Foreword

The University of Ibadan Distance Learning Programme has a vision of providing lifelong education for Nigerian citizens who for a variety of reasons have opted for the Distance Learning mode. In this way, it aims at democratizing education by ensuring access and equity.

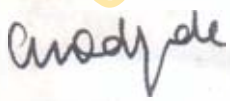
The U.I. experience in Distance Learning dates back to 1988 when the Centre for External Studies was established to cater mainly for upgrading the knowledge and skills of NCE teachers to a Bachelors degree in Education. Since then, it has gathered considerable experience in preparing and producing course materials for its programmes. The recent expansion of the programme to cover Agriculture and the need to review the existing materials have necessitated an accelerated process of course materials production. To this end, two major workshops were held in November 2002 and January 2003 which have resulted in a substantial increase in the number of course materials. The writing of the courses by a team of experts and rigorous peer review have ensured the maintenance of the University's high standards. The approach is not only to emphasize cognitive knowledge but also skills and humane values which are at the core of education, even in an ICT age.

The materials have had the input of experienced editors and illustrators who have ensured that they are accurate, current and learner friendly. They are specially written with distance learners in mind, since such people can often feel isolated from the community of learners. Adequate supplementary reading materials as well as other information sources are suggested in the course materials.

The Distance Learning Centre also envisages that regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks will find these books very useful. We are therefore delighted to present these new titles to both our Distance Learning students and the University's regular students. We are confident that the books will be an invaluable resource to them.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.



Prof Abiola Odejide
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Lecture One

Scope of Food Science and Technology

Introduction

In prehistoric times, man was basically a farmer, tilling the ground and obtaining his food from nature's bounty. His fruits and vegetables he got off trees and wild plants and his meat through his hunting prowess. His environment; soil, climate, topography of his place of abode and other factors beyond his control governed his everyday activities. The growth of big towns and cities and in recent times, megalopolis implied large concentration of people who neither till the ground nor practise any form of animal husbandry yet they require mega-tonnes of food of various classes for their daily activities. Food must therefore be sourced from distant places requiring conscious intervention of man in the natural processes for production, harvesting, processing, preservation and distribution of the foods.

Nations which succeeded in harnessing all these technological efforts in effectively controlling the forces of nature have access to varieties of abundant nutritious and wholesome foods as is evident in most of the western world. Where these efforts were not initiated or have failed, famine, nutritional diseases, pestilences, underdevelopment and the like are the vogue as in several countries of Africa, Asia and South America.

Objectives

At the end of this lecture, students should be able to:

1. Explain the meaning of Food Science and Technology.
2. Discuss the range of activities and challenges facing the food scientist.

Pre-Test

1. Give a concise definition of Food Science and Technology
2. Discuss the interrelationship of several scientific disciplines embodied in the field of Food Science and Technology.

CONTENT

Food Science and Technology Defined

Food Science and Technology is the totality of organised scientific and engineering knowledge applicable to the abundant production, storage, processing, preservation, modification, diversification and utilisation of food that is wholesome and safe for human consumption.

It is evident from this definition that the activities of food scientists are multifarious bordering on all facets of the physical and biological sciences. The following discussions touch on some of the well known areas in the field. They are neither exhaustive nor self exclusive and many more will become apparent to the student in his everyday living activities.

Food Preservation

With the increase in available quantity of food for human consumption has come the need to introduce varieties into food and protect food from spoilage from the point of production through to sales and consumption. Most often it is necessary to preserve foods. One of such methods is drying and it includes sun drying, freeze drying and hot air drying which is perhaps one of the oldest methods of food preservation. Curing with salt, nitrite and nitrate with or without smoking, has been in use for a long time in meat preservation. A gamut of food products arise from fermentation of raw materials by mould, yeast and bacterial colonies with formation in them of organic acids and alcohols which cause detoxification and destruction of anti-nutritive factors and natural toxins. Wine and beverages, *SOY OGI, IRU* and *GARI* fall into this group.

Other preservation methods include canning of a wide range of foods, freezing and refrigeration, use of chemical preservatives including antimicrobials, aseptic and modified atmosphere packaging, irradiation, use of high pressure, application of heat as in cooking or use of microwave oven and low temperature non-thermal process as with pulsed electrical field (PEF).

Food Chemistry/Biochemistry

The physical and mental well being of man depends on the nutritional quality of the food he eats. The food chemist determines the nutritional and qualitative composition of each food, the bioavailability, and utilization of nutrients in such foods in relation to human health as a prelude to setting nutrient standards and blending suitable nutritional supplements for such foods. Nutrient stability during cooking, processing, storage and distribution are also of interest. Some endoenzymes in foods continue to function physiologically after harvest and in storage bringing about autolysis, spoilage, colour reactions and other undesirable changes. Yet, other endoenzymes or added enzymes are consciously encouraged to bring about desirable end products. It is the work of food scientists to harness these

changes productively in producing good quality foods such as in evaluating the colour and flavour changes and chemical reactions accompanying the ripening process.

A rapidly expanding field is that of flavour chemistry for improvement of food tastes through development of new flavours in some foods or synthesizing artificial flavours resembling or enhancing real or natural flavours e.g. saccharin, aspartame and other sweeteners, monosodium glutamate in maggi cube and other flavour enhancers all of which can be cheaply and easily mass produced. Some food constituents also chemically react with other chemical constituents of processing machineries, cooking utensils, packaging materials and holding vessels resulting in off colour and sometimes toxicity. Food – drug interactions, presence of allergens in foods and nutritional impact of genetically engineered foods on human health are all equally of concern to the food scientist.

Food Engineering

This is of immense importance in the design and monitoring of all food processing operations from the farm to the final consumer. It deals with the functional layout of the processing factory, equipment design and material testing appropriate for the particular food being processed as well as the work flow and processing conditions for production of safe high quality foods and management of wastes. It determines the optimal use of resources such as raw material, energy and water and evaluates the rheological properties of foods. It is also involved in translating laboratory scale processes to industrial scale production of foods and in designing functional food packaging systems that will keep foods fresh and wholesome. Examples of application of food engineering are evident in the design of efficient and appropriate machineries for cassava and yam processing, rice and maize milling, beer brewing and others.

Food Microbiology

Various microbes, yeast and mould, virus, bacteria, helminth eggs and protozoan parasites are to be found variously in raw and poorly processed foods including drinkable water. They destroy crops in the field and spoil them in storage, during handling along the processing and marketing chain and at destination points thereby reducing their commercial value. More importantly of concern in public health are those food borne pathogens that are potentially harmful in causing food poisoning and infection. Among them are *coliforms, fecal streptococci, salmonella, staphylococcus, clostridium perfrigens, clostridium botulinum* and a host of others. *Viral Bovine Spongiform Encephalopathy (BSE)* (Mad cow disease) and African swine fever) are presently of topical issues. The goal of the food microbiologist is to find ways of totally eliminating the pathogens through "hurdle intervention" at all stages of food handling and processing.

And yet not all microbes are harmful, for others have been of immense functionality in the manufacture of many food products. All alcoholic drinks are products of yeast fermentation. Yogurt, dry and semi-dry sausages are fermented products using bacterial cultures. *Iru, gari, ogi, fufu* and many others are similarly naturally fermented products. Mycoproteins from fungi have also been made into functional and nutritious meat alternatives.

Food Quality Assurance

Quality control processes are necessary to provide food items at least a profitable cost to meet consumer quest for overall satisfaction. To meet this objective, stringent specifications are set for raw material quality, ingredient supplies, processing schedule, packaging materials and shelf life for uniformity of finished products. Involved also are the training of quality control personnel, appropriate testing for desired quality attributes along the processing chain using appropriate methodologies, proper keeping of quality control records and prompt re-evaluation and re-adjustment of processing schedule to minimize product rejects and process failure. Maintenance of a successful quality control programme therefore requires a good link between the overall managers of the food industry, the raw material procurement division, the production unit, the warehousing and sales division on the one hand and the quality control section on the other.

Food Additives

A host of substances are added to foods for specific purposes and as such become part of those foods. These substances, while edible are very rarely eaten by themselves. Among these are nutritional supplements like vitamins and minerals which are designed to upgrade the nutrient content of some foods, food grade colours to improve the appearance of an existing food colour or introduce a new one, anti-caking agents added to salt and some other foods to make them free flowing, anti-oxidants like BHA and BHT to retard rancidity in foods, flavour enhancers like maggi cube, and others containing monosodium glutamate to boost food flavour. Others serve preservative action in certain foods either by inhibiting or killing microorganisms, (antibiotics) destroying endogenous enzyme activities in foods, while others serve as texturizers.

Food Warehousing and Food Merchandising

Post harvest losses of farm produce in the tropics range from 20-50% from the farm gate to point of consumption due to insects, rodents, mould and other natural or human factors. Proper warehousing with proper protective measures mitigate this problem. It also helps to eliminate seasonal gluts and shortages through efficient processing and storage systems to even out supplies throughout the year within and beyond geographical regions without loss of quality. Thus, in time of plenty, banana, plantain, orange harvested at the half ripe stages could be stored over a long

period and the ripening process controlled until time for marketing. Food warehousing is an important aspect of a nation's food security against emergency situations during famine as in Somalia, and under natural and man-made disasters.

Foods, sometimes require transporting over long distances to service expanded and diversified markets requiring modifying control of natural physiological processes, temperature and humidity regimes to control spoilage, dehydration, chilling injuries during passage thereby increasing storage and shelf life. Processed foods in colourful eye-catching packages are brought closer to the final consumer through vigorous marketing campaigns. Such campaigns could be spread through radio, television, tabloid and internet advertising at prime time to create awareness on a global scale to increase the sales of each product.

New Foods Development

Limited only by the ingenuity of the food scientist, many new foods are now available in the market with more on the drawing board. They are the result of co-operative efforts of the farm producer, the food chemist, or analyst, the food engineer, the production crew, the quality control team, the packaging manufacturer, food advertising and food marketing team. Varieties are introduced into foods that are common as in the production of snacks and convenience foods like suya and kilishi from meat, kokoro from gari or maize fortified with soya bean protein, vitamins and minerals, breakfast cereals and gurudi from coconut.

New foods are also developed to improve diets of people suffering from various forms of protein-calorie malnutrition and to meet the needs of diverse ethnic and cross cultural groups and specific market tastes. Thus with rising income and more food taken away from home, traditional dishes will be made more available in ready to cook and ready-to-eat cuisines and fast foods. Specific foods are also directed at specific groups of people; the very young and the very old, women, students, pregnant and lactating mothers, diabetics requiring low sugar diet, hypertensive patients requiring cholesterol fighting foods, people with lactose intolerance and others with specific health problems. Some industrial processes convert unconventional raw materials and waste products into foods for human consumption e.g. cellulose into edible carbohydrates as in edible cellulosic casing, edible sugars and sweeteners. Food gum or methylcellulose has egg white functionality. Mycoproteins and phytoproteins have also been processed into meat analogs and other foods that are rich in protein and fibre. Other new foods of note include foods with exotic colours and flavours as in fruit drinks, vegetarian diets, encapsulated products, confectionary and energy foods, fish burgers and chicken nugget.

Nutraceuticals

A rapidly developing facets of food science is the production of a whole range of functional health food products, the so called nutraceuticals. They include botanicals, pre and probiotics which are claimed to be able to improve health when

taken in appropriate amount. The origin of many nutraceuticals are plants and animals that are not domesticated but live in the wild. They are used in form of pills, capsules, powders or liquids and as constituents of beverages, nutrition bars, snack foods and herbal medicines. They are believed to have some marginal nutritive value but more importantly, that they promote health by preventing certain diseases and inflammations especially, cardiovascular diseases, atherosclerosis, hypertension, cancer, diabetes, some nervous and nutritional disorders with some enhancement of the body's immune system. An example is garlic powder, which contain 5-allylcysteine, a known inhibitor of cholesterol synthesis. It has also been found to show anti-microbial, antithrombotic and anti tumor activities. Honey has also been known to have many therapeutic effects on body functions.

Food Laws and Regulations

The government of each country sets up regulatory bodies which are backed by laws and statutes which set out regulations relating to food production and processing, factory inspection, monitoring of substandard food products, food adulteration and potential hazards in foods. These laws also govern food labeling including ingredient and nutritional contents, manufacture and expiry dates, batch number of the product, declaration as to weight and volume and import-export status. In Nigeria, these regulatory functions are performed by the Standard Organisation of Nigeria (SON), and the National Agency for Food and Drug Administration and Control (NAFDAC).

Food Toxicology

Fertilizers used for dressing the soil and treating lawns and industrial chemicals often find their way into streams, lakes and other body of water where they pollute aquatic life including our sea foods. Man also uses insecticides, fungicides, germicides, antibiotics and other chemicals to enhance good crop yield as well as protect and preserve his foods both on the field and in storage. Some of these are carried over as toxic residues e.g. methyl-mercury in fish. Mycotoxins, phytotoxins and other toxic plant constituents, such as allergens, mold metabolites and various environmental contaminants that also serve as toxicants in our foods. Dioxin if found in the fat of contaminated meat, fish, egg or dairy products can on consumption by man cause reproductive failure, heart disease, diabetes and cancer. *Aspergillosis* is associated with the toxin produced by the mold *Aspergillus niger* in moldy grains. Gammalin wrongly used in fish capture has been known to kill consumers of such fish. The food toxicologists through the Federal Environmental Protection Agency (FEPA) monitor these hazards and ensure their complete elimination from the food chain.

Water Security

We obtain water for domestic and industrial uses through rainfall, streams, rivers, fresh water lakes, deep wells and boreholes, or even the ocean. Such water to be used in food processing must be safe to drink and therefore free of unacceptable odor, color, taste, clarity, chemical constituents and pathogenic microbes. It should be economically available in large quantities. Purification of water requires such treatments as sedimentation electrofloatation, flocculation, dissolved air floatation, filtration, chlorination, ultraviolet light irradiation or boiling among others. Such industrial and municipal water is delivered through the public water main. Water used in making soft drinks, beer, other beverages and foods are purer than tap water to prevent undesirable interaction between residual impurities in the water and the active ingredients. In recent years, water for drinking purposes have come in polyvinyl sachets and plastic bottles and are sealed, pure and portable. Such water packs must be certified by the controlling regulatory body, National Agency for Food, Drugs and Administration Control (NAFDAC) as shown by the NAFDAC number. **'Enhanced water'** may be fortified with minerals, vitamins and some natural flavours while **'Super oxygenated'** water contains fifteen times more oxygen than natural water and is good for athletes and others engaged in work or sport requiring energy use.

Sewage Pollution and Industrial Waste Management

The food processing operations involve various activities such as washing, sorting, peeling, slaughtering, cleaning, sanitizing and the like depending on each specific food. The solid wastes and waste effluent water from meat, milk, fruit juice, egg, starch and other food processing factories become sources of serious pollution when discharged in large volumes with attendant undesirable environmental impact. Controlled management of these wastes through creation of sewage lagoons, solid and liquid waste recycling and conversion into useful by-products would ensure proper environmental friendliness, water conservation, energy saving and added profitability to the food industry without compromising safety. The Federal Environmental Protection Agency (FEPA) is the regulatory body charged with ensuring that both sewage effluents and solid wastes do not become sources of pollution in the environment.

Food biotechnology is another recent but fast growing development involving cloning, gene transfer and genetic modification of some of our food resources. Some of the achievements attributed to genetic engineering of foods include the removal of allergy causing factor in such crops as groundnut and soya bean; production of livestock whose meat is resistant to bacterial growth and spoilage thereby providing disease resistance, reduced transmission of zoonotic micro-organisms and longer shelf life. Others include, selective improvement of the status of specific nutrients like *PUFA* in some foods or downgrading the status of less desirable ones like cholesterol.

Food Science Education, Research and Development

A virile food industry requires a staunch support base inspired by excellence in Food Science education, research and development. In Nigeria, the National University Council through its accreditations and minimum academic standards and the Nigerian Institute of Food Science and Technologists through its out-come based guidelines to Food Science Departments ensures that graduates of food science acquire the skills necessary for a rewarding career in food science. Food Science Education in all areas previously discussed and many more ensures the training of qualified personnel for career services at the secondary and tertiary institutions, research institutes, government agencies and parastatals, hospitals, and various food industries. The career opportunities are almost limitless.

Summary

In this chapter, aspects of the scope of food science have been discussed. These included food preservation, food chemistry, food engineering, food microbiology, food quality control, food additives, food warehousing and merchandising, new food development nutraceuticals, food laws and regulations, food toxicology, water security, sewage pollution and industrial waste management and food biotechnology. They are neither exhaustive nor mutually exclusive and other activities in relation to food science will continue to manifest as the student advances.

Post-Test

Which of these areas of food science have received minimal attention in Nigeria?

