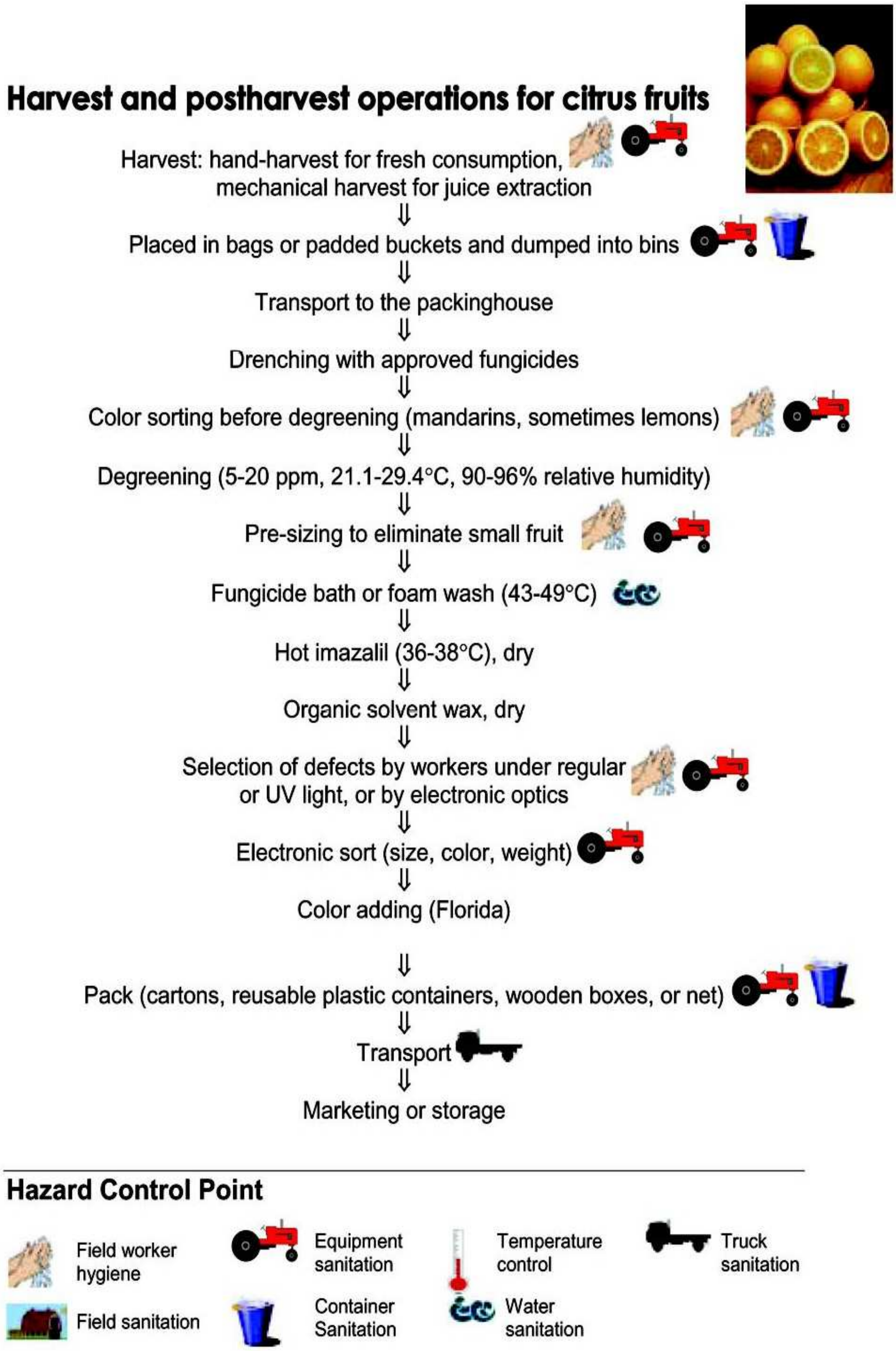
Using unclean equipment such as slicers, can openers and utensils to prepare food.
Using cutting boards and the same knife when cutting different types of foods, such as cutting raw chicken followed by salad preparation.

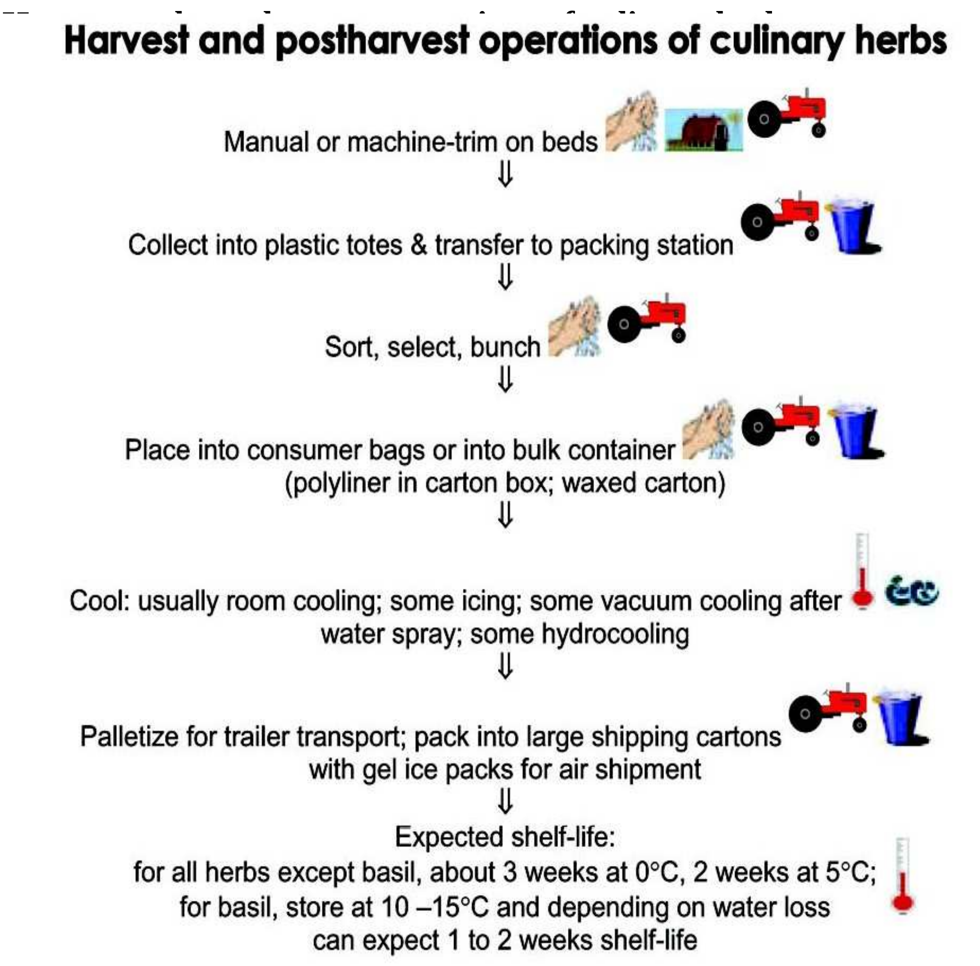
Storing a cooked product, such as a sauce, in an unsanitized container that previously stored raw meat.

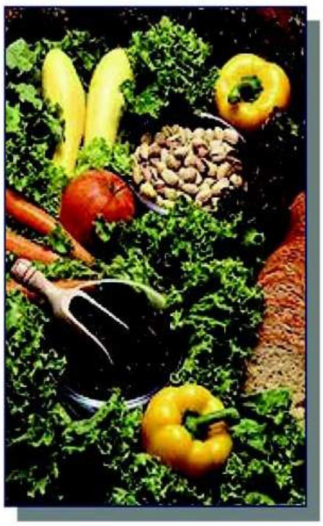
3.3 Preventing Cross Contamination

1. Wash your hands between handling different foods as well as before and after handling each food.
2. After cutting raw meats, wash hands, cutting board, knife, and counter tops with hot, soapy water.
3. Wash and sanitize all equipment and utensils that come in contact with food.
4. Marinate meat and poultry in a covered dish in the cooler.
5. Avoid touching your face, skin, and hair or wiping your hands on cleaning cloths.
6. Use a utensil (spoon or fork) only once to taste food that is to be sold or served.
7. Never store food or packages directly on the floor.
8. Keep wiping cloth for food contact surfaces and tabletops in sanitizer bucket when it is not being used for wiping.
9. Cloths used for wiping up raw animal juices must be kept separate from cloths used for other purposes.
10. Avoid bare hand contact with foods that are ready-to-eat (ready-to-eat: foods that require no further preparation or cooking before serving; e.g. relish trays and birthday cakes.). Use utensils, deli tissue, spatulas, tongs, single-use gloves or dispensing equipment.
11. Store foods properly by separating washed or prepared foods from unwashed or raw foods.
12. Try preparing each type of food at different times and then clean and sanitize food contact surfaces between each task.

3.4 Prevention of Contamination in Field Produce




Harvest and postharvest operations of culinary herbs
Manual or machine-trim on beds
Collect into plastic totes & transfer to packing station
Sort, select, bunch
Place into consumer bags or into bulk container
(polyliner in carton box; waxed carton)
Cool: usually room cooling; some icing; some vacuum cooling after
water spray; some hydrocooling
Palletize for trailer transport; pack into large shipping cartons
with gel ice packs for air shipment
Expected shelf-life:
for all herbs except basil, about 3 weeks at 0°C, 2 weeks at 5°C;
for basil, store at 10 –15°C and depending on water loss
can expect 1 to 2 weeks shelf-life
Hazard Control Point
Field worker hygiene
Field sanitation
Equipment sanitation
Container Sanitation
Temperature control
Water sanitation
Truck sanitation



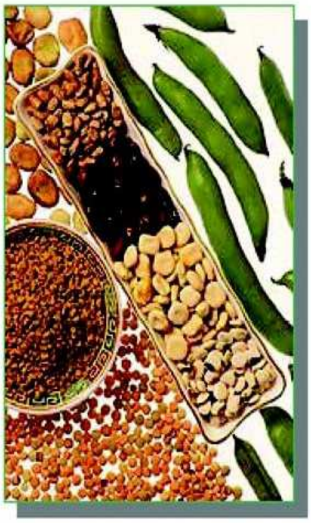

Harvest and postharvest operations of leafy vegetables: lettuce, celery, and green onions
Harvest (manual)
Field Packing
Cut, trim, sort, and size manu
either by harvester or worker
mobile packing platform
Wrap individual units
Pack into shipping containers
Palletize
Transport to cooling facility
Packinghouse Handling
Load into bulk bins or trailers
Transport to packinghouse
Unload
Trim
Wash
Sort and grade
Pack
Palletize
Cool
Temporary Cold Storage
Load for transport and distribution
Top-ice (some products)
Transport to market
Hazard Control Point
Field worker hygiene
Equipment sanitation
Temperature control
Truck sanitation
Field sanitation
Container Sanitation
Water sanitation

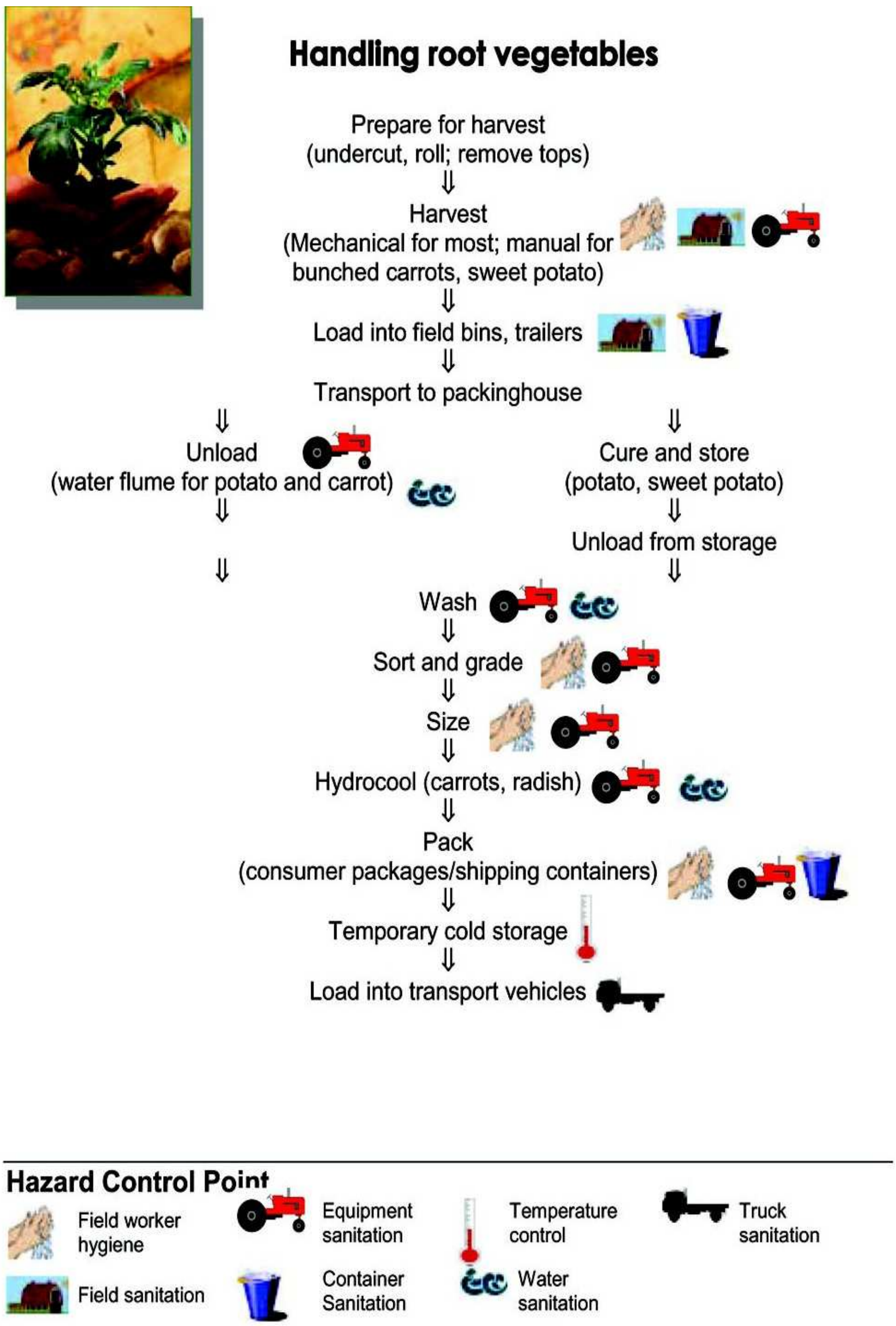
Harvest and postharvest operations of peas and beans

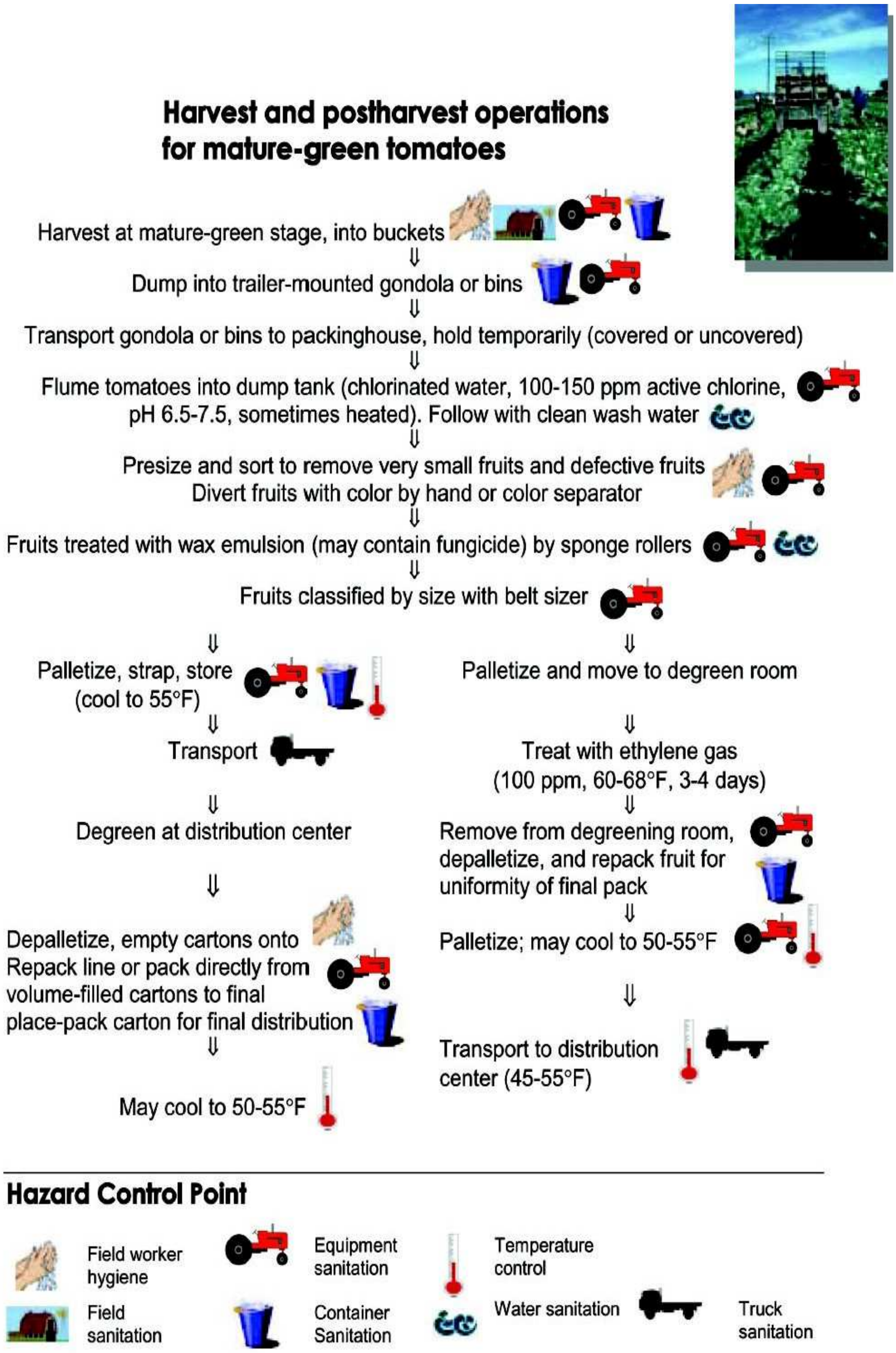
Harvest by manual or mechanical means
⇓
Transfer to a self-unloading truck
⇓
Transfer to the packinghouse, unloaded
⇓
Field debris removed and clusters separated by a series of machines
⇓
Sorted and graded manually
⇓
Packed into wirebound crates or waxed carto
⇓
Hydrocooled or forced-air cooled (peas are top-iced)
⇓
Shipped to the warehouse
⇓
Held at 3-6°C (peas held at 0°C) in warehouse, turnover 1-3 days
⇓
Retail outlets: stored at 5°C, sold within 3-4 days

Hazard Control Point

- Field worker hygiene
- Field sanitation
- Equipment sanitation
- Container Sanitation
- Temperature control
- Water sanitation
- Truck sanitation




Handling root vegetables
Prepare for harvest
(undercut, roll; remove tops)
Harvest
(Mechanical for most; manual for bunched carrots, sweet potato)
Load into field bins, trailers
Transport to packinghouse
Unload
(water flume for potato and carrot)
Cure and store
(potato, sweet potato)
Unload from storage
Wash
Sort and grade
Size
Hydrocool (carrots, radish)
Pack
(consumer packages/shipping containers)
Temporary cold storage
Load into transport vehicles
Hazard Control Point
Field worker hygiene
Equipment sanitation
Temperature control
Truck sanitation
Field sanitation
Container Sanitation
Water sanitation



4.0 CONCLUSION

Contamination in foods can be prevented by identifying sources of contamination, namely: (i) physical, (ii) chemical or (iii) cross – contamination.

5.0 SUMMARY

In this unit we have learnt that:

There are three major sources of food contamination: (a) Physical contamination (b) and (c) cross contamination.
Field produce like citrus, peas and beans, peppers, vegetables and tomatoes can be preserved from contamination by the techniques applied during post harvest storage.

SELF ASSESSMENT EXERCISE

i. How would you control bacteria contamination in foods commonly eaten in your locality.
ii. What are sources of heavy metal contamination in foods?

6.0 TUTOR MARKED ASSIGNMENT

Choose 2 farm produce and explain the techniques for the prevention of contamination during post harvest storage.

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UNIT 3 FOOD PROCESSING AND PRESERVATION OPERATIONS I: TEMPERATURE BASED PROCESSES

CONTENTS

1.0 INTRODUCTION

Preservation of food is accomplished by controlling and where possible, destroying the agents of food spoilage. These agents are present in abundance not only within food but also in the environments where foods are grown, harvested, processed, stored and consumed. Raw food materials can be processed by blanching, freezing, drying, heating, pasteurizing, sterilizing canning and cooking.

2.0 OBJECTIVES

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

- define food preservation and processing
- enumerate the different freezing methods used in preservation of foods
- differentiate between pasteurization and sterilization
- discuss food processing by canning, blanching, packaging and cooking.

