MOUNTAIN TOP UNIVERSITY

E-Courseware

COLLEGE OF BASIC AND APPLIED SCIENCES

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COURSE GUIDE

COURSE TITLE: Introduction to Food Science and Technology

COURSE CODE: FST 201

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COURSE OBJECTIVES

GENERAL INTORDUCTION AND COURSE OBJECTIVES

This course takes a review of global food situation with emphasis on Nigeria with a list of some foods of plant and animal origin. It aims at explaining the basic knowledge of food composition, chemical composition and some natural constituents of foods. It explains the principles involved in processing and preservation of various food commodities, its nutritional status and highlights the effect of various processing techniques on some food nutrients. Knowledge of the use of flowcharts, equations and stoichiometry as well as Engineering units and dimensions applicable to the food industry will also be acquired by the students. In summary, it deals with basic knowledge of food science and Technology and principles involved in food processing and preservation. The course requires foundational knowledge in Agricultural science, chemistry, Biochemistry and physics.

COURSE CONTENTS

MODULE ONE

By Dr. A. O. Idowu

LECTURE ONE

REVIEW OF GLOBAL FOOD SITUATION WITH EMPHASIS ON NIGERIA

1.0 Introduction

This lecture focuses on review of global food situation with emphasis on Nigeria. The starting point will be to examine global food situation in the developing world, in Sub Sahara Africa and in Nigeria.

Objectives

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

1. explain in details the global food situation particularly in Nigeria;
2. explain food insecurity, dimensions of food security and
3. way out of food insecurity in Nigeria

Pre-Test

1. Explain some cases of food insecurity in Nigeria
2. What are some of the indicators of food insecurity?

CONTENT

1.1 Review of global food situation

In the developing world as a whole, about 840 million people, that is 20% of world population were chronically undernourished lacking economic or physical access to sufficient food to live a healthy and productive life (FAO, 2006). In sub-Sahara Africa, 215 million (38-43%) is said to be a flash – point or locus of hunger Child malnutrition is another indicator of food insecurity. It is estimated that 28 million sub Saharan African children (30%) are under weighted. Micro nutrient deficiencies are also wide spread which result in poor health and productivity especially in iron, iodine and vitamin A (FAO, 1996).

1.2 Review of food situation in Nigeria

Nigeria is among the poorest countries in the world with the GNP per capital at N320 below the level at independence. About 70% of the population lives on less than $1 per day. Household spends 50 – 80 % of their income on food. (FAO, 1996), yet 50% of the children under 5 years are malnourished. Agriculture is the largest sector in the economy about 40%

of GDP, yet productivity is very low leading to growing food import. It is estimated that that Nigeria spent about $2 billion , $750 Million, $700 million, and $500 million on wheat, rice, sugar and milk and dairy products importation respectively in 2008 (Ojo and Adebayo, 2012).

1.3 Cases of food insecurity in Nigeria

a) In Nigeria, a nutritional survey conducted by the government of Nigeria and the United Nations Children Fund (UNICEF) (FAO, 1997) revealed that Kano State in the northern savannah zone of the country was facing worsening food insecurity. It had the highest prevalence in the country of stunning or chronic under nutrition among children under the age of five and alarming micro nutrient deficiencies in iron, vitamin A and iodine in adult and children. There is a high incident of malnutrition related diseases including marasmus, kwashiorkor and goiter which not only undermine health but hinder agricultural productivity in a state regarded as the FOOD BASKET OF NIGERIA!

b.) USAID (2007), reporting on the food security update in Nigeria as at July that year said "A few months after a normal start of the rainy season in May in northern Nigeria and early march in the south, household remain generally food secure due to high availability of food items, low prices of cereals and tubers and generally good rainfall conditions throughout the country.

However, as the June to August lean period sets in, poor households are turning to the market in greater number to purchase food after they had exhausted their food reserves from the previous year's harvest. The price of cereals and tubers would at that time have begun to increase astronomically which also reduce access to food as normal for households and cause food insecurity in localized areas.

c) Current situation of insurgency in North East part of the country resulting in internally displaced people (IDP) and the dwindling price of crude oil has made the situation worse in the country.

d) Farmers- Fulani herdsmen clashes leading to loss of lives, properties and wastage of food commodities.

1.4 Indicators of food insecurity

Indicators of food insecurity include: Hunger, malnutrition and poverty, as well as low productivity, micronutrient deficiency and poor physical and cognitive development

Hunger is usually understood as an uncomfortable or painful sensation caused by insufficient food energy consumption. Scientifically, hunger is referred to as food deprivation. Simply put, all hungry people are food insecure, but not all food insecure people are hungry, as there are other causes of food insecurity, including those due to poor intake of micro-nutrients.

Malnutrition results from deficiencies, excesses or imbalances in the consumption of macro- and/or micronutrients.

Malnutrition may be an outcome of food insecurity, or it may relate to non-food factors, such as:

- inadequate care practices for children,
- insufficient health services; and
- an unhealthy environment.

While poverty is undoubtedly a cause of hunger, lack of adequate and proper nutrition itself is an underlying cause of poverty.

A current and widely used definition of poverty is: "Poverty encompasses different dimensions of deprivation that relate to human capabilities including consumption and food security, health, education, rights, voice, security, dignity and decent work."