1. Food engineering.
2. Food microbiology.
3. Food quality control.
4. New food development.
5. Food toxicology.
6. Food biotechnology.

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WORK SHEET

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Course Title:..... Date:.....

Lecture Two

Food and Its Functions

Introduction

A hungry man is an angry man therefore the consumption of food is important to man as it plays an important role in his physical and intellectual development. Food supplies nutrients that are used for growth, maintenance and repair of body cells. The food needs of man are therefore classified into six groups of nutrients, namely, carbohydrates, fats, proteins, minerals, vitamins and water.

A single food does not contain all the above nutrients. Foods are therefore classified based on the nutrients they contain.

Objectives

At the end of this chapter, you are expected to be able to:

1. Explain why we should avoid eating too many foods of the same class.
2. Classify food into different groups.

Pre-Test

1. What do you understand by the word 'food'?
2. Why is food classification important?
3. Discuss briefly the functions of food.

CONTENT

Food and Its Functions

The science of nutrition is defined as the study of nourishing the body adequately. Three main purposes are thereby attained. These are:

1. Growth
2. Maintenance
3. Repairs of damaged body and worn out tissues.

Except for water (H_2O) and oxygen (O_2), food supplies the raw materials that are needed for growth, maintenance and repairs

In general, foods must contain substances that function in providing fuel. That is, foods are substances that on oxidation in the body release energy that is needed for the various activities of the individual. Foods must also build/maintain body tissues and lastly, food must regulate body processes.

An individual food could perform all the three functions, it could perform only one of the three. But the diet as a whole must serve the three functions in order that the individuals should remain healthy. Any chemical substance in food that functions in one or in the three ways is called **Nutrient**.

There are six kinds of nutrient that are needed by the body. These are the carbohydrates, proteins, fats vitamins, minerals, and water.

The carbohydrates, protein, and fats are often referred to as **Fuel Nutrients**. The fuel nutrients supply energy in the form that is suitable for work and heat. The fuel nutrients are **Organic Substances** that are combustible and these can be used interchangeably as the source of energy. The mineral, and water are called the **Inorganic Nutrients**. The protein, minerals and water are all found in the composition of the body tissues and they also function for the repair of the tissue.

The vitamins are diverse organic substances that are present in very small quantities in the food. Vitamins are essential for the normal growth and for maintenance of health. The vitamins and minerals are body regulators and they promote oxidative processes and the normal functioning of nerves and muscles.

Water also serves in regulating body functions by holding substances in solution. Water is also a component of the digestive juices and of blood, tissues and it regulates the temperature of the body. The excretion of waste product also occurs with the aid of water.

Food Groups

Foods are grouped together in the order of their general functions and foods in a particular group can readily substitute for other members of the group. Avoid eating too many food that are of the same class of food and also ensure that not one group is inadequately represented in the food that you consume.

Food Classification

There are 3 different ways of classifying food.

1. **The Ten Food Groups**:
   - (i) Grain products
   - (ii) Potatoes
   - (iii) Meat, poultry, fish and eggs
   - (iv) Dry beans, peas and nuts
   - (v) Milk, cheese and ice cream

(vi) Green and yellow vegetables
(vii) Citrus fruits and tomatoes
(viii) Other fruits and vegetables
(ix) Butter and other fats
(x) Sugars, syrups and sweets.

2. The Basic Seven

(i) Bread, flours and cereals
(ii) Meat, poultry, fish and eggs
(iii) Dry beans, peas and nuts
(iv) Milk, cheese and ice cream
(v) Leafy greens and yellow vegetables
(vi) Citrus fruits and tomatoes
(vii) Butter and fortified magarines.

3. The Four Main Groups

(i) Bread and cereals that consist of the inexpensive energy and protein sources. In this group we have the whole cereal grains that contain not only iron but also some vitamins.
(ii) Meat, poultry, fish, eggs, legumes and nuts. This group contains foods that are rich in protein, minerals and vitamins.
(iii) Milk and milk products; consist of foods that are the sources of proteins, calcium and other minerals and vitamins.
(iv) Vegetable groups: These are foods that are mainly the sources of vitamins and minerals.

Uses

The 10 basic group of food is used in planting crops to meet the food needs of a country. It covers all classes of foods.

The basic 7 is used for planning diet. The numbers of servings from each group is specified for ease of utilization.

The 4 main group is used primarily by the home economists. It forms the foundation of a good meal and it is simplified for general use.

Summary

The main functions of food include growth maintenance and repair of body tissues. Food contains substances that are referred to as NUTRIENTS. There are six basic nutrients found in food and these include carbohydrate, protein, fats vitamins, minerals, and water.

Foods are classified into 3 main groups: the ten food group, the basic seven and the four main groups.

Post Test

1. Discuss briefly why it is important to eat different classes of food.
2. Give a precise classification of food from a home economist's view.

Answer to Post Test

1. No single food contains all the nutrients. Foods in a particular group can readily substitute for other members of the group. One should avoid eating too many foods of the same class in order that the body may adequately be nourished.
2. The four main group is used primarily by the home economists since it forms the foundation of a good meal and it is simplified for general use (please see the four main group in the text)

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Food Distribution and Marketing

Introduction

In this lecture, we shall be discussing how food is distributed and marketed and the classification of food. Effective distribution and marketing of food is vital so that the food products gets to the consumer quickly and also to keep them informed about the kinds of products that exist.

Objectives

At the end of this lecture, students are expected to be able to:

Discuss food distribution and food trade in both rural and urban areas.

Pre – Test

1. How is the quality and quantity of food eaten in the rural areas different from that of Urban areas?
2. What is mal-nutrition?

CONTENT

Food distribution in Nigeria depends largely on the types of food that are produced. The populace relies on four major types of factors. These are the agricultural lands, seas, lakes and rivers for the food we obtain: the fish from water and crops and livestocks from agricultural lands. There are some others that rely on the forest e.g game and the wildlife. These foods that are classified either as plant origin or as animal origin can be broken down into distinct groups. These are plants and animal products.

Under each of these headings are various products

1(a) **Plants**

(i) ***Cereal:*** These include maize, sorghum, millet, wheat and rice.

(ii) ***Pulses:*** These include, cowpea, lima beans, and soyabean

(iii) ***Fruits:*** Banana, plantain, guava, pineapple, pawpaw, avocado pea, citrus fruits (oranges, lemon, tangerine, tangerlo, lime, grape).

(iv) ***Melon and Squashes:*** Melon, water melon, squash.

(b) **Vegetables**

(i) ***Leafy vegetables:*** Bitter leaf, waterleaf, lettuce, etc.

(ii) ***Root vegetables:*** Carrot and radish

(iii) ***Seed vegetables:*** Green peas, green beans, okro, pepper

(iv) ***Others:*** Onion, tomatoes, cucumber.

(c)

(i) ***Tuber:*** Yam, cassava, sweet potatoes, cocoyam

(ii) ***Nuts:*** Groundnut, cashew nut, and walnut.

(iii) ***Sugars:*** sugarcane, sugar beet and date

(iv) ***Oil Seeds:*** Cotton seed, olive, palm kernel, soyabean, coconut.

(v) ***Beverages:*** Cocoa, coffee, tea.

2. **Animal Products**

(a) Milk, butter and cheese

(b) Meat and entrails

(c) Eggs

(d) Fish

(e) Shellfish – crabs, crayfish, lobsters, shrimps.

3. **Manufactured Products (Modified Plants and Animals)**

The manufactured products are all obtained from the processing industries, they include;

(i) Canned foods

(ii) Frozen foods

(iii) Dehydrated foods
(iv) Salted and cured foods
(v) Dairy products: ice cream, yoghurt.
(vi) Meat products: Sausages, ham, etc.
(vii) Sea foods: fish, fillets
(viii) Oleomagarines
(ix) Fermented food.

Food Distribution in the Urban and Rural Areas

Urban Areas

It is important to note that in the urban area, income is a major determinant of the quality and the quantity of food that is consumed. The financial commitment also affects the disposable amount that is used for food. This commitment includes transportation, house rent, clothing, school fees and other related expenses. The other things that affect the quality and quantity of food are the prices of the foodstuff and the type of food consumed.

Roots, tubers and the grains form a bulk of the foods that are consumed by the low income group. Some of the low-income groups also consume maize, millet, sorghum and rice. Legumes are consumed in low quantity and the major legumes consist of groundnut and melon seed. Meat and meat products are expensive and are consumed in low quantity. The total food consumption both in quality and quantity are inadequate.

For the urban affluent, they eat more of grains and grain products. They consume wheat and wheat products in the form of bread, cakes, pastries, sausage rolls, spaghetti and wheat puff. They also consume rice and rice products. A number of them consume maize products especially in form of corn flakes. There are also some roots and tubers in their food. The root and tubers come mainly in the form of pounded yam. They eat very little of cassava produce, their meal is rich in meat, fish and snail and the presence of milk and milk products in their diet is a common feature. There are eggs and beverages in their diet. The beverages include wine and beer, carbonated drinks and fruit juices. On the whole, the urban affluent tends to be over nourished and the consequences include obesity and other health problems.

Rural Areas

In the rural areas, the economic situation is mostly subsistence and there is low income generally. There are two main types of the rural dwellers. They are either pastoral or agricultural. A number of people combine both activities.

Pastoral

Originally the pastoral groups are well nourished as their diets are rich in animal proteins and a number of them drink nothing but milk. With time and increase in the number of herd, over-gazing, soil erosion, and desertification occurred. The loss of pasture was followed by a reduction in the number of livestock and there was the increase in trans human activity. Consequently, conflicts arose between the pastoral and the agricultural groups.

Poor Food Distribution and Its Consequences

The food and nutrition strategies are designed to ensure satisfactory levels of nutrition among a given population. The nutritional levels are poor because of the food quantity and quality that are not in adequate supply on one hand while on the other hand there is over eating. The food distributed globally is not well balanced as industrial nations obtain more food than they need hence most developing nations experience periodic food shortages. These developing nations have to import foods especially grains. A term that is used to depict the level of food adequacy is malnutrition.

Mal-nutrition is a term that covers a range of different pathological conditions. Mal-nutrition could be shortage of energy, of protein or of the individual vitamins and minerals. But generally, mal-nutrition is due to multiple deficiencies. The predominant characteristics are:

(i) A lack of energy
(ii) A shortage of high quality protein
(iii) The deficiencies of specific vitamins such as vitamin A.
(iv) The deficiencies of specific trace mineral such as Iodine.

There are four types of mal-nutrition.

(i) The energy mal-nutrition – This is called marasmus.
(ii) The protein mal-nutrition – This is referred to as kwashiorkor.
(iii) The mineral deficiency in which minerals like I,Fe and Cu are deficient in the feed.
(iv) The vitamin deficiency in which vitamins like vitamin A, or any other may become deficient.

Food Distribution and Marketing

Generally, people talk about the protein calorie mal-nutrition (PCM) or protein energy mal-nutrition (PEM). The two terms are used as energy and protein mal-nutrition and tend to occur simultaneously in many cases e.g. in adults, a balance of hypocalorific diet induces a progressive loss of weight whereas in children the diet produces a slow growth and the tissue maturity is attained at a prolonged rate i.e. at the age that is later than normal. This type of mal-nutrition is called relative mal-

nutrition. Relative mal-nutrition occurs when there is poverty and the whole population may have stunted growth that is referred to as nutritional dwarfism. In this case the average weight and the height will be below their genetic potential. Denutrition (marasmus) leads finally to the progressive disappearance of proteinous fat and thus wasting away of active tissue as the subject emaciates. Marasmic denutrition is prevalent in babies that are sucking and in children that are given very diluted powdered milk. Between 10-20% of the death in infants that are under one year old could be attributed to marasmic denutrition in some localities.

Food Trade

The trade in foods becomes necessary as a result of over production in one country and underpopulation in another country. Food trade is designed to even out as much as possible the food situation in any one country. There are several products that are traded.

The tropical root tuber especially cassava had been identified as a desirable raw material for compounding livestock feeds. In the international trade, cassava is marketed as dried roots or as meal, chips, pellets, flour and also in the form of starch. In Germany, Denmark, Australia and Japan, most of the cassava that is imported goes into the food industry whereas in India and Netherlands, the cassava is used for industrial purposes.

Grains

It becomes necessary to distinguish between the grain legumes and the cereal grains. Both of these grains are used for food and they form items of trade either on a local level or as international items of trade. In Nigeria, the trade in grain legumes is essentially of local nature i.e. very little of the grain legumes is exported and it is neither imported. A major grain distribution centre is in the North. Cowpea is mainly produced in the northern states and the dried grains are transported to the South. The food grain legumes contain a range of 22 – 25% crude protein and Nigeria produces at least 950,000 tonnes per annum. The food legumes are the natural supplements to the staple diet of the cereal, grains, the root and the tubers. Beans serve as a major complement to the food of most Nigerians, than other grains.

Summary

This lecture has discussed the classification of food of either plant or animal origin and how such food is distributed into both the rural and urban areas. Poor food distribution and its consequences are also discussed.

Post – Test

1. What are the consequences of poor food distribution?
2. Why is food trade essential for any nation?

Answer to Post Test

1. Poor food distributions will result in;
   a. Poor nutritional levels because the quantity and quality of food are in inadequate supply.
   b. Developing nations will get poorer while developed nations will get more industrialized.
   c. Health hazards will result e.g. mal-nutrition of various grades will become prominent (Marasimus, kwashiorkor e.t.c.

- To even out as much as possible the food situation in any one country.
- To make available food that are not grown as a particular nations.

WORK SHEET

Instruction: *Use this work sheet to supply answers to the post-test questions at the end of this chapter. It should also be used to answer any assignment (practical or theory) given by your lecturer. You may use extra sheet(s) where necessary.*

Name:..... Matric no:.....

Department:..... Course code:.....

Course Title:..... Date:.....

Lecture Four

Composition and Structure of Nigerian and West African Foods

Introduction

In this lecture, we shall be discussing the composition and structure of some foods typical to Nigeria and West Africa.

Objective

At the end of this lecture, students are expected to be able to discuss the composition, and other typical characteristics of some Nigerian and West African foods.

Pre – Test

What are the similarities and differences in the composition of the following food items:

1. Yam
2. Cassava
3. Maize

CONTENT

Yam

Yam belongs to the genus *Dioscorea*. It contains about 600 species, but the main variety that will be discussed is: *Dioscorea rotundata.*

The yam tuber is economically the most important of the plant. The weight of a yam tuber may vary from 50kg – 200g. The tubers are bitter to taste due to the poisonous alkaloid that is called dioscorine. The toxic substance that is present in yam are made harmless by soaking yam in water or by boiling.

Yams are present naturally in only 3 areas of the world. These are

(i) West Africa

(ii) The Caribbean Island

(iii) South-East Asia

The global production is about 30 million tonnes per annum. --- By far, the largest average and of course the greatest amount of yam production takes place in West Africa. Over 95% of the world production of yam occurs in West Africa. Within the region of West Africa, yam production is confined to the region that stretches from Cote de voire, down to Cameroon. In this region, the major yam producing countries in order of importance are Nigeria, Cote de voire, Ghana, Togo and Benin Republic.* Nigeria accounts for 70% of the world production of yam. The Caribbean Island is the second most important yam producer apart from West Africa. The other countries where yam is significantly produced include Brazil, Venezuela, Papua New Guinea, China and Philippines.

Composition of Yam

Yam varies in composition. The variation is dependent on the cultural practices, climate and the edaphic factors. The conditions under which yam is grown therefore varies all over the world.

The maturity of the yam as well as the method and the length of storage all affect the composition of the yam. In general, yam consists of:

Moisture	53-73%
Carbohydrate	23%
Fat	0.12%
Crude protein	1.09 – 1.99%
Crude fibre	0.35 – 0.79%
Ash	0.63 – 2.56%

Yam is made up essentially of water as well as carbohydrates (CHO). The *CHO* consist of starch and there is a negligible amount of sugars. The sugar that is present in yam is less than 1 per cent. The main constituent of yam starch is *amylopectin*. The *amylopectin* exists in the form of starch grains within the cells. The protein content of yam is low and the proteins are low in sulphur containing amino acid mainly methionine and cystine.

Apart from being a good source of *CHO*, yam contains a significant amount of Vitamin C as well as iron, calcium and nicotinic acid. The calorie present in yam is one thousand calorie, gm/gm (1000 Cal., gm/gm)

Composition Per kg of Yam

Calories	1000 Cal, gm/gm
Protein	20g
Calcium	150mg
Iron	10mg

Thiamine	1mg
Riboflavin	0.3mg
Nicotinic acid	4mg
Vit. C.	50mg.

Storage of Yam

There is a conservative estimate that 15% of the yam that is produced annually do not get to the market due to post harvest losses. The losses are due to the lack of appropriate storage. In addition, a variety of diseases and pests as well as sprouting also account for losses.