3.0 MAIN CONTENT

3.1 Background to Food Preservation

Mankind's endeavour to ensure adequate supply of wholesome food continues today as it as been throughout the centuries. Effective methods of food preservation have been the subject of research by man since civilisation. Despite the endeavours, millions of people regularly lack sufficient food for good health while others suffer the consequences of food contamination by micro-organisms. The continuing crises in our world food supply dictate that spoilage be reduced as much as possible. The areas of the world with the greatest nutritional deficit are those with problems of inadequate food production, distribution and preservation.

Preservation processes offer benefits to the producer, the consumer and the society. The producer is able to keep his product on the shelf longer, thus minimising economic losses. The consumer can keep the product on his or her shelf longer, minimising economic and convenience losses. Society benefits by wasting less food, and in some cases, minimising public health hazards like botulism.

The shelf life of many perishable foods such as meat, eggs, fish, poultry, fruits, vegetable and baked products is limited in the presence of atmospheric oxygen, growth of aerobic spoilage microorganisms and attack by insect pests. Each of these factors, alone or in conjunction with one another, result in changes in colour, flavour, odour and overall deterioration in food quality.

Many kinds of agents are potentially destructive to the agreeable and healthy characteristics of fresh foods. Micro-organisms, such as bacteria and fungi, rapidly spoil food. Enzymes, which are present in all raw foods, are catalytic substances that promote degradation and chemical changes affecting especially texture and flavour. Atmospheric oxygen may react with food constituents, causing rancidity or colour changes. Equally as harmful are infestations by insects and rodents, which account for tremendous losses in food stocks and a wide variety of other chemical, biochemical, or physical factors. Most preservation processes are therefore aimed at destroying or inhibiting bacteria, moulds, and yeasts.

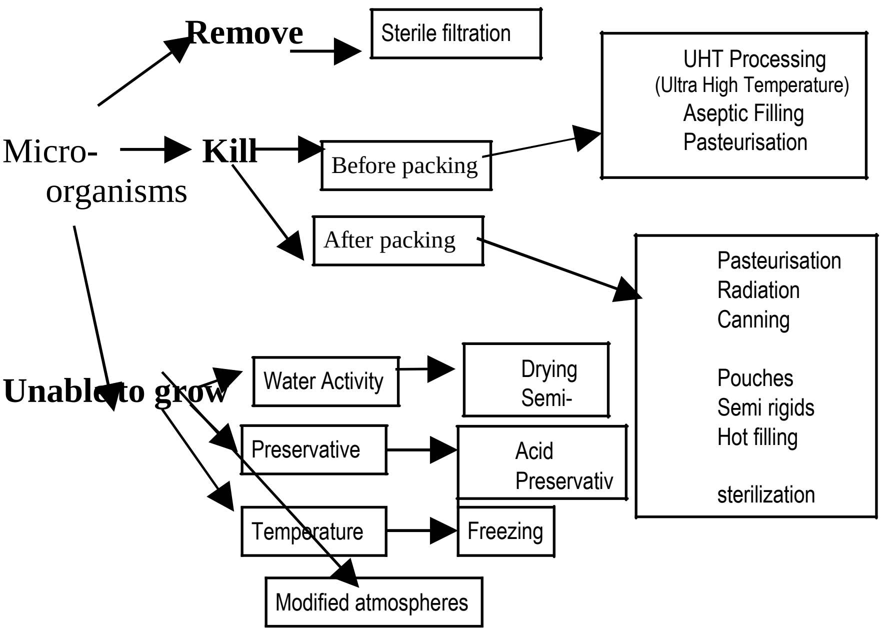
There are six major methods commonly employed in food processing and preservation. These methods are based on:

i. Temperature

Low temperature – Freezing, Cooling and Chilling
High temperature – Pasteurisation, Canning, Cooking and Tyndallisation.

ii. Irradiation – Radiolysis
iii. Moisture Reduction – Drying and Concentration
iv. Fermentation – Alcoholic, Acetic acid and Lactic acid.
v. Chemical Additives – Benzoates, sulphites, nitrites etc.
vi. Controlled /Modified Atmosphere

Schematic Representation Food Preservation Technologies



These preservation operations are designed to achieve the following goals, namely:

i. To change the form or characteristics of the product so as to make it easier to market and more attractive to consumers.
ii. Elimination of microbial concentration from the raw food materials.

iii. *Prevention of contamination from the processing environment during the processing operation.*

iv. To pack, store and distribute the processed food in such a manner as to minimise post-processing contamination.

3.1.1 Low Temperature Preservation

Storage at low temperatures prolongs the shelf life of many foods. In general, low temperatures reduce the growth rates of micro-organisms and slow many of the physical and chemical reactions that occur in foods. Low temperature preservation is based on the application of Van't Hoff equation, which shows that a decrease of about 10^0C in temperature of a food item halves the rate of the reactions going on in the food item. Low temperatures do not sterilise foods, but they slow down the growth of micro-organisms and decrease the rate of the chemical reactions that deteriorate foods. Because the process does not kill all types of bacteria, those that survive become active in thawing food and often grow more rapidly than before freezing. Enzymes in the frozen state remain active, although at a reduced rate. Vegetables are blanched or heated in preparation for freezing to ensure enzyme inactivity and thus to avoid degradation of flavour. In the freezing of meats, various methods are used depending on the type of meat and the cut. Pork is frozen soon after butchering, but beef is hung in a cooler for several days first to tenderise the meat.

There are three methods of low temperature storage, namely:

i. **Cooling**

This involves the removal of a small amount of heat from a food item. It is just a slight reduction in temperature.

ii. **Chilling**

This involves a more pronounced reduction in temperature but it remains above freezing temperature.

iii. **Freezing**

This is a sharp reduction in temperature of a food item such that the food, if in liquid form will change to a solid state. This condition helps to retard the growth of micro-organisms by the cold temperature and by the lack of water, which is unavailable to them when it freezes. This process can be slow or fast as highlighted below:

Slow Freezing

This is a condition in which ice formation is largely extra fibular in meat and extra cellular in plant tissues. Foods frozen by this method are characterised by large crystals. However, this is not often used because it is not economical and can cause physical rupture and separation of cells.

Fast Freezing

This is a condition in which ice formation is largely intrafibular in meat and intracellular in plant tissues. Foods frozen by this method are characterised by small crystals.

3.1.1.1 Refrigeration

Refrigeration is the process of lowering the temperature in a given space and maintaining it for the purpose of chilling foods, preserving certain substances, or providing an atmosphere conducive to bodily comfort. Storing perishable foods or other items under refrigeration is commonly known as cold storage. Such refrigeration checks both bacterial growth and adverse chemical reactions that occur in the normal atmosphere.

The life of many foods may be increased by storage at temperatures below 4°C (40°F). Commonly refrigerated foods include fresh fruits and vegetables, eggs, dairy products and meats. Some foods, such as tropical fruits (*e.g.*, bananas), are damaged if exposed to low temperatures. Although refrigeration retards deterioration, it cannot improve the quality of decayed food.

In mechanical refrigeration, constant cooling is achieved by the circulation of a refrigerant in a closed system, in which it evaporates to a gas and then condenses back again to a liquid in a continuous cycle. If no leakage occurs, the refrigerant lasts indefinitely throughout the entire life of the system. All that is required to maintain cooling is a constant supply of energy, or power and a method of dissipating waste heat. The two main types of mechanical refrigeration system are the compression system, used in domestic units for large cold-storage applications and for most air conditioning; and the absorption system, now employed largely for heat-operated air-conditioning.

3.1.1.2 Freezing

Freezing and frozen storage provide an excellent means of preserving the nutritional quality of foods. At sub-freezing temperatures, the nutrient loss is extremely slow for the typical storage period used in commercial trade.

The Freezing Process

The freezing of food involves lowering its temperature below 0°C, resulting in the gradual conversion of water present in the food into ice. Freezing is a crystallisation process that begins with a nucleus or a seed derived from either a non-aqueous particle or a cluster of water molecules (formed when the temperature is reduced below 0°C). This seed must be of a certain size to provide an adequate site for the crystal to begin to grow. If physical conditions are conducive to the presence of numerous seeds for crystallisation, then a large number of small ice crystals will form. However, if only a few seeds are initially available, then a few ice crystals will form and each will grow to a large size. The size and the number of ice crystals influence the final quality of many frozen foods; for example, the smooth texture of ice cream indicates the presence of a large number of small ice crystals.

In pure water, the freezing process is initiated by lowering the temperature to slightly below 0° C, called super-cooling. As ice crystals begin to grow, the temperature returns to the freezing point. During the conversion of liquid water to ice, the temperature of the system does not change. The heat removed during this step is called the latent heat of fusion (equivalent to 333 joules per gram of water). Once all the water is converted to ice, any additional removal of heat will result in a decrease in the temperature below 0°C.

The freezing of foods exhibits a number of important differences from the freezing of pure water. Foods do not freeze at 0°C. Instead, owing to the presence of different soluble particulates (solutes) in the water present in foods, most foods begin to freeze at a temperature between 0° and -5°C (32° and 23°F). In addition, the removal of latent heat in foods during freezing does not occur at a fixed temperature. As the water present in the food freezes into ice, the remaining water becomes more concentrated with solutes. As a result, the freezing point is further depressed. Therefore, foods have a zone of maximum ice crystal formation that typically extends from -1° to -4°C (30° to 25°F). Damage to food quality during freezing can be minimised if the temperature of the product is brought below this temperature range as quickly as possible.

Industrial Freezers

The rate at which heat is removed from a food during freezing depends on how fast heat can travel within the food and how efficiently it can be liberated from the surface of the food into the surrounding atmosphere. Industrial freezers remove heat from the surface of a food as rapidly as possible. There are several types of industrial freezers, including air-blast tunnel freezers, belt freezers, fluidised-bed freezers, plate freezers, and cryogenic freezers.

In *air-blast tunnel freezers* and *belt freezers*, precooled air at approximately -40°C is blown over the food products. Packaged foods, such as fruits, vegetables, bakery goods, poultry, meats and prepared meals, are usually frozen in air-blast tunnels. The packages are placed on hand trucks and then rolled into the freezer tunnels. In a belt freezer, food is placed on a conveyor belt that moves through a freezing zone. Bakery goods, chicken parts and meat patties (small flat pieces) are frozen using a belt freezer.

Fluidised-bed freezers are used to freeze particulate foods such as peas, cut corn, diced carrots and strawberries. The foods are placed on a mesh conveyor belt and moved through a freezing zone in which cold air is directed upward through the mesh belt and the food particulates begin to tumble and float. This tumbling exposes all sides of the food to the cold air and minimises the resistance to heat transfer at the surface of the food.

Plate freezers are used to freeze flat products, such as pastries, fish fillets, beef patties, as well as irregular-shaped vegetables that are packaged in brick-shaped containers, such as asparagus, cauliflower, spinach and broccoli. The food is firmly pressed between metal plates that are cooled to subfreezing temperatures by internally circulating refrigerants.

Cryogenic freezing is used to freeze food at an extremely fast rate. The food is moved through a spray of liquid nitrogen or directly immersed in liquid nitrogen. The liquid nitrogen boils around the food at a temperature of -196°C (-321°F) and extracts a large amount of heat.

3.1.1.3 Quality of Frozen Foods

Frozen foods have the advantage of resembling the fresh product more closely than the same food preserved by other techniques. However, improper freezing or storage of foods may result in detrimental quality changes. When foods with high amounts of water (e.g. fish) are frozen slowly, they may experience a loss of fluid, called *drip*, upon thawing.

This fluid loss causes dehydration and nutrient loss in frozen food products.

During frozen storage, the ice crystals present in foods may enlarge in size, producing undesirable changes in texture. Freezing causes the water in food to expand and tends to disrupt the cell structure by forming ice crystals. In quick-freezing, the ice crystals are smaller, producing less cell damage than in the slowly frozen product. This phenomenon is commonly observed when the storage temperature is allowed to fluctuate. For example, ice cream stored in an automatic defrosting domestic freezer becomes sandy in texture because the ice crystals increase in size as the temperature of the system fluctuates. Some liquid foods that are frozen slowly, such as egg yolk, may become coagulated. Quick-frozen foods retain their nutrients almost intact, and the characteristics of their flavour remain virtually undiminished. Frozen foods must be stored and kept at 0°C (32°F) or below, because even partial thawing and refreezing lowers the overall quality of the product.

Improperly packaged frozen foods lose small amounts of moisture during storage, resulting in surface dehydration (commonly called *freezer burn*). Frozen meats with freezer burn have the appearance of brown paper and quickly become rancid. Freezer burn can be minimised by the use of tightly wrapped packages and the elimination of fluctuating temperatures during storage. Because of the high cost of refrigeration, frozen foods are comparatively expensive to produce and distribute.

3.1.1.4 Benefits of Cold Temperature Handling of Foods

i. The storability of the food is extended.
ii. In production of carbonated beverages, $C0_2$ becomes more soluble in water.
iii. The organoleptic characteristics of wine are improved.
iv. The slicing response of bread is improved
v. Post harvest metabolic activities of plant tissues and post slaughter metabolism of animal tissues are reduced.
vi. It helps in precipitating waxes from edible oils.
vii. It also controls the rate of growth and metabolism of desirable food microorganisms e.g. cool ripening of cheese

3.1.1.5 Some Terms used in Cold Storage of Foods

i. **Super cooling:** Cooling below the freezing point of a food item.
ii. **Eutectic mixture:** A solution from which water cannot be crystallised.

iii. **Freeze drying:** This is a process in which frozen food is placed in vacuum thereby causing rapid loss of water by sublimation.

iv. **Lypholisation:** Freeze drying

v. **Freezer burn:** The drying of the surface of poorly wrapped foods due to sublimation of water (in solid state) e.g. bread.

vi. **Cook freeze:** Cooking, chilling and immediately freezing foods.

vii. **Regeneration:** A process in which food is returned to its original state for eating after chilling.

viii. **Chilling injury:** The result of freezing a food product under a wrong storage temperature because every food items has a specific temperature range of preservation.

Although refrigeration and freezing bring down the temperature of food, the two processes differ remarkably. The following is a brief outline of their differences:

	Refrigeration	**Freezing**
Temperature range	28 – 60°F	0° F or below
State	Liquid is present	All solid
Microbial activity	Some take place	None
Shelf life	Days/weeks	Months/years

> There is no single method of food preservation technique that provides protection against all hazards for an unlimited period of time.

3.2 Thermal Processing

Thermal processing is defined as the combination of temperature and time to eliminate a desired number of microorganisms from a food product. High temperature preservation is based on the principle that microorganisms and enzymes have optimum conditions, which if altered, inhibits their activities. It is also aimed at breaking the bonds in different food substances (glycosidic bonds in carbohydrates, peptide bonds in proteins, pi and sigma bonds in lipids) and making the nutrients available to the body.

The objective and intensity of a heat treatment is determined, to a large extent, by the nature of the food, the microorganisms that proliferate on it, the degree of contamination, the heat resistance of the microorganisms and their spores, heat transfer characteristics of the food, the condition of storage of the food as well as the pH (degree of acidity or alkalinity) of the food. Heat treatment to foods can be achieved by the following methods:

3.2.1 Pasteurisation

Pasteurisation is the application of heat to a food product to destroy pathogenic microorganisms, inactivate spoilage-causing enzymes and reduce/destroy spoilage microorganisms. The relatively mild heat treatment used in the pasteurisation process causes minimal changes in the sensory and nutritional characteristics of foods compared to the severe heat treatments used in the sterilisation process.

Pasteurisation is dependent on temperature and time. It can be High Temperature Short Time (HTST) or Low Temperature Long Time (LTLT). This involves either heating the food at a high temperature for a very short period or heating it at a low temperature for a long period. For sensitive foods (e.g. milk), flash pasteurisation (HTST) is used. The temperature and time requirements of the pasteurisation process are influenced by the pH of the food. When the pH is below 4.5, spoilage microorganisms and enzymes are the main targets of pasteurisation. For example, the pasteurisation process for fruit juices is aimed at inactivating certain enzymes such as pectinestearase and polygalacturonase. The typical processing conditions for the pasteurisation of fruit juices include heating to 77°C (171°F) and holding for 1 minute, followed by rapid cooling to 7°C (45°F). In addition to inactivating enzymes, these conditions destroy any yeasts or moulds that may lead to spoilage. Equivalent conditions capable of reducing spoilage microorganisms involve heating to 65°C (149°F) and holding for 30 minutes or heating to 88°C (190°F) and holding for 15 seconds.

When the pH of a food is greater than 4.5, the heat treatment must be severe enough to destroy pathogenic bacteria. In the pasteurisation of milk, the time and temperature conditions target the pathogenic bacteria *Mycobacterium tuberculosis, Coxiella burnetti,* and *Brucella abortus.* The typical heat treatment used for pasteurising milk is 72°C (162°F) for 15 seconds, followed by rapid cooling to 7°C. Other equivalent heat treatments include heating to 63°C (145°F) for 30 minutes, 90°C (194°F) for 0.5 second, and 94°C (201°F) for 0.1 second. The HTST treatments cause less damage to the nutrient composition and sensory characteristics of foods and therefore are preferred over the LTLT treatments.

Since the heat treatment of pasteurisation is not severe enough to render a product sterile, additional methods such as refrigeration, fermentation, or the addition of chemicals are often used to control microbial growth and to extend the shelf life of a product. For example, the pasteurisation of milk does not kill thermoduric bacteria (those resistant to heat), such as *Lactobacillus* and *Streptococcus,* or thermophilic bacteria (those that grow at high temperatures), such as *Bacillus* and *Clostridium*. Therefore, pasteurised milk must be kept under refrigerated conditions.

Liquid foods such as milk, fruit juices, beers, wines and liquid eggs are pasteurised using plate-type heat exchangers. Wine and fruit juices are normally de-aerated prior to pasteurisation in order to remove oxygen and minimise oxidative deterioration of the products. Plate-type heat exchangers consist of a large number of thin, vertical steel plates that are clamped together in a frame. Small gaskets that allow the liquid to flow between each successive plate separate the plates. The liquid product and heating medium (*e.g.,* hot water) are pumped through alternate channels and the gaskets ensure that the liquid product and heating or cooling mediums are kept separate. Plate-type heat exchangers are effective in rapid heating and cooling applications. After the pasteurisation process is completed, the product is packaged under aseptic conditions to prevent recontamination of the product.

3.2.2 Sterilisation

This is total destruction of life in the food item. However, this cannot be achieved without destruction of the nutrients in the food which makes the food of no value. As such, sterilisation cannot be used for food items but can only be applied as commercial sterilisation, which means the same as pasteurisation. Heat and chemicals can be used to achieve sterilisation.

Sterilisation is designed to destroy *all* viable microorganisms in foods. When foods are thermally processed, they are referred to as being *commercially sterile* i.e. the food material is free of microorganism and their spores under normal storage conditions. The most heat resistant microorganism, *Bacillus stearothermophillus* is used as the indicator organism in sterilisation operations. The presence or otherwise of this organism is a measure of the efficiency of the heat treatment given to a food item.

3.2.3 Tyndallisation

This is also pasteurisation but special attention is paid to the spores. This involves heating the food item to about 80 – 100^{0}C to destroy the vegetative pathogens, then allowing it to cool to about 37^{0}C so that the spores can gamete. This cycle (heating and cooling) is repeated until satisfactory level of microbial destruction has been achieved. This method is more reliable than pasteurisation since spores are taken into consideration. However, this process is accompanied by severe nutrient losses in the food item so processed.

3.2.4 Aseptic Processing

The aseptic process involves placing a sterilised product into a sterilised package that is then sealed under sterile conditions. It began in 1914 with the development of sterile filters for use in the wine industry. However, because of unreliable machinery, it remained commercially unsuccessful until 1948 when William McKinley Martin helped develop the Martin system, which later became known as the Dole Aseptic Canning System. This system involves the sterilisation of liquid foods by rapidly heating them in tubular heat exchangers, followed by holding and cooling steps. Cold sterile products are then filled into sterilised cans (lids too) and sealed in an atmosphere of superheated steam. By the 1980's, the use of hydrogen peroxide became popular for the sterilisation of polyethylene surfaces.

3.2.5 Commercial Sterility

In aseptic processing the thermal process is based on achieving commercial sterility *i.e.* no more than 1 non-sterile package for every 10,000 processed packages. The aseptic process uses the HTST method in which foods are heated at a high temperature for a short period of time. The time and temperature conditions depend on several factors, such as size, shape and type of food. The HTST method results in a higher retention of quality characteristics, such as vitamins, odour, flavour and texture, while achieving the same level of sterility as the traditional canning process in which food is heated at a lower temperature for a longer period of time.

The heating and cooling of liquid foods are carried out using metal plate heat exchangers. These heat exchangers have large surface areas that result in improved heating and cooling rates. Other types of heat exchangers involve surrounding the food with steam or directly injecting steam into the food. The sterilised products are then pumped into a vacuum chamber where they are cooled rapidly.

Liquid foods that contain large solid particles are heated in scraped-surface heat exchangers. These heat exchangers use blades to continuously scrape the inside surface of the heating chamber. The scraping action protects highly viscous foods from being burned on the heating surface.

Another method often used for heating foods is called *ohmic* heating. This process involves passing a low-frequency electric current of 50 to 60 hertz directly through the food. Liquid foods containing solids (such as diced fruit) is pumped through a pipe surrounded by electrodes. The product is heated as long as the electrical conductivity of the food is uniform throughout the entire volume. This uniform rate of heating prevents the over-processing of any individual region of the food.