It is argued that a strategy for attacking poverty in conjunction with policies to ensure food security offers the best hope of swiftly reducing mass poverty and hunger. However, recent studies show that economic growth alone will not take care of the problem of food security. What is needed is a combination of:

- income growth; supported by
- direct nutrition interventions; and
- investment in health, water and education.

1.5 Dimensions of food security

Food security exists when all people at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Four Dimensions of food security include:

i) Physical availability of food

ii) Economic and physical access to food

iii) Food utilisation

iv) Stability of the other three dimensions over time

Physical availability of food - Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.

Economic and physical access to food - An adequate supply of food at the national or international level does not in itself guarantee household level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives.

Food utilisation - Utilisation is commonly understood as the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, diversity of the diet and intra household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.

Stability of the other three dimensions over time-Even if your food intake is adequate today, you are still considered to be food insecure if you have inadequate access to food on a periodic basis, risking a deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.

For food security objectives to be realized, all four dimensions must be fulfilled simultaneously

1.6 What are the ways out of food insecurity?

In Nigeria, the number of undernourished people is put at about 11.5 million FOS (2003), while postharvest food losses was put at about 25-30 % of the total production especially in fruits and vegetables. The way out of food insecurity therefore include:

i.) Improve food productivity

ii.) reduce postharvest losses-from the farm gate through food value chain up to consumers' table

iii.) improve access- to markets, to efficient distribution, to resources including credit

iv.) improve efficiency-enhance energy

v.) Increase land area under agriculture production (Extensification)

vi.) Encourage farmers-this will minimise rural-urban migration particularly among youths

vii.) Reduce food importation

Post-Test

1. Explain the dimensions of food security.
2. Enumerate ways out of food insecurity

Bibliography

1. Food and Agricultural Organisation of United Nations FAO Stat (2006). Food Security Statistics, Nigeria.

2. IFT 2014 Food Technology www.ift.org Future Food 2050

3. Ojo, E.O. and Adebayo, P.F. (2012). Food security in Nigeria an over view. European Journal of sustainable development (1) 2 199-222.

4. USAID (United State Agency for International Development). 2007.

LECTURE TWO

FOOD AND ITS IMPORTANCE, FOOD NUTRIENTS, AND ITS FUNCTIONS

1.0 Introduction

This lecture focuses on importance of food and functions of nutrients in food. It is important to note that nutrients are essential for various physiological functions as well as social functions.

Objectives

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

1. identify various food sources of nutrients
2. understand the functions of nutrients.
3. Explain the reasons for studying food science
4. Define some food science terminologies

Pre-Test

1. Define food.
2. Explain the various classes of nutrients, their functions and examples of food sources.

CONTENT

1.1 Definition of food

Food is any substance (liquid or solid) that contains nutrients (for growth, energy, repair of worn out tissues) which are useful to the body. It originates from plants and animals. Food is made up of chemical substances which when consumed, digested and absorbed by the body, promotes growth, supplies energy and regulates different body processes. E.g. Rice, Beans, eggs etc.

1.2 Importance of food

It sustains and nourishes our body and keeps it healthy.

It’s not only essential for survival but also plays a crucial role in every feature of our existence such as Physiological function and Social function.

1.3 Classes of food nutrients

There are six major classes of food nutrients.

1. Protein – beans, milk, fish, meat, eggs, cheese etc.
2. Carbohydrate – rice, maize, yam, potatoes etc.
3. Fat & oil – groundnut, palm-oil, cheese etc.
4. Vitamins – fruits (oranges, pineapple, apples) vegetable (carrot, cucumber, Amaranthus, water-leaf, cabbage etc.
5. Minerals (iodine, iron, calcium) e.g. fruits & vegetables, bone meal etc.
6. Water e.g. portable drinking water, fruit & vegetable juices. etc.

Nutrients	functions	food sources
1. Carbohydrate	***Source of energy***	***Yam, cassava, potatoes, plantain, cereals, sugar.***
2. Protein	***Growth, tissue maintenance and repair. It also provide energy***	***Meat, eggs, insects, fish, milk, legumes, nuts & seeds***
3. Fats and oil	***Source of energy, provide heat and energy, protect vital organs of the body***	***Palm oil, coconut oil, animal fat, nuts, melon seeds, fish oil, butter margarine.***
4. Vitamins ***Fat soluble ADEK*** ***Water soluble B&C***	***Regulate body processes.*** ***It helps the growth of children.*** ***Protects against diseases.***	***Tropical leafy vegetables, pods & seed vegetables root vegetables, fruits, sea weeds***
5. Minerals	***Regulate body processes.*** ***Growth & replacement of tissues.***	***Tropical leafy vegetables, pods and seed vegetables, root vegetables, fruits, sea weeds.***
6. Water	***Control of body processes***	***Portable water, tropical fruits and vegetables.***

1.4 Importance of food science

1. It helps to understand the nature and composition of food. Nature of food like color, texture, consistency, keeping quality.
2. It facilitates an understanding of the changes that occurs in food during storage, preparation and processing.
3. it fosters the knowledge of the ideal method of food storage, preparation and processing to conserve

a) The nutritive value and increase acceptability

b) To retain the nutrient to the maximum and increase acceptability.