It is estimated that a million tonnes of yam tubers are lost annually during storage in West Africa. The sources of storage losses include rotting of yam, pests, respiration as well as sprouting. Sprouting causes a reduction in the food resources by translocating the carbohydrates from the tubers into the sprouts for metabolic processes. Sprouting also increases the respiration rate, thereby increasing the rate of loss of dry matter. There is also the acceleration of moisture loss through the permeable surface of the sprouts. As a result, the yam becomes progressively soft to the touch from the bottom upwards, thereby resulting in the rotting of the yam.

Sprouting of the yam can be delayed by a non-lethal dose of gamma radiation. The rotting in the yam tuber causes the greatest loss of dry matter during storage. Rotting is due mainly to the effect of fungi and bacteria. In particular the *Servatia spp* have been implicated. To prevent rotting of yams during storage, wounding of the tubers have to be prevented. The curing of yam tubers at about 25°C with a low humidity of between 55-62% for a period of 5 days before storage prevents to a certain degree the yam from rotting. There is also substantial loss of yams due to rodents and insects.

Respiration

Respiration is a serious source of the storage loss in yam. Since harvested tubers are living things, they continue to respire and the substrate for the respiration is the dry matter, which is stored in the tubers.

Up to 10% of the dry matter may be lost in the yams that are stored for a period of 5 months as a result of respiration. The effective way to reduce the respiratory loss is to keep the temperature low but not below 16°C.

Yams are stored for two major reasons.

(i) To preserve the yams as planting materials for the next years crop.

(ii) To preserve the yams for future use as food.

In general the storage of yams for consumption should not last longer than 6 months.

Yam Processing

Yam could be boiled, fried or roasted. Pounded yam could also be made by peeling the tubers, removing the inedible parts, cutting the yams into pieces and by boiling the yams until it is soft. The boiled pieces are then pounded using a wooden mortar and pestle, until the cellular and to some extent, the starch granule become soft and a stiff glutinous dough is obtained.

The *discorea rotundata* is the most viscous of all yams. It also has a high gel strength and these properties make the *discorea* yam the preferred species for the making of pounded yam because a stiff dough can readily be obtained.

Apart from pounded yam, the yam flour which is a composite flour for baking can be made from yam. At least 50% of the yam flour goes into the mixture for baking purposes. The instant yam flakes are also produced from yam.

Non-Food Uses of Yam

A number of yam species contain small amounts of *sapogenins* as well as *alkaloids*. In particular, the *alkaloid Discorine* ($C_{13}H_{19}O_2N$) are more abundant. There are various species of *saponins* and *sapogenins* and these occur in varying quantities in the various species of yams.

The *saponins* are usually hydrolysed to form the *sapogenins* and the major *sapogenin* that is found in the yam is the *diosgenin*. All the important *sapogenins* in yams are steriod in nature and they are all related to the steriod that is called *cortisone*. They are used as raw materials for the manufacture of corticosteriod drugs in the pharmaceutical industries. The corticosteriods are used as anti-inflamatory agents, as metabolic stimulants and as general stress reaction protectives.

There is the commercial production of Diosgenin especially in Mexico where *Dioscorea mexicana, Discorea rotundata* and *Discorea composita* are all grown mainly for medicinal purposes.

The alkaloids that are present in yams include the *Dioscorine* especially in the *Dioscorea hispida* as well as *dihydro dioscorine* that is found in *Dioscorea dumentorium*.

Dioscorine is toxic as it causes paralysis of the Central Nervous System (CNS) while the *saponines* are haemolytic.

Cassava

Cassava is a product that is grown mainly in the equatorial region and the region is bounded by latitude 30°N and 30°S of the equator. Cassava is restricted to zones that are less than 200m above the sea level. There is an annual rainfall of between 200 – 2000mm. Within these region, cassava is an important staple food for about 900 million people. The annual per capital intake of cassava is greatest in Africa. The average consumption is 120 kg per year. In the central Africa republic, Congo

and Gabon and in the Democratic republic of Congo, the annual rate of consumption of cassava exceeds 300kg per person per year. In Latin America, the average consumption is around 40kg per person per year.

The fresh peeled cassava is eaten as a vegetable after boiling or roasting. In some West African countries cassava is boiled and pounded with boiled plantain to form an elastic dough. The dough is eaten with vegetables and meat soups. The peeled cassavas are often sliced, dried and ground into flour. This is called kokonite in Ghana. The main form in which cassava is eaten in the whole of West Africa is as a roasted granular product that is prepared from peeled, grated and fermented cassava roots called "*Gari*".

However, in South America and Latin America, a product that is called the *farinka demadioca* is very popular. The *farinka demandioca* is similar to gari but it is considerably less fermented during its preparation.

There is another African product from cassava called *Chickwangwe*. *Chickwangwe* is prepared by soaking the cassava in water for a period of 2-7 days until it softens after which the root is peeled and the product is mashed. The fibres are removed and the paste that remains is firm and elastic. This firm and elastic product is wrapped in palm leaves or banana leaves. It is found in the East African countries.

In the Philippines, cassava is made into the landtang (cassava rice). There are other products obtained from cassava. These include biscuits, cakes and beer. Generally, animal feeds are also obtained from cassava.

Animal Feeds Obtained from Cassava

In animal feeds, cassava is used as a source of energy. Cassava pellets as well as chips are used for animal consumption. For the production of chips, the fresh roots are washed peeled and cut into slices with the slices usually 3-6cm in length. The slices are then dried on large concrete surfaces in the open spaces. The pellets are made from the chips. The dried chips are ground into cylindrical pellets that are about 2cm long and up to 1cm in diameter. The cassava chips and pellets are exported mainly from Thailand, Malaysia and Indonesia.

These products are exported to the European community and the United States of America where they are used mainly for feeding animals.

Industrial Products from Cassava

Cassava is an important raw material for the non food industries. It contains a low amylose content and there is a high amylopectin present in cassava. This gives the necessary viscocity and cassava is therefore used in areas where high adhesive properties are required. It is therefore useful in the paper and textile industries. The cassava starch is also used in glues. A very important industrial product that is made from cassava is ethyl alcohol (ethanol). Ethanol is used for fuel in automobiles in Brazil and Mexico.

The Composition of Cassava

Cassava has a high moisture content.

Content	Peeled tubers Total matter %	Dry tubers %
Moisture	66.2	33.8
Starch	27.2	81.5
Sucrose	1.0	3.0
Glucose	0.4	1.1
Fructose	0.3	0.8
Protein	0.4	1.3
Fats	0.2	0.4
Minerals	0.8	2.5
Dietary fibre	1.5	4.3

About 35mg of 100g (35mg/100g) of ascorbic acid is found in cassava and this level of ascorbic acid is significant considering the amount of cassava that an individual consumes. Unfortunately, a large proportion of the ascorbic acid is lost during the processing of cassava. The protein content is low (0.4%) and those who rely heavily on cassava are prone to kwashiokor. The main amino acid that are present in cassava are the *arginine, histidine, isoleucine, leucine* and *Lysine*. The sulphur containing amino acids that are present in cassava are deficient and in addition the cassava roots contain prussic acid. The level of the prussic acid is in the range of 10-490mg/kg of the fresh cassava tuber.

Toxicity and Detoxification

Cassava contains two major cyanogenic glucosides. These are:

(i) The linamarin

(ii) The lotaustraline

Both of these compounds can be hydrolysed to produce the hydrocyanic acid, which is also called HCN prussic acid. The HCN is poisonous especially when it comes in contact with the enzyme *Linamarase*. The enzyme *linamarase* is released when the cells of the root are ruptured.

The presence of the cyanogenic glucoside in most cassava cultivas necessitates a certain degree of detoxification of the cassava before it is consumed. The prussic acid is very lethal if more than about 0.1g of the prussic acid is contained in the food that is eaten at any one time. In general, three methods of detoxifications are employed.

(i) Microbial detoxification, through fermentation.
(ii) Decomposition of the glucosides especially by heating above 150°C.
(iii) Rupture of the cells to allow intimate interaction between *linamarase* and glycosides. There is then the volatilization of the resulting hydrolytic products.

It is important to note that all forms of cassava processing only decrease the level of the cyanogenic glycosides in the final product. In other words, it is difficult to produce a cassava product that is absolutely free of prussic acid.

Maize

Maize is also called corn. It plays an important role in the diets of millions of people. This is so for several reasons among which are:

(i) High capacity to produce a large amount of dry matter.
(ii) The ease of its cultivation
(iii) The versatile food mass and its usage
(iv) Its storage characteristics.

On account of these properties, maize is grown throughout the world. Most of the maize that is grown in the Western Hemisphere is fed to animals whereas in Asia, Africa and Latin America, a large proportion of the maize that is produced is for human consumption.

The three leading producers of maize are the U.S.A; China and India. There are various cultivars of maize that are produced in the world and the most important maize varieties are the flint corn, floury soft corn, dent corn and the pop corn. Other varieties of minor importance include the sweet corn, waxy corn and the starchy sweet corn.

The Use of Maize as Human Food

It has been estimated that bout 200 million people make use of maize as food and the maize comes in the form of thin round unleavened cake. They make use of maize in the form of porridge. In Africa South of the Sahara, porridge is the most wide spread form in which maize is consumed. In Western countries, maize is consumed usually as cornflakes. In West Africa, especially in Ghana, "*kenkey*" is very popular. There is also the maize porridge or the maize gruel. In East Africa the maize meal or maize dough is used for cakes and other foods. In Cameroon *Koga* is prepared by mixing ground maize, palm oil, salt and pepper. The mixture is rolled and it is steamed in plantain leaves. In Nigeria, maize could be boiled and eaten with or without coconut. Maize could also be roasted and eaten. In all of these cases, maize is usually consumed for its carbohydrate content. In many countries, alcoholic drinks could also be prepared from maize. In South Africa, a non-alcoholic drink that is called *MAHEWU* is prepared from maize. The maize starch is used as a thickening agent especially for soups. The maize starch is used as

a gel-forming agent especially in confectionery. It is also used as a moisture retention agent in cake icing. The oil from maize is very good. It is highly digestible and corn oil is a good source of the essential fatty acids.

Maize as Animal Feed

The bulk of maize that is produced in the industrialized countries are fed to livestock. In the U.S.A, between 75-90% of the maize that is produced is fed to livestock. Maize starch is produced from the wet milling and maize oil is also obtained. The residue then forms the basis for several animal feeds. These include the maize soluble also known as the steep liquor or condensed fermented maize extractives and:

(i) Pericap and other fibrous materials that may contain some of the un-recovered endosperm.

(ii) Gluten – the proteinous part of the endosperm

(iii) Germ residue – Remnants after oil refining

(iv) Mother liquor: It is obtained from the crystallization of dextrose

All these feed products are obtained during the distillation process. They are mainly mixtures of fibre, gluten, germ, unfermented endosperm and the yeast cells. The yeast cells are separated from the soluble. The maize gluten is traditionally fed to the ruminant animals whereas the condensed fermented maize extracts serve as growth factor for the chickens. The maize gluten meal is used to feed poultry because of its high xanthophyll content. The xanthophylls colour the egg yolk, the body fat, shank and the beak of the birds.

Maize as a source of food for human and animal consumption has some limitations. It is primarily an energy source with poor quality and quantities of protein. It is also relatively low in vitamin content. Pigs, the poultry, human beings require high qualities of protein, while on the other hand cattle, sheep and goat can utilize maize very profitably.

Composition of Maize

The composition of maize varies with the cultural practice types of seeds that are produced and it also depends on weather conditions.

Constituents	Composition (% dry weight)
Carbohydrate	80
Protein	10
Oil	4.5
Fibre	3.5
Minerals	2.0

On account of the high carbohydrate content, maize is regarded as a starchy product. The protein of maize contain Albumin (7% of the total protein), Globulin (10% of the total protein), Zein (39% of the total protein) and Glutelin (35% of the total protein). The albumin, glubulin and glutelin are the major proteins that are present in germ while zein and other glutelins are concealed in the endosperm. The protein of maize are deficient in both glycine and tryptophan. Starch is predominant in maize and the ratio of amylose to amylopectin is 27.73. In other words, there is a large proportion of amylopectin that is present in maize.

Maize Oil

The maize oil varies considerably in its physical and chemical properties. The variation depends on the method of cultivation and the genetic background of the maize kernel. The oil also varies with the method of recovery and also with the method of estimation. Maize oil like other vegetable oils has a variable composition. It melts within a certain temperature range and the melting point is dependent on the crystal structure of the glycosides. The crude oil contains up to 3% of the free fatty acid. The level of the free fatty acid depends on the level of refining to which the maize oil has been subjected.

Free Fatty Acid of the Maize Oil

Myristic acid	0.5%
Palmitic acid	9.7%
Stearic acid	3.6%
Hexadecanoic acid	0.2%
Oleic acid	30.4%
Linoleic acid	55.6%

The bulk of the unsaponifiable matter of the maize oil and fats consist essentially of sterines. The sterines are in the form of free fatty acids. They are esterified with fatty acids and they exist as glycolipids. The sterine content of the crude maize oil is in the range of 0.58 and 1.0%.

The Cornflakes

Cornflakes are hydrothermally treated maize products with worldwide popularity. They are high in nutrient content and they also combine these high nutrient values with low caloric content. They are highly digestible. In its manufacture of flaking is undertaken. Flaking is a process that consists of cooking fragments of the cereal kernel grit to a mass with a certain consistency. The mass is then pressed after cooking. The rollers that are used then form the flakes and there is the roasting of the flakes at an appropriate temperature.

The Flow Chart for the Production of Cornflakes

Maize grit → Cleaning → Cooking → Drying → Tempering → Flaking → Roasting → Cooling → Cornflakes.

Cornflakes are produced exclusively from grit. Grits are obtained from the endosperm of the maize kernel. Grits are cooked for 2-2$^1/_2$ hours at a temperature of 120°C. The mass that results are then mixed with corn syrup, sugar, salt and some vitamins. The grits are then passed into a drier in which pre heated air is blown to reduce the moisture content to about 15%. The grits are then held in the tempering tanks for a period of 6-8 hours. The tempering is undertaken to permit the residual moisture to become equally distributed. The equal distribution of the moisture is important to ensure uniform toughness for the flaking process.

The tempered grits are then pressed into flakes. In the process of flaking, the rollers that revolve at a speed of 180-200 revolution per minute are cooled by the internal circulation of water. The cooling prevents the flakes from sticking to the rollers. The flakes from the rollers are passed on to the toasting oven for a period of 3-5 minutes at a temperature that varies between 200 –250°C. The flakes then emerge with less than 3% moisture content, after which they are cooled to room temperature before they are packed for distribution.

During the process of converting grits into cornflakes there are 3 important steps that occur.

(i) The starch granules are ruptured by the application of heat. The starch forms a gel of soluble starch dextrin.

(ii) Two major reactions occur viz. (a) the particles undergo a browning reaction. This browning reaction is due to the interaction of protein and sugars.

(iii) The dextronization and caramelisation of sugars occur as a result of the high temperature in the oven. The flakes become crisp as a result of the reduction of its moisture content.

Generally, a 100g of Cornflakes contain approximately 7.5g of protein, 0.7g of fat and 85g of carbohydrate. The bulk density of Cornflakes is about 120-140g/litre.

Summary

This lectured has discussed the composition and classification and structure of Nigerian and West African foods like yam, maize and cassava.

Post – Test

What are the similarities and differences in the composition of the following food items:

(i) Yam

(ii) Cassava and (iii) Maize

Answers to Post Test

The all have high carbohydrate content. However, maize is high in protein and oil but low in moisture while yam and cassava are very low in protein and fat but high in moisture.

WORK SHEET

Instruction: *Use this work sheet to supply answers to the post-test questions at the end of this chapter. It should also be used to answer any assignment (practical or theory) given by your lecturer. You may use extra sheet(s) where necessary.*

Name:..... Matric no:.....

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Lecture Five

Contamination of Foods from Natural Sources

Introduction

Viable microorganisms could be found in all possible milieu. They are actively involved in the natural processes of recycling carbon, nitrogen and sulphur. Surfaces of all parts of plants and animals and the gastrointestinal tracts of animals are inundated with bacteria, yeast and moulds. Animals also give off microbes in their various excretions. However, the healthy inner tissues of these plants and animals are relatively sterile since they contain very few or no living microbes.

Most of the natural microorganisms on the surface of raw ingredients used in food preparation as well as contaminations from various other sources may be inactive or harmless. More importantly however, there are present some microorganisms which serve as agents for food spoilage, food poisoning and infections.

Objectives

At the end of this lecture, students should be able to identify and discuss:

Contaminations arising from the air, water, soil, plants and their fruits, animals, sewage and food processors and vendors.