Ohmic heating yields a food product of higher quality than those processed using conventional systems.

Packaging Aseptically Processed Products

The packaging containers used in aseptic processing are sterilised separately before they are used. The packaging machinery is sterilised using steam, sterile gases or hydrogen peroxide. The sterilisation process is generally monitored by culturing a test organism. For example, the presence of the highly heat-resistant bacterium, *Bacillus subtilis globigii*, can be used as a marker to measure the completeness of sterilisation. Packages must be sealed under sterile conditions, usually using high-temperature sealing plates. Foods that are aseptically processed do not require refrigeration for storage.

3.2.6 Canning

Nicolas Appert, a Parisian confectioner by trade, is credited with establishing the heat processing of foods as an industry. In 1810, he received official recognition for his process of enclosing food in bottles, corking the bottles and placing the bottles in boiling water for various periods of time. In the same year, *Peter Durand* received a British patent for the use of containers made of glass, pottery, tin and other metals for the heat preservation of foods. In 1822, *Ezra Daggett* and *Thomas Kensett* announced the availability of preserved foods in tin cans in the United States. Tin-coated steel containers, made from 98.5 percent sheet steel with a thin coating of tin, soon became common. These cans had a double seamed top and bottom to provide an airtight seal and could be manufactured at high speeds. The establishment of the canning process on a more scientific basis did not occur until 1896, when *Émile van Ermengem* discovered the microorganism *Clostridium botulinum*, with its lethal toxin causing botulism.

Canned food stored in Antarctica near the South Pole remained edible after 50 years. Such long-term preservation cannot however be duplicated in the hot climate of the Tropics.

Pre-Canning Procedures

Selected crop varieties are grown specially for canning purposes. The harvesting schedules of the crops are carefully selected to conform to the cannery operations. A typical canning operation involves cleaning, filling, exhausting, can sealing, heat processing, cooking, labelling, casing, and storage. Most of these operations are performed using high-speed, automatic machines. Cleaning involves the use of shakers, rotary reel cleaners, air blasters, water sprayers or immersion washers. Any inedible or extraneous material is removed before washing, and only potable water is used in the cleaning systems.

Automatic filling machines are used to place the cleaned food into cans or other containers, such as glass jars or plastic pouches. When foods containing trapped air, such as leafy vegetables, are canned, the air must be removed from the cans prior to closing and sealing the lids by a process called exhausting. Exhausting is accomplished using steam exhaust hoods or by creation of a vacuum. Immediately after exhausting, the lids are placed on the cans and the cans are sealed. An airtight seal is achieved between the lid and the rim of the can using a thin layer of gasket (sheet or ring of rubber etc shaped to seal the junction of metal surfaces). The anaerobic conditions prevent the growth of oxygen-requiring microorganisms. In addition, many of the spores of anaerobic microorganisms are less resistant to heat and are easily destroyed during the heat treatment.

Sterilisation

The time and temperature required for the sterilisation of foods are influenced by several factors, namely: type of microorganisms found on the food, size of the container, acidity (pH) of the food and the method of heating. The thermal processes of canning are generally designed to destroy the spores of the bacterium *C. botulinum.* This microorganism can easily grow under anaerobic conditions, producing the deadly toxin that causes botulism. Sterilisation requires heating to temperatures greater than 100° C (212° F). However, *C. botulinum* is not viable in acidic foods that have a pH less than 4.6. These foods can be adequately processed by immersion in water at temperatures just below 100° C.

The sterilisation of low-acid foods (pH greater than 4.6) is generally carried out in steam vessels called retorts at temperatures ranging from 116 – 129°C (240 - 265°F). The retorts are controlled by automatic devices, and detailed records are kept of the time and temperature treatments for each lot of processed cans. At the end of the heating cycle, the cans are cooled under water sprays or in water baths to approximately 38°C (100°F) and dried to prevent any surface rusting. The cans are then labelled, placed in fibreboard cases either by hand or machine and stored in cool, dry warehouses.

Quality of Canned Foods

The sterilisation process is designed to provide the required heat treatment to the slowest heating location inside the can, called the *cold spot*. The areas of food farthest from the cold spot get a more severe heat treatment that may result in over-processing and impairment of the overall quality of the product. The use of flat, laminated pouches reduce heat damage caused by over-processing.

A significant loss of nutrients, especially heat-labile vitamins, may occur during the canning process. In general, canning has no major effect on the carbohydrate, protein, or fat content of foods. Vitamins A, D and beta-carotene are resistant to the effects of heat. However, vitamin B_1 is sensitive to thermal treatment and the pH of the food. Although the anaerobic conditions of canned foods have a protective effect on the stability of vitamin C, it is destroyed during long heat treatments.
The ends of processed cans are slightly concave because of the internal vacuum created during sealing. *Any bulging of the ends of a can may indicate deterioration in quality due to mechanical, chemical or physical factors*. This bulging may lead to swelling and possible explosion of the can.

Blanching

Blanching refers to brief immersion of fruits, vegetables, etc in boiling water or steam. It is a thermal process used mostly for vegetable tissues prior to freezing, drying, or canning. Blanching serve several purposes, namely: cleaning of the product, reducing the microbial load, removing any entrapped gases, and wilting the tissues of leafy vegetables so that they can be easily put into the containers. Blanching also inactivates enzymes that cause deterioration of foods during frozen storage.

Blanching is carried out at temperatures close to 100°C (212°F) for two to five minutes in either a water bath or a steam chamber. Because steam blanchers use a minimal amount of water, extra care must be taken to ensure that the product is uniformly exposed to the steam. Steam blanching leafy vegetables is especially difficult because they tend to clump together. The effectiveness of the blanching treatment is usually determined by measuring the residual activity of an enzyme called peroxidase and catalase responsible for many browning reactions in many fruits and vegetables.

Although it is commonly used for plant materials, blanching has been proposed for fish in order to kill cold-adapted bacteria on their outer surface. This brief heat treatment is designed to accomplish the following:

Inactivation of most of the plant enzymes which otherwise might cause toughness, change in colour, mustiness, loss in flavour, softening and loss in nutritive value
Reduction (as large as 99 percent) in the numbers of micro organisms on the food
Enhancement of the green colour of vegetables such as peas, broccoli, and spinach
Wilting of leafy vegetables such as spinach, making them pack better
Displacement of air entrapped in the tissue.
Denaturation of enzymes present in the food.

3.3 Cooking

This is a process of heating in order to alter odour, flavour, and texture and particularly to improve digestibility of the food components. Cooking may take different forms of heating methods, which include:

Baking**:** Cooking in an oven with dry heat (100 – 232^{0}C)
Barbecuing: Direct heating over glowing, smokeless wood fire
Boiling**:** Cooking in high temperature usually water (100^{0}C)
Braising: Short frying followed by stewing
Broasting: Pressure frying
B*roiling*: Cooking with direct rays of heat.
F*rying:* *C*ooking in heated fat or oil (160-200^{0}C)
G*rilling*: Cooking with direct rays of heat.
I*nfrared Cooking*: Cooking by infrared rays
M*icrowa*ve *Cooking*: Cooking by microwaves (high frequency *power)*
Poaching: Cooking in a minimum volume of liquid at slightly below boiling temperature.
Roasting**:** Cooking in open or closed vessel with just a little fat.
Sautéing**:** Tossing food in small quantity of oil (a kind of semi-shallow frying).
Quick- fat-frying in small quantity of oil
Simmering: Cooking in water with gentle heating.
Steaming: Cooking in steam (at 100^{0}C)
Stewing**:** Simmering in a small amount of water in a closed container.

4.0 CONCLUSION

Food products can be processed and preserved at low temperature by different methods of freezing, packaging and canning. Other processing methods include Pasteurization, Sterilization and Thermal Processing.

5.0 SUMMARY

In this unit we have learnt that:

- Low Temperature preservation involves the application different freezing methods.
- Foods can be Thermal processed using the methods of Pasteurization, Sterilization Drying and Dehydration.
- Foods can also be processed by canning, packaging aseptically and blanching.
- In the homes foods can be processed and preserved by cooking.

SELF ASSESSMENT EXERCISE

1. Describe the process of food preservation by lowering the freezing temperatures.
2. Examine the advantages of low temperature storage.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between Pasteurization and Sterilization.
2. Enumerate the type of foods usually subjected to each method of Pasteurization and Sterilization.

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UNIT 4 FOOD PROCESSING AND PRESERVATION OPERATIONS II: USE OF IRRADIATION AND MOISTURE REDUCTION

CONTENTS

1.0 INTRODUCTION

Food irradiation involves the use of either high-speed electron beams or high-energy radiation with wavelengths smaller than 200 nanometres, or 2000 angstroms (*e.g.* X rays, gamma rays and corpuscular radiations capable of producing ions directly or indirectly). These rays contain sufficient energy to break chemical bonds and ionise molecules that lie in their path. The two most common sources of high-energy radiation used in the food industry are cobalt-60 (^{60}Co) and caesium-137 (^{137}Cs). For the same level of energy, gamma rays have a greater penetrating power into foods than high-speed electrons.

Treatment of food with ionising radiation is a useful tool for control of the presence of food borne non-spore-forming pathogenic bacteria and micro-organisms such as *Campylobacter*, *Escherichia coli* 0157:H7, *Listeria monocytogenes*, *Salmonella*, *Staphylococcus aureus* and parasitic organisms such as trichina. These organisms cause diarrhoeal diseases and in some cases, death.

The unit of absorbed dose of radiation by a material is denoted as the gray (Gy), one gray being equal to the absorption of one joule of energy by one kilogram of food. The energy possessed by an electron is called an electron volt (eV). One eV is the amount of kinetic energy gained by an electron as it accelerates through an electric potential difference of one volt. It is usually more convenient to use a larger unit such as mega electron volt (MeV), which is equal to one million electron volts.

Irradiation employs the use of radiolysis – the splitting of water molecules into irreversible form – thereby preserving the food because the water is unavailable for microbial and enzymatic activities.

2.0 OBJECTIVES

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

- define food irradiation
- enumerate the positive and negative effects of food irradiation
- discuss the preservation of foods by moisture reduction
- discuss the methods employed in achieving concentration of moist foods.

3.0 MAIN CONTENT

3.1 Food Irradiation and Moisture Reduction

3.1.1 Biological Effects of Irradiation

Irradiation has both direct and indirect effects on biological materials. The direct effects are due to the collision of radiation with atoms, resulting in an ejection of electrons from the atoms. The indirect effects are due to the formation of free radicals (unstable molecules carrying an extra electron) during the radiolysis (radiation-induced splitting) of water molecules. The radiolysis of water molecules produces hydroxyl radicals, highly reactive species that interact with the organic molecules present in foods. The products of these interactions cause many of the characteristics associated with the spoilage of food, such as off-flavours and off-odours.

3.1.1.1 Positive Effects

The bactericidal (bacteria-killing) effect of ionising radiation is due to damage of the bio-molecules of bacterial cells. The free radicals produced during irradiation may destroy or change the structure of cellular membranes. In addition, radiation causes irreversible changes to the nucleic acid molecules (*i.e.,* DNA and RNA) of bacterial cells, inhibiting their ability to grow. Pathogenic bacteria that are unable to produce resistant endospores in foods such as poultry, meats, and seafood can be eliminated by radiation doses of 3 to 10 kilograys. If the dose of radiation is too low, then specialised enzymes repair the damaged DNA and life continues for them. If oxygen is present during irradiation, the bacteria are more readily damaged. Doses in the range of 0.2 to 0.36 kilograys are required to stop the reproduction of *Trichinella spiralis* (the parasitic worm that causes trichinosis) in pork, although much higher doses are necessary to eliminate it from the meat.

The dose of radiation used on food products is divided into three levels, namely:

i. ***Radurisation****:* The use of low doses of ionising radiation adequate for reducing the numbers of spoilage organisms. It is a dose of 1 to 10 kilograys that, like pasteurisation, is useful for targeting specific pathogens.
ii. ***Radicidation****:* The use of doses sufficient to reduce the numbers of specified viable non-sporing pathogens below detectable levels. It involves doses of less than 1 kilogray for extending shelf life and inhibiting sprouting.
iii. ***Radappertisation***: Treatment with doses of ionising radiation sufficiently high for reducing the number of organisms below detectable levels (also called commercial sterility). It is a dose in the range of 20 to 30 kilograys, necessary to sterilise a food product.

3.1.3 Negative Effects

In the absence of oxygen, radiolysis of lipids leads to cleavage of the inter-atomic bonds in the fat molecules, producing compounds such as carbon dioxide, alkanes, alkenes and aldehydes. In addition, lipids are highly vulnerable to oxidation by free radicals, a process that yields peroxides, carbonyl compounds, alcohols and lactones. The consequent rancidity, resulting from the irradiation of high-fat foods, is highly destructive to their sensory quality. To minimise such harmful effects, fatty foods must be vacuum-packaged and held at subfreezing temperatures during irradiation.

Proteins are not significantly degraded at the low doses of radiation employed in the food industry. For this reason irradiation does not inactivate enzymes involved in food spoilage, as most enzymes survive doses of up to 10 kilograys. On the other hand, the large carbohydrate molecules that provide structure to foods are de-polymerised (broken down) by irradiation. This de-polymerisation reduces the gelling power of the long chains of structural carbohydrates. However, in most foods other food constituents provide some protection against these deleterious effects. Vitamins A, E and B_1 (thiamine) are also sensitive to irradiation. The nutritional losses of a food product are high if air is not excluded during irradiation.

3.2 Safety Concerns

Based on the beneficial effects of irradiation on certain foods, several countries have permitted its use for specific purposes. These include the inhibition of sprouting of potatoes, onions and garlic; the extension of shelf life of strawberries, mangoes, pears, grapes, cherries, red currants, and cod and haddock fillets; as well as in the insect dis-infestation of pulses, peanuts, dried fruits, papayas, wheat and ground-wheat products.

The processing room used for irradiation of foods is lined with lead or thick concrete walls to prevent radiation from escaping. The energy source, such as a radioactive element or a machine source of electrons, is located inside the room (radioactive elements such as ^{60}Co are contained in stainless steel tubes. Because an isotope cannot be switched on or off, when not in use, it is lowered into a large reservoir of water) Prior to the irradiation treatment, personnel vacate the room. The food to be irradiated is then conveyed by remote means into the room and exposed to the radiation source for a predetermined time. The time of exposure and the distance between the radiation source and the food material determines the irradiation treatment. After treatment, the irradiated food is conveyed out of the room, and the radioactive element is again lowered into the water reservoir.

Large-scale studies conducted around the world have concluded that irradiation generally does not cause harmful reactions in foods. In 1980, a joint committee of the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), and the World Health Organization (WHO) declared that:

> An overall average dose of radiation of 10 kilograys was safe for food products.
> The maximum energy emitted by ^{60}Co and ^{137}Cs is too low to induce radioactivity in food.
> When the energy output of electron-beam generators is carefully regulated, the energy outputs are too low to cause radioactivity in foods.

Some 20 countries, including the United States, Holland and South Africa have approved irradiation for use on a limited group of foods: fresh fish, shellfish, spices, potatoes and tropical fruits. In 1990, the U.S. Food and Drug Administration approved the use of irradiation for poultry, in order to reduce the threat of salmonella, a bacterium that causes food poisoning. By 1995, irradiation has been approved for use in 25 countries. In 1996, a symposium on Irradiation technology was held in Nigeria to examine its suitability for local products. The impact of irradiation on preservation of foods and agricultural produce, mutation in plants for production of high-yielding and disease resistant varieties, sterile insect techniques, sterilisation of medical devices, pharmaceutical products and packages, improvement of mechanical, thermal and electrical properties of plastics and induced cross-linking and vulcanisation of rubber latex were evaluated. At the end of the symposium, the participants observed that there are immense benefits derivable from the application of irradiation technology. It was also noted that although some research work is being done in Nigeria on the application of irradiation technology in agriculture, health and industry, there is need for more research work on some Nigerian foodstuffs that have not been fully investigated. Considering the newness of this technology in the country, the participants suggested that a public awareness program should be embarked upon to educate the people on the merits of introducing irradiation technology in Nigeria, particularly to preserve food safe for human consumption, reduce losses, enhance food security and price stability and thus facilitate the acceptance of the technology.

Irradiation delays ripening of fruits and vegetables; inhibits sprouting in bulbs and tubers; disinfests grain, cereal products, fruits and vegetables (fresh and dried) and destroys bacteria in fresh meats. However, public concern over the safety of irradiation has limited its full-scale use. See appendix 3 for recommended dose levels for different food items.

3.2.1 Advantages

i. Any food can be irradiated at correct doses – solid, liquid, gases or liquids in frozen state.
ii. Shapes and sizes of the food item are no barriers.
iii. Materials other than food can be sterilised by irradiation
iv. It destroys parasites and enhances odour of essential oils.
v. It can be used to improve microbiological quality without significantly affecting the physical state and sensory qualities of the products.
vi. It avoids the risk of recontamination
vii. Most of the psychotropic microorganisms of importance to microbiological safety or keeping quality of chilled foods are relatively sensitive to radiation
viii. The incidence and contamination levels of pathogenic bacteria are usually low.
ix. It saves energy in production, distribution and marketing under ambient conditions.

a. Irradiated foods last longer and can be accessible to a greater number of people at lower cost.
b. It enhances rural incomes since producers are able to sell a higher proportion of their product while it remains wholesome.
c. The ability to store products without risk of spoilage evens out fluctuations in food availability and price and so improves food security, especially for low income earners.

3.2.2 Disadvantages

If it is not used in the correct dose, it can lead to off-flavour

It can deposit carcinogenic matter in food that can cause malignant growth in the body.

It is dangerous and expensive to run.

3.3 Preservation by Moisture Reduction

Water that is present in a food item is expressed in the following terms:

1. ***Bound water***: This is the water, which forms part of the structure of the food. It cannot be removed.
2. ***Water activity*** (a_w): This is the water in excess of the water which forms part of the structure of the food and is available for microbial and enzymatic activities. It can be removed.
3. ***Water content***: This is the total amount of water present in a food item.
4. ***Moisture content:*** This is the scientific measure of water present in a food item. It can be measured on wet weight basis or on dry weight basis.
5. ***Interstitial water***: This is the water present in between the cells of a food items.

Processing and preservation operations based on moisture reduction employ the principle of lowering the water activity – either by adding solutes such as sugar, glycerol and salt or by removing water through dehydration.

3.3.1 Controlling Water Activity

Foods containing high concentrations of water are generally more susceptible to deterioration by microbial contamination and enzymatic activity. The water content of foods can be controlled by removing water through dehydration or by adding solutes to the food. In both cases, the concentration of solutes in the food increase and the concentration of water decrease.

3.3.2 Drying and Dehydration

Although both these terms are applied to the removal of water from food, in Food Technology, drying refers to *natural desiccation,* such as spreading fruit on racks in the sun, and dehydration designates *drying by artificial means,* such as a blast of hot air. Dehydration of food is an effective weapon against microbial attack, since the free water in food is essential for the proliferation of bacteria. Although the preservation of food by drying is an ancient practice, advances in Food Science and Technology have created wholly new forms, such as compressed, freeze-dried foods that resume their original shape on rehydration.

Foodstuffs may be dried in air, superheated steam, vacuum, or inert gas or by direct application of heat. Air is the most generally used drying medium, because it is plentiful and convenient and permits gradual drying, allowing sufficient control to avoid overheating that might result in scorching and discoloration. Air may be used both to transport heat to the food being dried and to carry away liberated moisture vapour. The use of other gases requires special moisture recovery systems.

Loss of moisture content produced by drying results in increased concentration of nutrients in the remaining food mass. The proteins, fats and carbohydrates in dried foods are present in larger amounts per unit weight than in their fresh counterparts, and the nutrient value of most reconstituted or rehydrated foods is comparable to that of fresh items. The biological value of dried protein is dependent, however, on the method of drying. Prolonged exposure to high temperatures can render the protein less useful in the diet. Low-temperature treatment, on the other hand, may increase the digestibility of protein. Some vitamins are sensitive to the dehydration process. For example, in dried meats significant amounts of vitamin C and the B vitamins – riboflavin, thiamine, and niacin – are lost during dehydration.

Dried eggs, meat, milk and vegetables are ordinarily packaged in tin or aluminium containers. Fibreboard or other types of material may be employed but are less satisfactory than metal, which offers protection against insects and moisture loss or gain and which permits packaging with an inert gas.

In freeze-drying, a high vacuum is maintained in a special cabinet containing frozen food until most of the moisture has sublimed. Removal of water offers excellent protection against the most common causes of food spoilage. Microorganisms cannot grow in a water-free environment, enzyme activity is absent, and most chemical reactions are greatly slowed down. This last characteristic makes dehydration preferable to canning if the product is to be stored at a high temperature.

In order to achieve such protection, practically all the water must be removed. The food must then be packaged in a moisture-proof container to prevent it from absorbing water from the air. For this reason a hermetically sealed can is frequently used to store dried foods. Such a can offers the further advantage of being impervious to external destructive agents such as oxygen, light, insects and rodents.