4. To learn the selection of food quality and nutritive food, keeping in consideration the economic standard of the family.
5. To improve the digestibility of food. Some processes like simple cooking, soaking and fermentation improve digestibility of food.
6. To maintain the quality and safety of food. The knowledge of food science ensures that food is carefully handled while processing, storing and cooking to minimize food spoilage and to maintain the quality of food.
7. To understand the meaning of food, and it enables us to know the importance of food in life, food does not only satisfy hunger it also fulfils physiological needs of the body and sociological needs of human being

1.5 Definition of some terminologies

Food science embraces other disciplines such as; Agricultural science, Chemistry, Biochemistry, Physics. It deals with the study of food, its composition, nature and the changes that take place during its production, processing, cooking, preservation and storage.

FOOD SCIENTIST: This refers to one who studies the basic chemical properties, physical bio-chemical and bio-physical properties of foods and their constituents. A food scientist ensures that the crop harvested, the fish caught, animals slaughtered, egg laid and the milk produced reach the consumers in the most acceptable nutritious, safe and wholesome condition.

FOOD TECHNOLOGIST: This is referred to one who applies the knowledge of food science to the preservation, processing and preparation of food and to their packaging, storage and transportation. The type of food that one eats, its quality and its quantity largely determines one's physiological well-being. Food science concerns itself with the process of

transforming food in its natural state into those forms that could be consumed, such as transformation of cereals into bread.

FOOD AND NUTRIENTS: Food is made up of chemical substances which when consumed, digested and absorbed by the body promotes growth, supplies energy and regulates different body processes while Nutrients are the chemical components of food that perform this function.

Food processing encompasses all the ways in which agricultural and livestock products are treated to preserve them and/or prepare them for consumption as food. Food processing prepares agricultural products for consumption, example of agricultural products are yam, maize, rice, beans etc. Preservation methods include, canning, chilling or freezing, drying. Fermenting (as in prickles, gari) and adding chemical preservatives (as in curing meat), salting and more recent innovation like hurdle technology.

Post-Test

1. With the aid of a table, show the various food nutrients, its functions and examples of food sources.

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Mudambi, S.R. and Rajagopal, M.V. (2007). Food science. Macmillan publishers.

LECTURE THREE

FOODS OF PLANT AND ANIMAL ORIGIN

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However, as the June to August lean period sets in, poor households are turning to the market in greater number to purchase food after they had exhausted their food reserves from the previous year's harvest. The price of cereals and tubers would at that time have begun to increase astronomically which also reduce access to food as normal for households and cause food insecurity in localized areas.

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Food security exist when all people at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

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viii.) Improve food productivity

ix.) reduce postharvest losses-from the farm gate through food value chain up to consumers' table

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xiv.) Reduce food importation

Post-Test

1. Explain the dimensions of food security.
2. Enumerate ways out of food insecurity

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MODULE TWO

By Dr. O. E. Fayemi

LECTURE FOUR

INTRODUCTION TO FOOD MICROFLORA

1.0 INTRODUCTION

Microflora refers to the collection of live microscopic organisms that flourish inside a given medium. The microbial groups important in foods consist of several species and types of bacteria, yeasts, moulds, and viruses. Some algae and protozoa as well as some worms (such as nematodes) are important in foods. Bacteria, yeasts, moulds, and viruses are the most microorganisms of great significant in food for their ability to cause foodborne diseases and food spoilage and to produce food and food ingredients.

Objectives

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

1. enumerate important microorganisms associated with food and their significance
2. describe the morphology of microorganisms of importance in food
3. explain in details the beneficial and harmful effects of microorganisms in food.

Pre-test

1. Enumerate the beneficial roles of microorganisms in food
2. List the general differences in the morphology of yeasts, moulds and bacteria, important in food.

CONTENT

1.1 MICROORGANISMS OF IMPORTANCE IN FOOD

Microorganisms of importance in food include:

- Bacteria
- Fungi (Yeasts and Moulds)
- Virus
- Parasites
- Others include: Protozoa, Algae

1.1.1 Morphology of microorganisms associated with foods

a) Bacterial Cells:

Bacteria are unicellular - ca. 0.5–1.0 ×2.0–10 mm in size Cytoplasmic materials are enclosed in a rigid wall on the surface and a membrane beneath the wall. Nutrients in molecular and ionic form are transported from the environment through the membrane by several but specific mechanisms.