Pre-Test

1. List and expatiate on the various sources of food microbial contaminants.
2. How would you purify air and water?
3. Of what importance is the Presumptive Coliform Test?
4. How does the internal flesh of an animal get contaminated?

CONTENT

Sources of Contamination

Air

The air by itself does not contain any natural microorganism of its own, neither does it support their growth and multiplication. But microbes are blown into and dispersed by air on suspended solids like dust and lint, as droplets when we cough or sneeze, in sprays from water falls, streams, lakes or ocean, as dusts from powdery foods and feeds to name a few.

Types of micro-organisms present in the air are therefore characteristic of the environmental source or location and their number would vary subject to rate of air movement, humidity, chemical activity of gaseous oxygen, intensity of radiant energy, microbial quality of suspended dust and spray or falling rain.

Microorganisms which do not require much water live longest in the air. Mould spores present dominance in air because they are small in size with light weight, a large number of spores are formed and scattered at a time, they are not readily damaged by desication and radiant energy. They also do not readily sediment in humid air as they are not readily wetted. Molds that are important in food spoilage include mucor, *aspergillus* and *penicillium.*

Bacteria are dispersed on dust particles or on moisture droplets or by skin flakes continuously being shed by animals including man. Spores of bacteria are not found in dust free air. Gram-positive cocci and rod shaped vegetative cells are more numerous than gram-negative bacteria which die rapidly in air. Most encountered species are *micrococci, corynebacterium, bacillus* and *streptomyces.*

Methods for Purifying Air

(a) Filteration with cotton wool, fibre glass, asbestos or activated carbon.

(b) Washing by rain or snow.

(c) Sterilization with ultraviolet rays of the sun and use of ultraviolet lamps

(d) Sedimentation

(e) Bubble gas through some chemical solutions or spray aerosols such as *triethylene* and *propylene glycols*, *formaldehyde* or *hypochlorites*

(f) Electrostatic precipitation of dust particles and microbes.

Water

In addition to normal microorganisms associated with water in streams, rivers, lakes, lagoon and oceans, these bodies of water may be further contaminated from the soil, by animal and human activities and from sewage and other waste products. These organisms may be drunk with water or picked up by fishes and shellfish which when eaten cause diseases like typhoid fever, cholera, and hepatitis in man. The most

encountered species of microbes are *Pseudomonas*, *Chromobacterium*, *Escherichia coli* (*choliform group*), *Aerobacter* and *Streptococcus*.

Water to be used for drinking and to process foods must meet the following criteria:

(a) Freedom from sewage contamination

(b) Acceptable taste, odor, colour, clarity, chemical properties and bacteria count

(c) Availability in sufficient volume and uniform composition

The extent to which water is contaminated by sewage and other food wastes containing organic water is measured by its Biochemical or Biological Oxygen Demand (BOD). This is the quantity of oxygen needed by aerobic microorganisms and reducing compounds to oxidize the organic compounds present at a given time and temperature usually 5 days at 20C.

The presence of sewage contamination is tested for by the presumptive test for the *coliform bacteria E. coli.* It gives an indication of the possible presence of intestinal pathogens.

Water can be Purified By

(a) Filteration through sand and filters as in municipal water works or naturally through layers of soil as in ground water or bore holes

(b) Natural sedimentation in reservoirs and lakes or artificially following flocculation with chemicals like alum and lime.

(c) Chlorination with liquid chlorine or calcium and sodium hypochlorites

(d) Natural ultraviolet irradiation from the sun or from U.V. lamps as in pure water sterilization

(e) Heating as in boiling of water.

Soil

The soil contains the most diverse types of microorganisms. It provides strains used for industrial production of amino acids, vitamins, enzymes, antibiotics and various other pharmaceuticals. Soil microbes are also involved in carbon, nitrogen and sulphur recycling which are important in plant growth and by the same principles accelerate food spoilage. Most important species of microbes are present in the soil. The soil is itself further contaminated with microbes from faeces of animals, urine, decayed dead animals and plants and sewage used as fertilizers. Often encountered are strains of *Bacillus*, *Clostridium*, *Pseudomonas* and *Corynebacterium*, *Alcaligenes* and *Escherichia*. Soil microbes contaminate the surfaces of animals and plants that come in contact with the soil. Soil dust is raised by strong air currents, passing vehicles, matching students and soldiers or carried after rain on to running

water and then on to foods e.g. *Lafun* and *elubo* spread to dry by the way side or slightly muddy water used to wash vegetables, fruits, meat and poultry.

Most of the microbes are washed off the surfaces of foods during post harvest handling and processing.

Foods of Plant Origin

A variety of microbes are found on the surfaces of plants and their products arising from contamination from the soil on which they grow, wash down effects of the rain and inadvertent contamination from burst sewage pipes, urine from man and his livestock and the like. Plant products like contaminated flour, spices and the like cross contaminate other foods with which they are mixed.

The type and number of microbes present vary with the type of plant or fruit and the ability of the microbes to stick to their surfaces. Most encountered species are *Corynebacterium*, *Pseudomonas*, *Alcaligenes*, *Flavobacterium Achromobacterium*, *Bacillus* and *Coliforms.* Also important are the lactic acid bacteria including *Lactobacillus brevis* and *L. plantarium*, *Leuconostock messenteroides*, *Streptococcus faecium* and *S. feacalis* and molds like *Aspergillus.* These are responsible for spoilage of fruits, vegetables, cereals, oilseeds, root crops and others.

Animals

The internal flesh of animals are relatively very sterile. However, the exterior including the skins, hides, hoofs, hair, feather and feet of poultry, carry typical flora associated with the beddings, manure, feed, water and air in the vicinity. The nose and throat of animals carry microbes which though normally harmless occasionally cause disease under stressful conditions. Some of these microbes are important spoilage organisms or may be pathogenic causing diseases. The gastro-intestinal tract of animals including man, through fecal wastes contaminate foods with such pathogen as *Salmonella, Enterobacteriaceae* and the *protozoan.* Other species are the coliforms, the lactics or lactic acid forming bateria, the *propionics, Bacilli* and *Clostridia* among others.

Sewage

Sewage arises from domestic activities (night soil) or as industrial waste products from food processing factories. It may be discharged into lagoons and streams from which contaminated water may be taken to wash fruits, vegetables, meat etc. as can be seen in some slaughter slabs and markets. Man and his animals defeacate on crop lands and burst sewage pipes which often serve as source of microbial contamination of crops growing in the vicinity. Raw foods so contaminated may be infected with human pathogens especially those causing gastro intestinal disorders.

The most encountered species of microbes are *coliform* bacteria, *salmonella, enterococci* and other intestinal bacteria. Diseases, caused by sewage contamination of water and foods include typhoid, cholera, diarrheoa, dysentery and *hepatitis.*

Natural water contaminated with sewage will affect shell fishes like crabs, lobsters, shrimps and oysters, fish and other sea foods. Sewage supports growth of *phytoplanktons* on which *zooplanktons* depend. Both serve as feed to aquatic organisms. Some of these planktons when eaten by some shellfishes render them highly toxic with shell-fish poison causing paralysis of the extremities and ultimate death by respiratory failure. The extent of sewage contamination of foods and water can be determined by estimating the Biochemical Oxygen Demand (BOD) and the presumptive coliform test.

Food Handlers and Processors

Food contamination can take place before food is harvested, during handling and processing, from various equipments coming in contact with foods, from packaging materials, from personnel and caterers with low personal hygiene in restaurants, institutions, religious and other civic camps.

Microbes most associated with food handlers are *staphylococcus, salmonella,* and *shigella.* The preventive measure is to avoid contamination from infected food handlers or carriers, personnel with respiratory diseases, gastro-intestinal problems or boil. Hands, equipments and utensils should be properly washed and scrubbed with germicidal detergents and personal hygiene of workers should be paramount.

Summary

In this lecture, we have discussed the various ways a food substance may become contaminated. We also mentioned some of the microbes that may be so transmitted. Since these microbes are ever present around us, the students may wish to identify other examples of microbial contamination occurring daily around them.

Post-Test

1. Why is the air usually inundated with mould spores?
2. What are the properties of safe drinkable water?
3. How do animals contaminate foods?
4. Which diseases are associated with sewage contamination of foods?

Answers to Post-Test

1. Small in size
   Light weight
   Not easily wetted

Resistant to desiccation
Not easily destroyed by radiant energy
Large number of spores formed
Spores easily scattered by wind

2. Free of sewage contamination
Available in sufficient volume
Of uniform composition
Acceptable taste, odour, colour
Acceptable chemical properties
Low bacterial count.

3. Through their:
Hides and skin
Hoofs and hair
Feather and feet of poultry
Beddings and litter
Nose and throat
Feed, water and air

4. Typhoid,
Cholera,
Dysentery
Diarrhea
Hepatitis.

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Frazier, W. C. (1977). *Food Microbiology*. New York: McGraw-Hill Books Co.

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WORK SHEET

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Lecture Six

Deterioration and Spoilage of Foods

Introduction

All foods are perishable to various degrees. Based on ease of spoilage, a food is said to be perishable, semi perishable or stable. Deterioration of food begins almost as soon after a crop is harvested, milk and eggs are collected or an animal is slaughtered. It continues to downgrade the aesthetic, nutritive and quality values of the food until the food reaches the table. A food is assumed to be properly spoilt when such food is no longer fit for human consumption. Spoilage of food can result from activities of bacteria, yeast and moulds, insects, enzymes naturally present in foods (autolysis) and purely chemical reactions. However, of most concern is spoilage arising from bacteria, yeast and mold activities. This would be the subject of this lecture.

Objectives

At the end of this lecture, students should be able to:

1. Explain the characteristic growth curve for microbes.
2. Identify the application of the growth curve to the food preservation processes.
3. Appreciate those factors which enhance microbial growth.
4. Describe spoilage symptoms in specific classes of food.

Pre-Test

1. What do you understand by the microbial growth curve?
2. Define generation interval.
3. List and explain the factors which enhance growth and multiplication of microbes.
4. Define water activity.
5. How do foods get spoilt by microbes?
6. What are spoilage indicators in different foods?

CONTENT

Microorganisms are naturally present on food surfaces even though the undisturbed interior may be sterile. They are also present in air, around the raw foods, the soil on which they were grown or fall on during harvesting, the water used to wash the food, on the hands and utensils used in handling and processing the food. These microorganisms' bacterial, yeast and mould invariably cause food spoilage unless something is done to stop or slow down their activities in foods through food processing and preservation.

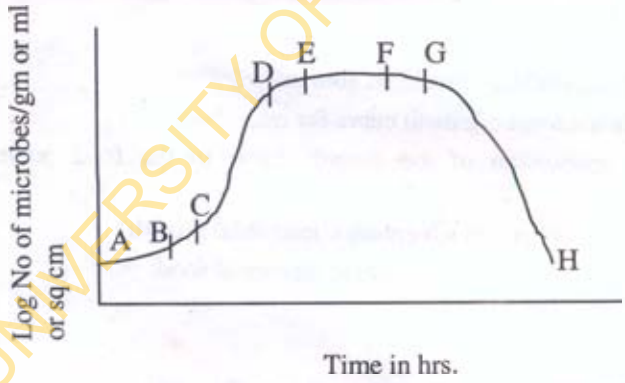
To understand food spoilage, we must first understand the growth characteristics of microbes.

The Microbial Growth Curve

Microbes are present in foods as vegetative cells or spores. To grow, the spores must first germinate into vegetative form. A single vegetative cell divides first into two. Each daughter cell again divides into two making four daughter cells. The process continues until millions of daughter cells are formed.

If we plot the log of the total number of cells formed against the time taken to form them, a logarithmic growth curve similar to Figure I is obtained. The curve shows the various phases of growth in the microbial population.

Fig. I THE MICROBIAL GROWTH CURVE



A-B	Lag phase
B-C	Positive acceleration phase
C-D	Log pr exponential phase
D-E	Negative acceleration phase
E-F	Maximal stationery phase
F-G	Accelerated death phase
G-H	Death phase

Lag Phase: No apparent growth. Microbe adjusts to its new environment and repairs earlier injuries

Positive Acceleration Phase: Increase in number through cell division at increasing rate

Exponential or Logarithmic Phase: very rapid but constant increase in growth rate. Microbes fully adjusted to abundant supply of nutrients.

Negative Acceleration Phase: Number continues to increase at decreasing rate as available nutrients start to decline and toxic waste starts to accumulate.

Maximal Stationary Phase: Rate of cell division equals rate of cell death i.e. births rate equals death rate.

Accelerated Death Phase: More cells die rapidly as the environment becomes very hostile.

Death Phase: Cell numbers reduce to very low level.

Generation or Doubling Interval

This is the time taken for one newly formed cell to divide into two new daughter cells. It is shortest during the log phase and longest during the lag phase.

Application to Food Preservation Processes

In food preservation, it is desirable to lengthen the lag phase and the positive acceleration phase. We can do this by:

(i) Keeping initial load of microbes as low as possible,

(ii) Avoid contamination or recontamination with microbes in their log phase by personnel, unclean equipments, containers and utensils and by introducing.

(iii) Introduction of hurdles of one or more unfavourable environmental conditions e.g. low moisture, low temperature, acid pH, use of inhibitors.

(iv) Causing physical damage to microbes with heat or irradiation or pressure.

Factors which Affect Microbial Growth in Foods

a. **pH:** Most microbes grow well at neutral pH and few grow below pH of 4. Moulds survive and grow at pH of 2 to 8.5 but more in the acid range. Yeast grows best at pH 4 to 4.5. Bacteria grow best at neutral pH although some are favoured by acid or alkaline pH.

Each microbe has a minimum and a maximum pH at which they grow. There is a succession of different species of microbes as pH changes.

b. ***Temperature:*** Microbes grow well and cause food spoilage over a large range of temperature (-5C to 70C). Each microbe also has its own specific minimum, optimum and maximum growth temperature. Psychrophiles grow *best at 0 to 10C, mesophiles at 20 to 45C and thermophiles at above 45C.*

c. ***Moisture Content:*** Microbes require various amounts of available moisture in the food for growth. Such water is defined in terms of water activity, a_w or the ratio of water vapour pressure of food substrate (P) to the vapour pressure of water (P_o) at the same temperature.

Water Activity $a_w = P/P_o$

It is related to Relative Humidity as follows:

$RH = 100 \times a_w$.

Table 1 Shows the Minimum a_w for Microbial Growth

Table I: Minimum a_w for Microbial Growth in Foods

Microbial Group	Minimum a_w
Most gram negative bacteria	0.97
Most gram positive bacteria	0.90
Most yeast	0.88
Most filamentous fungi	0.80
Xalophilic bacteria	0.75
Xerophilic bacteria	0.61

Fresh vegetables, meat, fish and milk with high a_w are more likely to be spoilt by bacteria than bread and other bakery products with low a_w.

d. ***Relative Humidity*** relates to the amount of water vapour in the environment. It affects growth of microbes on the food surface. With high relative humidity, a dry food absorbs moisture from the air while at low relative humidity, a moist food loses water. This vapour exchange modifies the water activity of the food.

e. ***Nutrients*** Microbes require water, sources of energy and protein, vitamins and other growth factors as well as minerals in forms that may sometimes be specific for the microbes.

f. ***Oxidation – Reduction Potential:*** Some microbes grow in the presence of oxygen (aerobes), in its absence (anaerobes), or under both conditions (facultative microbes). Moulds are aerobic, most yeasts grow aerobically while different species of bacteria grow under the three conditions.

Spoilage Effect of Microbes in Foods

Foods contain complex organic compounds as carbohydrates, proteins, and lipids. These are digested by various microbial enzymes to simpler chemical products. The undesirable products are manifested as food spoilage and may include toxins which cause food poisoning and objectionable taste, odour, colour or texture in the food.

Some end products may however be desirable as are observed in industrial food fermentation as part of food preservation processes.

Putrifaction involving terrible odour occurs when protein, peptides or amino acids are broken down anaerobically in high protein foods. Carbohydrates are decomposed to simple sugars and to CO_2 and water by aerobes.

Anaerobically, various types of fermentation can occur with formation of alcohols like ethanol, butanol and propanol, acids like acetic, lactic, butyric and propionic acids and gases like carbon dioxide and hydrogen which cause swelling in spoilt canned foods. Lipids are broken down to various fatty acids and glycerol which may all be subject to rancidity.

Examples of Microbial Spoilage in Foods

Meats: Bacterial greening and iridescence, taints, souring, putrifaction and other off odour and taste, surface sliminess, rancidity, stickiness, gassy or bloated cans and vacuum packages.

Fish: Fishy and other off odours, green or grayish gills, soft flesh, dull sunken eyes, sliminess.

Eggs: Fungal whiskers, blue green and black mould spots in egg white, black, white, green or pink bacterial rot.

Milk: Souring, gas (H_2 + CO_2) formation, curdling and coagulation, ropiness, swelling of canned milk, various flavour defects, discolouration.

