Course Code: MCB 401

Course Title: Food Microbiology

Course Duration: Three hours per week

COURSE DETAILS:

Course Coordinator: Dr. Flora Oluwafemi B.Sc; M.Sc; PhD

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Office Location: **A111, COLNAS**

Other Lecturer: **Dr. O. R. Afolabi**

COURSE CONTENT:

Taxonomy, ecology, biochemistry and analytical technology of food microorganisms; sources of microorganisms in food, role and significance of microorganisms in food, intrinsic and extrinsic parameters of foods that affect microbial growth; fermentation; principles of food preservation: high temperature, low temperature, radiation, pressure, use of additives, drying, the microbiology of local foodstuffs: garri, palm wine, ogi, foofoo etc; food borne diseases; investigation of food-borne disease outbreaks, indices of food sanitary quality and food microbiological standards; food sanitation control and inspection, hazard analysis critical control point

COURSE REQUIREMENTS:

This is a compulsory course for all students in the department of Microbiology who are in the 400 level. A minimum of 75% attendance is required to be able to write final examination.

READING LIST:

1 Franzier, W. C. and Westhoff, D. C. 1995. Food microbiology 4th Edition. Tata McGraw-Hill
Publishing company Ltd, New Delhi

2. Adams, M.R. and Moses, M.O. Edition. Royal Society of Chemistry, Cambridge, UK

3. World Health Organization (WHO),
Geneva: http://www.ifst.org

4. Blackbun C.W.2006. Food spoilage Microorganisms, Woodhead publishing, Cambridge, UK

5. WHO 1997. HACCP introducing the hazard analysis and critical control point system. WHO/FSF/FOS/97.2

LECTURE NOTES

Taxonomy, ecology and technology of Food Microorganisms

Foods originate from plant and animal sources, all foods will have microorganisms associated with them that are involved in reducing the food to inorganic compounds in order to perpetuate the gas and mineral cycles on earth.

If the kinds of organisms associated with plant and animal foods in their natural state are known , then the general types microbes that will occur on these foods at some later stage in processing and the types of spoilage that may occur can usually be predicted .

In the past, classification of organisms into related groups was primarily based upon numerical taxonomy, a system that arranged organisms on the basis of phenotypical similarities and differences among them. Today, taxonomists try to group organisms phylogenetically, a classification scheme that mirrors evolutionary (genetic) relationships

Foods are ecosystems which composed of the environment and the organisms that live in it.

*** The food environment is composed of intrinsic factors inherent to the food (e.g pH, water activity and the nutrients) and the extrinsic factors external to it (e.g temperature, gaseous factors and the presence of other bacteria) .**

*** The extrinsic and the intrinsic factors could be manipulated to preserve foods**

- **Ecology was defined by International Commission on Microbial Specifications for foods as the study of the interactions between the chemical, physical and structural aspects of a niche and the composition of its specific microbial population.**

***Interaction emphasizes the dynamic complexity of food ecosystems.**

Factors that affect microbial growth are:

- **Intrinsic factors: Factors inherent to the food. They are chemical and physical characteristics of food.**
- **Extrinsic factors: Storage conditions of the food i.e. properties of the environment in which the food is stored.**
- **Intrinsic factors include:**
  - **Acidity (pH)**
  - **Water activity (aw)**
  - **Oxidation- reduction potential/ redox potential (Eh)**
  - **Nutrient content**
  - **Presence of antimicrobials**
  - **Biological structures**

Presence and activities of other microorganisms

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Presence and activities of other microorganisms

- **Microorganisms are able to grow in an environment with a specific pH, as shown in table 1:**

Microoganisms	Min. pH value	Opt. pH value	Max. pH
Gram +ve bacteria	4.0	7.0	8.5
Gram –ve bacteria	4.5	7.0	9.0
Yeasts	2.0	4.0- 6.0	8.5- 9.0
Molds	1.5	7.0	11.0

- **Some bacteria are:**
- **Acidophilic bacteria e.g. Lactic acid bacteria (pH 3.3 – 7.2) and acetic acid bacteria (pH 2.8 – 4.3).**
- **Basophilic bacteria e.g. *Vibrio parahaemolyticus* (pH 4.8- 11.0) and *Enterococcus spp* (pH 4.8- 10.6).**
- **Increasing the acidity of foods either through fermentation or the addition of weak acids could be used as a preservative method.**