Vegetables, fruits, meat, fish, and some other high moisture foods may be dried to one-fifth of the original weight and about one-half of the original volume. The disadvantages of this method of preservation include the time and labour involved in rehydrating the food before eating. Further, reconstituting the dried product may be difficult, because it absorbs only about two-thirds of its original water content; this phenomenon tends to make the texture tough and chewy.

Present-day dehydration techniques include the application of a stream of warm air to vegetables. Protein foods such as meat are of good quality only if freeze-dried. Liquid food is usually dehydrated by spraying it as fine droplets into a chamber of hot air (spray drier), or occasionally by pouring it over a drum internally heated by steam (drum drier).

In-package desiccants (drying agents) improve storage stability of dehydrated white potatoes, sweet potatoes, cabbage, carrots, beets and onions and give substantial protection against browning. Retention of ascorbic acid (vitamin C) is markedly improved by packaging at temperatures up to 49°C (120°F); the packaging gas may be either nitrogen or air.

Advantages

i. Low water activity, which aids food preservation.
ii. There is reduced weight compared to the initial weight of the food item, which eases packaging, storage and transportation.
iii. It allows for the production of certain convenience foods e.g. tea, coffee.

Disadvantages

i. Cooked flavour might result.
ii. It can also cause darkening of the food item.

3.3.3 Concentration of Moist Foods

This is the partial removal of water from a food item, giving rise to a syrup-like product. Food items such as syrups, evaporated milk, tomato ketchup and condensed soups are examples of concentrated food item. Sun drying cannot be said to be concentration because in concentration, the water is removed partially whereas the amount of water that is being removed cannot be controlled in sun drying. Foods with substantial acidity, when concentrated to 65 percent or more soluble solids, may be preserved by mild heat treatments. High acid content is not a requirement for preserving foods concentrated to over 70 percent solids.

Fruit jelly and preserve manufacture, an important fruit by-product industry, is based on the high-solids-high-acid principle, with its moderate heat-treatment requirements. Fruits that possess excellent qualities but are visually unattractive may be preserved and utilised in the form of concentrates, which have a pleasing taste and substantial nutritive value. Jellies and other fruit preserves are prepared from fruit by adding sugar and concentrating by evaporation to a point where microbial spoilage cannot occur. The prepared product can be stored without hermetic sealing, although such protection is useful to control mould growth, moisture loss and oxidation. In modern practice, vacuum sealing has replaced the use of a paraffin cover.

The jelly-forming characteristics of fruits and their extracts are due to pectin, a substance present in varying amounts in all fruits. The essential ingredients in a fruit gel are pectin, acid, sugar and water. Flavouring, colouring agents as well as pectin and acid may be added to overcome any deficiencies in the fruit.

Candied and glazed fruits are made by slow impregnation of the fruit with syrup until the concentration of sugar in the tissue is sufficiently high to prevent growth of spoilage microorganisms. The candying process is conducted by treating fruits with syrups of progressively increasing sugar concentrations, so that the fruit does not soften into jam or become tough and leathery. After sugar impregnation the fruit is washed and dried. The resulting candied fruit may be packaged and marketed in this condition or may be dipped into syrup, becoming coated with a thin glazing of sugar and again dried.

The methods employed in achieving concentration are as follows:

i. **The kettle method**: This involves the use of open kettles or pans. It is of benefit in foods where caramelisation is desirable e.g. malt drink, stout, ale etc.

ii. **Flash method**: This involves the application of superheated steam to the food items in steam jackets. The process is commonly used for purees.

iii. **Film method:** This involves pumping the food into a heated vertical cylinder. A film of the food, which gets dry fast, is produced.

iv. **Vacuum method**: This is applied to heat sensitive foods.

v. **Freeze concentration method:** This involves the removal of frozen water from food items via sublimation). With the removal of water, a concentrated food item is got.

vi. **Ultra-filtration and reversed osmosis**: This process involves the use of a selectively permeable membrane, which filters micromolecules (water molecules) and leaves the macromolecules.

4.0 CONCLUSION

Food irradiation is safer than fumigation of Foods but nonetheless Food irradiation carries advantages and disadvantages. Also Food Preservation can be achieved either by reduction in Moisture contents or concentration of Moist foods.

5.0 SUMMARY

In this Unit we have learnt that:

Irradiation of Foods is a useful tool for control of the presence of food borne non-spore-forming pathogenic bacteria and micro-organisms;
There are however, serious Biological Effects of Food Irradiation, some of which are advantageous, while others are undesirable;
Preservation of foods is achieved by Moisture Reduction;
Alternatively preservation may be achieved by concentration of Moist foods.

SELF ASSESSMENT EXERCISE

1. Discuss the advantages and disadvantages of food irradiation.
2. Discuss (i) Drying (ii) Freeze drying and (iii) Dehydration.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the advantages and disadvantages of Food Irradiation.
2. Discuss methods employed in achieving concentration of Moist Foods.

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UNIT 5 FOOD PROCESSING AND PRESERVATION OPERATIONS III: USE OF FOOD ADDITIVES, MODIFIED ATMOSPHERES AND FERMENTATION

CONTENTS

1.0 INTRODUCTION

Food Additives are compounds that are added to foods as an aid to processing, improving the keeping qualities, flavour, colour, texture, appearance and stability of the food. Vitamins, minerals and other nutrients added to fortify or enrich the food are generally excluded from the definition of additives, as are herbs, spices, salt and yeast or protein hydrolysates commonly used to enhance flavour. Where laboratory testing has shown that high intakes of an additive have adverse effects (on experimental animals), the amount that may be used is controlled by law to ensure that the total intake from all foods in a daily diet is within a safe range. This *Acceptable Daily Intake (ADI)* is usually *one-hundredth of the highest dose that has no detectable effect in laboratory tests*. Compounds for which no adverse effects can be detected, even using extremely high levels of intake, are classified as "ADI not determined", and may be used without any limitation, although the intensity of colour and flavour will usually limit the amount that is used. Additives are classified by their function. The following is a review of the major types.

2.0 OBJECTIVES

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

define " additive"
classify the additives according to functions
discuss the use of modified technology to improve qualities of foods
enumerate the types of fermentation of foods.

3.0 MAIN CONTENT

3.1 Types of Additives

3.1.1 Colourants

These refer to a range of organic compounds, some synthetic chemicals, and naturally occurring plant pigments, namely: chlorophyll, carotenoids and anthocyanins, that may be added to foods to enhance the colour. When a desirable food process leads to a loss of colour from the food, or a new product looks unduly insipid, the processor wisely takes steps to make it more attractive through the use of food grade colours. Some mineral salts are also used as colours e.g. salts of calcium and iron which enhance the nutritional value of the food as well as its colour.

3.2 Preservatives

The Food and Drug Administration defines a chemical preservative as "*any chemical that when added to food, tends to prevent or retard deterioration, but does not include common salt, sugars, vinegars, spices or oils extracted from spices, substances added to food by direct exposure thereof to wood smoke or chemicals applied for their respective insecticidal or herbicidal properties*".

The ideal chemical preservative must be able to inhibit the growth of moulds, yeasts and bacteria. It must be non-toxic to test animals and ultimately to humans. It should be capable of being metabolised by the body and not subject to further detoxification procedure in the liver. There should not be a residue build-up in fatty tissue. Ideally, it would be water-soluble; if it is fat-soluble it might be unavailable for antimicrobial action, since micro-organisms grow in the aqueous phase. It should be stable in the food product and not react with other additives or natural components of food. It should exhibit no taste, odour or colour. It should be cheap and be able to pay for itself by reducing spoilage and minimising food borne illness.

Preservatives are used to protect foods against the growth of micro-organisms that might cause spoilage or food poisoning, and so increase the safe storage life of the product. Such compounds include sorbic and benzoic acids and their salts, sulphur dioxide and its salts, as well as nitrites and nitrates used in pickling salts. The following is a review of commonly used preservatives.

3.2.1 Benzoates

These are the preservatives with the longest history of use in foods. The optimum pH range for antimicrobial activity by benzoates is 2.5 – 4.0, which is lower than that for sorbate or propionate. The reason for this lower range is that the antimicrobial activity is primarily due to the undissociated acid molecule. Sodium benzoate has activity against yeast, mould and bacteria but is not usually recommended for bacterial control because of its decreased activity above pH 4.5, where bacteria are the greatest problem. The lower pH range makes benzoates well suited for preservation of foods that are acidic or readily acidified, such as carbonated beverages, fruit juices and pickles. Under FDA regulations, benzoates are generally recognised as safe (GRAS) for use in foods, but a maximum level of 0.1% is set. Benzoates have an advantage of low cost compared to other antimicrobial additives.

3.2.2 Parabens

Parabens is the name given to the alky esters of parahydroxy benzoic acid which are used as food preservatives and are structurally related to benzoic acid. The parabens are very versatile in that they are not weak acid compounds; because of its esterified carbonyl group, the active undissociated molecule can be retained over a wide pH range. The antimicrobial property of parabens is directly proportional to the chain length, however, solubility decreases as the chain length increases. Very often, a combination of methyl and propyl esters is often employed. In general, the parabens are most active against gram-negative bacteria. The parabens are more costly than the other preservatives and are not water-soluble (solubility is 0.25% for the methyl ester). The methyl and propyl ester are considered GRAS with a maximum total use level (methyl + propyl) of 0.1%. They are used in cakes and fillings, soft drinks, fruit juices and salads, and artificially sweetened jams and jellies. The heptyl ester is used in beer at a maximum level of 12 ppm.

3.2.3 Propionates

Propionates were among the first monocarboxylic fatty acids to be used as an antimicrobial agent in foods. Propionates have good antimicrobial activity against moulds but little against yeasts and bacteria. They are considered as GRAS for use in foods and have no upper limits except in products such as bread, rolls and cheese – the limits are 0.32% of flour in white bread and rolls, 0.38% in corresponding wheat products and 0.3% in cheese products. Calcium and sodium propionate are equally effective, but the calcium salt is used in breads and rolls because of the enrichment contribution of calcium. The sodium salt is used in chemically leavened products because the calcium ion interferes with the leavening action.

3.2.4 Sorbates

Sorbic acid is another monocarboxylic fatty acid that is used to preserve our food. Sorbic acid and potassium sorbate are the most popular forms used. Sorbic acid is only slightly soluble in water whereas the potassium salt is very water-soluble, up to 139g/100ml at 25°C. The optimum pH range of effectiveness extends up to pH 6.5, higher than the upper range of benzoates and propionates but below that of parabens. The traditional applications for sorbates are cheese products, baked goods, beverages, syrups, fruit juices, wines, jellies, jams, salads, pickles, margarine and dried sausages. Sorbates have traditionally been used as antifungal agent in foods and food wrappers and to control yeasts and moulds. Sorbates are considered as GRAS. Being a fatty acid, sorbates are metabolised by the body to carbon dioxide and water. The principal disadvantage of sorbates is their cost. However, they are usually used in lower quantities than the cheaper benzoates and propionates in the higher-pH products to achieve the desired effect.

3.2.5 Acetates

Derivatives of acetic acid e.g. monochloroacetic acid, peracetic acid, dehydroacetic acid and sodium diacetate have been recommended as preservatives, but not all are approved by the Food and Drug Administration. Dehydroacetic acid has been used to impregnate wrappers for cheese to inhibit growth of moulds and a temporary preservative for squash. Acetic acid in the form of vinegar is used in mayonnaise pickles, catsup and pickled sausages. Acetic acid is more effective against yeast and bacteria than against moulds, and its effectiveness increases with a decrease in pH, which would favour the presence of the undissociated acid. Sodium diacetate has been used in cheese spreads and malt syrups and as treatment for wrappers used on butter.

3.2.6 Sulphites

In aqueous solutions, sulphur dioxide, sulphite salts, bisulphate salts and metabisulphite salts form sulphurous acid, the active antimicrobial compound. The effectiveness of sulphurous acid is enhanced at low pH values. The fumes of burning sulphur are used to treat most light-coloured dehydrated fruits, while dehydrated vegetable are exposed to a spray of neutral bisulphite and sulphites before drying. Sulphur dioxide has also been used in syrups and fruit juices and wine making. Some countries permit the use of sulphites on meat and fish.

In addition to the antimicrobial action of sulphites, they are also used to prevent enzymatic and non-enzymatic changes or discolouration in some foods. They are most effective against yeasts, moulds and bacteria. However, current levels are limited because at about 500 ppm the taste becomes noticeable. SO_2 and several sulphite salts are considered GRAS, but they may not be used in foods which have substantial amounts of thiamine. In addition to its antimicrobial activity, bisuphites have been shown to degrade aflatoxin B_1 and G_1.

3.2.7 Nitrites and Nitrates

Combinations of these salts have been used in curing solutions and curing mixtures for meats. Nitrites decompose to nitric acid, which forms nitrosomyoglobin when it reacts with the heme pigments in meats and thereby forms a stable red colour. Nitrates probably only act as a reservoir for nitrite, and their use is being restricted. Nitrites can react with secondary and tertiary amines to form nitrosamines, which are known to be carcinogenic. The problem of possible carcinogenic nitrosamines appears to be greatest in bacon (cured meat from the back or sides of pig). The extended future for the use of nitrites in foods is therefore questionable and at least controversial.

They are currently added in the form of sodium nitrite, potassium nitrite, sodium nitrate, or potassium nitrate. Recent work has emphasised the inhibitory property of nitrites toward *Clostridium botulinum* in meat products, particularly in bacon and canned or processed hams. Nitrates have a limited effect on a limited number of organisms and would not be considered a good chemical preservative. See appendix 4 maximum allowable limits of approved preservatives.

3.3 Smoke

The smoking of foods usually has two main purposes, adding desired flavours and preserving. Other desirable effects may result, however, e.g. improvement in the colour of the inside of meat and in the finish, or "gloss" of the outside and a tenderising action on meats. Commonly, smoke is obtained from burning wood, preferably a hard wood like hickory, but is may be generated from burning corn cobs or other materials. Other woods used are apple, oak, maple, beech, birch, walnut and mahogany.

Preservative action is provided by bactericidal chemicals in the smoke such as formaldehyde, guaiacol (2-methoxyphenol), and creosote, which has limited bactericidal and antioxidant action and by the dehydration that occurs in the smokehouse.

Woodsmoke contains a large number of volatile compounds that differ in their bacteriostatic and bactericidal effect. Woodsmoke is more effective against vegetative cells than against bacterial spores, and the rate of germicidal action of the smoke increase with its concentration and the temperature and varies with the kind of wood employed. The residual effect of the smoke in the food has been reported to be greater against bacteria than against moulds. The concentration of mycostatic material from woodsmoke necessary to prevent mould growth increase with a rise in the humidity of the atmosphere of storage.

The application of "liquid smoke", a solution of chemicals similar to those in woodsmoke, to the outside of foods has little or no preservatives effect although it contributes to flavour.

3.4 Sugar and Salt

These compounds tend to tie up moisture and thus have an adverse effect on micro-organisms. Salt have the following effects on food items:

i. It causes high osmotic pressure and hence plasmolysis of cells; however, the percentage of salt necessary to inhibit growth or harm the cell varies with the micro-organism.
ii. It dehydrates foods by drawing out and tying up moisture as it dehydrates microbial cells.
iii. It ionises to yield the chlorine ion, which is harmful to organisms
iv. It reduces the solubility of oxygen in the moisture

v. It sensitises the cell against carbon dioxide
vi. It interferes with the action of proteolytic enzymes.

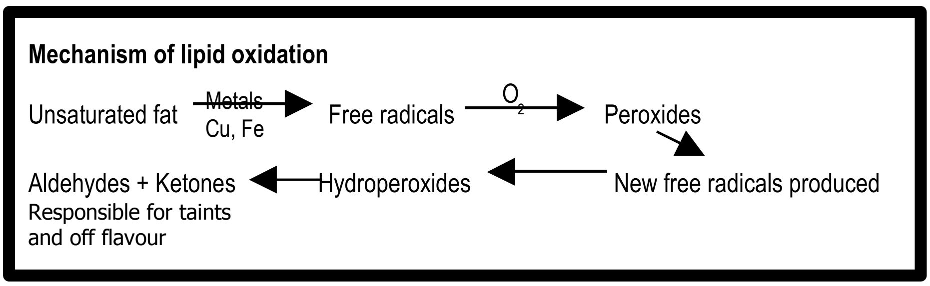
Sugars such as glucose or sucrose, owe their effectiveness as preservatives to their ability to make water unavailable to organisms and to their osmotic effect. Examples of foods preserved by high sugar concentrations are sweetened condensed milk, fruits in syrups, jellies and candies

3.5 Formaldehyde

The addition of formaldehyde to foods is not permitted, except, as a minor constituent of wood smoke, however this compound is effective against moulds, bacteria and viruses and can be used where its poisonous nature and irritating properties are not objectionable. Thus, it is useful in the treatment of walls, shelves, floors, etc to eliminate moulds and their spores. Paraformaldehyde can be used to control bacterial and fungal growth in tapholes of maple trees. Formaldehyde probably combines with free amino groups of the proteins of cell protoplasm, injures the nuclei, and coagulates proteins.

3.6 Antioxidants

These are used to prevent rancidity in fatty foods and to protect the fat-soluble vitamins (A, D, E and K) against damage by oxidation. As far as food is concerned, protection must be given to the unsaturated fat it contains, not only because of the noxious taints that could develop, but also because of the loss of valuable essential fatty acid that would follow. Synthetic antioxidants include esters of gallic acid, tertiary butylhydroquinone (TBHQ), butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA). BHA and BHT are not permitted in baby foods while L-Ascorbic acid is preferred for moist foods, e.g. meat, bakery products and beer. Vitamins C (as Ascorbic acid, sodium



L- and calcium ascorbate) and E (α-tocopherol) are also commonly used as antioxidants; they obviously enhance the nutritional value of the food to which they are added; indeed, there is some evidence that synthetic antioxidants used in food manufacture also have useful antioxidant action in the body. Some spices have value as antioxidants, but their primary function is flavour enhancement, as is the use of the additive monosodium glutamate.

3.7 Acidity Regulators (Acidulants)

Acidulants act to reduce the pH, minimise microbial growth and to enhance the effect of the weak acid preservatives. Alkalis, including sodium, potassium, calcium, and magnesium hydroxides, may be used to neutralise excess acidity (sourness) in foods. Acids and their salts are used as flavourings and also to control the pH of foods. Some, including acetic acid (vinegar), lactic acid (formed in soured or fermented milk), propionic, malic and fumaric acids, also have valuable antimicrobial action, and may, in addition, be classified as preservatives. Others, including ascorbic (vitamin C), citric, tartaric, phosphoric, hydrochloric, sulphuric acids and their salts, as well as carbon dioxide and carbonates or bicarbonates may be used either as buffers or for special purposes, including acting as emulsifying agents, raising agents or anticaking agents.

3.8 Emulsifiers and Stabilizers

An emulsifier is a substance which aids the formation of a stable mixture of two otherwise immiscible substances e.g. fat and water. A stabilizer, on the other hand, helps to maintain an emulsion when it is formed. The stabilizer may have the same basic characteristic with an emulsifier, or it may serve to thicken one or more participant in the emulsion, or make it more viscous and hence less likely to separate into its components. Additives in this group are used to enable oils and fats to mix with water and to form smooth emulsions (for example margarine and mayonnaise), to give a smooth creamy texture to foods, and to slow the staling of baked goods. Many are also used to form jellies. A variety of plant gums, including alginates, agar, guar gum, and carob gum, may make a useful contribution to the intake of non-starch polysaccharide (dietary fibre), as may pectins and the various cellulose derivatives that are widely used. Other emulsifying agents include lecithin and a variety of salts and esters of fatty acids.

3.9 Anticaking Agents

These are anhydrous substances that can pick up moisture without themselves becoming wet. In other words, they immobilise moisture coming in contact with a food material. They are added to particulate products, such as dry mixes, to prevent the particles from clumping together and so keeps the product free flowing. Anticaking agents are used to ensure that powders such as flour or salt remain free flowing; compounds that are used include bone meal (which is also used for enrichment of flour with calcium), polyphosphates, silicates (including Aluminium, magnesium, and calcium salts of silicic acid), stearates, gluconates, salts of long chain fatty acids (e.g. myristic, palmitic and stearic).

3.10 Humectants

They are required to keep certain food products moist as in bread and cakes. Humectants pass any incoming moisture into the product to compensate for losses due to natural drying. All humectants are hygroscopic in nature. Common humectants include glycerol, sorbitol and propan-1, 2-diol

3.11 Sequestrants

Certain metals, especially copper and iron can act as pro-oxidant catalyst and therefore need to be immobilised. Sequestrants are compounds added to do just that. Commonly used sequestrants include EDTA, phosphates, tribasic citric acid, tartaric acid and its salts.

3.12 Flavouring Agents

These include sweeteners, some fruit acids, natural extracts of fruits and herbs, and synthetic compounds designed to mimic natural flavours. In addition, a number of compounds are used to enhance the flavour of foods, without giving any particular flavour of their own; such compounds include glutamic acid and its salts (especially monosodium glutamate), and nucleic acid derivatives.