Cereals: Souring, moldiness with red, white, green black or yellow colouration, ropiness.

Vegetables and Fruits: various types of rots by bacteria, yeast and mould, undesirable colour, odour, watery or soft texture, mildew, sliminess, shriveling, mushiness, ropiness, souring.

Fruit Juices: Cloudiness, ropiness, sour, acid or bitter taste, foul smell, gassy or swollen cans, yeasty flavour and odour.

Summary

In this lecture, you were introduced to the concepts of microbial growth curve and the generation or doubling interval. Factors, which affect microbial growth in foods, were discussed. Indicators of spoilage in some classes of foods were also given.

Post Test

1. Define generation interval; when is it the longest?
2. What factors are important for the growth of microbes?
3. Do all foods spoil at the same rate?

Answer to Post Test

1. The time taken for a newly formed cell to divide into two new daughter cells.

   It is longest during the lag phase.
2. pH

   Temperature

   Moisture content

   Relative humidity

   Nutrient

   Oxidation – Reduction Potential
3. All foods do not spoil at the same rate. Their chemical compositions defer and therefore their ability to support the activities of microbes defer as different spoilage organisms require different optimal factors for growth, multiplication or toxin development.

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Lecture Seven

Principles of Food Processing and Preservation (Part I)

Introduction

In the second lecture, foods and their various functions were discussed. In this lecture and the next, the basic principles employed in the processing and preservation of foods will be expatiated. This is important because a large part of the food which are actually harvested do not get to the consumers' table because of physical abuse as well as chemical and microbiological spoilage. Chemical spoilage arises from continued physiological activities in the raw food in the presence of endoenzymes or presence of toxic chemical constituents. Microbiological spoilage is the result of activities of bacteria, yeast and mold, some viruses and parasites.

Objectives

At the end of this lecture, students are expected to be able:

1. To identify the various food preservation methods
2. To introduce the idea of *barriers* or *hurdles* and the principles governing them.
3. To have an understanding of the roles of asepsis, removal of micro-organisms, anaerobic conditions, heat and low temperatures in food preservation.

Pre-Test

1. List the various methods used in preserving foods
2. What principles are involved in the preservation processes?
3. Discuss some of the various preservation methods listed.

CONTENT

Food Preservation Methods

These include the following:

(i) Asepsis
(ii) Removal of micro organisms
(iii) Maintenance of anaerobic conditions
(iv) Preservation by heat
(v) Use of low temperature
(vi) Drying
(vii) Use of chemical preservatives
(viii) Irradiation
(ix) Mechanical destruction of micro-organisms
(x) Combination of two or more of above methods.

Principles Involved in the Preservation Processes

The primary objective of preservation processes is to create one or more barriers or hurdles, which are inimical to the activities of microbes or endoenzymes present in the food. These hurdles are governed by the following basic principles.

1. **Prevention or Delay of Microbial Spoilage**
   - **(a)** By keeping out micro-organisms as in asepsis
   - **(b)** By removal of micro-organisms as in filtration
   - **(c)** By hindering the growth and activity of micro-organisms as with low temperature, drying, anaerobic conditions and chemicals
   - **(d)** By killing the micro-organisms.
2. **Prevention or Delay of Autolysis or Self Decomposition of Foods**
   - **(a)** By destruction or inactivation of food enzymes as by blanching
   - **(b)** By prevention or delay of purely chemical reactions as in the use of antioxidants to prevent oxidation.
3. **Prevention of Damages by Insects, Animals and Chemicals**

   Most often, methods used in controlling micro-organisms are sufficient for destroying or delaying enzymatic activities. In some however, auto-oxidation or chemical deterioration may continue if proper precaution is not taken.

Preservation by Asepsis

- **(a)** Under normal conditions the surfaces of most raw food materials are heavily contaminated from natural sources.

(b) Such raw foods possess natural barriers e.g. skin of fruits and vegetables, shell of eggs, hide or skins of animals, which through various mechanisms prevent these microbes from reaching the internal tissues. These therefore remain fairly sterile unless these natural barriers are damaged.

(c) This natural prevention of contamination of the interior of raw food is a form of asepsis

(d) The same goal is achieved when a food that has been previously pasteurized or sterilized is dispensed into a sterilized container like cans or pouches among others and sealed under conditions that prevent microbial recontamination.

(e) Aseptic packaging has wide application with fluids like milk, fruit juices, beer and homogenous soups which can undergo High Temperature Short Time continuous pasteurization

(f) Some advantages are that natural flavor of such foods are retained. Glass or metal containers can be replaced with flexible multi-layered packaging which are cheaper. However, it may not completely prevent diffusion of oxygen through the packaging material

(g) Aseptically packaged fruit juices retain its quality for more than 6 months at room temperature.

Removal of Microorganisms

We most often wash our raw foods like fruits and vegetables with clean water before eating and meat also before cooking. We also peel the skin, or remove spoilt portions of tubers and other foods followed by washing prior to cooking as a way of removing microbial contamination from natural sources. In the food industry, filtration through special filters helps in removing microorganisms from fermented beer and wine. Flocculation, filtration and sedimentation are integral processes in purification of water.

Anaerobic Conditions

Maintenance of anaerobic condition is a must in many packaged foods such as those metal or glass cans, plastic and composite pouches and others. Anaerobic condition is achieved by completely filling the container prior to sealing it aseptically either by sealing it under vacuum (vacuum packaging) or replacing the air in the container with nitrogen gas or carbon dioxide. Anaerobic condition ensures that micro-organisms, which survive processing in foods, cannot germinate or grow in the absence of oxygen even though moisture is present.

Preservation by Heat

Preservation by heat includes all methods that utilize temperatures higher than the ambience for food preservation. Microorganisms in foods are destroyed through the coagulation of their proteins. Enzymes in foods are similarly inactivated thereby preventing further metabolism from proceeding in the food. Different foods require different heat treatments depending on the characteristic nature of the food. The kind of organism present in the food whatever its state whether in spore or vegetative form and the environment during heating are also of important consideration. Spores or vegetative cells may be killed in part or almost completely at a given temperature as they differ in their resistance to heat treatment. Some have low resistance to heat and are killed rapidly as temperature begins to rise. Most have medium resistance while a small number will grow at temperatures that are destructive to most bacteria.

Heat loving bacteria are called thermophilic bacteria or thermophiles. They survive and grow within a minimum temperature of 45C and maximum temperature of 70C but are at their best between 50 and 60C. If they can survive but will not grow at high temperatures, they are said to be thermoduric.

Heat Treatment Methods

1. Pasteurization

(a) This is a preservation method that kills part but not all the micro-organisms that are present in food.

(b) The temperature achieved during pasteurization is 60-80C.

(c) The source of heat is by steam, hot water, dry heat or through electrical energy.

(d) Pasteurized foods must be cooled rapidly thereafter.

(e) Pasteurization is applied mostly to fluid foods especially milk.

A food is pasteurized

(a) When a more rigorous heat treatment would be harmful to the product quality such as destruction of vitamins and other valuable nutrients or affect the flavor.

(b) When spoilage organisms are not heat resistant.

(c) To eliminate all pathogenic bacteria, yeast and moulds including all vegetative cells as in milk, beer and fruit juices.

(d) To kill competing microbes leaving behind desirable ones as with starter cultures in cheese manufacture.

(e) When surviving spoilage organisms will be subjected to additional preservative method like chilling of milk.

Pasteurization methods

(a) High Temperature Short Time (HTST) methods: milk is heated as follows

72C for 15 sec

89C for 1.0 sec

94C for 0.1sec

or 100C for 0.01 sec.

(b) Low Temperature Long Time (LTLT) methods: milk is heated at 63C for 30 min.

2. Sterilization

(a) Food is heated to temperature above 100C using steam under pressure or live steam in steam – pressure sterilizers or retorts.

(b) Temperature increases from 100C at atmospheric pressure to 121.5C at 1.01kg/sqcm steam pressure

(c) The few surviving organisms are non-pathogenic and cannot develop within the product at normal condition of storage

(d) Products have long shelf life and are room stable.

3. Canning

(a) Process developed initially by Nicolas Appert in France in 1810. This is the preservation of foods in sealed containers.

(b) Process carried out in tin cans or tin coated steel, glass and aluminum containers, plastic pouches and other composite materials.

(c) Tin coated steel containers may be lined internally with enamel specific to milk, meat, beer, fruit juices, etc to slow down discolouration of food or corrosion.

(d) Complete sterilization is desired but not always possible

(e) Eliminates all pathogenic and spoilage bacteria but surviving bacteria are harmless and do not grow at normal storage temperature

(f) Such cans are commercially sterile, practically sterile or bacterially inactive.

(g) Temperature required is less in high acid foods than in low or neutral foods. Foods liable to damage at high temperature may be acidified and heated at lower temperature.

(h) Some fluid foods may be sterilized in bulk, filled into sterilized containers with sterilized lids and sealed aseptically.

(i) Cans can be heated in retorts by direct gas flame or with live steam, by heating in fluidized bed of granular solids or with hydrostatic sterilizer.

(j) Cans must be cooled rapidly inside the retort or by immersion in or by spraying with cold water.

4. Blanching or Scalding

(a) Blanching is a low heat pre-treatment of foods by immersion in hot water or use of steam followed by other preservation methods.

(b) Initial vegetative microbial loads on foods may be reduced by as much as 99%.

(c) It inactivates endoenzymes which otherwise would cause autolysis and other undesirable changes in foods during subsequent storage. For this reason yam for example is blanched before drying in the production of yam flour and vegetables too before storage in the freezer.

(d) It sets, fixes or enhances the green colour of some vegetables like waterleaf, greens and amaranthus.

(e) It softens the tissue by wilting thereby enhancing packaging of leafy vegetables

(f) It expels entrapped air from plant tissue thus enhancing vacuum formation during packaging.

Preservation at Low Temperatures

Low temperatures are used to keep foods in fairly fresh state as natural chemical reactions in the food are reduced. Also the activities of natural enzymes, the so called endoenzymes, are retarded and growth and multiplication of bacteria, yeast and moulds are partially or wholly inhibited. **Chilling temperatures** are from **refrigerator temperatures** to slightly below room or ambient temperatures i.e. 5C to 15C. We keep vegetables and fruits like greens, okro, oranges at these temperatures for a limited time to keep their freshness. Refrigerator temperatures are anything from 0C to 7C but usually 4C. This temperature range is good for most fresh foods. Examples are the various dairy products, fresh meat, and poultry, eggs and cooked foods like stew, rice and bean. **Freezer temperature** is usually at –18C and below and helps to preserve food for a very long time depending on the food.

Effectiveness of low temperature preservation increases as the temperature decreases because chemical, enzymatic and microbial activities are temperature dependent. Most foods contain a variety of microorganisms, which can cause food spoilage under favourable growth conditions. Each of these microbes grow well within a specific temperature range but dies off rapidly as the prevailing temperature increases or decreases. There is therefore a measure of succession in the growth and death pattern of the various microbes present in the food. Thus the predominating

microbe at any particular time would under normal conditions be typical of the prevailing temperature.

Since warm temperatures (20-45C) favour the growth of most mesophilic bacteria, a large number of them are destroyed as the cooling temperature falls. Those bacteria that thrive well between 0C and 10C are referred to as psychrophilic (cryophilic) bacteria. At 0C, very few organisms can grow and multiplication is extremely slow. However, certain bacteria, yeast and mould can grow at temperatures well below freezing.

In the following section, we would discuss in a little more detail the characteristics of the temperature regimes employed in preservation of foods at low temperatures.

Cellar or Airy Room Storage

In the developing countries, most people have no access to natural cold of autumn or winter nor to mechanical refrigeration. Sometimes however, temperatures of between 15C and slightly above are to be found in cellars, house basements, airy corners in some rooms or even in some airy wooded shades. Root crops like yam, cocoyam, potato, various fruits and vegetables, eggs and meat carcasses and some other foods can be temporarily stored. Spoilage by natural enzymes or microorganisms on the food is not prevented but occurs more slowly than at room temperature.

Chilling and Refrigerated Storage

Chilling storage at 5 to 15C is achieved by covering the food with a generous amount of ice chips as with poultry and fish in an icebox for a limited period only. Refrigerated storage at 0 to 7C is mechanical in nature and cooling is achieved by controlled vaporization of refrigerant liquids like liquid ammonia, freon.

The home refrigerator is the most common for refrigerated storage. However, cold rooms of various sizes are industrially used in holding fish and other seafood, meat, vegetables and dairy products. Large supermarkets also use refrigerated display cases for various foods. Storage periods vary from a few days to a few weeks. Therefore refrigeration is an important factor in maintaining an efficient cold chain in the food industry from the farm gate through processing to the table. Spoilage due to food enzymes and microorganisms are greatly reduced and a temperature of 5.6C or less is necessary to delay growth of psychrophiles and prevent growth of pathogens. Chilling elicits cold shock which causes injury and cell death in microbes. Similarly some foods are damaged by cold injury and tissue breakdown at chilling temperatures resulting in loss of quality and accelerated microbial deterioration e.g. pawpaw. Relative humidity is intimately controlled in large cold rooms.

Low humidity causes dehydration, weight loss, wilting and shrinkage in the stored product while high humidity favours rapid growth of bacteria yeast and mould. Where prolonged refrigerated storage is required, ultraviolet irradiation from UV lamps and other rays may be combined with chilling. The atmosphere or air in the cold room can also be modified by the presence of ozone or carbon dioxide.

Freezing Preservation

Deep freezing has made it possible for long term preservation of foods such that the food remains fresh, retains its nutrient completely and surfers no serious quality loss. Frozen chicken, turkey, meat and fish can be obtained easily in various towns and cities as with other similar products of the food industry. Mechanical refrigeration is expensive and mechanical freezing is more expensive.

Although freezing point of water is 0C, foods start to freeze at – 0.5 to 3C due to the solutes present in the cells. As more of the water in the food gets frozen, first outside the cells and then inside, the solute in the remaining water increases in concentration and the freezing point is continuously lowered. In a food that appears solidly frozen some water still remain unfrozen and may be the focal point for spoilage.

Under normal freezing storage, microbial growth is prevented entirely, food enzyme activities are greatly retarded but continues slowly and may cause spoilage. For this reason, we scald or blanch vegetables and pack aseptically before freezing.

Methods of Freezing

(a) **Sharp Freezing:** This uses a slow freezing process at the temperature range of –15C to 29C. The common home freeze temperature is at 18C and is used for most foods.

(b) **Quick-Freezing:** The freezing time is for 30 minutes or less. It is good for food packages of small sizes. Quick freezing can be achieved by three methods:

  (i) Direct immersion of food in refrigerant e.g. fish in very cold brine (solution of common salt) as in fish trawleys.

  (ii) Indirect contact with refrigerant. Here the refrigerant passes through passages within the flat platform on which the product is placed. The freezing temperature is at –18C to –46C.

  (iii) Air blast in which air at –18C to –34C is blown across the food product.

(c) **Freezing in Liquid Nitrogen:** Foods already packaged in aluminum containers are submerged in liquid nitrogen at –100C followed by ordinary freezing storage.

(d) **Dehydrofreezing:** Foods to be frozen are subjected to 50% reduction in moisture content prior to freezing.

Summary

In this lecture, we mentioned the various methods used in preserving foods. We also identified them as barriers or hurdles to destroy or prevent the growth and activities of microbes and endoenzymes naturally present in foods and which cause food spoilage. Some of these preservation methods were discussed in greater detail.

Post-Test

1. List the various methods used in food preservation.
2. Discuss the principles that govern the food preservation processes.
3. How and why do we pasteurize foods?
4. What is dehydrofreezing?

Answer to Post-Test

Please refer to the text above.

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Lecture Eight

Principles of Food Processing and Preservation (Part II)

Introduction

In continuation of our discussion on the basic principles employed in the processing and preservation of foods, the roles of dehydration, chemical preservatives, irradiation, and mechanical pressure including grinding and pressure by ultrasonic and supersonic sound waves will be highlighted.

Objectives

It is expected that at the end of this lecture, the students will be able to:

1. Discuss the various methods of preserving foods by drying.
2. Discuss the use of chemical preservatives.
3. Describe the types of radiation and their effects in food preservation
4. Describe the effect of mechanical pressure.

Pre-Test

1. What are the advantages of drying foods?
2. Discuss the various methods of drying foods
3. Differentiate between preservatives and additives
4. How does irradiation and mechanical pressure affect foods?

CONTENT

Preservation by Drying

Drying or dehydration is perhaps one of the oldest methods known for preserving foods. It is also one of the easiest and the cheapest.