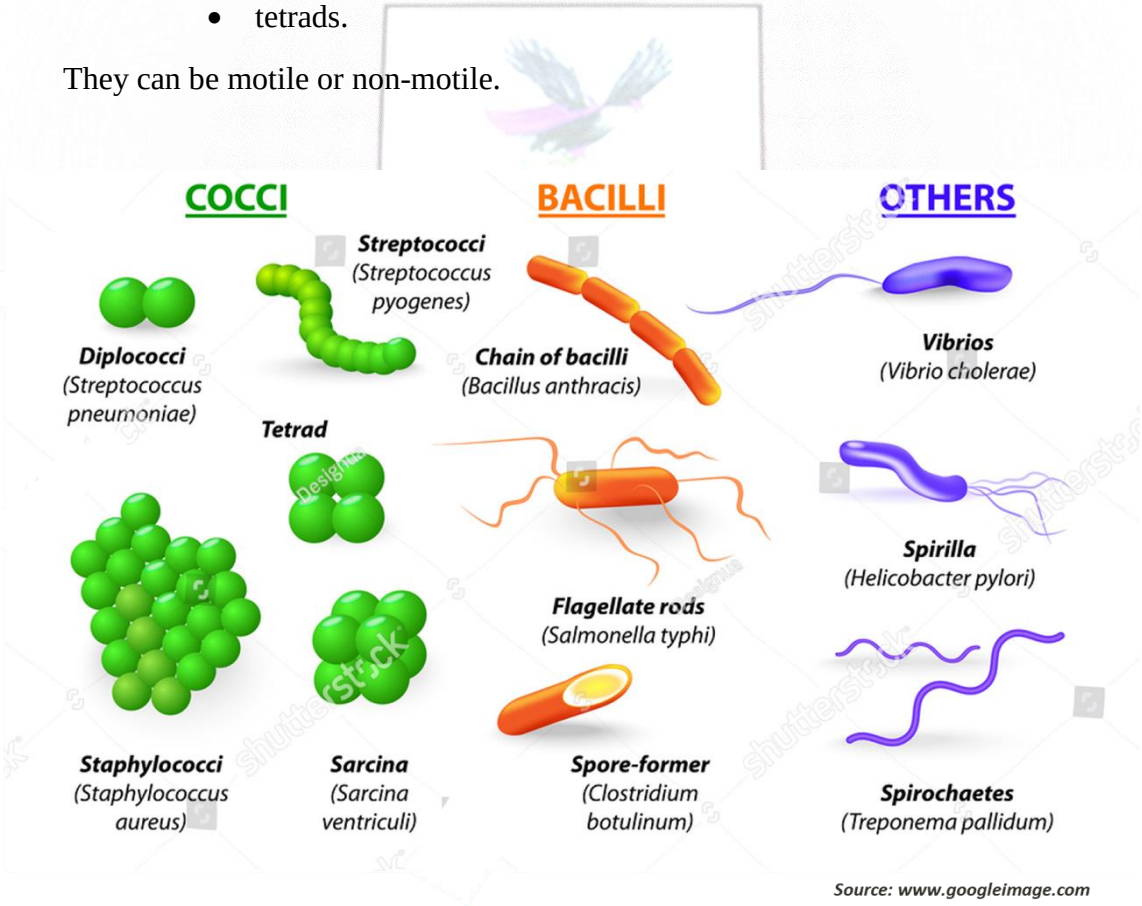
Three basic morphological forms of bacteria are:

i. spherical (cocci)
ii. rod shaped (bacilli)
iii. curved (comma)

They can also form associations such as

- clusters
- chains (two or more cells),
- tetrads.

They can be motile or non-motile.



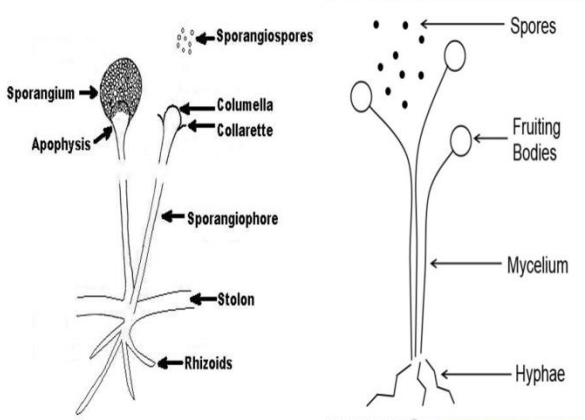
SHAPES OF BACTERIA

b) Yeasts and Moulds

Both yeasts and moulds are eukaryotic but yeasts are unicellular whereas moulds are multicellular.

Moulds

- ✓ non-motile, filamentous, and branched.
- ✓ The cell wall is composed of cellulose, chitin, or both
- ✓ A hypha can be vegetative or reproductive.
- ✓ The reproductive hypha usually extends in the air and form exospores, either free (conidia) or in a sack (sporangium).



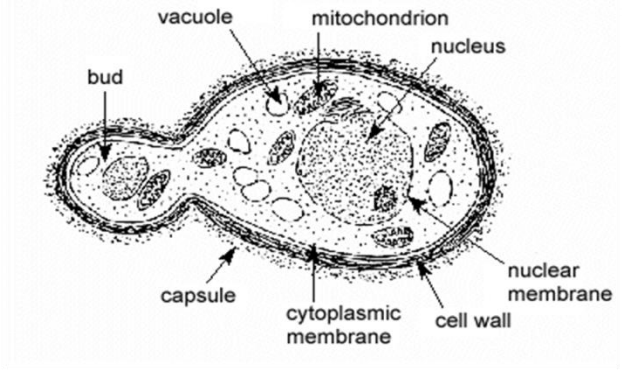
Structure of a typical mould

Growth of moulds in agar plate and food

c) Yeasts

The cells are oval, spherical, or elongated

- ✓ (5–30 × 2–10 µm in size)
- ✓ They are nonmotile. The cell wall
- ✓ Contains polysaccharides (glycans), proteins, and lipids.
- ✓ Are widely distributed in nature



Structure of yeast

d) Viruses

- Viruses are regarded as non-cellular entities
- Bacterial viruses (bacteriophages)
- important in food microbiology are widely distributed in nature

A bacteriophage attaches itself to the surface of a host bacterial cell and inoculates its nucleic acid into the host cell. Formation of many phages form inside a host cell and are released outside following lysis of the cell.

Several pathogenic viruses have been identified as causing foodborne diseases in humans. The two most important viruses implicated in foodborne outbreaks are hepatitis A and Norwalk- like viruses.