3.13 Use of Modified Atmospheres

The normal composition of air is 20% oxygen (O_2), 79% nitrogen (N_2) and 1% carbon dioxide (CO_2). A modified atmosphere (MA) is one in which the normal composition of air around a food material is changed or “modified” at the point of packing. This modification usually results in a reduction of the O_2 content of air while increasing the level of CO_2 and N_2. A controlled atmosphere (CA) is a process whereby the gaseous environment is modified to a desired level and controlled at that level, with strict limits, throughout storage and usually applied to bulk storage products. A modified atmosphere applies to food packaged in small convenient retail units in which the gaseous atmosphere is modified or changed at the point of packing.

However, unlike CA storage, the gaseous atmosphere in MA packaged products changes continuously throughout the storage period. Thus, while both CA and MA mean that the gaseous atmosphere around the product differs from air, CA has more precise gas compositional control than MA. The various methods by which the gaseous atmosphere within a packaged product can be modified are reviewed below.

3.13.1 Vacuum Packaging

This is the most common method of modifying the internal package environment and is used extensively by the meat industry to extend the shelf life and keeping quality of fresh meat. The product is placed in a film of low oxygen permeability, air is evacuated and the package is sealed. Under conditions of a good vacuum, headspace O_2 is reduced to <1% while CO_2, produced form tissue and microbial respiration, eventually increases to 10-20% within the package headspace. These conditions, i.e. low O_2 and elevated CO_2 levels, help extend the shelf life of meat by inhibiting growth of normal aerobic meat spoilage microorganisms particularly *Pseudomonas* and *Altermonas* species.

However the shelf life of a vacuum packaged meat depends on a number of inter-related factors, specifically the microbiological quality and pH of meat at time of packing, packaging film permeability, package integrity and storage temperature. The main disadvantage of vacuum packaging from a commercial viewpoint is that the depletion of oxygen, coupled with the low oxygen permeability of the packaging film, results in a change of meat colour from red to brown. In addition, vacuum packaging cannot be used on soft products such as pizza, pasta or baked products.

3.13.2 Gas Packaging

This technique involves packaging the product under an atmosphere of various gases such as CO_2, N_2, O_2 and sometimes CO. The most commonly used, and perhaps the most effective being CO_2 with or without other gases. For example, with meat O_2 is necessary for the bright red colour or “bloom” which is associated with good quality meat. However, O_2 also promotes microbial growth. Carbon dioxide is a bacteriostatic agent, i.e. it inhibits microbial growth, but it will discolour fresh meat. The problem of balancing these two separate effects can be overcome by using a gas mixture incorporating CO_2, O_2 and N_2. The N_2 is needed to prevent the packaging film collapsing around the product as CO_2 dissolves the meat.

The major advantages of gas packaging are: increased shelf life, increased market area, reduction in production and storage costs, reduction in use of inhibitors, improved presentation, fresh appearance, clear view of product and easy separation of slices. Some of its disadvantages include high initial cost of packaging equipment, films, etc; discolouration of meat pigments, leakage, fermentation (by CO_2 resistant microorganisms), swelling and potential growth of organisms of public health significance

3.13.3 Oxygen Absorbants

Oxygen absorbants consist of iron oxide packaged in small sachets like a desiccant (sold under the trade name "*ageless*") and come in a variety of sizes that absorb 20 – 2000 cc of oxygen. When used in conjunction with a film of low oxygen permeability, the headspace O_2 is reduced to less than 0.05% within hours in the packaged product and remains at this level for the duration of the storage period. Oxygen absorbants have been widely used in Japan to extend the mould-free shelf life of bread, pizza crusts and cakes as well as prevent oxidation of fats in potato chips, dried fish, beef jerky, semi-moist cookies and chocolates.
A recent technology in atmosphere modification from Japan is the use of CO_2 generators. These substances not only absorb headspace oxygen from the packaged product but also generate equal volumes of carbon dioxide into the package headspace.

3.13.4 Ethanol Vapour Generators

Despite the widespread use of ethanol as a germicidal agent, few studies have evaluated ethanol as a food preservative. However, a novel and innovative method of generating ethanol vapour, again recently developed in Japan, is through the use if ethanol vapour generators, sold under the trade name "*ethicap*". Ethicap comprises of a paper/ethyl vinyl acetate sachet containing food grade ethanol adsorbed onto a fine silicon dioxide powder. When a food is packed with a sachet of Ethicap, moisture is absorbed from the food and ethanol vapour is released from encapsulation and permeates the package headspace. However, both the initial and final level of ethanol vapour in the package headspace is a function of sachet size and water activity. Ethanol vapours are extensively used in Japan to extend the shelf life of high moisture baked products.

3.14 Fermentation and Pickling

Although microorganisms are usually thought of as causing spoilage, they are capable under certain conditions of producing desirable effects, including oxidative and alcoholic fermentation. The microorganisms that grow in a food product and the changes they produce, are determined by acidity, available carbohydrates, oxygen and temperature.

Fermentation may be defined as *the process of anaerobic or partial anaerobic oxidation during which enzymes from microorganisms or the food material break down carbohydrates or carbohydrate-like material into simpler substances.* It may also be defined as *an ATP generating metabolic process in which organic compounds serve both as electron donors and as electron acceptors.* By these definitions, fermentation may be separated into that caused by microorganisms and those influenced by enzymes. However, only those products involving the *deliberate fermentative growth of microorganisms* are described as being fermented. Products whose manufacture primarily involves the *activity of indigenous or added enzymes* are better referred to as being enzyme hydrolysed. In cases where the hydrolysis is purely due to *indigenous enzymes,* this will be properly described as autolysis.

Generally, fermentation results in the breakdown of complex organic substances into simpler ones through catalysis. For example, by the action of diastase, zymase, and invertase, starch is broken down (hydrolysed) into complex sugars, then simple sugars and finally alcohol. Fermentation is employed in the processing of some food items like burukutu, bread, milk products, matured palm wine to mention but a few.

It seems quite contradictory that microorganisms and enzymes, which are known to be responsible for food spoilage and deterioration, are also used for food preservation. Microorganisms and enzymes are able to achieve this due to the following reasons:

- The environment of the food item is saturated with the fermenting organisms. These organisms lower the pH and prevent entry of other microorganisms. As the pH is reduced, preservation is ensured.
- Macromolecules in the food would have been broken down into micromolecules which can no longer be attacked by microorganisms
- They produce alcohols, acids etc which are capable of preserving the food. In fact, the keeping quality of alcoholic beverages depends on the percentage of ethanol produced. The higher the percentage produced, the longer the shelf life.

The action of certain bacteria on undigested carbohydrates causes fermentation in the human intestine. As a result, gases such as hydrogen sulphide and carbon dioxide may form in amounts large enough to cause distension and pain. Acids such as lactic acid (due to the action of lactase on milk) and ethanoic acid may also form in the intestines of infants, causing diarrhoea.

Pickling deals with preservation of foodmaterials, especially vegetables, in brine, vinegar (sour liquid got from malt, wine, cider, etc by fermentation) and mustard. The process results in absorption of salts, which in turn, result in removal of water from the flesh to a level that impedes microbial growth and enzyme activities. Fresh fruits and vegetables soften after 24 hours in a watery solution and begin a slow, mixed fermentation-putrefaction process. The addition of salt suppresses undesirable microbialactivity, creating a favourable environment for the desired fermentation. Pickling may therefore be used to preserve most green vegetables and fruit.

When the pickling process is applied to cucumber, its fermentable carbohydrate reserve is turned into acid, its colour changes from bright green to olive or yellow-green, and its tissue becomes translucent. The salt concentration is maintained at 8 to 10% during the first week and is increased 1% a week thereafter until the solution reaches 16%. Under properly controlled conditions, the salted, fermented cucumber, called *salt stock*, may be held for several years. Salt stock is not a consumer commodity. It must be freshened and prepared into consumer items. In cucumbers, this is accomplished by leaching the salt from the cured cucumber with warm water (43° - 54°C) for 10 to 14 hours. This process is repeated at least twice, and, in the final wash, alum may be added to firm the tissue and turmeric to improve the colour.

Meat may be preserved by dry curing or with a pickling solution. The ingredients used in curing and pickling are sodium nitrate, sodium nitrite, sodium chloride, sugar, and citric acid or vinegar. Various methods are used: the meat may be mixed with dry ingredients; it may be soaked in pickling solution; pickling solution may be pumped or injected into the flesh; or a combination of these methods may be used. Curing may also be combined with smoking. Smoke acts as a dehydrating agent and coats the meat surfaces with various chemicals, including small amounts of formaldehyde.

Fermented foods and pickled products require protection against moulds, which metabolise the acid developed and allow the advance of other microorganisms. Fermented and pickled food products placed in cool storage remain stable for several months. Longer storage periods demand more complete protection (as in canning). Nutrient retention in fermented and pickled products is about equal to retention for products preserved by other methods. In some instances, nutrient levels are increased because of the presence of yeasts.

3.14.1 Types of Fermentation

A very important type of fermentation is alcoholic fermentation, in which the action of zymase secreted by yeast converts simple sugars, such as glucose and fructose, into ethyl alcohol and carbon dioxide. Many other kinds of fermentation occur naturally, as in the formation of butanoic acid when butter becomes rancid and of ethanoic (acetic) acid when wine turns to vinegar.

Alcoholic Fermentation

Alcoholic fermentation involves the use of yeast to breakdown glucose into alcohol and carbon dioxide. This step is involved in the alcoholic fermentation of starchy materials by species of *Saccharomyces* (*carlsbergensis* or *cerevisiae*). It has found application in the brewing industry where beer andsimilar cereal beverages that undergo fermentation are produced.

Acetic Acid Fermentation

This involves the conversion of ethanol into acetic acid by *Acetobacter* (acetic acid bacteria). This step is involved in the souring of wine

Lactic Acid Fermentation

Lactic acid is usually prepared by fermentation of lactose, starch, cane sugar or whey. This acid, generated in milk by fermentation of lactose, causes the souring of milk. The lactic acid bacteria, as presently constituted, consists of the following four genera *Lactobacillus, Leuconostoc*, *Pediococcus* and *Streptococcus*. They all share the property of producing lactic acid from hexose sugars. Lactic acid is used in preparing cheese, sauerkraut, soft drinks, and other food products. In this type of fermentation, glucose is converted to lactic acid by *Lactobacillus* (lactic acid bacteria). Lactic acid fermentation is employed in dairy for the production of sour milk products.

4.0 CONCLUSION

The food industries employ many methods to improve the qualities of their products including:

(a) The use of additives to improve colour, flavour and shelf life.
(b) The use of modified atmosphere to create conducive environment for the non-growth of microorganisms
(c) The use of various preservatives to prevent spoilage

5.0 SUMMARY

In this unit we have learnt that:

Additives are used extensively in the food industry to improve colour, flavour and preservation.

Modern biotechnology can be applied in (a) fermentation (b) vacuum packaging and (c) gas packaging to improve the shelf life and qualities of meat and beverages.

SELF ASSESSMENT EXERCISE

1. List the common additives that are used in beverage industries to improve colour.
2. Enumerate the common additives that are used in industries to improve flavour.

6.0 TUTOR-MARKED ASSIGNMENT

What are the advantages of?

1. Vacuum packaging.
2. Gas packaging commonly used in the beverage industries?

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MODULE 3

UNIT 1 COMPOSITION AND STRUCTURES OF NIGERIA AND WEST AFRICAN FOODS

CONTENTS

1.0 INTRODUCTION

The fundamental purpose of Food Technology is to preserve food from deterioration and to present it to the consumer in a digestible and nutritious form to the ultimate consumer. A secondary interest of the

Food Technologist, is that of modifying the quality of food stuffs so that they may become acceptable and attractive to the people for whom they are intended. However, the extent to which this can be done depends, to a large extent, on the nature of the commodities, their composition and technologies available for processing it.

2.0 OBJECTIVES

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

- discuss the nutrient composition of some Nigerian African foods
- classify the foods according to their composition e.g. energy foods, proteinous foods and fatty foods
- relate the composition of foods to the use of therapeutic diets.

3.0 MAIN CONTENT

3.1 Nutrient Composition of Some Nigerian Foods

3.1.1 Moisture Content

The Moisture content of Nigerian/African foods may fluctuate greatly with season, length of storage, etc. In calculating energy values of food, moisture contents must be accurately determined and subtracted from whole to estimate total dry matter. Water in itself does not provide either nutrients or energy.

3.1.2 Food Energy

The energy values of the foods represent the available energy calculated by the specific Atwater factors for protein, fat, and total carbohydrate by difference, which is obtained by subtracting the sum of the figures for moisture, protein, fat, and ash from 100. These factors have taken into account the losses in digestion and metabolism.

3.1.3 Protein

The values for protein were computed from the nitrogen content as determined by the Kjeldahl method, multiplied by a conversion factor. From the fact that most proteins contain approximately 16 per cent nitrogen, protein contents were calculated with the factor 6.25 for the conversion of nitrogen to protein.

For those foods in which the protein is known to differ from this figure, the specific factors for converting nitrogen, as suggested by Breese Jones and listed below:

Foods	**Factors for Converting Nitrogen to Protein**
Milk	6.38
Groundnut	5.46
Soybeans	5.71
Nuts and Seeds	5.30
Rice	5.95

3.1.4 Vitamins

Apart from the macro nutries of Carbohydrate, Proteins and Fats Foods supply micronutrients in form of Vitamins and Minerals.

The Vitamins are divided into two major groups: (a) FAT SOLUBLE and (b) WATER SOLUBLE, Ascorbic acid or Vitamin C belongs to both groups.

The FAT SOLUBLE VITAMINS

Vitamin A,
Vitamin D,
Vitamin E
And Vitamin K

THE WATER SOLUBLE VITAMINS Thiamine (B1), Riboflavin (B2), Pyridoxal Phosphate (B6), Niacin, Pantothenic Acid, Folic Acid, and Vitamin B_{12}. Vitamin C is both water soluble and fat soluble because it is retained in the blood plasma where its level can be estimated.

3.1.5 The Minerals

The micronutrients known as minerals also occur in foods in minute amounts but are very essential for body metabolisms. They act as catalysts and coenzymes to facilitate body reactions in intermediary metabolisms. Examples of minerals include Sodium (Na); present in abundance in common salt (Nacl.); Potassium (K); Calcium (Ca); Iron (Fe); Phosphorus (P); Magnesium (Mg).; Iodine (1_2); Zinc (Zn); Cobalt (C_o); and Sulphur (S).

3.2 Proximate Composition of Cereal Products

		Waste g	Moisture %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Maize, white whole, dried	0	10	1722	412	10.7	4.1-	-	88	-	-	0.4	0	2.7
2.	Maize, fresh boiled	-	59	1170	280	5.0	2.1	-	60	-	-	-	-	-
3.	Maize Eko/Agidi	-	79	585	140	1.9	1.2	-	30	-	-	-	-	-
4.	Cornflakes	0	8	1313	314	8.9	1.2	-	67	32	63.5	1.1	0	-
5.	Maize, Egbo	-	60	1484	355	6.0	30.7	-	14	-	-	-	-	-
6.	Maize, 'Guguru', roasted	-	5	1756	420	8.1	5.0	-	86	-	-	-	-	-
7.	Maize, yellow, dried	-	10	1714	410	10.7	4.0	-	83	-	-	1.3	0	3.7
8.	Maize while toasted/ roasted	-	16	1605	384	11.0	3.1	-	76	-	-	1.7	-	1.5
9.	Maize roasted paste (kokoro)	-	2	2115	506	8.8	23.4	-	65	-	-	-	-	2.8
10.	Maize Pap, fermented gruel "Ogi"	-	41	1731	414	11.5	39.0	-	83	-	-	1.1	-	0.4
11.	Rice, polished	0	10	-	-	9.1	0.1	-	-	-	-	0.3	-	0.6
12.	Rice, boiled	0	70	522	123	2.2	0.3	-	30	0	30.0	0.8	-	-
13.	Bread White Bread	0	39	991	233	7.8	1.7	-	50	1.8	48.0	2.7	-	-
14.	Spaghetti	0	72	499	117	4.2	0.3	-	26	0.8	25.2	-	-	-

Source: Oguntona and Akinyede, 1995

Cereal products refer to grains from plant sources and include Acha grain, maize, white, whole, dried, Maize freshly boiled, maize prepared into Eko/Agidi; maize roasted “Guguru”, maize yellow, dried; maize white roasted, maize roasted and made into paste “Kokoro”, maize papa, fermented gruel “OGI’. Others are Millet finger, Millet bulrush grain; and Millet pap, gruel. Rice is also a cereal, Rice, brown raw, Rice polished, and rice boiled, fried or oil mixed “Jollof”. Others are sorghum grain and sorghum, pap/gruel. The most popular cereal is wheat grain from which bread is produced. “Give us this day our daily bread”. Wheat grain can be boiled; wheat flour can be produced; wheat bread white or brown; and assorted wheat confectionaries can be produced. Spaghetti is a cereal product which can be boiled and eaten as such. Mane breakfast cereals are known such as cornflakes, Granuola and Rice cripies. most baby complementary foods or weaning foods are prepared from cereals mixed with milk e.g. Cerelac and Bebena or mixed with vegetable proteins e.g Nutrend.

3.3 Proximate Composition of Roots and Tubers

		Waste g	Moisture %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Cassava bitter, peeled, raw	26	72	1634	391	2.6	0.5	-	94	6.7	81.4	1.4	-	1.3
2.	Cassava grated	-	14	1605	384	1.2	0.4	-	94	6.2	98.6	2.3	-	2.1
3.	Cassava Flour	-	13	1618	387	2.2	0.9	-	93	-	-	1.4	-	2.9
4.	Cassava sweet, peeled, raw	-	72	1572	376	1.7	0.7	-	91	-	-	1.6	-	5.2
5.	Cocoyam	-	68	1618	387	5.4	0.4	-	90	-	-	1.8	-	2.0
6.	Cocoyam	-	-	-	-	-	-	-	-	-	-	-	-	-
7.	Cocoyam	-	67	1626	389	5.1	0.5	-	91	-	-	1.6	0	1.8
8.	Potato Irish, peeled, raw	14	78	315	75	1.7	0.1	-	18	1.0	17.0	0.6	-	1.6
9.	Potato Irish, boiled	4	79	318	76	1.6	0.1	-	18	0.7	17.6	2.0	-	-

10.	Potato, sweet, white, peeled cooked	-	71	1635	391	5.2	0.5	-	92	-	-	0.1	-	2.7
11.	Yam, water, peeled raw	-	76	1559	373	7.3	0.6	-	86	-	-	2.3	-	4.0
12.	Yam, water, peeled grated (Ojojo)	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	Yam, water, peeled raw	-	70	1593	381	5.3	0.3	-	90	-	-	1.5	-	2.7
14.	Potato, sweet, white, peeled cooked	-	64	1613	386	5.0	0.4	-	91	-	-	0.6	-	3.4

Source: Oguntona and Akinyede, 1995

The composition of roots and tubers include the cassava species, cassava bitter, peeled, raw' cassava grated, fermented, dried "Gaari"; Cassava meal, fermented and cooked, "Eba"; cassava flour; "Lafun"; cassava sweet, peeled, raw; Cocoyam (Tania), peeled cooked, cocoyam (Taro) peeled, cooked; potato irish, peeled boiled; potato irish boiled; potato, sweet, white peeled and cooked; yam, water, peeled, raw; yam water, peeled, grated "Ojojo".

3.4 Proximate Composition of Legumes and Legume Products

		Waste g	Moisture %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Cowpea, blackedeyed pea, dried	-	11	1430	342	23.1	1.4	-	61	-	-	4.8	-	3.3
2.	Cowpea, blackedeyed pea, cooked	-	68	598	143	6.2	5.7	-	18	-	-	1.2	-	2.0
3.	Cowpea, Vigna Spp, young green pods	-	89	163	39	3.7	0.6	-	5	-	-	1.2	-	0.8
4.	Cowpea, Vigna Spp, mature pods, dried	-	11	1413	338	22.5	1.4	-	61	7.0	50.0	54	-	3.7
5.	Cowpea, Vigna Spp, whole meal	-	12	1584	379	24.9	1.6	-	66	-	-	3.0	-	4.2
6.	Cowpea, Vigna Spp, whole bean boiled (Ewa)	-	51	2475	592	24.6	2.1	-	66	-	-	3.0	-	3.2

7.	Cowpea, Vigna Spp, bean cake (Akara)	-	36	2533	606	26.3	27.3	-	38	-	-	2.9	0	5.1
8.	Cowpea, Vigna Spp, steamed cake (moinmoin)	-	39	2558	612	24.0	12.0	-	57	-	-	2.4	-	2.9
9.	Cowpea, Vigna Spp, Steam paste (Ekuru)	-	69	2508	600	22.6	-	-	-	-	-	-	-	-
10.	Cowpea, Vigna Spp, Soup (Gbegiri)	-	73	2671	639	26.8	21.2	-	43	-	-	2.4	-	5.1
11.	Lima bean, raw	0	11	1446	346	91.8	1.3	-	65	-	-	-	-	3.0
12.	Pigeon Pea, whole	-	10	1442	345	19.5	1.3	0	65	7.0	51.0	7.3	0	3.8
13.	Pigeon Pea, flour	0	5	1467	351	22.4	2.6	-	59	-	-	3.8	-	5.8
14.	Soyabean seed, dried	-	10	1693	405	33.7	17.9	0	34	0	29.0	4.7	0	5.0

Source: Oguntona and Akinyede, 1995

Legumes include cowpea, blackeyed pea dried; cowpea, blackeyed pea cooked; cowpea vigna spp, mature pods dried; cowpea, vigna spp, whole meal; cowpea vigna spp peeled; cowpea vigna spp, whole boiled "Ewa"; cowpea vigna spp bean cake "Akara"; cowpea vigna spp. steamed cake "Moinmoin" and cowpea vigna spp. steamed paste "Ekuru". Others include lima beans raw; mesquite african seeds, whole dried; pigeon pea whole; pigeon pea flour; and soya bean seed dried.