❖ **Water activity (aw)**

- **Water activity is a measure of the water available for microorganisms to grow or reactions to take place i.e. measure of the amount of water disposable for the microorganisms.**
- **It is a ratio of water vapour pressure of the food substance to the vapour pressure of pure water at the same temperature.**
- **Water activity is expressed as:**
- **Water activity (aw) = P/ Pw where P= water vapour pressure of the food substance and Pw= water vapour pressure of pure water (Pw = 1.00).**
- **The growth of microorganisms is limited due to minimum water activity values (Table 2):**

Microoganisms	Minimum water activity (av
Gram +ve bacteria	0.95
Gram –ve bacteria	0.91
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- **No growth of any microbe below aw = 0.60**
- **Exceptions are : Halophilic bacteria (min. aw = 0.75 e.g. *Halobacter spp*), Xerophilic molds (min. aw = 0.60 e.g. *Xeromyces bisporus*) and Osmophilic yeasts (min. aw = 0.60 e.g. *Zygosaccharomyces rouxii*).**
- **The water activity of a food ranges from 0.00 – 1.00**
- **Water activity of a completely dehydrated food is 0.00**

- **Technologies to control water activity in foods are:**

✓ **Drying**

✓ **Addition of salts, sugars and glycols**

✓ **Concentrate**

❖ **Oxidation- Reduction potential (O/R or Eh)**

- **This is the ratio of the total oxidizing (electron accepting) power to the total reducing (electron donating) power of a substance.**
- **Eh is a measurement of the ease by which a substance gains or losses electrons.**
- **Eh is measured in millivolts (mV)**
- **The more oxidized substances, the higher the Eh; the more reduced substances, the lower the Eh.**
- **Microorganisms that grow at:**

✓ **high Eh or +ve Eh (require oxygen) – Aerobes**

✓ **low Eh or –ve Eh (oxygen is toxic)- Anaerobes**

✓ **high and low Eh (+ve /-ve Eh) – Facultative anaerobes**

✓ **relative low Eh values – Micro-aerophilic**

- **Technologies to control O/R in foods:**

✓ **vacuum packaging**

✓ **skin tight packaging**

✓ **gas flushing**

✓ **canning**

✓ **antioxidants**

❖ **Nutrient content**

- **Microorganisms require**

a. **Energy source such as carbohydrates, amino acids, proteins, organic acids and alcohol.**

b. **Nitrogen source such as amino acids, peptides, nucleotides, urea, proteins and ammonia.**

c. **Carbon source**

Minerals such as phosphorus, iron, manganese, magnesium, calcium and potassium.

e. Vitamins and other growth factors

❖ **Presence of antimicrobials**

- **Natural constituents of foods which affect microbial growth are:**

✓ **Lysozyme e.g. Eggs**

✓ **Lactoferrin e.g. Milk**

✓ **Lactoperoxidase e.g. Cow's milk**

✓ **Conglutinin e.g. Cow's milk**

✓ **Essential oils e.g. Spices and vegetables**

- **Preservatives such as benzoic acid, sorbic acid and nisin**

❖ **Biological structures**

- **Natural physical barriers of foods are:**

✓ **Cell walls e.g. Fruits and vegetables**

✓ **Shells e.g. Eggs**

✓ **Skin e.g. Fish**

Microbiology of local foodstuffs

Fermented foods: Fermented legumes, fermented animal protein, fermented milk, cereal, alcoholic beverages, etc.

Benefits of fermentation:

- Preservation
- Variety in flavor, types
- Inedible food become edible
- Improved digestibility
- Enhanced nutrient level
- Anti-viricidal, anti-tumour, anti-microbial etc.

Principles of food preservation

*Asepsis

*Removal of microorganisms e.g. filtration

* Maintenance of anaerobic condition

* Use of high temperature

*Use of low temperature

* Drying

* Chemical preservation

* Irradiation

* Combination of 2 or more methods

Food-borne illness: Definition---------Food-borne illness has been defined by WHO as a disease of an infectious or toxic nature caused by or thought to be caused by

the consumption of food or water. Most of food-borne diseases are microbial in origin and an important cause of reduced economic productivity.