1.2 Beneficial/desirable effects of microorganisms

- ✓ Food fermentation-microorganisms (enzymes) alter properties of food such as yoghurt, bread.
- ✓ Food bio preservation-fermented food exhibits longer shelf life, bacteria involved are used to control spoilage and render pathogens inactive
- ✓ Health benefits-through probiotics such as fermented milk products
- ✓ Food bio processing - use of genetic engineering to produce better strains of starter culture e.g. beer

1.3 Harmful effects of microorganisms in foods can be divided into the following two categories:

1.3.1 Food spoilage-certain microorganisms cause spoilage and make food unfit for consumption. These organisms are bacteria, yeasts and moulds

1.3.2 Foodborne diseases - some pathogens (disease-causing organisms) are ingested when in contact with foods.

Table 1 Harmful and beneficial effects of micro-organisms in foods

Harmful effects	Beneficial effects
Foodborne diseases • Food poisoning or intoxications: resulting from production of toxins • Food infections • Viral borne infections **Food spoilage**	**Fermentations** • Yoghurt • Cheese • Wine • Fermented sausages • Sauerkraut **Probiotics**

1.4 Important microorganisms associated with some foods and their significance

1.4.1 Mould Genera:

Moulds are important in food because they can grow even in conditions in which many bacteria cannot grow, such as low pH, low water activity (Aw), and high osmotic pressure.

Examples:

- ✓ *Aspergillus:* Are involved in spoilage of foods such as grains, jams, cured ham, nuts, and fruits and vegetables (rot). Some species or strains produce mycotoxins e.g. *Aspergillus flavus* produces aflatoxin.
- ✓ *Fusarium:* Are associated with rot in citrus fruits, potatoes, and grains. They form cottony growth and produce septate, sickle-shaped conidia e.g. *Fusarium solani*.
- ✓ *Geotrichum:* Form a yeast-like cottony and creamy colony. They establish easily in equipment and often grow on dairy products e.g. *Geotrichum candidum*.
- ✓ *Mucor*: Some species are used in food fermentation and as a source of enzymes. They cause spoilage of vegetables e.g. *Mucor rouxii*.
- ✓ *Penicillium*: Some species such as *Penicillium roquefortii* and *Pen. camembertii* are used in cheese. Many species cause fungal rot in fruits and vegetables. They also cause spoilage of grains, breads, and meat. Some strains produce mycotoxins (e.g., *Ochratoxin A*).

1.4.2 Yeast Genera

Yeasts are important in food because of their ability to cause spoilage. Some are used to produce food additives.

- ✓ *Saccharomyces:* Saccharomyces cerevisiae variants are used in baking for leavening bread and in alcoholic fermentation. They also cause spoilage of food.
- ✓ *Candida*: Many species spoil foods with high acid, salt, and sugar and form pellicles on the surface of liquids. Some can cause rancidity in butter and dairy products e.g., *Candida lipolyticum*.
- ✓ *Rhodotorula*: They are pigment-forming yeasts and can cause discoloration of foods such as meat, fish, and sauerkraut. E.g *Rhodotorula glutinis*.
- ✓ *Zygosaccharomyces*: Cause spoilage of high-acid foods, such as sauces, ketchups, pickles, mustards, mayonnaise, salad dressings e.g. *Zygosaccharomyces bailii*.

1.4.3 Bacterial Genera

- ✓ *Gram-Negative Aerobes*: Cause souring of alcoholic beverages and fruit juices and used to produce vinegar e.g *Acetobacter aceti, Gluconobacter* etc.
- ✓ *Gram-Negative Facultative Anaerobes:* They are found in the intestinal contents of humans, warm-blooded animals, and birds. They are used as an indicator of sanitation in coliform and faecal coliform groups. E.g *Escherichia coli.*
- ✓ *Rickettsias:* Relatively resistant to high temperature - can be killed by pasteurization. E.g *Coxiella burnetii* causes infection in cattle and has been implicated with Q fever in humans (especially on consuming unpasteurized milk).
- ✓ *Gram-Positive Cocci:* Frequently involved in foodborne diseases and are also used for processing of some fermented foods e.g *Staphylococcus, enterococcus, Pediococcus* etc. *Streptococcus thermophilus* - used in dairy fermentation
- ✓ *Gram-Positive, Endospore-Forming Rods:* Some species cause foodborne disease (e.g *Bacillus cereus*) and food spoilage, especially in canned products (e.g *Bacillus coagulans*).
- ✓ *Gram-Negative, Endospore-Forming Rods:* One species important in food is Delsufatomaculum nigrificans – Cause spoilage of canned food.
- ✓ *Gram-Positive, non-sporeforming Irregular Rods:* Some species cause food spoilage. They are found in different cheeses and raw milk e.g brevibacterium, Bifidobacterium etc.
- ✓ *Gram-Positive, Nonsporulating Regular Rods:* Many are used in food bioprocessing e.g *Lactobacillus delbrueckii* subsp. *bulgaricus*) and some are used as probiotics. Several strains produce bacteriocins, of which some having a wide spectrum can be used as food biopreservatives. Some species are important foodborne pathogens e.g *Listeria monocytogenes.*

1.5 Microorganisms associated with some specific food products

- ✓ **Fresh meat** - *Salmonella* and *Clostridia* (perfringens), *Staphylococcus aureus*
- ✓ **Whole meat** - *Pseudomonas, Acinetobacter, Bacillus* and *Clostridia* (*perfringens*).
- ✓ **Vegetables** - yeasts, moulds, bacteria (Lactic acid bateria) e.g *Leuconostoc, Lactobacillius, Streptococcus*
- ✓ **Fruits** - yeasts and moulds are more important in spoilage of fruits because pH of fruits may not favour bacterial growth.