3.5 Proximate Composition of Nuts and Seeds

		Waste g	Moisture %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	"Amusa"-nut, seed, dried	-	8	1751	419	28.7	18.3	-	41	-	-	2.8	-	4.0
2.	Bambara groundnut, fresh, raw	25	8	1442	358	21.1	6.5	-	53	-	-	5.1	-	3.8
3.	Benniseed, dried, raw	-	5	2432	595	17.9	48.4	-	22	-	-	4.5	-	6.2
4.	Benniseed, dehuled, roasted	-	3	2592	573	17.6	46.5	-	21	-	-	8.9	-	3.4
5.	Cashew nut, dried, raw	-	8	2265	542	17.4	43.4	-	29	-	-	1.4	-	2.4
6.	Cashew nut, roasted	-	6	2299	550	18.6	43.7	-	29	-	-	2.4	-	2.5
7.	Coconut, mature kernel, fresh	30	42	1622	351	3.2	36.0	-	4	3.7	-	13.6	0	1.0
8.	Groundnut, fresh, raw	31	5	2364	570	24.3	49.0	-	9	3.1	5.5	8.1	-	2.5
9.	Groundnut, cooked	-	45	982	235	16.8	8.3	-	26	-	-	6.1	-	4.8
10.	Groundnut, dried, roasted	-	2	2487	595	23.2	50.9	-	22	-	-	3.2	-	2.4
11.	Groundnut, roasted, ground, fried "Kulikuki"	-	5	-	-	48.6	22.9	-	19	-	-	-	-	4.8
12.	Kolanut K. nitida, fresh, raw	-	-	-	-	-	18.8	2.0	-	-	-	5.1	-	5.8
13.	Melon seed, dried, without shell	25	5	2370	567	28.4	52	-	8	-	-	2.7	-	3.6
14.	Melon seed, roasted	-	5	2429	581	27.1	50.3	-	16	-	-	2.3	-	2.7

Source: Oguntona and Akinyede, 1995

Nuts and seed include walnut “Awusa”; bambara groundnut, fresh, raw: beeniseed dehulled, roasted; beeniseed, dried, raw; cashew nut dried, raw; cashew nut roasted,; coconut, mature kernel, fresh; groundnut fresh, raw; groundnut cooked, groundnut d ried and roasted; groundnut, roasted, ground , fried “Kulikuli”; Kolanut Kinitida fresh, raw; melon seed dried without shell; and melon seed roasted and fried “robo”.

3.6 Proximate Composition of Fruits

		Waste g	Moisture %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Banana, ripe, peeled	37	70	1605	384	4.2	0.5	0	91	-	-	0.1	0	4.5
2.	Banana, unripe, peeled	-	75	1639	392	3.6	1.6	-	91	86	34.0	0.8	-	3.4
3.	Bush mango (African) pulp ripe	-	81	255	61	0.9	0.2	-	16	-	0.2	0.4	-	1.6
4.	Cashew, fruit, pulp	-	86	222	53	1.0	0.7	-	12	-	-	0.6	-	0.4
5.	Citrus, orange/tangerine, ripe	25	88	185	44	0.6	0.4	-	10	9.0	1.0	0.6	0	0.5
6.	Citrus, grapes fruit/shaddock	49	90	142	34	0.8	0.1	0.1	9	7.0	1.0	0.6	0	0.5
7.	Citrus, lemon/lime fruit	41	90	165	40	0.6	0.8	0	8	5.0	3.0	0.7	0	0.4
8.	Dates, dried	31	17	1225	293	2.7	0.6	0	78	7.0	4.0	3.9	0	1.9
9.	Guava, ripe whole	19	82	675	64	1.1	0.4	-	16	-	-	5.3	0	0.6
10.	Mango, ripe, peeled	34	83	253	59	0.5	0.0	0	15	15.3	0	1.5	-	0.5
11.	Pawpaw, ripe, fruit	46	85	134	32	4.1	0.6	-	9	6.4	1.0	6.0	-	3.9
12.	Pineapple peeled, pulp	47	84	194	46	0.5	0.0	-	12	11.6	-	1.2	-	-
13.	Tamarind, fruit, dried	-	19	1359	325	8.8	2.5	-	67	41.2	0.6	2.2	-	2.9
14.	Water melon	45	94	92	22	0.5	0.1	-	5	-	-	0.4	-	0.3

Source: Oguntona and Akinyede, 1995

Among fruits are banana, ripe, peeled; Banana unripe peeled; bush mango (African) pulp, ripe, cashew fruit pulp; citrus orange/tangerine, ripe; citrus lemon/Lime fruit; Dates dried; Guava, ripe whole; Mango ripe peeled; Pawpaw ripe, fruit: Pineapple, pulp; and Water melon.

3.7 Proximate Composition of Meals

		Waste g	Moist ure %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Amala + Ewedu	-	70	1722	412	17.6	4.4	-	76	-	-	1.5	-	1.1
2.	Beans and Bread	-	-	2738	655	18.4	4.8	-	-	-	-	2.8	-	2.5
3.	Eba and Okoro Soup	-	75	1977	437	9.9	10.0	-	72.0	-	-	3.5	-	4.6
4.	Foodoo + Okro SOup	-	-	2876	688	8.5	4.7	-	-	-	-	1.9	-	1.3
5.	Jollof Rice	-	41	1985	475	46.5	20.5	-	26	-	-	2.8	-	3.9
6.	Lafun + Ewedu + Meat Stew	-	-	2504	599	8.5	6.7	-	-	-	-	2.1	-	2.2
7.	Maize + Beans (Adalu)	-	-	2738	655	18.6	9.1	-	-	-	-	3.9	-	3.4
8.	Pounded yam + Afia Efere (Plain Soup)	-	75	1630	390	11.3	6.6	-	77	-	-	-	-	5.0
9.	Rice and Beans	-	63	2211	529	12.3	13.2	-	68	-	-	2.7	-	3.9
10.	Rice and Stew	-	-	2847	681	11.6	8.4	-	-	-	-	0.4	-	3.0
11.	Tuwo and Dawa	-	76	1747	418	20.8	4.2	-	74	-	-	-	-	0.4
12.	Yam + Bean + Stew	-	-	2220	531	13.6	4.1	-	-	-	-	2.0	-	3.2
13.	Yam Pudding	-	73	2232	334	4.4	23.6	-	62	-	-	7.0	-	3.3
14.	Yam + Stew	-	-	2546	609	4.9	5.4	-	-	-	-	0.8	-	1.2

Source: Oguntona and Akinyede, 1995

African meals common to West Africa especially Nigeria include "Amala" (yam or plantain flour) made into meals eaten with stew, okro or "ewedu"; Beans and Breas, Benas in stew, "Eba" (Cassava fermented into "gari" made into meals) with Stew "Ewedu"; Foofoo (fufu) with stew, okro or "ewedu", Jollof Rice; fried rice plus stew plus meat/fish/chicken; pounded yam plus meat/fish or assorted meat.

3.8 Mineral and Vitamin Content of Fruits and Vegetables

		Waste g	Moist ure %	KJ g	Keal g	Protein g	Fat		Carbohydrates				Alcohol g	Ash g
							Total g	Chol	Total g	Mono g	Poly g	Fibre g		
1.	Banana, ripe, peeled	37	70	1605	384	4.2	0.5	0	91	-	-	0.1	0	4.5
2.	Banana, unripe, peeled	-	75	1639	392	3.6	1.6	-	91	8.6	34.0	0.8	-	3.4
3.	Bush mango (African) pulp ripe	-	81	255	61	0.9	0.2	-	16	-	0.2	0.4	-	1.6
4.	Cashew nut, fruit, pulp	-	86	222	53	1.0	0.7	-	12	-	-	0.6	-	0.4
5.	Citrus, orange/tangerine, ripe	25	88	285	44	0.6	0.4	0.1	10	9.0	1.0	0.6	0	0.5
6.	Guava, ripe, whole	19	82	675	64	1.1	0.4	0	16	-	-	5.3	0	0.6
7.	Pawpaw, ripe, fruit	46	85	134	32	4.1	0.6	-	9	6.4	1.0	0.6	-	3.9
8.	Pineapple, peeled, pulp	47	84	194	46	0.5	0.0	-	12	11.6	0	1.2	-	-
9.	Tamarind, fruit, dried	-	19	1359	325	8.8	2.5	-	67	41.2	0.6	2.2	-	2.9
10.	Water Melon	45	94	92	22	0.5	0.1	-	5	-	-	0.4	-	0.3
11.	Amaranth leaves, cooked	506	1.7	62	-	-	0	1700	60	-	-	-	-	34
12.	Bitter leaf, dried	1.5	5.5	536	-	-	-	-	-	-	-	-	-	20
13.	Carrot, fresh	35	0.7	38	250	49	-	5480	0.04	0.25	0	0.6	8	8.0
14.	Mushroom	20	1.5	1000	470	9	0	0	0.1	0.4	0.1	0	4.0	2.3

Source: Oguntona and Akinyede, 1995

This group includes Banana ripe, peeled; Banana unripe peeled, Bush mango Cashew, fruit pulp; Citrus and Orange/Tangerine ripe. Others are Guava, ripe, whole; Pawpaw, ripe fruit; Pineapple, peeled pulp; Tamarind, fruit, dried and Water melon. Among the vegetables are Bitter-leaf, dried; Carrot fresh; and mushroom.

3.9 Amino Acid Contents of Meat Poultry and Eggs

Essential Amino Acids																						
		N g	Total mg	Total mg	Cys mg	Ile mg	Leu mg	Lys mg	Met mg	Phe mg	Thr mg	Tyr mg	Trp mg	Val mg	Ala mg	Arg mg	Asp mg	Glu mg	Cly mg	His mg	Pro mg	Ser mg
1.	Beef, moderate fat	-	6150	2680	80	300	460	530	160	270	220	270	70	320	380	400	560	1020	330	200	320	160
2.	Egg, Chicken, raw	2.0	12320	5590	220	690	1020	770	630	630	490	220	670	750	1320	1480	370	300	390	470	970	930
3.	Egg, Guinea fowl, raw	-	6245	3057	143	314	578	431	252	294	279	225	121	420	339	387	671	752	184	129	281	445
4.	Mutton, moderate fat	2.7	16205	7475	307	933	1395	1580	598	764	375	212	1028	1300	1446	2320	794	454	441	598	770	870
5.	Offals, heart	-	6260	2900	100	330	570	540	140	290	290	210	80	650	390	400	530	950	380	160	220	330
6.	Offals, intestine cattle	-	-	-	121	959	1007	1411	611	529	626	492	-	701	-	1232	-	-	-	-	369	-
7.	Offals, liver	-	5850	2740	90	270	490	530	150	310	270	190	80	360	330	540	760	310	230	330	320	290
8.	Offals, tongue boiled	-	6050	2640	90	290	440	660	110	220	260	190	80	300	330	370	540	980	350	250	330	260
9.	Offals, tripe dressed	-	6450	2480	80	250	420	500	150	240	270	180	80	310	420	440	530	940	950	150	530	310
10.	Pork, moderate fat	1.90	11496	5203	133	608	897	961	496	583	426	162	654	756	1060	1718	696	391	321	542	496	616
11.	Poultry chicken	3.2	19800	8780	260	590	1540	1840	920	550	720	230	1180	1280	1870	3380	1020	620	490	850	820	980
12.	Rabbit, stewed with bone	-	6240	2770	80	310	480	550	170	290	270	230	70	320	380	4000	600	1030	320	160	320	240
13.	Snail, dried	-	-	-	-	384	742	725	104	314	410	216	240	474	771	387	1202	2154	1227	-	1843	502
14.	Termites, dried	-	-	-	187	511	783	542	75	438	275	302	143	744	900	694	1045	885	393	514	-	119

Source: Oguntona and Akinyede, 1995

Beef with moderate fat; Chicken eggs; Guinea fowl eggs; Mutton; Offals; Pork with moderate fat; Chicken; Rabbit; Snail and Termites.

4.0 CONCLUSION

The Composition of Nigerian and African foods is very rich and adequate in terms of macro nutrients (Carbohydrates, Proteins and Fats) and micro nutrients vitamins and Minerals.

5.0 SUMMARY

In this unit we have learnt that:

Nigerian and African foods are very rich in the supply of energy rich foods mainly as Roots and Tubers.

The micro nutrients of Vitamins and Minerals are abundant in fruits and vegetables.

Protein for body growth and repairs are supplied by animals and fish products.

Vegetables oils in form of palm oil, groundnut oil and corn oil supply the fat and the fatty acids.

SELF ASSESSMENT EXERCISE

List the common foods in the Nigerian diet that will favour:

1. High Energy
2. High Protein
3. High Fats

6.0 TUTOR-MARKED ASSIGNMENT

1. List nutrient composition of some Nigerian food.
2. Discuss two of the above listed.

7.0 REFERENCES/FURTHER READINGS

Aiyeleye F.B. and Eleyinmi A.F. (1997). Improved Traditional Processing Techniques for Selected Tropical Food Commodities. FADCOL Educational Press, Akure, Ondo State, Nigeria.

UNIT 2 PROCESSING OF SPECIFIC FOOD COMMODITIES I: ROOTS, TUBERS, CEREALS AND LEGUMES

CONTENTS

1.0 INTRODUCTION

In a developing country like ours, the need for improved preparation, processing, preservation and storage techniques as a way of enhancing demand for indigenous, locally consumed foods, coupled with increased application of food science and technology not only to boost our dwindling agricultural production, but also to ensure that the seasonal foods harvested are adequately preserved and/or kept under good storage conditions, cannot be over-emphasized. This practice has brought wealth and prosperity to many nations and has greatly contributed to the raising of the standard of living in the industrialized countries of the world.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss the examples of:

- tubers (yam, cassava) that are processed by dehydration to make flours
- cereals and legumes that are also dehydrated and milled to flour to produce new food
- the fermentation of maize and African locust bean to make new flavoured foods.

3.0 MAIN CONTENT

3.1 Processing of Specific Food Commodities in Nigeria

3.1.1 Root and Tuber Crops

Roots and tuber crops are agricultural products which grow beneath the soil. These include Yam (*Dioscorea sp*), Cassava (*Manihot sp)*, Sweet potato (*Ipomoea batatas*) and Cocoyam. They represent the most important source of energy in the diet of the tropical man. They have very high amounts of carbohydrates and trace amounts (if any) of the other major food groups. Thus, they are often taken with other food materials that will provide fats, proteins and other essential nutrients. Sweet potato and cocoyam are often consumed without processing. Major traditional food products of importance are obtained from yam and cassava.

3.1.1.1 Yam

Yams make up the genus *Dioscorea* of the family Dioscoreaceae. The water yam is classified as *Dioscorea alata,* the Chinese yam, or Chinese potato, as *Dioscorea batatas*, the air potato as *Dioscorea bulbifera*, the elephant’s foot as *Dioscorea elephantipes,* and cush cush, or yampi, as *Dioscorea trifida.* Yams are good sources of the chemical diosgenin, a precursor of progesterone, cortisone, and other medically important steroids. Yam is the common name for any of several members of a genus of perennial herbs. Many varieties occur within these species, and the resulting yams may grow up to 2.4 m (8 ft) long and weigh up to 45 kg (100 lb) with brown or black skin and flesh that is white, purple, or red. Yams have been domesticated independently in many different parts of the world for their edible tubers.

Yams are a valuable source of carbohydrates to the people of Nigeria and indeed of West Africa. The most economically important species grown in Nigeria are white yam (*Dioscorea rotundata* Poir.), water yam (*Dioscorea alata* L) and yellow yam (*Dioscorea cayenensis Lam*.).

Yams are grown in fairly high rainfall areas with a distinct dry season of not more than five months and a rainy season of not less than five months grown mostly in middle belt areas to the southern parts of Nigeria.

The usual method of propagation is to use the crowns of the large tuberous root or to plant whole small tubers. The climbing vines are supported on stakes or on a trellis. The plants are spaced 30 to 60 cm (12 to 24 in) apart in rows. The roots are harvested after they reach a suitable size and can be stored for several months at temperatures of 12 -15 ° C (54 - 58 °F).

Traditionally yams are processed into several products for immediate consumption in Nigeria. They are often eaten as boiled yam, roasted or fried yam (*Dundu*), grated and fried balls (*Ojojo*) pounded yam (*Iyan*) and yam flour (Elubo). The only traditional method for processing yam for storage is to process it into yam flour called "Elubo" in Nigeria and "Kokonte" in Ghana.

3.1.1.2 Yam Flour (Elubo)

"Elubo" is a dehydrated milled product obtained from yam of the Dioscorea species. It is a smooth brown powder, and being a wholly yam based product, it is a rich source of carbohydrates. Elubo is common among the Yoruba speaking people of Nigeria. Elubo is now gradually increasing in popularity among groups where "amala" has never been a staple food. This may be due to its the ease of production, its shelf stability and a convenient way of adding value to tubers mechanically injured (i.e. cut, bruised or damaged tubers) during harvesting. These damaged tubers generally have short keeping qualities. Elubo is prepared by reconstituting in boiling water with continuous stirring until a stiff gel of the desired consistency (called *Amala)* is obtained. It is commonly served for lunch and dinner with stew and vegetables. Elubo is commonly produced in large quantities in Oyo, Oshun, parts of Kwara and Kogi States. Apart from it being a good food, it is an economic item whose appeal cuts across all strata of social and economic class. Production of Elubo is now gradually increasing in popularity among ethnic groups where *amala* has never been a staple food.

Traditional Production of Elubo

Raw yams are peeled manually (usually from late evening), sliced (optional), washed and heated over a wood fire (parboil). The fire under the vessel is removed when the water is uncomfortably hot and left for about 8 – 13 hours after which they are removed and spread outside in the sun for drying. The dried pieces are then crushed, milled and sieved to obtain the characteristic smooth brown powder called Elubo.

Problems Associated with the Traditional Process

i. Low level of hygiene.
ii. During parboiling, some of the yam pieces become overcooked and such pieces are usually discarded.
iii. Drying time depends on the prevailing weather conditions. Under the best conditions, it takes 2 – 5 days.
iv. Since they are usually spread on bare floor, chances of contamination by extraneous matter and infestation by rodents and pests is quite high.
v. The operations involved vary from one place to the other, leading to inconsistencies in the products obtained from different locations.
vi. The finished product often contains pebbles, faecal matter, dead insects and their eggs among others.

3.1.1.3 Ojojo

“Ojojo” is a fried food product obtained from grated water yam (*Dioscorea alata*) It is a popular food product in the southern part of Nigeria, especially among the Yorubas where it can serve as a snack or main meal with “eko” (corn meal) as accompaniment. Of the various species of yam available, only water yam is suitable for use in its preparation.

Traditional Production of Ojojo

Water yam is peeled, cut into large pieces and manually grated yam is the mixed with chopped peppers, onions, tomatoes and salt after which it is made into small balls and fried in groundnut oil for about 5-8 minutes. The resulting product is Ojojo. It keeps for about three days (maximum) and is often refried as means of preservation.

Problems Associated with the Traditional Production Process

Grating: The manual grating operation is time consuming, labour intensive, and with a high risk of injury.

Browning: Water yam undergoes browning right from when it is peeled. It undergoes further browning during and after grating especially when it is not fried immediately.

Hygiene: The traditional processors generally have a low level of hygiene. This is probably a contributory factor to the short shelf-life of the commodity.

3.1.2 Cassava

Cassava is the common name for any of several related plants native to tropical regions in the Americas. It forms the staple diet of over 500 million people in the tropics. Cassava is the West Indian name; manioc, or mandioc, is the Brazilian name; and juca, or yucca, is used in other parts of South America. The plant grows in a bushy form, up to 2.4 m (8 ft) tall, with greenish-yellow flowers. The roots are up to 8 cm (3 in) thick and 91 cm (36 in) long. Manioc, or cassava, is widely cultivated as an important source of starch and staple food among many tropical peoples. It is one of the most important world food crops. Many varieties and closely related species contain the poison hydrocyanic acid, which can be removed only by cooking the root. A related species, *M. dulcis,* is sometimes grown as fodder for livestock.

There are two major species of cassava in Nigeria. These are the sweet cassava (*Manihot palmata*) and bitter cassava (*Manihot utilissima*) respectively. The bitter variety contains a poisonous bitter juice (hydrocyanic acid) which must be extracted before it is safe for consumption. Because the bitter species predominates in Nigeria, it undergoes rigorous processing to ensure that the cyanide content is reduced to harmless levels. Because the volatile poison can be destroyed by heat in the process of preparation, both varieties yield wholesome foods. Human consumption of fresh unprocessed roots has been linked with a number of chronic disorders, high occurrence of endemic goitre and various neurological degenerative syndromes (particularly in malnourished populations) such as ataxic neuropathy and cretinism and occasionally, death due to the presence of toxic cyanogens.