Raw foods may be naturally dry at harvest or require further drying to prevent autolysis (activities of natural enzymes present in foods) or spoilage by microorganisms. Drying is good for seasonal foods like yam, and plantain, the excess of which can be preserved for use in the period of scarcity. Such foods may

be reduced in weight and size as with yam and cassava for yam and cassava flour. Dried foods may shrink and have dense texture as with kundi or kilishi or expand and have a porous structure as with bread and breakfast cereals. Dried products have low water activity(^{a}w) and are shelf stable for a long time. They are also easily packaged and transported over long distances. There may be extensive denaturation of proteins and case hardening

Methods for Drying Foods

Sundrying: It is the method primarily used for most foods in the tropics. Drying heat is harnessed from the radiant energy. The food materials are spread out during the day on trays, mat, tarpaulin, concrete or even on swept tarred road sides or hung on ropes in the breeze depending on the type of food. The food is turned periodically until properly dried. Heat transfer to the food surface and its interior is by radiation, conduction and convection from the sun, the heated container and the surrounding air. There is need to guard against food recontamination from the soil, insects vermin and the effects of the elements.

Various types of solar dryers have been developed in recent time, which have been used to dry banana chips, rice, maize and indeed many different foods.

Mechanical Drying

Foods are artificially dried in mechanical dryers in which the air drying temperature and relative humidity are controlled. Heat is generated by burning kerosene, liquefied natural or petroleum gas, wood chips, rice or maize hulls.

The following are examples of mechanical dryers.

(a) ***Kiln:*** Heated air from the bottom of the kiln rises through layers of perforated trays containing foods being dried

(i) ***Tunnel Drying:*** Forced heated air is passed over the food in a tunnel or the food in perforated trays on a conveyor belt is passed through warm air in the tunnel.

(b) ***Drum Drying or Roller Drying:*** Liquid or pasty foods are applied to the surface of rotating hot stainless steel drum and the dried food is removed with a scraper. It is applied in drying skinned milk and potato powder.

(c) ***Spray Drying:*** Liquid or semi liquid foods are sprayed from the top into a counter current of hot air and the atomised particles collected at the bottom e.g. milk and egg powder, cocoa products.

(d) ***Vacuum Drying:*** Water in foods are removed under vacuum with heat administered by convection or by radiation. The system is applicable to very delicate foods like fruit juices where 1-3% moisture content is required.

(e) ***Freeze-drying or Lyophilization:*** Water is sublimed off frozen foods (from solid ice state to vapour state) under low heat and vacuum as with meat, apple, and some seafood.

(f) ***Foam Mat Drying:*** The liquid food is whipped into a foam and dried in warm air. The dried foam is then crushed into a powdery form e.g. whole and defatted milk powder, egg white powder, meat powder, and coffee.

(g) ***Fluidized Bed Drying:*** Heated air under pressure is applied under a finely perforated plate on top of which are small particles of food to be dried. The heated air passing through the perforations at appropriate pressure continually lifts the food particles some distance before the particles fall down while heat exchanging is effected. The method has been used for drying various foods like potato granules and paddy rice.

(h) ***Tower Drying:*** This is applied to sensitive foods just like spray drying. The food is injected at the top of the tower into dehumidified air at 30C or lower e.g. puree from tomato, fish meat, etc.

(i) ***Osmotic Drying:*** Reusable strong osmotic syrups or liquids remove water by desorption from the food. Such liquids are honey, sucrose syrup, saturated brine and may be reconstituted by evaporation. The final products may require supplemental drying and do have flavour change.

The Use of Preservatives

Preservatives are chemical substances which when present in foods help to retard or completely arrest the growth of microorganisms in the food and prevent any other deteriorative changes. These changes can occur as a result of the activities of microorganisms enzymes naturally present in the food or by purely chemical reactions within the food. The preservatives may be added to the foods or may be developed in the foods by microorganisms.

Additives however, are substances used to assist in processing by favourably affecting the food texture, food colour, food flavour and nutritional quality but not necessarily preventing deteriorative changes.

Characteristics of Ideal Preservatives

(a) They are microbicidal (kills microbes) or microbistatic (arrests their growth) thus preventing food poisoning.

(b) They are harmless to consumers at the level they are added to foods

(c) They are not inactivated or rendered useless by the food.

(d) They carry out their preservative activities efficiently.

(e) They do not cover up any inferior characteristics of the food

(f) They do not add objectionable colour, odor or taste to the food

(g) They are not a replacement for good hygiene.

The importance of the safety aspect of these chemical preservatives limits the number that can be applied to foods. Therefore the term **GRAS** has been used to refer to those food preservatives and additives that are generally regarded as safe by qualified experts for their intended use in foods.

Some examples of food preservatives and their functions are listed below.

Organic Acids and their Salts

(a) ***Benzoic acid/Benzoate*** applied at 0.1% maximum is effective against yeast and moulds in bread and cake where it prevents ropiness, in carbohydrated fruit juices, margerine, jams and other acid foods.

(b) ***Parabens*** (methyl and Propyl parahydroxybenzoic acids) and their sodium and calcium salts applied at 0.1% max. are effective against bacteria, yeast and mould in jams, baked confectionery, beer, soft drinks, fruit drinks and beverages

(c) Sorbic acid/sorbates applied at 0.2% maximum inhibits moulds, and yeast and aerobic bacteria in cheese, baked foods, fresh poultry meat and fish and perishable fruits

(d) ***Propionic acid/Propionates*** applied at 0.32% maximum are fungistatic preventing ropiness in bread and baked goods like moinmoin, akara, cake.

(e) Others are lactic acid, acetic acid, citric acid, alcohols like ethanol propylene glycol and others.

Inorganic Acids and their Salts

(a) ***Sodium Nitrite/Nitrate*** applied at 0.12% maximum is effective against a wide range of spoilage and food poisoning bacteria especially C. botulinum. They are also employed in meat curing. On reduction to nitric oxide in meat, the nitric oxide reacts with meat pigment to produce the characteristic pink colour, nitrosyl haemochrome, of cooked cured meat.

(b) ***Sulphites:*** Generally included in this group of preservatives are sulphur dioxide gas, sulphurous acid and the sodium or potassium salts, of sulphite,

bisulphite and metabisulphite. They have application in the inhibition of enzymatic and non-enzymatic browning in foods like yam, potato, apple. They are protective against certain bacteria, yeast and mould in wine, maize and others.

(c) ***Sodium Chloride*** is used for its high osmotic effect, which has a drying action on both food and microbes when it is used at higher concentration than for seasoning foods. It is used in preserving fresh meat and fish.

(d) Others are chlorine and chlorine oxide gas, sodium hypochlorite, acetic and dehydroacetic acid, boric acid and borates, trisodium phosphate and other polyphosphates, silver ion, hydrogen peroxide, and gases such as carbon dioxide, nitrogen, ozone, ethylene and propylene oxides.

Sugars: These include glucose, sucrose and honey. They also, like NaCl, exert high osmotic and drying action on foods. They are widely used in jam, candies, and condensed milk.

Antibiotics: Some few antibiotics have been approved for use in some foods and in conjunction with heat treatment as in canning. Some few antibiotics have also been approved for use on fish, meat and poultry to increase shelf life at cold temperatures and in conjunction with head treatment in some canned foods. Examples are nicin for controlling spoilage of cheese by C. botulinum, natamycin against yeast and mold in fruit juices, subtilin against certain bacteria species.

Wood Smoke improves the flavour of certain foods like meat sausages, suya, and smoked fish. It exerts preservative action by the effective heat and drying action, which accompanies the smoking activity and the chemical constituents present in the smoke. Examples of these are formaldehyde and other aldehydes formic acid, alcohols, ketones, tar and cresoles among others.

Spices: Certain spices and condiments contain substances that are harmful to microbes. Examples of such are spices mustard, cinnamon, clove, garlic, onion and mace, rosemary, sage.

Antioxidants: These chemicals are used primarily to prevent rancidity in foods and to a lesser extent against microbes. Examples are butylated hydroxyanisole (BHA), butylated hydroxytolene (BHT), propyl gallate, the tocopherols. Certain antioxidants are naturally present in foods. Examples are eugenol in clove, tocopherols and carotene in carrot and tomatoes, quercetin in tea leaves and onion, chlorogenic acid in potatoes, guaiaretic acid in guaiacic gum and vitamins C and E.

Developed Preservatives are Products of

Preservation by Irradiation and Mechanical Pressure

Various forms of radiation have been employed in food processing with each type affecting food and the microorganisms present in various ways.

(a) ***Heating Radiations*** are applied using alternating electrical current at low frequencies as in the pasteurization of milk and fruit beverages and in the boiling of water.

(b) ***Microwave*** heating of foods is achieved in microwave electronic ovens. Intense excitation of water molecules present in the food causes high temperature in the food within seconds killing microbes and inactivating enzymes.

(c) ***Ionizing Radiations*** that are useful in food preservation include Beta rays, X rays and Gamma rays. They kill susceptible microorganisms by ionizing water present in the food to release free radicals, which are destructive to the organism and by causing lethal mutation in the microbes. Ionizing radiation has been used in conjunction with other preservative methods to extend the shelf life of certain meats, fish fruits and vegetables and to prevent sprouting in onions and yam.

(d) ***Ultraviolet Rays*** are non-ionizing and microbicidal causing deadly photochemical changes in the proteins and nucleic acid of a broad range of microbes especially at wavelengths of 2500 to 2800A. It is used to sterilize food packages, sanitize food processing equipments and in the treatment of water for beverages and 'pure water'.

Mechanical Pressure is achieved when air or fluid is subjected to very high pressure. Such high pressures inactivate enzymes and destroy completely or prevent the growth of microorganisms present. This principle is applied in preserving soft drink and fruit juices under CO_2 gas pressure and milk under oxygen pressure thereby extending the shelf life appreciably. Foods exposed to intense grinding action or ultrasonic and supersonic sound waves beyond the range of human audibility can also similarly have microbes present physically damaged or destroyed.

Summary

In the foregoing lecture, we looked at the application of drying or dehydration, preservatives, irradiation and mechanical pressure including grinding and sonication to the processing and preservation of foods. Examples of foods so preserved were mentioned. The students should also identify other foods, which have been preserved by these methods and others.

Post-Test Questions

1. Which drying methods are likely to be used for:
   (a) Potato puree
   (b) Egg White
   (c) Fruit juice
   (d) Meat and Fish
   (e) Cassava Puree
   (f) Coffee
2. What are the characteristics of ideal preservatives?
3. List the different sources of radiation.

Answers to Post-Test Questions

1(a) Roller drying, spray drying
(b) Spray drying, freeze drying, foam mat drying
   (i) Vacuum drying, spray drying, tower drying
   (ii) Kiln, tunnel drying, freeze drying, tower drying. Osmotic drying
   (iii) Sun drying, tunnel drying,
   (iv) Foam mat drying, freeze drying, vacuum drying.

2(a) They are microbicidal or microbistatic
(b) Harmless at prescribed level of administration
(c) Not rendered useless by the food
(d) Highly effective preservation
(e) Does not cover up poor quality in foods
(f) Does not impart objectionable colour, odour or taste to foods
(g) Not a replacement for good hygiene.

3(a) Heating radiations by direct or alternating electrical currents
(b) Microwave
(c) Ionizing radiations by beta rays, X rays and Gamma rays
(d) Ultraviolet rays.

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Lecture Nine

Food Poisoning and Its Prevention

Introduction

Several disturbances in the digestive system and elsewhere in the body have resulted through eating of unwholesome foods. Some of these are temporary as in allergic response to consumption of dairy products containing lactose – the so called lactose intolerance, or the consumption of some sea foods by some individuals.

Serious and sometimes lethal food poisoning and infections generally arise from the consumption of toxic chemicals; microbial toxins developed in foods prior to or after ingestion; growth and multiplication of certain microbes and parasites present in the foods at time of ingestion.

Objectives

An the end of this lecture, students should be able to:

1. Discuss some known causes of chemical poisoning
2. Identify some toxic factors in some poisonous plants and animals
3. Highlight the various casual agents of food poisoning and infection
4. Identify ways of preventing food poisoning and infection.

Pre-Test

1. Differentiate true poisoning from infection.
2. What are the possible causes of food poisoning?
3. What would predispose you to having food infections?
4. How would you prevent being a victim of food poisoning and infection?

CONTENT

Chemical Poisoning does occur when foods with residual fungicides, herbicides, insecticides and other chemicals are eaten. Gammalin used in catching fish, lead or arsenic residues from fruit sprays on fruit surfaces, sodium flouride, an anti cockroach agent accidentally added to food in place of baking powder, flour or dry

milk powder which it resembles are avenues for chemical poisoning. So also is the kerosene used in singeing hair off cattle, sheep and goat or the liquid detergent mistakenly added to food instead of oil. Certain alkaloids like strychnine and heavy chemicals including salts of cadmium, antimony, lead and mercury are similarly poisonous when taken orally.

Also included are, nitrites, nitrates and nitrosamines, veterinary drugs and antibiotic residues.

Poisonous Plants and Animals

Stomach upset and death can result from their consumption e.g. cyanide poisoning from certain cassava cultivars, muscarine from poisonoous varieties of mushroom and oxalic acid poisoning from certain cultivars of cocoyam. Paralytic shellfish poisoning or saxitoxin occurs when toxic oysters and some other sea foods are eaten e.g. shark meat.

True Poisoning occurs when food containing toxins produced by microbes present is consumed.

Bacterial Food Poisoning

(a) Botulism caused by toxin produced by germinating spores of Clostridium botulinum in vacuum packaged or canned meat, fish, vegetables and other foods

(b) Clostridium perfringens food poisoning caused by toxin produced by germinating spores of Clostridium perfringens in meat foods cooked one day and consumed next day

(c) Staphylococcal food poisoning caused by Staphylococcus aureus and other strains of Staphylococcus in foods of animal origin like ham, bacon.

(d) Other bacteria species that cause food poisoning: *Bassillus cereus* and *Bacillus subtilis* is in starchy foods. *Escherichia coli* and others in the coliform group. *Listeria monocytogenes* in dairy foods, meat, poultry and vegetables

Fungal Food Poisoning or Mycotoxins

These are produced by certain molds in groundnut, wheat and various cereals, ground beef peanut butter and whole wheat bread may cause illnesses or death in animals and man.

(a) Aflatoxins produced by *Aspergillus flavus* and *Aspergillus parasiticus*

(b) Penicillic acid by *Penicillium puberulum*

Viral Food Poisoning

Viruses do not grow in foods but food acts as the carrier for intestinal viruses. Hepatitis A virus causes infectious hepatitis and is found in raw or partially cooked shellfish from polluted waters

Food Infection occurs when certain causal bacteria grow in food reaching a microbial load of 10 million or more viable organisms or colony forming units (10^6 cfu) per gram or millilitre of food or per sq cm of the surface.

(a) **Salmonellosis** is caused by a large number of salmonella species e.g. *Salmonella typhimurium*, *Salmonella paratyphi* which are responsible for typhoid, paratyphoid fever respectively. It is associated with eating infected eggs, poultry, meat meat, products and several other foods. Symptoms include nausea, vomiting, abdominal pains, headache, fever and diarrheoa.

(b) **Streptococcal infections** caused by Streptococcus faecalis in foods contaminated with faeces and by infected food handlers.

(c) **Other Pathogens:** These do not grow in foods but the foods act as carrier. The diseases are intestinal or respiratory

(i) **Intestinal diseases:** Bacillary dysentery or shigellosis by species of Shigella. Amoebic dysentery or Amoebiasis by *Entamoeba histolytica.* Cholera by *vibrio cholerae.*

(ii) **Throat and Respiratory diseases**

Tuberculosis from Mycobacterium tuberculosis from raw contaminated milk and dairy products. Scarlet fever and septic sore throat caused by *Beta hemolytic stroptococci* from nasal and oral discharge. Diptheria by *Corynebacterium diptheriae* from nasal and oral discharges.

(iii) **Other Diseases**

Septic sore throat, Q fever by *Coxiella burnetii* through infected milk. *Brucellosis* by Brucella abortus through infected raw milk.

(d) **Trichinosis** caused by the nematode worm *Trichinella spiralis* obtained by eating raw or incompletely cooked pork containing the encysted larvae.

Prevention of Food Poisoning and Infection

(a) Wash thoroughly fresh fruits, vegetables and other relevant raw foods before eating.

(b) Eat only wholesome foods having the least number of microorganisms present from the start.

(c) Preserve foods when necessary such that microbes present are kept in their lag phase and phase of positive acceleration for as long as possible

(d) Avoid recontamination of your food with microorganisms in their log or exponential phase (C-D) from sick and unclean food handlers, uncleasne equipments, containers and utensils, insects, vermins, contaminated ingredients, soil and sewage.

(e) Introduce one or a combination of several unfavourable environmental conditions for microbial growth, the so called hurdles, in your food processing and storage e.g. low moisture (low a_w), heat, low temperature, acid pH, preservatives, vacuum, anaerobic and modified atmosphere packaging etc.