- ✓ **Dairy products** - Microorganisms found on cow's skin (including soil and faecal bacteria). This include: gram +ve and gram –ve bacteria, yeast, mould, lactic acid bacteria (*enterococci*, *lactococci*, *Lactobacillus*).
- ✓ **Eggs** - *Salmonella* contaminates liquid eggs from external surface.
- ✓ **Cereals and baked goods** - *Bacillus aureus* is common in grains and flours. *Rhizopus stolonifer* is common bread mould and other baked goods.
- ✓ **Fermented foods and beverages** - low pH of these products does not allow growth of pathogens, but spoilage can occur.
- ✓ **Beer and wine** (pH 4.5) can be spoiled by yeast and bacteria

Post-Test

1. List four species of moulds and two species of yeasts most important in food.
2. Explain in details the beneficial uses of microorganisms in food.
3. List two genera from each of the following groups associated with some foods and their significance: (a) Gram-negative aerobic rods, (b) Gram-negative facultative anaerobic rods, (c) Gram-positive cocci, (d) Gram-positive endospore-forming rods, (e) Gram-positive nonsporulating rods

LECTURE FIVE

PRIMARY SOURCES OF MICROORGANISMS FOUND IN FOODS

1.0 INTRODUCTION

Microorganisms get into foods from both natural (including internal) sources and from external sources to which a food comes into contact from the time of production until the time of consumption. Natural microflora exist in ecological balance with their hosts, and their types and levels vary greatly with the type of plants and animals as well as their geographical locations and environmental conditions. Besides natural microorganisms, a food can be contaminated with different types of microorganisms coming from outside sources such as air, soil, sewage, water, feeds, humans, food ingredients, equipment, packages, and insects.

Objectives

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

i. Describe the common sources of microbial contamination in foods
ii. indicate the measures that should be implemented to reduce microbial contamination in foods.

Pre-test

1. what are the major sources of pathogen contamination in foods?
2. in what ways can the microbial contamination of food be prevented?

CONTENTS

1.1 Some of the environmental sources of microorganisms into foods are:

1.1.1 *Soil and Water:* Soil organisms may enter the atmosphere by the action of wind and later enter water bodies when it rains.

They also enter water when rainwater flows over soils into water bodies. The use of such water for food processing without proper purification will result in food contamination.

1.1.2 ***Plants and Plant Products:*** Few microorganisms find the plant environment suitable for growth. Those that persist on plant products do so by attaching to plant surfaces so that they are not easily washed away thereby contaminating foods from plant origin. Examples: Bacterial plant pathogens in the genera *Corynebacterium, Curtobacterium*, *Pseudomonas, Xanthomonas*, and pathogenic fungi.

1.1.3 ***Food Utensils:*** The utensils used for food process can also be a source of microbial contamination of food and food products. The cutting block, cutting knives and grinders in a meat market may be sources of contamination.

1.1.4 ***Gastrointestinal Tract*****:** Large intestinal contents can have as high as 10^{10} bacteria/g.

Many animals can harbour pathogens such as *Salmonella*, pathogenic *Escherichia coli* and *Campylobacter jejuni*.

1.1.5 ***Food Handlers****:* Improperly cleaned hands, lack of aesthetic sense and personal hygiene, and dirty clothes and hair can be major sources of microbial contamination in foods.

1.1.6 ***Microorganism from sewage****:* Major concern with organically grown food and many imported fruits and vegetables is the application of untreated sewage and manure as fertilizer. Pathogenic parasites can also get into food from sewage.

1.1.7 ***Microorganisms from Equipment:*** A wide variety of equipment is used in harvesting, slaughtering, transporting, processing, and storing foods. Many types of microorganisms from air, raw foods, water, and personnel can get into the equipment and contaminate foods. Example: Biofilms formation in milk processing

Post-test

1 List five major sources of foodborne pathogens in foods and indicate the measures that should be implemented to reduce their incidence in foods.

LECTURE SIX

FACTORS AFFECTING MICROBIAL GROWTH

1.0 INTRODUCTION

The ability of microorganisms to grow or multiply in a food is determined by the food environment and the environment in which the food is stored. These environments are designated as the intrinsic and extrinsic environment of food. The factors that affect microbial growth in foods, and the associations that develop from such factors determine the nature of spoilage and any health risks posed to the consumers.

Objectives

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

i. explain in details factors that affect microbial growth in foods
ii. describe the implications of those factors on food spoilage

Pre-Test

1. what are the major factors that enhance the growth of microorganisms in foods?
2. in what ways can a food microbiologist use those factors to prevent food spoilage?

CONTENTS

Two major factors that affect microbial growth are:

1.1 Intrinsic factors (Food Environment)

1.2 Extrinsic factors

1.1 Intrinsic factors: These are physical and chemical characteristics of food. These factors include:

i. Nutrient content
ii. Growth Factors and Inhibitors in Food
iii. Water Activity and Growth
iv. pH and Growth
v. Redox Potential (Oxygen and growth)

1.2 Extrinsic factors: Extrinsic factors important in microbial growth in a food include the environmental conditions in which it is stored. The extrinsic factors are:

i. Temperature,
ii. Relative humidity, and
iii. Gaseous environment.