The cyanogenic glycosides produce hydrocyanic acid (HCN) when the action of an endogenous enzyme, linamarase, is initiated by crushing or otherwise damaging the cellular structure of the plant. The cyanide in cassava exists as bound glucosides, cyanohydrins and free cyanide (HCN). The utilisation of cassava roots for both human and animal nutrition appears to be limited by the presence of these cyanogenic glycosides. As a result, the roots have to be processed by a wide range of traditional methods in order to reduce their toxicity and improve palatability.

Large tuberous cassava roots are processed into cassava flour, or tapioca, or they may be fermented into an alcoholic beverage. Cassava products are also used as laundry starches and fabric sizings and in the manufacture of explosives and glues. The root in powder form is used to prepare *farinha,* a meal used to make thin cakes sometimes called cassava bread. The starch of cassava yields a product called Brazilian arrowroot. In Florida, where sweet cassava is grown, the roots are eaten as food, fed to stock, or used in the manufacture of starch and glucose.

In Nigeria, about 70% of cassava produced is channeled into *gari* production. Other products commonly obtained from cassava processing are *fufu* and *lafun*.

3.1.2.1 Garri

"Garri" is a fermented, gelatinous granular flour obtained from cassava *Manihot* spp). It is one of Nigeria's most popular staple food and is reputed to contribute as much as 60% of the total calorie intake of the population. Being a source of cheap carbohydrate for many Nigerians it is consumed sometimes twice a day, either it's intact from with sugar, groundnut or salt or further transformed into garri meal (eba) and eaten with vegetable or any mucilaginous soups. Because it is a ready-to-eat and easy to prepare food item, its acceptability cuts across all economic and social strata. The popularity of garri a major staple food is at a peak among the Yoruba and Ibo tribes of Nigeria where it is commonly served for lunch or dinner.

Traditional Production of Garri

Cassava is peeled, washed, rated into a watery pulp, poured into sacks, and allowed to ferment for about 2-4 days. The resulting pulp is sieved, roasted and spread out in an open area to cool. Gari is then bagged in sacks of various sizes till it is needed for commerce or consumption.

Problems Associated with Traditional Production

Nature of Cassava: No emphasis is placed on the use of freshly harvested cassava tubers. The result is that the cassava often used have been harvested for 2-3 days before processing starts.

Peeling and Washing: Cassava is peeled manually – a process which takes considerable time. Rather than continue processing immediately, the peeled cassava is often left overnight resulting in browning of the tubers. Washing of the tubers is usually carried out with water obtained from streams. To the traditional processors, the nature, the type and source of water is not a critical factor.

Grating: The grating operation is carried out using outstretched, perforated tin cans the efficiency of which is a function of the degree of perforation and applied pressure. This process apart from being crude,

increases the chances of accidental bruising of hand, especially the fingers.
Roasting: More often than not, the gari is not allowed to dry completely, rather it is half dried and spread in the sun thus sacrificing quality in the name of profit maximisation.

Dewatering: This is done by placing heavy stones on the grated mash packaged in jute bags and sackcloths. This process is not only unhygienic, it also result in accumulation of sand particles inside the final product.

3.1.2.2 Fufu

"Fufu" is wholly carbohydrate based food material obtained from cassava. It is commonly eaten in the core East and Southwest parts of the country. The type of soup that goes with it depends on the locality in question. It has a generally wide acceptance as reflected in the fact that it can serve either as a breakfast, lunch or dinner meal in fufu-eating areas of the country.

Traditional Production of Fufu

Raw cassava tubers are manually peeled (mostly by women) and soaked in a big clay pot for about 3-4 days. During this period, fermentation takes place. The fermented tubers are then crushed, sieved and allowed to settle (sedimentation). The sediment (wet fufu) is then packed in sacks and de-watered under heavy stones. The de-watered product is stored in sacks until it is needed for commerce or consumption.

Problems Associated with Traditional Production

The major shortcomings of the traditional process are its irritating and undesirable odour as well as its low shelf life. Furthermore, the basic tenets of hygiene are not observed.

3.1.2.3 Lafun

"Lafun" is wholly carbohydrate-based food material obtained from cassava. It is commonly eaten in the Western part of Nigeria as a lunch or dinner meal usually with vegetable in "egusi" soup. Its appeal however, cuts across all strata of economic life.

Traditional production of Lafun

Freshly harvested cassava tuber is peeled and soaked in water either in a pot or big container. After about three days, the soaked tubers is hand-crushed after which it is spread on the floor or a platform for solar drying. The drying process takes three or more days depending on the environmental conditions. When it is sufficiently dry, it is then milled and sieved to obtain lafun. It is then stored in sacks of jute bags till it is needed. In addition lafun may be stored or packed in nylon containers or baskets.

Problems of Traditional Production

Drying Process: The sun-drying process is inefficient, time consuming and erratic. This becomes significant where weather conditions fluctuate. When improperly dried, the flour cakes and is susceptible to yeast and mould attack.

Hygiene: Very little consideration is given to hygiene. This is evidence in the grooming of the processors and the dirtiness of the floor where the crushed tubers are spread.

Process Time: The process is time consuming. So much time is lost during the manual peeling process as well as during the sun-drying operation.

3.1.3 Sweet Potato

The sweet potato belongs to the family *Convolvulaceae*. It is classified as *Ipomoea batatas*. The species called wild sweet-potato vine, manroot, or man-of-the-earth is classified as *Ipomoea pandurata*. The plant, which is native to tropical America, is cultivated on sandy or loamy soils throughout many warm regions of the world, and exists as an important food staple in a number of countries. It is planted primarily for its thick, edible roots, called sweet potatoes. Two main types are commonly cultivated: a dry, mealy type, and a soft, light-to-deep-yellow, moist-fleshed type. The species often called wild sweet-potato vine, manroot, or man-of-the-earth is not edible, but is cultivated as an ornamental vine.

The sweet potato yields an important starch, which is used commercially for sizing textiles and papers, for the manufacture of adhesives, and in laundries. The pink and yellow varieties are rich in carotene, the precursor of vitamin A.

3.2 Cereal and Legumes

In the topics, the common cereals are maize, sorghum, rice, and millet. They are good sources of carbohydrates, vitamins and minerals. Apart from being articles of commerce, they can be processed into a wide

range of food items and snacks. This characteristic feature makes cereals indispensable in the diet of the tropical man.
Legumes refer to the group of edible plant proteins which belong to the family leguminosae. They are major type of plants that supply the body with proteins. In this category are pigeon pea (*Cajanus canjan*), lima bean (*Phaseolus lunatus*), cowpea (*Vigne unguiculata*) and groundnut (*Arachis hypogea*). Legumes play very important roles in the diet of people in the tropics. Apart from being good sources of proteins, they supply important minerals and vitamins essential for the normal functioning of metabolic activities.

3.2.1 Kokoro

"Kokoro" is a snack common among the Egbas of Yorubaland. It is often taken as light refreshment and can be used in entertaining guests with soft drinks. There are two main types of kokoro. The white and the brown type for the purpose of the text, the brown kokoro will be studied, being the most popular form in which kokoro is consumed.

Traditional Production of Kokoro

Maize is washed, dried and milled to obtain maize flour. The flour is pregelatinized during which sugar and salt are added to taste. The resulting dough is cooled, sprinkled with maize flour and molded into desired shapes and sizes. It is then fried in vegetable oil, drained and cooled to obtain the ready-to-eat snack, kokoro. The product is usually covered with leaves and packaged in thin polyethylene nylons. The main method of preservation is by refrying in oil.

Problems of Traditional Production

Shelf life: Freshly prepared kokoro keeps for 4 – 5 days after which it is no longer suitable for consumption.

Preservation technique: The method of preservation often employed predisposed the commodity to oxidative rancidity and development of burnt flavours.

Raw materials quality: No consideration is given to the quality of maize, sugar and oil used.
Hygiene: The level of hygiene of the processors as well as the processing environment is generally low.

3.2.2 "Ogi" or Pap

"Ogi" (also called "Akamu") is fermented product obtained from maize or guinea corn. It is a staple cereal meal of the Yorubas in Nigeria and is the first major food given to babies at weaning. It is commonly eaten with "Akara" (Bean cake) or "Moin-moin" (Bean meal). Ogi can also be consumed in the form of "Agidi" or "Eko" (a solid cooked form of Ogi). It is a wholly carbohydrate based food and has been implicated in the incidence of kwashiorkor in children fed solely with it. The wet ogi is normally reconstituted with hot water to form a paste which is the form in which it is consumed.

Traditional Production of Ogi

Raw maize grains are steeped in warm or cold water for 2-3 days. It is the wet-milled and sieved. The filtrate is allowed to settle and the water drained off. The resulting product is Ogi. It is usually packed in leaves or stored under water until it is needed.

Problems of Traditional Processing

The product is susceptible to microbial spoilage due to its high moisture content and low hygiene ratings. The shelf life is considerably low. Storage under water encourages post-processing fermentation which leads to sources over a period of time. It is of poor nutritional status being a wholly carbohydrate based meal.

3.2.3 "Tuwo"

"Tuwo" is a corn-based meal made from milled corn. It is produced either from white or yellow corn although yellow corn is preferred. It is a wholly carbohydrate-based meal, commonly eaten as a lunch or dinner with "Gbegiri" (bean stew). Tuwo can also be produced from rice- a delicacy popular among the Hausas and the Fulanis. When produced from rice, it is referred to as Tuwo-shinkafi. The corn cased Tuwo would be the focus of this treatise.

Traditional Production of "Tuwo"

The epidermal covering of freshly harvested maize cob is manually removed. The grains are then removed manually and sun-dried for 2-4 weeks (duration depends largely on the prevailing environmental conditions). When it is sufficiently dry, it is winnowed, milled and bagged till it is needed for consumption.

Problems of Traditional Processing

The sun-dried grains are susceptible to attack from rodents, birds and other corn eating animals. This greatly reduces the quality and quantity of the grains and by extension, the quality of the flour.

Heavy stony particles are usually not removed during winnowing. When milled with the grains, the flour becomes grainy the result is low quality product.

Its shelf life is considerably short. This could be attributed to the high moisture content of the commodity (a direct consequence of inefficient drying) and the oxidation of the oil content of the germ.

The flour is subject to infestation by micro-organisms like *bacillus aureus, Clostridium welchi, Salmonella, etc.* They could be transferred from animals to the grains during the drying process, birds, dusts and soil. These micro-organisms are of public health significance.

3.2.4 "Donkwa"

"Donkwa" is a corn and groundnut based snack common among the Hausa of Nigeria. It is referred to as "Tanfin" among the Yoruba; it is often used as light refreshment with or without soft drinks as accompaniment. The wide acceptance the snack receives is not unconnected with its sweet taste and pleasant aroma.

Traditional Production of Donkwa

Groundnuts and corn are roasted dry and milled to obtain a fine powder. Ingredients referred to among the Yoruba as "atare" "iyere" "conofuru" "eso oganwo" and dry pepper are milled and mixed with the corn-groundnut flour. Sugar and salt are added, mixed homogeneously, and then pounded in a mortar. The mixture is then moulded into desired shapes and sizes to obtain donkwa in the ready-to-eat form.

Problems of Traditional Production

Nature of raw materials: No emphasis is placed on the use of good quality corn and groundnut. In addition, the ingredients added are not obtained under sanitary conditions. This is all the more important because the commodity is in the ready-to-eat state.

Oxidation: Oil is released during the pounding operation. This oil is susceptible to oxidation leading to rancidity and development of off-flavours

Packaging and Storage: The commodity has no packaging material. They are simply displayed in glass shelves, aluminium pans and bowls. The implication of this is their increased susceptibility to pest and rodent attack.

Hygiene: Traditional processors give little or no regard to the tenets of hygiene. Thus, the prospect of cross-contamination is quite high. The unhygienic conditions employed can equally be source of food borne infection and intoxications.

3.2.5 "Robo"

"Robo" is a locally prepared snack common among the Yorubas is Nigeria. It is liked for its sweet and delicious taste. Its main raw materials "Egusi" (Melon – *Citrullis vulgaris*) and pepper (*Capsicum* spp). It comes in a wide range of shapes and figures. It is commonly eaten as a snack or as a main meal in conjunction with "Ogi" or "Gari".

Traditional Production of Robo

Raw melon seed is harvested and sun dried till the husk is sufficiently strong to be removed. It is then shelled manually and ground on a millstone to obtain a thick paste. At this stage onion (*Allum cepa*) is ground and homogeneously mashed with the melon paste. The resulting slurry is hand squeezed, mixed with wet milled pepper and salt and then moulded to the desired shapes and sizes. After shaping, the resulting product is fried in melon oil (previously extracted) until it turns brown. It is then cooled and packaged in small nylon packs.

Problems of Traditional Processing

The sun-drying process is time consuming (it depends on the prevailing weather conditions) and exposes the seed to attack from pests and rodent.

The shelling process is done manually, usually by woman. This process, apart from being slow, leaves little room for proper hygiene.

Grinding on a millstone is time-consuming and chance of cross-contamination is quite high.

Manual mixing, mashing, and moulding expose the product to contamination from the processors. Where personal hygiene is given very little consideration, it could pose a serious health risk to consumers.

Packaging is done in thin transparent nylon packs. This exposes the commodity to both oxidative and hydrolytic rancidity, which in turn, reduces its appeal and shelf life.

Storage is by re-frying in melon oil after two or three days. This makes the commodity more susceptible to rancidity and leads to the development of burnt flavours.

3.2.6 Ekuru

The traditional name of bean meal is "Ekuru". Being a wholly cowpea-based food item it is quite rich in essential amino acids. Locally, it is consumed as a lunch or dinner meal with "eko" (fermented maize gruel) as accompaniment. It is one; of the popular forms into which beans is processed among the Yoruba's of Nigeria.

Traditional Production

Beans are soaked in water for 2-3 hours. It is then dehulled and milled using small quantities of water to obtain a slurry of the right consistency. The resulting slurry is stirred, carefully wrapped in leaves, and steamed for about 45 minutes. The resulting product – ekuru – is ready to be eaten. Traditional storage is by steaming at regular intervals, usually, every other day.

Problems Associated with the Traditional Method of Preparing Ekuru

Some of problem associated with the traditional production process are enumerated below:

It is time consuming. So much time is spent during soaking, decoating and milling (on a milling-stone).

It cannot last for a very long time after preparation.

Significant deleterious organoleptic and nutritional changes do take place after a couple of days. This is due, in part, to interaction (chemical or otherwise) between the leaves and the food item and the activities of micro-organisms.

3.2.7 Groundnut Cake

This is a wholly groundnut based snack commonly referred to as "kulikuli", among the Yoruba's of Nigeria. It is either eaten alone, or more commonly with "gari". Its appeal cuts across the country. The wide acceptance it receives is due largely to its sweet taste.

Traditional Production of Kulikuli

Freshly harvested groundnut is sundried, sorted, immersed in brine for few minutes, drained and sundried. The dried nuts are then roasted in a heated sandfilled slay or iron pot and stirred continuously with a wooden spoon until a golden brown colour is obtained. The roasted grains are then cooled, dehulled winnowed, and pounded until it is sufficiently smooth. The resulting paste is kneaded and pressed (squeezed) to extract it oil. At this point, some ingredients like ground pepper and salt are added to taste. The groundnut meal is the shaped and fried in the previously extracted oil (groundnut oil) until the golden brown colour characteristic of the ready-to-eat kulikuli is obtained. The resulting cakes are cooled, and packed in open baskets.

Problems Associated with Traditional Production

Hygiene: As with most other traditional products, very little attention is given to hygiene (both personal and environmental) by the processors.

Raw materials: No attempt is made to sort out unwholesome and defective grains.

Winnowing: The method employed is grossly inefficient as chaff, dirts and other extraneous matter still remain in the commodity.

Pounding: The pounding process is energy, labour and time – consuming.

Packaging: There is no standard packaging material (or method) for kulikuli. They are simply poured in sacks and open baskets until they are needed for commerce or consumption.

3.2.8 Iru

"Iru" is fermented African locust bean (*Parkia biglobosa*) It is one of the most important food condiment in the entire savannah region of West and Central Africa. Apart from its flavouring attribute, it contributes significantly to the intake of protein, essential fatty acids and B Vitamins, particularly riboflavin. It is also known as Dawadawa (Hausa land) and Ogiri – Igala (Ibo land). The popularity of the fermented beans as a major condiment necessitates a review of the traditional process with a view to enhancing its image, especially among the ever increasing urban populace who place more premium on hygienically produced food items.

Traditional Production of Iru

Locust beans are boiled for about an hour to soften the seed for removal. The hulls are removed, followed by washing and boiling for additional ten to twelve hours to soften the cotyledon. The cotyledons are allowed to undergo wild fermentation for about two to three days. During this period, the characteristics colour (brown) and odour (ammoniated) are developed. Iru is prepared in the solid non-mucilagenous form (woro) or in the marshy mucilaginous state (pete) for sale or consumption.

4.0 CONCLUSION

Food processing technology is widely applied to African foods to make convenient snacks and meals. For example, tubers are dehydrated into flours. Cereals are also treated in similar fashions. Also the process of fermentation is applied to African locust beans to make condiments.

5.0 SUMMARY

In this unit we have learnt that:

Tubers like yam are boiled, dried and turned into other products e.g. pounded yam and elubo.

Similarly, cassava is grated after peeling, pressed and dried to make gari and other snacks

Cereals can be fermented and dried to ogi and eko products

Legumes are also processed. For example, groundnuts are toasted and ground to make kulikuli

SELF ASSESSMENT EXERCISE

Enumerate some of the difficulties of processing of African (i) tubers (ii) Cereals (iii) Legumes and Oilseeds into convenient foods.

6.0 TUTOR-MARKED ASSIGNMENT

1. How would you improve the shelf life of (a) Elubo (b) Fufu (c) Kokoro and (d) Robo?
2. Discuss the possible process line for the production of gari.

7.0 REFERENCES/FURTHER READINGS

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UNIT 3 PROCESSING OF SPECIFIC FOOD COMMODITIES II: FRUITS, VEGETABLES, MILK, MEAT AND FISH

CONTENTS

1.0 INTRODUCTION

In a developing country like ours, the need for improved preparation, processing, preservation and storage techniques as a way of enhancing demand for indigenous, locally consumed foods, coupled with increased application of food science and technology not only to boost our dwindling agricultural production, but also to ensure that the seasonal foods harvested are adequately preserved and/or kept under good storage conditions, cannot be over-emphasized. This practice has brought wealth and prosperity to many nations and has greatly contributed to the raising of the standard of living in the industrialized countries of the world.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss the processing of:

fruits and vegetables locally
alcoholic and non-alcoholic beverages from cereals
milk products from milk
meat and fish products.

3.0 MAIN CONTENT

3.1 Processing of Various Traditional Produce

3.1.1 Fruits and Vegetables

3.1.1.1 Tomatoes

Tomatoes (*Lycopersicon esculentum*) are a circular red pigment fruit (vegetable belonging to the family of plants called Solanacae. It is rich in vitamins. A.B,C and minerals like Iron. Sodium, Potassium as well as trace amounts of carbohydrates and proteins. Tomatoes are commonly used in sauce, salad and they enhance the red colour of stew. Its major defect lies in its short shelflife due largely to its tender nature and high moisture content.

Traditional Processing of Tomatoes

Tomatoes have no traditional processing method. Rather they are stored in jute bags, baskets and leaves till they are needed for consumption or commerce.

Problems of Traditional Handling

Mechanical Damage

Storage in basket leads to bruises which, in turn leads to microbial proliferation, deterioration and spoilage. Storage in sacks leads to pressure build-up such that produce at the bottom gets crushed. The product is also subject to injury from improper handling during harvesting.

Shelf Life

The shelf life of mature ripe tomatoes is about 2-3 days. The result of this is a drop in its commercial value. The mature unripe fruits can hardly keep for 10-12 days in the absence of any form of preservation.

3.1.1.2 Green Leafy Vegetables

Green leafy vegetables grow abundantly during the rainy season in most parts of Nigeria. The availability of these vegetables during this period makes them an important inclusion in the diet of most people. During the dry season, however, these vegetables become scarce and expensive. The principles discussed below for bitter leaf applies to all edible green leafy vegetables. Debittering operation applies only to vegetables with bittering principles.

Traditional Processing of Bitter Leaf

The leaves are removed from the stalk for washing with subsequent shredding (optional). The leaves are rubbed between the palms in cold water (containing table salt, NaCI). Shredding – usually with knives and wooden table – is to reduce the leaves into small fragments. The shredded produce is either sun-dried or moulded (wet) into ball-like structures and kept till it is needed for consumption. Sun-drying – probably the oldest method of food preservation in developing countries for the drying of fruits and vegetables – involves spreading the products of the ground in an area that has been cleaned of leaves, stones, grass and dirt or they can be spread on mats.

The disadvantages of open-air sun drying are numerous. They are:

(i) The intermittent nature of solar energy throughout the day and at different times of the year.

(ii) The possible contamination of the food material by dirt and rodents.

(iii) The infestation of the food by insects.

(iv) The exposure to weather elements – such as rain and wind – which cause spoilage and losses.

(v) It is inefficient and will generally not lower moisture content below about 15%, which is too high for storage stability of many products.

To better utilize solar radiation as a source of energy for drying foods and foodstuffs, effective system have to be developed based on specific produce needs.