(f) Properly heat, pasteurize or blanch relevant foods like milk, fruit juices and vegetables.

(g) Avoid foods that have been cooked, held for sometime and not properly reheated. Boil suspect foods for at least 15 minutes.

(h) Avoid raw or precooked foods that have been frozen and thawed repeatedly at room temperature.

(i) Do not consume or taste foods that have awful odor, tainted or sour flavour, objectionable colour, off texture, slimminess or mouldiness as these are often signs of spoilage.

(j) Do not eat the so called rich salads and other susceptible foods unless you are sure of the source and they have been kept continuously refrigerated at 3C or below.

(k) Do not consume canned foods that are gassy, swollen, leaking, or rustic for these are also signs of spoilage.

(l) In case of *trichinosis*.

(i) Cook all pork so that every part of it attains at least 58.3C

(ii) Quick freeze pork and store at – 15C or less for at least 20 days or more.

(iii) Treat with 100 kilorads of ionizing irradiation.

(iv) In processed pork like sausages, follow acceptable protocol of curing, drying, smoking and refrigeration.

Summary
In this chapter, agents which cause poisoning and infection as a result of eating unwholesome foods were discussed. Suggestions on how to prevent exposure to food poisoning and infections were also made.

Post Test

1. Define true food poisoning and food infection.
2. List with examples the various types of food poisoning.
3. How would you prevent trichinosis?

Answers to Post Test

True Food Poisoning is the ingestion of food containing toxins produced in that food by certain classes of microbes e.g. C. botulinum leading to discomfort or death. Food infection is the ingestion of food in which certain casual bacteria e.g. salmonella or streptococcus species have grown reaching a microbial load of 1 million or more colony forming units (10^6 cfu) per gm, or ml of food or per sq. cm of the food surface or in which certain parasitic larva like that of the nematode worm, *Trichinella spiralis* is present as in infected pork thereby causing discomfort and occasional death.

Bacterial Food Poisoning

(i) Botulism by C. botulinum

(ii) Staphylococcal food poisoning by *S. aureus*

Fungal Food Poisoning

(i) Aflatoxin by *Aspergillus flavus*

(ii) Penicillic acid poisoning by *Penicillium puberulum*

Viral Food poisoning by Hepatitis A virus

(i) Freeze pork quickly and leave at –15C or less for at least 20 days.

(ii) Irradiate with 100 kilorads of ionizing irradiation.

(iii) Cook pork meat to at least 58.3C.

(iv) Follow approved methods of curing, drying, smoking and refrigeration of processed pork like hams or sausages.

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Sensory Qualities of Foods – Texture and Flavour

Introduction

There is a complex inter-relationship among food sensory qualities and nutrition. Food acceptability is related to its texture and flavour encompassing taste and aroma, juiciness and colour. An acceptable junk food while giving psychological satisfaction, may not be nutritive. Highly nutritive foods like natural soyabean based products often have poor bland taste and eye appeal. The organoleptic characteristics of such foods can be made more acceptable through judicious use of food grade colours, texturizers, stabilizers, sweeteners and other food additives. Good quality in foods enhances their appearance, ease of processing, marketability, high prices, long shelf and storage life.

Objectives

At the end of this lecture, students should be able to:

1. State those factors that contribute to the sensory qualities of foods.
2. Assess and improve some of these qualities in foods.

Pre-Test

1. Define food sensory quality.
2. What textural properties would you look for in assessing a given food?
3. What determines food flavour?

CONTENT

Definition

Sensory quality of foods, is the combination of all desirable characteristics of that food as detected by the sensory organs in terms of its texture, colour, flavour, and overall acceptability.

Food Texture and Rheological Properties

Textural Properties of a food refers to the sensations, which a consumer experiences through his sense of feel with his fingers and in his mouth and through his sense of sight as to the physical appearance of the food such as the size. Rheology refers to the flow characteristics of liquid and semi liquid foods.

(a) **Finger Feel**

We often assess the quality of some foods by touching and compressing the food with our fingers. Such foods may be **hard, firm or soft** in ascending order of degree of resistance to compression. Such food may also feel **dry, moist, wet** or **watery** when such foods are squeezed reflecting their level of juiciness.

(b) **Mouth Feel**

The perception of mouth feel is through the sensory cells of the tongue, walls of the mouth and muscles of mastication. Some easily perceived mouth feel characteristics of foods are:

(i) **Tenderness** and toughness describing increasing range of resistance to cutting action of the teeth.

(ii) **Chewiness** reflects resistance of foods to grinding action of the teeth.

(iii) **Fibrousness** in foods high in fibre or material residue requiring thorough chewing as in over ripe corn

(iv) Oiliness and greasiness in foods containing too much oil or fat which coat the tongue as in fatty beef or pork meat.

(v) **Gumminess** and **Stickiness** when the food clings tenaciously to the teeth, tongue and mouth wall as with chewing gum

(vi) **Grainy, gritty** or **stony** foods contain small and hard particles in form of sand, grit or stones.

(vii) **Crunchy** and **crumbly** foods are brittle or friable and easily break to pieces as with crackers and chinchin.

(viii) **Softness, firmness** and **hardness** as reflected in the ease with which the teeth compress the food

(ix) **Food temperature** in terms of hotness, warmth, tepidity and coldness. Some foods elicit the sensation of heat when eaten e.g. pepper and other spicy foods.

Other texture descriptive terms are crisp, limp, soggy, smooth, lumpy

(a) **Rheological properties** of a liquid food refers to its ability or inability to flow. Liquid foods which flow easily are said to be **fluid** e.g. water, orange juice, milk. Those which show various degrees of resistance to

flow are said to be **viscous** e.g honey, pap *(ogi)*, heated starch and tapioca, jams and jellies, gelatin and others.

(b) **Sound as a Texture Profile**

Some foods break with a sharp sound when we take a bite and chew. Examples are the crackling sound of biscuit cracker, and fresh pop corn, snapping sound of carrot and coconut and screeching sound of fresh cabbage and half-ripe pawpaw.

(c) **Size and shape of Foods**

Sizes and shapes of foods are important in processing, packaging and marketing.

In food processing operations, products are sorted into uniform sizes and shapes to facilitate washing, weighing, cutting, peeling, grinding and other successive operations, since many machines and equipments are designed for specific sizes of raw materials.

The shape of a product may make it unsuitable for machine or other operations leading to its rejection and loss of value.

By presorting into different uniform sizes, a producer is able to sell at higher prices than when the products are of mixed sizes. A consumer is also able to make his preferred selection at acceptable prices.

Uniformity of symmetry means absence in food products of mixed samples of irregular sizes and shapes.

Uniformity in sizes makes for easy packaging. Thus a carton of frozen fish or chicken is more likely to contain products of the same size.

Products can be sorted by weight, volume, bulk and apparent densities or weight-volume ratio, and linear measurements such as length, width, or diameter especially when minimum and maximum standards are set.

Food Flavour

The flavour of a food is a composite of its **taste** and **aroma**. Food taste is as perceived by the taste cells on the tongue and mouth walls. That of aroma or odor is by the sense cells in the nose. The sensation of taste is gustatory while that for aroma is olfactory.

Food flavour perception may be modified by pH of the food, physiological and psychological state of the individual, fatigue, adaptation, sickness such as malaria or catarrh and change in temperature or even personal bias.

Food Flavour Constituents

Flavour precursors in foods are mostly small soluble organic compounds. These are amino acids and peptides produced as a result of proteolysis or protein breakdown

and short or middle size chain fatty acids produced by lipolysis or breakdown of fats and oils.

(i) **Aroma** is the first sensation a consumer perceives. Several hundred volatile odourous compounds, including *aliphatic esters, terpenes, terpenolds, alcohols, diacetyl, ketones, aldehydes* and *acetone* are normally present in any one food. Each has its different threshold level of odor sensation or activity. Some volatile compounds occur only in infinitesimal amount but exert very strong odor sensation. Few of the volatile compounds present in each food are important for the foods characteristic odor.

(ii) The sensation of taste is in response to non-volatile compounds in the solid or liquid food. These compounds are responsible for the following five most important sensations:

Sweetness: e.g. glucose, fructose, lactose, galactose, dextrose, honey, mapple syrup, and miraculin from the West African miracle fruit saccharine and others.

Bitterness: e.g. quinine, strychnine, nicotine, caffeine, bitter leaf and bitter cola

Saltiness: Common salt, certain chlorides, bromides, iodides, nitrates and nitrites.

Sourness: High food acidity measured as total or titratable acidity in foods

Savory: Palatability, pleasing taste and smell.

Other flavour descriptive terms are bland, burnt, fishy, meaty, mouldy, musty, oily, pungent, putrid, rancid, sharp, spicy sulphurous, taint, tangy among others.

Added Food Flavours

The addition of various spices, seasonings, flavour intensifiers like monosodium glutamate and other salts of glutamic acid (present in maggi and knorr cubes including Ajinomoto, AI, etc.) positively modify taste perception of foods like meat, poultry, and soup.

Many natural flavour extracts are used in the food industry. Examples are spice extracts or essences, banana, mango, vanilla flavours. Many industrial food flavours are synthetic chemicals, which are easily and cheaply mass-produced. They are used mostly in diet beverages, fruit drinks, dairy, cereal foods and snacks to simulate natural flavours, introduce new flavours to existing products or as replacement for sugar to sweeten foods that have bitter, harsh or astringent taste.

Examples of artificial sweetners are *Neotame, aspartame, saccharin, sucralose* and *acesulfame K.*

Food Flavour as an Aspect of Food Quality

As we have seen above, flavour is a composite of desirable taste and aroma. It is attributed to flavor compounds, both volatile and non volatile which are naturally present in small amounts in foods. Other distinctive and pleasant fragrances are developed in different foods as they mature or ripen, during post harvest storage, processing, cooking, drying, irradiation, and fermentation and during other processes to which the food may be subjected. Some other flavours may be lost or destroyed or undesirable flavours developed in certain foods under adverse conditions such as excessive heating, fermentation and spoilage. A fruit like unripe orange is sharp and acid in taste yet the ripe orange is sweet. It takes appropriate heating to develop desirable flavours in bean, meat, bread and a lot of other foods. We are also familiar with the rotten taste of spoilt meat and eggs. As most flavour compounds are fat soluble, fat controls the release of flavour in foods.

Some flavours are better perceived at warm temperatures e.g. coffees while others are at their peak when chilled e.g. wines and beer. Some foods leave an after taste flavour following the primary taste sensation e.g. sweet taste following the bitterness of bitter leaf. Undesirable warmed-over flavour develops in boiled meat during refrigerated storage. Foods that have been warmed and re-warmed such as soup or beans have a more matured taste than fresh soup.

Flavour Assessment of Foods

Flavour assessment of foods is by subjective or by objective methods.

Subjective methods are said to be sensory or organoleptic as the flavour quality is determined using the human sense of taste and smell. Sensory rating is done on a hedonic scale, which may range from 1 (dislike extremely) to 7 or 1 to 9 (like extremely) from the worst to the best flavour preference.

Objective methods are by chemical or instrumental determinations. The Gas Chromatography Olfactometer or Electronic nose or Aroma Scan is all used for evaluating the odor or aroma characteristics of the food. They duplicate the human olfactory system by using chemical sensors, which detect and quantify volatile odor components released by the food.

Similarly, the electronic tongue assesses the non-volatile chemical components present in the food thereby measuring sweetness, bitterness, saltiness and sourness.

Summary

In this lecture, we have attempted to define the concept of food sensory qualities characterised by texture, colour and flavour. We also discussed how some of these characteristics are perceived in foods and ways of quantifying them.

Post Test

1. Identify the food quality traits
2. What objective methods would you use to evaluate food flavour?
3. Differentiate between textural and rheological properties of foods.

Answer to Post Test

1. The food quality traits are texture, colour and flavour which is a composite of taste and aroma
2. For aroma we use the electronic nose or gas chromatograph olfactometer
   For taste we use the electronic tongue.
3. Textural properties of a food are experienced through finger-feel, mouth-feel or sight in respect of shape and size of the food. They are applied primarily to solid and semi solid foods.
4. Rheological properties on the other hand are applied to liquid and semi liquid foods and their ability to flow.

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Lecture Eleven

Sensory Qualities of Foods – Colour

Introduction

Where consumers have choices, the first factor considered in making food selection is the appearance of that food of which colour is the chief determinant. If the colour is unacceptable or abnormal, that food is rejected irrespective of its nutritional or other qualities. Most foods are brightly coloured in nature and off-colours in fresh or processed foods invariably indicates spoilage in such foods.

The colour of foods may change as they are processed. It is also a common practice in the food industry to improve the appearance of foods qualitatively by adding acceptable food grade, natural or artificial colours.

Objectives

At the end of this lecture, students should be able to:

1. Discuss the familiar with the role of pigments in natural food colours, how colour in foods and other objects are perceived and defined and how colour affects food quality.
2. Discuss the causes of browning reaction in foods and some methods for assessing food colours.

Pre-Test

1. What determines food colour?
2. Define colour. How is it perceived in foods and other objects?
3. How does food colour affect its quality?
4. How can food appearance be improved?
5. By what methods can food colour be assessed?

CONTENT

Food Colours

Each food has its natural characteristic colour which is determined by the nature and amount of natural pigments present. These pigments usually in large number and in various combinations, are responsible for the red, green, blue, yellow orange and other colours observed in foods. Natural food colours are usually bright and eye-appealing.

Types of food pigments

These can be grouped into

(i) **Flavonoids:** These include the anthocyanins which are responsible for the red, blue and violet colours in a variety of fruits and the flavones which are responsible for the various shades of yellow colour in some fruits and vegetables. Anthocyanins are high in black currants of which the chief component of ribena.

(ii) **Carotenoids** are fat soluble carotene and xanthophylls responsible for the red, yellow and red pigments in certain fruits and vegetables and other foods e.g. carrot, pepper, tomato, banana, yellow maize, palm oil from palm fruits, butter and egg yolk. Some carotenoids are readily converted into vitamin A in the body e.g B- carotene

(iii) **The Tetrapyrroles** include the chlorophylls, which is responsible for the varieties of green colouration in fruits and leafy vegetables like green pepper, *ugwu*, greens and *amaranthus*. Also included are *myoglobin* and *haemoglobin* which are responsible for the red colour of meat and blood respectively.

What is Colour?

Colour is characteristic of visible light that can be measured in terms of radiant energy and wavelength. A wavelength of visible light extends from 380mm to 770 mm which covers the colour of the visible rainbow. Thus for an observed food colour, its wavelength is present more than the wavelengths of other colours.

How do we Perceive Food Colour?

In total darkness, we cannot perceive any colour. However, when light falls on an object, part of it is reflected and passes through the eye lens and is brought to focus on the retina. Here light impulses are converted to electrical impulses, which are conducted through the optic nerves to the cerebral cortex of the brain for recognition.

To understand fully the nature of the light reaching the eye we need to look at the characteristics of light.

When a beam of radiant light hits the surface of a mirror it is reflected but that hitting a plane glass passes through with very little reflection. When the same beam of light hits a triangular prism at the appropriate angle, it is both transmitted and refracted such that it is broken up into the seven colours of the rainbow.

Any visible object possesses the colour of one or a mixture of more or all the visible colours of the rainbow, the so called additive mixing, based on its ability for differential reflectance or absorption of light reaching its surface. If all the light reaching the surface of the object is reflected in entirety, the surface assumes a white colour. If all are absorbed, the observed colour is black. If all colours of the visible spectrum are only partially absorbed to the same degree on the surface, than the colour will be gray. If one primary colour is reflected to a greater extent than the others, then the apparent colour of the object will be reasonably that of the dominant colour wavelength.

Each colour is defined by its characteristic hue, chroma and value.

(i) The **hue** is related to the dominant light wavelength of the observed range of visible light or colours of the rainbow that is reflected by an object e.g. red, orange, yellow etc.

(ii) The **chroma** or **purity** or **saturation** of reflected light relates to the intensity or **strength** of the fundamental colour or given wavelength relative to all the other colours with which it is mixed.

(iii) The **value** relates to the level of brightness or darkness of the observed colour. In other words, it is the amount of light of all wavelengths present that is reflected vis-à-vis that absorbed by the viewed object.

Some surfaces have most of the light reaching its surface reflected towards the same direction thus making the surface look glossy or sheeny such as we have at the surface of an oily food. The light may be reflected, scattered or absorbed at the surface or body in all directions making the object look dull.

Food Colour as an Aspect of Food Quality

Fresh foods are usually brightly coloured as a result of the reflection, scattering and transmission of light from the red, green, blue, yellow or orange pigments naturally present in the foods. These along with the food's physical structure determines the food quality.