1.1.1 Nutrient content

Microorganisms can use foods as a source of nutrients and energy. Inability of a microorganism to utilize a major component of a food material will limit its growth and put it at a competitive disadvantage compared with those that can. Microorganisms require proteins, carbohydrates, lipids, water, energy, nitrogen, sulphur, phosphorus, vitamins, and minerals for growth.

1.1.2 Growth Factors and Inhibitors in foods

Food inhibitors, depending on their mode of action, can prevent, reduce growth or kill microorganisms. Some of the natural inhibitors are lysozyme in egg, agglutinin in milk, and eugenol in cloves.

1.1.3 Water Activity (a_w) and Growth

The cytoplasm of microorganisms is surrounded by a membrane which is permeable to water molecules Water molecules pass freely from the cytoplasm to the environment and from the environment to the cytoplasm. The a_w of a food can be expressed by the ratio of water vapour pressure of the food (P, which is <1) to that of pure water (Po, which is 1).

1.1.4 pH and microbial growth

The pH of a food has a profound effect on the growth and viability of microbial cells. Each species has an optimum and a range of pH for growth. When the pH in a food is reduced below the lower limit for growth of a microbial species, the cells not only stop growing but also lose viability, the rate of which depends on the extent of pH reduction.

1.1.5 Oxidation–reduction (O–R) potential

The redox or oxidation–reduction (O–R) potential measures the potential difference in a system generated by a coupled reaction in which one substance is oxidized and a second substance is reduced simultaneously. This is usually ascribed to a combination of oxygen depletion and the production of reducing compounds such as hydrogen the microorganisms.

Redox potential (Eh) is important in microbial spoilage of a food (such as purification of meat by *Clostridium* spp. under anaerobic conditions) and to produce desirable characteristics of fermented foods (such as growth of *Penicillium* species in blue cheese under aerobic conditions).

1.2 Extrinsic factors

1.2.1 Temperature of storage,

Microbial growth is accomplished through enzymatic reactions. Within a certain range, with every 10^{o}C rise in temperature, the catalytic rate of an enzyme doubles. Similarly, the enzymatic reaction rate is reduced to half by decreasing the temperature by 10^{o}C.Because temperature influences enzyme reactions; it has an important role in microbial growth in food. The growth of microorganisms is affected by the environmental temperatures.

1.2.2 Presence and concentration of gases in the environment (Gaseous Atmosphere)

This relates to the presence and concentration of gases in the food environment. Various microorganisms require for growth, either high oxygen tension (aerobic), low oxygen tension (micro-aerobic) or absence of oxygen (anaerobic). Some microorganisms may grow either in high oxygen tension, or in the absence of oxygen (facultative anaerobes).

1.2.3 Relative humidity of food storage environment

Relative humidity is the amount of moisture in the atmosphere or food environment. Foods with low water activity placed at high humidity environment take up water, increase their water activity and get spoiled easily. For example, dry grains stored in a environment with high humidity will take up water and undergo mould spoilage.

Post-test

1. Briefly discuss how an understanding of the microbial sources in food can be helpful to a food microbiologist.
2. List five major sources of foodborne pathogens in foods and indicate the measures that should be implemented to reduce their incidence in foods.

LECTURE SEVEN

FOOD SPOILAGE & FOODBORNE DISEASES

1.0 INTRODUCTION

Food produced under proper sanitary conditions generally contains lower lever of microorganisms than that at which spoilage occurs. Growth of some of the microbial species among those initially present enables the microorganisms to reach the spoilage detection level. It is impossible to prevent access of microorganisms in food from some sources. However, it is possible to control their access to food in order to reduce the initial load and subsequently minimize microbial spoilage and health hazard. This is what regulatory agencies advocate and food processors try to achieve through sanitation.

Objectives

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

1. enumerate different forms of food spoilage
2. explain in details different methods of controlling food spoilage
3. recognize the causes of foodborne diseases, the role of microorganisms and several other agents in foodborne diseases.
4. state the importance of predisposing factors in the occurrence of a foodborne disease.

Pre-Test

1. state with specific examples the different forms of food spoilage
2. what are the major ways of preventing microbial spoilage of foods?

CONTENTS

1.1 Forms of spoilage

i. *Sliminess* e.g. in fish, meat and vegetables. It results from bacteria growth which produces tints and odour.
ii. *Rotting* e.g. root and tubers, fruits and vegetables.
iii. *Discolouration* e.g. onions. Coloured pigments are produced by microorganisms (e.g *Aspergillus niger*) growing on food undergoing spoilage
iv. *Ropiness* caused by lactic acid bacteria which cause a viscous, sticky material on foods e.g. bread, milk, soft drinks etc. others include; whiskers, putrefaction, fermentative spoilage

1.2 Control food spoilage/Food Preservation

In controlling food spoilage, several methods, either individually or in combinations are used.

The methods aimed at:

i. Controlling access of the microorganisms in foods.
ii. Physically removing the microorganisms present in foods.
iii. Preventing or reducing the growth of microorganisms and germination of spores present in foods.
iv. Killing microbial cells and spores present in foods.