3.1.1.3 Palm Oil

Palm oil is a deep orange, viscous liquid obtained from the fruits of the palm tree. The palm tree is widely cultivated in the Western and Easter part of Nigeria due largely to the favourable weather conditions for their survival in these areas. It is an indispensable part of the Nigerian diet as it serves as a base material for a wide range of soups, gravies and other delicacies. It is also a good source of energy and fat soluble vitamins (A, D, E and K).

Local Extraction Process

Although the process involved vary from one locality to the other, the following unit operations show the major steps involved in the traditional extraction process.

Fruit Bunches

↓

Separation of Fruits from Bunch

↓

Separation from Calyx

↓

Boiling

↓

Separation of fruit from Nut

↓

Boiling

↓

Palm

Palm fruits (together with the calyx) is separated from the stalk. It is then packed in heaps covered with banana leaves and left for about three days before the fruit is separated from the calyx. The separated fruits are poured into a big drum and boiled for about four hours to soften the pericarp. It is then transferred into a wooden mortar or a cemented pit where it is crushed gently with pestle and pegs till a mixture of nuts and crushed pulp of even consistency is obtained. Floating oil is collected from the pit, transferred into a drum 1/3 full with water and heated continuously until the crude oil is sufficiently extracted. The crude oil - in its ready-to-use form. The oil is stored in earthenware pots, metallic drums an plastic kegs till it is needed for use.

Problems Associated with Local Extraction Process

1. Oxidation

The fruit is exposed and subjected to microbe-induced lipoxidation if left for about 3-4 days after harvest without processing. The process (lipoxidation) leads to hydrolyses of the oil with the subsequent production of undesirable free fatty acids.

2. Inconsistency in the Maturity and Degree of Ripeness of Fruits

When unripe fruits are used, oil of low quality and volume is obtained. On the other hand when over ripe fruits are used, the oil produced deteriorates rapidly and has high level of free fatty acids.

3. Hygiene

The level of hygiene on the part of the processors an processing environment is generally low. This increases chances of cross contamination.

4. Risk of Injury

The leg crushing exercise is generally unsafe. Apart from the risk of injury on a slippery floor, chances of microbial infestation are quite high especially if the state of health and hygiene of the labourers is poor.

5. Labour and Time requirement

The entire process is labour intensive and time-consuming.

6. Storage

The Storage system employed is grossly inefficient. The packaging material used range from earthenware pots to metallic plastic kegs.

Earthenware pots predispose the oil to hydrolytic oxidation which leads to development of flavours and rancidity.

Metallic can rust and become particles in the oil. The rust could also lead to rancidity.

Plastic kegs might impart their characteristic odour on the oil when stored for a considerable period of time.

3.1.1.4 Dried Okra (Orunla)

"Orunla" is a product of the dehydration of okra pods (*Hibiscus esculentus*). The varieties mainly grown in Nigeria include long pod, green velvet pod, long green and lady finger. The harvest is done manually by snapping then off the stem when their tip are still tender and break with a snap. Orunla is very popular among the Yorubas. It is commonly made into soup with or without palm-oil, fish and other condiments and served with "Fufu", "Lafun", "Amala" or "Eba" where its mucilaginous property aids bolus movement in the oesophagus. At times, it is boiled fresh and served with rice.

Traditional Production of Orunla

Freshly harvested pods are sliced and spread on trays or flat surface for solar drying for about 3-5days (depending on atmospheric conditions). The dried okro is packed in that state or milled into powdery form before packaging (wrapping) in paper or thin nylon sachets.

Problems `of Traditional Processing

1. Apart from the many problems associated with the sun-drying process, there are major defects in the commodity due largely to the drying method employed? These include:

(i) Loss of Colour: The colour of the dried product is brown. In the fresh state it is green.
(ii) Loss of mucilaginous property.
(iii) Loss of nutrients, especially vitamin C.
(iv) The risk of microbial infection e. g. Bacillus cereus can be contacted from the soil or dust.

2. There is increased chance of skin irritation-induced by the spines on the skin of okra pods when large quantities are processed.

3.2 Alcoholic and Non-Alcoholic Beverages

3.2.1 "Sekete"

"Sekete" is a local wine obtained by the fermentation of plantain (*Musa paradisiaka*). Plantain is very common in the southern part of Nigeria and its colour ranges from complete green (unripe) to complete yellow (ripe) Being a wholly carbohydrate based crop makes it a good substrate for fermentation. Sekete is commonly served for entertainment and during certain traditional ceremonies and festivities. It is preferred for its taste and alcoholic content.

Traditional Production or Sekete

Mature ripe plantain is peeled cut into small sizes and soaked for fermentation to take place. Often times, this process (fermentation) is catalysed by the addition of palm wine sediments (containing the *Saccharomyces* yeast). After about five days the resulting liquor Sekete is filtered, filled into bottles and is ready to drink.

Problems of Traditional Processing

1. Hygiene

The level of hygiene among the traditional processors (mostly women and nursing mothers) is generally low. The poor hygiene and low level of cleanliness of the processing environment aggravates the low level of hygiene.

2. Water

The water often used for soaking is usually not of potable grade. It is obtained from streams and stagnant pools. This increases the chances of water borne infections and contaminations.

3. Fermentation

The fermentation process is wild. This result in a wine with different types of alcohols – many of which are not food grade. The only food grade alcohol is ethanol.

4. Shell life

The shelf life of the product is about two to three days. This is because the fermentation process still continues after bottling a situation which results in the depletion of the sugar base and development of an undesirable sour taste. Since there is really no effective method of storage, the over-fermented liquor is distilled to obtain “Ogogoro Local gin”)

3.2.2 “Ogogoro”

The most widely accepted and cherished traditional alcoholic drink, especially in the southern part of Nigeria is the local gin, fondly referred to as “ogogoro”. It is a product obtained by the fermentation of palmwine – a whitish sap obtained from the oil palm tree. Ogogoro finds use during ceremonies and festivities. Industrially, it is used as organic solvent and in the manufacture of certain drugs and chemicals.

Traditional Production of Ogogoro

Freshly tapped palmwine is collected, filled into a big container covered with a piece of cloth, and allowed to undergo fermentation for about 3 to 4 days. The fermented liquor is then distilled and ogogoro is collected through delivery tubes connected to the distillation apparatus. It is then filtered and filled into kegs and bottles.

Problems Associated with Traditional Production

1. Area of Fermentation

(i) Places where palm wine is kept for fermentation are filthy most times. This is unhygienic and leads to contamination of the wine.

(ii) Local producers rely wholly on the natural yeast in palm wine for fermentation. This makes the process time consuming and less profitable.

2. Area of Distillation

The heating of the fermented wine is done with naked flame and the smoke from the flame can contaminate the wine.

3. Area of Condensation

Locally, the method used in condensing the wine vapour is neither effective nor efficient and a reasonable amount of the wine is lost in the process.

4. Hygiene

The level of hygiene is generally low.

3.2.3 Burukutu

"Burukutu" originated from the Northern part of Nigeria, from the Hausas from where it spreads to other parts of the country, most especially the Southern and Western parts. It is produced from fermentation of cereals like maize, sorghum, millet, guinea corn, etc. This makes it rich in carbohydrates and therefore, it is a satisfying energy giving drink. It is creamy and dirty white in colour and highly alcoholic (28-40%). Non-alcoholic "Burukutu" is produced by skipping the fermentation operation. The cereal of choice is the sorghum specie. It is used to entertain visitors and during traditional festivals. Apart from being a ceremonial product, it is also produced for economic purposes. It is, infact, one of the best and popular local wines in Nigeria.

Traditional Production of Burukutu

“Burukutu” is produced in different ways, depending on the locality and the type of cereal used for the production. The following is one of the commonest methods frequently employed in the traditional production process. Guinea corn is washed, steeped for 24 hours and pitched into baskets to drain-off the water present. It is then allowed to germinate for about 4 to 5 days after which it is washed, milled (on a grinding stone) and mashed with starchy powder (from cassava tubers).

The mash is then filtered with pure white cloth. (Non alcoholic Burukutu is derived here by adding sugar to the filtrate). The filtrate is then allowed to ferment in a sack called “Apo-Idoho” for about 2-3 days. Wild yeast are often used to hasten the fermentation process.

The fermented liquor is then boiled for about 2 hours and allowed mature for a day. The wine is then ready-to-drink after maturation.

3.2.4 Kunnu

“Kunnu” is a millet based non-alcoholic beverage flavoured with spices. It is very popular among the Hausa’s of Nigeria; however, its popularity in other parts of the country is fast on the increase. Kunnu is taken as refreshment and for its purported sedative (laxative) effect especially when served chilled.

Traditional Production of Kunnu

The major raw materials used are millet, guinea corn, ginger, spices and chillies. These materials are washed, soaked and milled. The resulting slurry is sieved and the filtrate allowed to sediment while the water atop is decanted off. 75% of the thick residue obtained is boiled with periodic addition of calculated amounts of water. The remaining 25% is then mixed with the cooled residue and sieved to obtain the ready-to-drink Kunnu. Sugar, if desired, is added to taste. Kunnu has no traditional method of storage.

Problems of Traditional Production

1. Shelf life

Its shell life is short. It can hardly stay for more than 2 days. After this period, it gets soured up. This can be attributed to uncontrolled fermentation taking place in the commodity.

2. Hygiene

The level of hygiene of the processors and processing environment is generally low. Chances of contamination and contracting food borne infection are higher. This is because kunnu is made up of 25% uncooked portion. Local processors are nursing mothers who tends babies during production.

3. Texture

The drink produced is often grainy. This may be attributed to improper or inadequate sieving.

4. Over Boiling

Oftentimes, the drink is over boiled. The result is the development of a flat, burnt flavour.

5. Addition of Ingredients

If other ingredients used are not properly selected, it influences negatively the taste and quality of the final product. The critical ones being ginger and chillies.

6. Quality Control

The quantities of ingredients vary with the different production centres. This is left entirely to the judgement of the processor, thus, kunnu tastes differently depending on the point of production.

3.2.5 "Pito"

"Pito" is a light-brown, sweet-sour beverage with fruity flavour obtained from malted maize and/or sorghum. It is a highly nutritious drink that has found place after meals, during ceremonies, festival and other social gatherings. Pito is reputed to be rich in minerals and certain B-Vitamins. Two types of pito are common, the alcoholic and non-alcoholic pito. The difference lies in the incorporation of fermentation step for alcoholic pito. This review will focus more attention on the alcoholic pito, being the more complex of the two.

Traditional Production of Pito

Maize or sorghum is steeped in water for 3-4 days, washed, milled and sieved to obtain a filtrate. The filtrate is allowed to sediment while the liquid atop is poured into a container where it undergoes fermentation for 2 – 3 days. Sugar is dehydrated, added into the fermenting liquor and boiled for several hours. The liquor is cooled and sugar is added to taste. The resulting product is the alcoholic pito. For non-alcoholic pito, fermentation step is omitted. Storage is in clay pots and large calabashes.

Problems of Traditional Production

1. Hygiene

The level of hygiene is generally low. Local processors (usually women) give little or no regard to personal hygiene not to mention hygienic food processing practices and environment.

2. Quality of grains

No attempt is made to ensure that the grins used are viable and wholesome.

3. Fermentation

The fermentation process is wild and uncontrolled. The result is a product with off-flavour and high levels of acetic acid.

4. Heating process

Heating is by firewood. This leaves no room for temperature regulation during mashing and dehydration of sugar. Wood smoke freely interferes with the food system and this could alter (affect) the taste and colour of pito negatively.

3.3 Traditional Milk Product

3.3.1 “Wara”

Warankasi (commonly abbreviated as wara) is a Nigerian soft, white, unripened cheese which derives its origin from cattle Fulanis from Northern Nigeria, who refer to the liquid from cold milk as “Wara” and the curd texture of the cheese as “Kashi”. Wara is popular among the Hausas, Fulanis and the Yorubas of Nigeria. Much of the raw milks produced by the cattle Fulani of Nigeria would have been wasted save for the possibility of wara production. “Wara”, is a product of lactic acid fermentation of cow’s milk. Being a milk-based product, wara contains appreciable amounts of essential amino acids, minerals and salts of sodium and potassium. It provides a good source of milk for lactose-intolerant people.

Traditional Production of Wara

Fresh cow milk is mixed with Sodom apple leaf extract and heated for about 15-20 minutes. The milk coagulates, the surface scum removed and heating is intensified to boiling (cooking). The loose curd pieces obtained are drained and cut into various sizes for onward transmission to the ultimate consumers. The traditional method of preservation is to hold the fresh product in its whey (the fluid portion of milk drained from the curd) or water, a procedure which keeps wara fresh for 2-3 days in the absence of refrigeration.

Problems Associated with Traditional Production

1. Quality Control

The traditional method has no quality control measures. As a result, the finished product lacked the consistency and finesse of imported cheeses.

2. Hygiene

Traditional processors give little or no regard to hygiene. This is evidenced in the grooming of the processors as well as the processing environment. The implication of this is cross-contamination and microbial infestation which is capable of giving rise to food borne infections and intoxications.

3. Health of Cows

The health of the cows is of paramount importance because it is a function of the quality of milk produced. Little attention is given by the processors to the health of the cows. This could be due, in part, to the absence of veterinary doctors in nomadic areas as we; as the high cost of veterinary drugs.

4. Shelf Life

Its maximum shelf life is about 2-3 days if stored traditionally. Wara is prone to microbial spoilage because it is highly nutritious.

3.4 Meat Products

3.4.1 "Suya"

"Suya" is a roasted meat product (berbecue) obtained from beef, pork, mutton, chicken and other desirable animals. Although it is peculiar to cattle rearing areas of the country, its acceptability has made it a national product that can be found in all nooks and crannies of the country. It is a common entertainment commodity with drinks (both alcoholic and non-alcoholic) and spices as accompaniments. The popularity of this product underscores the importance of a review of its traditional production.

Traditional Production of Suya

Meat is cut into small flat pieces, rinsed and salted. The salted pieces of meat are then inserted in a pit and sprinkled with pepper and groundnut oil such that its (meats) external surface is covered completely. The resulting product is sundried for about 30-60 minutes after which it is roasted with direct heat from hot coal for about 1-2 hours. The roasted meat (suya) is ready-to-eat when the meat turns brown Suya has no local storage or packaging device, hence, it is regularly reheated to improve its appeal.

Problems of Traditional Processing

1. **Intensity of heat:** Hot flames from coal, which is in direct contact with the meat, can lead to burning and destruction of valuable nutrients of the meat.

2. **Time Consuming**

The process is time consuming as it can take some 4-6 hours to prepare. Considerable time is spent during the manual slicing of meat and preparation of red-hot coals.

3. **Ease of Contamination**

Suya is commonly displayed uncovered in environments that are anything but clean. This makes the product highly susceptible to microbial attack. In addition, the smoke, which contains good doses of harmful gases like carbon monoxide and hydrogen sulphide, can be source of deleterious chemical changes.

4. Hygiene

The level of hygiene on the part of the processors is generally low. The processing environments and water used in washing fall below expected standards. These conditions predispose the commodity to spoilage and reduces its shelf life.

5. Packaging and Storage

Presently, Suya has no packaging or storage device. The implication of this are:

(i) Only small amounts of meat can be processed at any given time
(ii) Remnants have to be discarded as it cannot stay more than 2 days before deterioration sets in.
(iii) The production process is made highly labour intensive.

6. State of Animal

The processors give no thought to the state of health of animals. In some localities, diseased animals are favourites. In other areas too, the use of carmel meat, which is reputed to have high amounts of mercury, is in vogue. And yet others do not wink an eye at the use of dead animals for suya.

3.4.2 "Tinko"

"Tinko" is a fibrous hard and dried meat product peculiar to cattle rearing areas of the country. It is a delicacy among the Hausas and Yoruba's of the country where it is commonly used in soup preparation and gravies. It is a common form into which raw meat is processed to extend its shelf life locally. Compared to boiled meat, tinko is reputed to have a higher aroma, flavour and protein rating. Many people equally believe that it is more palatable than ordinarily boiled meat.

Traditional Production of Tinko

Live animals, usually camels, donkeys and horses are slaughtered, cut into pieces, washed and parboiled until it is cooked without being soft or tended. Salt and ashes are added and the product is sundried until the meat develops a deep brown colouration. The resulting products in tinko

Problems of Traditional Processing

1. Nature of the product

The product has a dirty brown colour and is usually stony, a situation which could predispose consumers to health risks like appendicitis.

2. State of Animals

The use of unhealthy and dead animals is a Common practice. This practice is common in localities where the owner sees the illness or death of his animal as an economic loss. To mitigate his perceived losses, the sick animals or its carcass is processed into tinko. This practice is of public health significance in view of the recent scare of the mad-cow disease.

3. Drying Method

The drying method employed (sundrying) is grossly Inefficient and gives very little consideration to hygiene.

4. Storage Method

The storage method (packing in sacks and baskets) is equally inefficient and inadequate. This gives room for microbial proliferation as well as light and oxygen induced deterioration.

3.5 Fish Products

3.5.1 Smoked Fish

Although the supply of fresh fish is ample only in riverside area of the country, fish processing is not the exclusive prerogative of the fish producing communities. This is due to the availability of frozen fish in non-fish producing communities.

In many developing countries, fish processed by traditional smoking methods are extremely popular. This popularity is due to the chemical changes that occur during the smoking process. In fact it is the chemicals produced during the smoking process that is responsible for the characteristic flavour of smoked fish. Smoked fish has a wide appeal among the general populace. It is a common accompaniment in soups, sauces and other food preparations. The need for proper smoking operation cannot therefore be over emphasized.

Traditional Production of Smoked Fish

Frozen fish is thawed salted and smoked by placement on wire gauze placed atop a smoke source. Where fresh fish is available, it is sometimes folded and kept in place by a broom stick. It is then salted before smoking. In all the cases, the viscera matters are left intact as this is believed to make the final product bulkier. The final product has a fairly shiny gloss with considerable amount of water. Packaging is non-existent and storage is in open baskets.

Problems Traditional Processing

(i) Hygiene

Very little consideration is to given to hygiene. The process is a cottage industry in Nigeria, hence production is usually carried out by women who give very little or no regard to cleanliness. The processing area is also filled with flies while no provision is made for washing prior to the smoking operation. Smoking is done in the open with no provisions made to protect the fish from dusts, pebbles, stones and other extraneous matter.

(ii) Splitting/Evisceration

The guts, gills and kidneys are usually not removed. The high microbial load of these intestinal organs predisposes the locally smoked fish to spoilage.

(iii) Salting

Since traditionally smoked fish are seldom salted, the final gloss and taste is significantly affected.

(iv) Smoking

This is commonly done over open fires from dried wood. However, because it is done in the open, chances of contamination from external sources are quite high.

(v) Storage

There is no particular method of storage. The smoked fish are usually re-smoked at periodic intervals to keep warm. Hence the shelf life of traditionally smoked fish is very low (about 3-5 days)

3.5.2 Dried Fish

Another very popular form to which fresh fish is processed is dried fish. Species commonly used are referred to in Yoruba speaking areas as “agbodo” and “ebolo”. Since a large proportion of fish are locally subjected to the drying operation, a review of the traditional process ensures that appropriate recommendations are made for improvement.

Traditional Production of **Dried Fish**

Raw fish is salted and exposed to direct sunlight for about 8-14 days until it is sufficiently dry. On the alternative, the salted fish is place on a wire mesh with red-hot charcoal beneath. This is continued till the fish is sufficiently dry. The dried fishes are then stored in baskets and jute bags till it is needed for consumption or sales

Problems of Traditional Processing

1. Sun-drying

Where sun-drying is involved, the product is exposed to hazards of weather and there is virtually no form of protection against insects, pests or rodents attack. Furthermore, sand, stones, faecal matters and other extraneous matters become ingrained in the product. In addition, the drying process is inefficient and grossly inadequate. This can be attributed to the unpredictable nature of weather and intermittent sunshine. This certain level of deterioration may set in before fish finally dries.

2. Handling

The fishes are usually not washed before drying. Where this is done, it is with water of poor drinking quality. In addition, very little regards given to the quality of the raw fish as the primary consideration is purely economic. This in turn imperils the quality of the final product.
It is a very time consuming process especially where sun-drying is involved.

4.0 CONCLUSION

Food processing techniques are used exclusively in the production of alcoholic and non-alcoholic drinks as sekete, ogogoro, burukutu and pito. Also milk products are turned into cheese by enzymes from leaves. Meat is smoked into suya, while whole fish is smoked into dried fish. Meat is sometimes parboiled and dried into tinko.

5.0 SUMMARY

In this unit we have learnt that:

Fruits (e.g. tomatoes) are not usually processed but marketed in basket in the fresh state. Vegetables are sold in the fresh or dried form.

Both alcoholic and non-alcoholic beverages are made from cereals and palm juices.

Milk is processed into cheese; meat into suya and tinko; fish is popularly smoked.

SELF ASSESSMENT EXERCISE

Describe the traditional production of: (i) Sekete (ii) Ogogoro (iii) Burukutu (iv) Kunnu and (v) Pito.

6.0 TUTOR-MARKED ASSIGNMENT

Why are the following products acceptable to Nigerians?

1. Suya
2. Tinko
3. Smoked fish

7.0 REFERENCES/FURTHER READINGS

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