Many fruits and vegetables tend to change colour as they become ready for harvesting. Orange fruit changes from dark green to yellow or orange with its juice changing from an acid taste to sweetness. Similarly, tomato changes from light green to rich red, plantain and banana from green to yellow, bean pods from green to khakhi brown. Here, colour change is a measure of state of maturity.

Grayness or dullness indicate some measure of spoilage and deterioration and such foods contain less than the normal nutritive value. Similarly, abnormal colour or discolouration such as freezer burn, brown, green, black and colours not peculiar to the food substance may be indicative of bacterial yeast, mold or physical spoilage. A rotten yam tuber has its colour changed from white to brown or black while black, red or yellow mold growth on bread renders it uneatable.

Processing Effect: On cooking, meat changes from cherry red to brown, puff puff, bread crust, and other pastries change from dirty white to brown. Colour change during processing of a food product will depend on method and medium of processing and type of food.

Browning Reactions in Foods

Many complex browning reactions occur in foods during handling and processing which may or may not be desirable. The following browning reactions are of importance in foods.

(i) **Maillard Reaction** is a browning reaction of sugars or carbonyl compounds with amines, free amino acids and amine groups of peptides, polypeptides and protein. It is respondible for the nutty, corny bread odours, browning colour and flavour of baked bread, cake and other pastries, chocolate, honey, maple syrup, potato chips, molasses among others.

(ii) **Caramelization** occurs when dry sugar or highly concentrated sugar solution is heated to a brown burnt state that is readily soluble in water. The caramel so formed is used for flavouring or colouring various foods, in beverages, spirits and wines, cakes.

(iii) **Enzymatic Browning** occurs in some cut fruits and vegetables as a result of the activities of endogenous enzymes generally classed as *phenolases*. Examples are *polyphenoloxidase phenoloxidase, tyrosinase, oxidases* and many others. These enzymes are responsible for the browning observed in yam, potato, sweet potato, banana and plantain, apple, mushroom and cassava. Though undesirable, this browning is not indicative of spoilage. Enzymatic browning can be prevented by blanching to inactivate the enzymes, treating the food with *sulphur dioxide* or *sodium bisulphite*, incorporating ascorbic acid in the food or by vacuum packaging.

Added Food Colours

The first determinant of food acceptability is its appearance of which its colour is a prime factor. Food grade colours are natural colour extracts or artificial/synthetic colours. They are added deliberately to foods to appeal to children or people who like novelty and something different, create varieties in existing foods and enhance product appearance. They are applied in bakery products, beverages, juice drinks yogurt, candies, chewing gum and many other foods. Examples of food colours

product appearance. They are applied in bakery products, beverages, juice drinks, yogurt, candies and sweets, chewing gum and many other foods. Examples of food grade colour additives which are generally regarded as safe (GRAS) are Beta carotene, mixed carotene, red pepper, caramel, citrus oil, annato, red grape, mango yellow, purple carrot, copper chlorophyll to name a few.

Colour Assessment of Foods

Scientific assessment of food colour may be visual or objective. Visual assessment of food colour is made by comparing with colour charts of probable colours normally encountered in that food as indicators of wholesomeness or spoilage e.g. Yolk colour fan for eggs and colour and discolouration standards or charts for meat.

Objective Assessment is Instrumental.

(i) In the **Munsell Colour System**, a composite of the hue, chroma and value of the observed food colour is taken into account in reflecting actual visual perception of the food colour.

(ii) The **CIE** system and the **Hunter Colour Difference Meter** employ the tristimulus additive mixing of the three primary colours red, green and blue each at variable intensities to match the observed food colours in a tristimulus colorimeter. The three or tristimulus colour dimensions determined are L (a measure of lightness on a 0 to 100 scale from black to white), **a** (a measure of redness or greeness) and **b** (a measure of yellowness or blueness)

(iii) We can also estimate food colour by extracting the pigment present with an appropriate solvent and measuring the amount of light of known wavelength transmitted through the extract in an instrument called a colorimeter or spectrophotometer. As the concentration of the pigment increases due to richness of the colour, the light transmission through the extract decreases. The pigment concentration can be quantified against a standard.

Summary

In this lecture, we have discussed aspects of food colours, how they are perceived by the consumer and how they affect food quality. We also discussed some of the many methods for assessing colour in foods.

Post-Test

1. What is responsible for the colour of foods?
2. Why do some foods exhibit browning reactions?
3. How would you characterise colour?

Answers to Post-Test

1. Food pigments: Flavonoids
   Carotenoids
   Tetrapyrroles

2. In response to: Maillard reaction
   Caramelization
   Enzymatic Browning reaction

3. In terms of: Hue
   Chroma
   Value.

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Determinants of Food Consumption Pattern

Introduction

Most people eat to live with a neglible few living to eat. With world population approaching six billion landmark, it is estimated that 3.3 trillion kg of food would be needed per year for optimal sustainance. Different parts of the world have different natural environments that determine the nature and kind of available food supply. Thus, while some areas have almost limitless number of available food products, others lack the variety depending, only on a few staple foods for their nourishments. The food we eat is also culture bound for while there is an instinctive requirement for food, culture determines which of the available foods we eat and in what form it is eaten. People of similar cultural background tend to cherish the same types of foods albeit with minor variabilities and individual preferences. Man is however subject to aculturation from external sources through which he is exposed to foods of other cultures.

Objectives

At the end of this study, the students should be able to:

1. Discuss those factors which determine the types of food that are available in his environment.
2. Recognize the personal attribute which affect food consumption pattern.
3. Examine other factors which are characteristic of the larger society and ethic groups.

Pre-Test

1. What are the main determinants of food consumption pattern.
2. Discuss circumstances which can modify food consumption patterns.

CONTENT

What Determines the Food you Eat?

For a food to be eaten, it must be available and for it to be available it must have been grown naturally at one time or the other. Synthetic foods are few and are to be found mainly as supplements to naturally grown foods. Successful production of foods is therefore greatly affected by the following factors.

(a) **Land:** Crop plants require rich cultivable land which supplies it with all the nutrients it requires such as minerals (trace, minor and major) and water. As part of his food chain, man either eats these crops directly or indirectly by eating meat, milk and eggs from other animals which may have had their nutrients supplied by eating plants in the first place. The greater the arable land with the appropriate topography in a country, the greater the potential to produce more food. Arable land may be increased through proper land management including fertilizer application and irrigation, land reclamation, soil conservation and the like.

Marginal lands which otherwise may not be ideal for crop production are often applied to animal husbandry. Societies lose arable land to development of parks and gardens, city and urban housing developments, express ways and other roads, effect of erosion both by wind or water, environmental pollution of all sorts as is happening in the Niger Delta. Arable lands are also lost through poor management of irrigation water and fertilizer application, ceremonial and traditional secret grooves, stadiums and the like. Depending on the soil types, certain crops will do well, some will do moderately well while others will not grow at all. Where land is limited certain crops can be grown in water using the technology of hydroponics as is used for rice in East Asia.

(b) **Water:** All living things require water in adequate amount for their growth. It is of the utmost importance in crop and animal husbandry through which we obtain all our nutrients. Water availability is through rainfall the intensity of which is tied up with the climate. We get water also through streams, rivers, fresh water and man-made lakes, wells and boreholes which all supply added water for irrigation. In its absence, desertification occurs and plant and animal life and therefore food supply from them become limited. Brackish and fresh water in our riverine areas and some lakes supply fresh water fish and shellfish in large amount as well as marine fish from our oceans and salt lakes like lake Chad. The scope of food supply from these sources can be magnified greatly through aquaculture.

(c) **Climate:** The climate determines the type of food crops that can be grown. Adequate sunlight is essential for the photosynthetic process. Some crops require short to medium photoperiods. Similarly, some require very warm temperatures while some require cool or even

subfreezing temperatures. Fortunately, daylight period in Nigeria hovers around 12 hr with a temperature mean of 28C allowing varieties of crops to be grown. Examples of these are yam, cassava, maize, millet, sorghum, potato, rice and a host of others. For the above reason, wheat rye barley cannot be grown in Nigeria while apple and potato, which require cool temperatures are grown on Plateau in the North East and are just now becoming common items nationwide. Length of growing season is intimately linked with the climate. Fortunately, growing season for most of our food crops is year round although some areas may require supplementary irrigation.

(d) **Labour:** in its wide sense involves human labour aided or not with the assistance of draught animals like donkeys and bullocks and machineries like tractor and combined harvesters. A large number of human labour is needed to produce a variety of foods in sufficient quantity for the country. The food production efficiency is improved by practising mixed cropping and mixed farming. Mechanization greatly multiplies the quantity and varieties of items that can be raised with very much fewer human labour input but lends itself to monocultural crops and livestock production.

(e) **Technological Factors** which can increase food availability include agricultural mechanization, scientific and timely application of appropriate fertilizers, herbicides and pesticides, food biotechnology, availability of storage facilities, food processing and preservation technologies frozen storage and refrigeration especially for seasonal and perishable foods, transportation of all kinds from areas of plenty to needy areas, local and world food trade.

(f) **In-born Factors:** To eat is instinctive, what is eaten is learnt. A new born babe's first instinct is to suck her mothers breast for sweet and refreshing milk. Universal likeness for the sweet foods is often seen as a survival instinct for their energy rich content. Most new born always refuse milk from mastitis infected breasts because the milk from such is usually sour. Foods targeted at younger children are often sweetened for increased acceptance. For the same reason most children would refuse to drink gari without sugar.

(g) **Sensory qualities:** Foods that possess tantalising aroma, visual appeal, strong and desirable flavour as well as juiciness and tenderness characteristic of the type of food are usually physiologically satisfying and therefore frequently eaten. Foods are prepared or cooked in various ways so as to modify their sensory attributes. Non palatable foods are least acceptable but eaten only as a last resort unless the taste is modified with good flavouring agents. What one considers a good food may not necessarily be related to its nutrient content. Thus cowhide and cow leg traditionally prepared into ponmo or bokoto (yor) ,Kanda (hausa) or

apoanu (ibo) is nutritionally flat containing very little of the very essential amino acids needed as building block for protein synthesis. Yet many people demand for and are willing to pay much for it when tastefully prepared in traditional stews at the bukateria or for home consumption.

(h) **Food habit** is an expression of self and one's communal relationship with others within the society he lives in. Foods defer from each other in taste, odor, flavour, texture, colour, shape, size and temperature and each consumer has a preferred characteristic combinations of these traits. What you eat is greatly dependent on what is available in your locality and which you are familiar with. Food consumed becomes monotonous in the absence of variety of choices e.g gari prepared in various ways and consumed in the morning, afternoon and evening. For most people, food habit is shaped by the foods to which they were exposed as children.

Like or dislike for such foods may be carried over to adulthood. Adverse mental or psychological blocking may be responsible for some people strongly detesting having to eat beans, eggs or chicken. People generally eat foods that give them physiological and emotional satisfaction and feeling of security. Peer group as defined by age, sex, educational level, occupation, interest group and others all influence food habits. Some individuals are finicky while others are glutonous in their food habits. Some would prefer home cooked meals while others would eat on the go at restaurants, fast foods and bukateria joints. Occasionally, the event at hand may influence the choice of an expensive food dish if such would boost one's status and ego.

(i) **Acceptability continuum:** In any society, certain foods such as bread, rice, meat are cherished and accepted by virtually every member of the society. Yet some other foods like bread fruit, insects e.g. cricket, silkworm, caterpillar despite their high nutritive value receive strong rejection. The widest range of foods fall within the group with variable acceptability as they have mutual replacement values. In this group we have gari, beans, yam and indeed most of the foods we eat.

(j) **Price:** The consumer demand for a food item is intimately linked with its price. Most staple foods are readily stored and are therefore cheaper and stable in price. Seasonal foods are most subject to price variations. Beginning from July during the yam and maize glut, their prices come down and they are preferentially consumed at the expense of the higher priced bread and eggs, which consequentially suffer low sales. A reversal of this trend occurs in between harvesting periods between December and March. Egg and chicken prices shoot up following sales and slaughter of hen layers at Christmas. Similarly, as people of the Muslim faith demand for rams during the Muslim festivals; ram prices increase precipitously. The following annual price variations have been established for gari, 22%; rice, 12%; Beans, 30%; yam 108%; maize, 44%; plantain, 17%;

beef, 16% and palm oil 32%. Prices also tend to be higher in urban areas especially for stables and quality fresh but perishable foods. Prices of the latter nose-dives with advanced stage of perishability. Imported, refined or processed foods are relatively more expensive than locally available raw or partly processed foods.

(k) **Urbanisation:** The greatest resource our nation is endowed with is her human population. Between 1980 and 2010 AD, this population is projected to grow at a rate of 3.52% annually. Current population figure is about 120 million with almost 40% of the total population living in cities many of which have at least half a million inhabitants. The rural-urban drift continues. Urbanisation involves a cash economy with people buying everything they need including foods, fuel for cooking, water and waste disposal.

The effect of urban living on food habits is phenomenal. Back in the villages, population density is low and scattered. As farmers grow their own foods, food prices are low, foods are cooked from the raw state which takes a long time and energy to accomplish. The same monotonous foods are eaten all the time and because of poverty, low grade foods like cassava, cocoyam, cowhide (ponmo-yoruba), rats, bush meat and the like provide the nutrients as the high priced foods are sent to the cities for sale. Women mostly breast feed their babies and use home prepared infant foods. In the cities, high population density means high demand for expensive foods of diverse varieties. High grade foods, meat poultry, fishes like express, clarias, imported processed foods for infants and adults become readily available and affordable. Ready to cook and ready to eat fast and convenience foods is much sort after as are restaurant and bucateria foods. Breast-feeding is replaced with infant food formula.

(l) **Socio-cultural Factors:** Man is a product of his environment. His food is therefore determined by the beliefs, hopes and fears of the society in which he lives. Among these factors are:

Religion which affects the nature of food consumed in various ways. People of the muslim faith would neither touch nor eat pork anytime but would consume especially mutton from ram during the various muslim festivals. The christians consume a lot of chicken and turkey at Easter, Christmas, harvest and other festivals but during lenten season would prefer fish or snails in lieu of meat/animals with blood. Catholics abstain from eating meat on Fridays while the Seventh Day Adventist avoid eating animal flesh entirely. The Ogun worshippers eat dog-meat as their sacrificial offering. Some animals serve as totem or objects regarded with awe and affection and therefore a taboo to be eaten as is the case with buffalo among the people of Ile-Oluji in Ondo state and cattle among the Hindus of India.

Customs and taboos in some areas restrict protein intake especially by children and women in the reproductive and child bearing vulnerable groups as they are denied access to milk, fish, eggs or even meat. As a result morbidity and mortality is very high reaching 25-30% before age three. Snail meat is regarded as a delicacy in Western Nigeria. Among some people, snakes and other reptiles, insects like cricket, locust, silkworm caterpillar, palm tree maggots form the main source of animal protein, but yet are regarded with revulsion by others.

(m) Income and Societal Status: The economic health of a people determine how much of their disposable income is devoted to food and the ability to eat adequate balanced diet. Poverty is the major cause of hunger, malnutrition disease and death. With poverty, food choices in terms of quantity and quality remain limited consuming almost all the available income for cheap but stomach filling foods. Foods eaten consist mainly starch, especially cassava, potato, maize and local rice, proteins like beans, frozen fish and leafy vegetables. Gross allocation of money to food increases as income increases, then levels off as diet becomes satisfactory. Thereafter, its percentage of the total income decreases sometimes falling to as low as 18%. As income increases above poverty level, there is a shift to more expensive and palatable protein foods like milk, meat, fresh fish like catfish and eggs and to high class cereals like wheat and rice, fats, sugars and a variety of quality green vegetables.

Societal status derives from income, financial and material wealth, and societal hierarchy. People of the higher echelon tend to look down on certain foods believed to be the preserves of the poor e.g. cocoyam and breadfruit. They however, readily accept with pride those foods that are favourites of the elite: imported long grain parboiled rice, corn flakes, and other breakfast cereals, canned foods, exotic tea and coffee.

(n) Ethnicity and Nationality: Ethnicity or the group that a person originates from has a strong effect on food choices. Each ethnic group has overtime-developed appropriate methods for preparing localised dishes that are of specifically acceptable taste and preference to members of that group. Eating certain foods may be a taboo in one ethnic group but a relish in others e.g. eating of dog meat.

In regionalisation, people of similar cultural background but different geographical locations tend to eat variants of the same food prepared in slightly different ways. Thus yam is preferentially served as *amala* in Oyo state and *iyan* in Osun and Ekiti states with the latter being prepared with various textural properties nationwide. Similarly, corn porridge is preferred as the soft *eko* in the South West but as the hard textured *agidi* in South East of Nigeria with both dishes differing only in the moisture content. Other foods with similar disposition are rice, groundnut, melon seed and more importantly cassava, the good famine relief.