Irrespective of the methods used, it is important to recognize that a control method is more effective when a food has fewer microbial cells and when the cells are in the exponential growth phase and are injured.

1.2.1 Control by physical methods

The method can partially remove microorganisms from food, and reduce the microbial level thereby enhancing other antimicrobial steps that follow to become more effective.

These methods include:

(i). **Centrifugation** - After centrifugation, food will have fewer thermoduric microorganisms (bacterial spores) that otherwise would have survived mild heat treatment (e.g., milk pasteurization).

(ii). **Trimming** - Fruits and vegetables showing damage and spoilage are generally trimmed.

(iii). **Filtration** - Filtration of liquid foods (such as wine, water, beer, soft drinks, juices etc.) will significantly reduce bacterial populations or eliminate them entirely. This method is commonly used in beer production - in order to preserve the aroma and flavour.

(iv). **Washing** - Fruits and vegetables are washed regularly to reduce temperature (which helps reduce the metabolic rate of a produce and microbial growth) and remove soil. Washing also helps remove the microorganisms present, especially from the soil.

1.2.2 Control by Heat

Heating food is to destroy vegetative cells and spores of microorganisms which include moulds, yeasts, bacteria, and viruses (including bacteriophages). Drastic heat treatment (sterilization) can be used to kill all the microorganisms present in a food. Some microorganisms also produce heat-stable proteinases and lipases in food.

1.2.3 Control by Low Temperature

Low-temperature preservation of food is to prevent or reduce growth of microorganisms. Low temperature also reduces or prevents catalytic activity of microbial enzymes, especially heat-stable proteinases and lipases.

1.2.4 Control by Reduced water activity (Aw)

Reducing A_w in food is to prevent or reduce the growth of vegetative cells and growth of spores of microorganisms. Prevention of toxin production by toxigenic moulds and bacteria is also an important consideration. Microbial cells (not spores) also suffer reversible injury and death in foods with low Aw. Reduced Aw is also used to retain viability of starter-culture bacteria for use in food bioprocessing.

1.2.5 Control by Low pH and Organic Acids

The use of weak organic acids is to reduce the pH of food to control microbial growth. As the pH drops below 5.0, some bacteria become injured and die.

1.2.6 Control by modified Atmosphere (or Reducing O-R Potential)

In this method, a food is enclosed in a high gas-barrier packaging material. The air is removed from the package, which is then flushed with a particular gas or combination of gases; and the package is hermetically sealed. The growth of aerobes (moulds, yeasts, and aerobic bacteria) is prevented in products that are either vacuum packaged or flushed with 100% CO2, 100% N2, or a mixture of CO2 and N2. Under these conditions, anaerobic and facultative anaerobic bacteria can grow unless other techniques are used to control their growth.

1.2.7 Control by Antimicrobial Preservatives

Several factors need to be considered in evaluating the suitability of an antimicrobial agent as a food preservative.

These include:

- ✓ Antimicrobial properties;
- ✓ Suitability for application in a food, and ability to meet regulatory requirements.
- ✓ To be suitable for application in a food, a compound should not only have the desired antimicrobial property but also not affect the normal quality of a food (texture, flavour, or colour).

1.2.8 Control by Irradiation

A food is irradiated because of the destructive power of ionization on microorganisms. Depending on the method used, it can either completely or partially destroy moulds, yeasts, bacterial cells and spores, and viruses. In addition, irradiation can destroy worms, insects, and larvae in food.

1.2.9 Control by Hurdle Technology

Instead of setting one parameter to the extreme limit for growth, hurdle technology combines a variety of factors such that lower concentrations of each are needed to inhibit growth. Hurdle technology is most effective when it combines two stressors that act by different mechanisms.

Examples:

- ✓ Limiting Aw of 0.85 or a limiting pH of 4.6 prevents the growth of foodborne pathogens.
- ✓ Hurdle technology might obtain similar inhibition at pH 5.2 and a_w of 0.92.
- ✓ Hurdle technology assaults multiple homeostatic processes.

1.3 FOODBORNE DISEASES

i. *Foodborne illness* – any illness carried to humans by food.

ii. *Foodborne infection* – an illness caused by the ingestion of live bacteria in or on food.

iii. *Foodborne intoxication* – an illness caused by ingestion of toxins in food, regardless of the presence or absence of live bacteria. *Toxins* – compounds produced by living organisms that cause harm to other organisms.

Examples include: Botulism caused by *Clostridium botulinum*, *Staphylococcus* infection caused by *Staphylococcus aureus*

iv. *Food poisoning* may occur due to the following:

- ✓ contamination with harmful bacteria
- ✓ toxic chemicals
- ✓ allergic reactions to certain proteins
- ✓ chemical contamination
- ✓ Mycotoxins- e.g. Aflatoxins in cereals and other harvested products

Common types of bacteria involved in food poisoning are: *Salmonellae*, *Staphylococci*, *Clostridium welchii* and so on. Symptoms –abdominal cramps, nausea, vomiting, diarrhoea etc. Causes-over eating, allergy, nutritional deficiencies, food poisoning from chemicals, toxic plants and animals, animal parasites, microorganisms, toxins produced by bacteria.

Post-Test

1. Define foodborne intoxication, infection, and illness, and give two examples for each.
2. Write in details various methods of controlling microbial spoilage of food.

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