Types of food-borne diseases

1. Food intoxication: an illness caused by a toxin or poison in food The toxin is an exotoxin, extracellular, gram +ve bacteria and occasionally gram –ve. It is protein in nature and present in filtrates of growing cell
2. Food infection: An illness caused by infection produced by organisms present in food when consumed. The toxin is an endotoxin and is cell-associated. It is a complex lipopolysaccharide of gram-ve bacteria. Toxin is intracytoplasmic and only released on autolysis or extraction of cell. The endotoxin is less potent and more specific in their action than the exotoxins

Possible causes of foodborne illness: Bacteria, Fungi, Chemicals, Viruses, Protozoa, Helminths & Algae.

Microbiological agents of foodborne illness:

BACTERIA:

Aeromonas, Bacillus cereus, Brucella species, *Campylobacter jejuni, Clostridium botulinum, Cl. Perfringens, Escherichia coli, listeria monocytogenes, Mycobacterium bovis, Salmonella Typhi, Salmonella (non-Typhi), Shigella, Staphylococcus aureus, Vibrio cholera 01, Vibrio cholerae, non-01, Vibrio parahaemolyticus, Yersinia enterocoalitica*

VIRUSES:

Hepatitis A virus, Norovirus, Rotavirus

PROTOZOA:

Cryptosporidium parvum, Entamoeba histolytica, Giardia lamblia

HELMINTHS:

Ascaris lumbricoides, Taenia saginata and *T. solium, Trichinella spiralis, Trichuris trichiura*

Factors contributing to outbreaks of food poisoning:

Preparation too far in advance, Storage at ambient temperature, inadequate cooling, contaminated processed food, undercooking, contaminated canned food,

inadequate thawing, cross contamination, food consumed raw, improper warm handling, infected food handlers, use of left over, extra large quantities prepared

The pathogenesis of diarrhoeal disease:

Causative agents confined to gut and its immediate vicinity

Patient presents acute gastroenteritis characterized by diarrhea and vomiting.

Common features of mechanisms involved in diarrhea:

Excessive evacuation of too-fluid faeces

Gut unable to absorb 8-10 litres of fluid it receives daily

Illness due to damage to host by microorganisms

Toxins are the direct cause of diarrhea (Exotoxins & Endotoxins)

Typical example is cholera toxin produced by Vibrio cholerae.

Toxin (MW84,000) comprises five B subunits and a single A subunit

B subunits bind to specific ganglioside receptors and creates hydrophilic channel

A subunit passes through the hydrophilic channel thus stimulating several biochemical reactions

Na+ and Cl^- inhibited

Cl^-, HCO_3 and Na^+ stimulated

Creates osmotic imbalance

Balancing osmosis requires massive outflow of water into intestinal lumen

Results in profuse watery diarrhoea

Investigation of food-borne disease

Necessary information obtained from the following:

Persons who ingested suspected food

Surveys of food preparation

Survey of food storage

Survey of serving operations

Samples taken and processed rapidly in the laboratory

Complete questionnaires from infected persons

Collect remnant of suspected food aseptically

Identify origin of sample, date, time of collection, name of Scientist

Brief description of symptoms of patients & suspected organism or chemical

Water samples should be taken

All sewage and plumbing be evaluated

Presence of insects and rodents must be determined

Determine any ill food handler(6-8 weeks) prior to outbreak

Any diarrhea or vomiting from food handlers, boils, carbuncles and respiratory infections

Mycotoxins: mostly food-borne, natural toxic metabolites of fungi, potent carcinogens, mutagens, teratogens, immunosuppresants

Common mycotoxins and corresponding mycoflora

Mycotoxin	Mycoflora
Aflatoxin	*Aspergillus flavus, A. parasiticus, A. nomius*
Fumonisin	*Fusarium verticilloides*
Zearalenone	*F. graminearum*
Ochratoxin	*A. Ochraceus, Penicillium verrucosum*
Patulin	*Penicillium expansum*
Ergot alkaloids	Claviceps purpurea

Toxicity of aflatoxins:

High doses----------lethal, affects lungs, myocardial and kidney tissues

Sub-lethal doses-------- causes chronic toxicity e.g liver cirrhosis

Low dose---------- human hepatocellular carcinoma

Mutagenicity: Aflatoxin B_1 binds to DNA, induces G to T transversions (p53 mutations)

Teratogenicity: embryonic abnormalities

Forms synergy with hepatitis B virus to cause liver cancer

Stunted growth in children

Immunosupression

Hazard Analysis Critical Control Point:

Detailed surveillance of a production process

Control of known hazards at specific critical stages

Objective assessment of hazards using a flow-chart

Identification of critical control points(CCPs)

Monitoring at CCPs to ensure process continues within pre-determined tolerance limit