

# FOOD MICROBIOLOGY

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# Introduction

- “ Food production occurs at specific areas and at certain periods of the year due to variation in weather conditions.
- “ Food therefore has to be collected and stored for use during periods of low or no food production.
- “ However, storage is complicated by the fact that food begin to deteriorate shortly after harvest, gather or slaughter.

# Food spoilage

- “ **Food spoilage** is defined as damage or injury to food rendering it unsuitable for human consumption.
- “ Food must be considered spoiled if it is contaminated with pathogenic microorganisms or various poisonous agents, such as pesticides, heavy metals etc.

# Table 1: Storage life of some foods

Food product	Storage life (days) at 21°C
Raw beef and mutton	1-2
Raw fish	1-2
Raw poultry	1-2
Dried salted or smoked meat and fish	360 or more
Fresh fruits	1-7
Dried fruits	360 or more
Leafy vegetables	1-2
Root crops	1-20
Dried seeds	360 or more

## Food spoilage cont....

- “ In most cases there does not need to be an evident sign of spoilage, the food might look normal and only after eating it or by careful bacteriological and toxicological investigation, one is able to realize the defect.
- “ Food decay or decomposition is implied when the term spoiled is used.

# Causes of food spoilage

- “ **(a). Growth and activity of microorganisms**  
Bacteria, yeasts and molds are microorganisms that cause food spoilage. They produce various enzymes that decompose the various constituents of food.
- “ **(b). Enzyme activity:** Action of enzymes found inherently in plant or animal tissues start the decomposition of various food components after death of plant or animal.
- “ **(c). Chemical reactions:** These are reactions that are not catalysed by enzymes.,e.g. oxidation of fat

## Causes of food spoilage cont...

- “ (d). **Vermin**. Vermin includes weevils, ants, rats, cocroaches, mice, birds, larval stages of some insects. Vermin are important due to:
  - (i). Aesthetic aspect of their presence,
  - (ii) Possible transmision of pathogenic agents,
  - (iii). Consumption of food.
- “ (e). **Physical changes**. These include those changes caused by freezing, burning, drying, pressure, etc.

# Microbial spoilage of food

- “ Bacteria, yeasts and molds are the major causes of food spoilage.
- “ They produce various enzymes that decompose the various constituents of food.
- “ **Molds** are the major causes of spoilage of foods with reduced water activity e.g dry cereals and cereal product
- “ **Bacteria** spoil foods with relatively high water activity such as milk and products.



# Sources of microorganisms in food

The primary sources of microorganisms in food include:

1. Soil and water
2. Plant and plant products
3. Food utensils
4. Intestinal tract of man and animals
5. Food handlers
6. Animal hides and skins
7. Air and dust

# Factors affecting microbial growth in food

## (a) Intrinsic factors:

These are inherent in the food. They include:

- Hydrogen ion concentration (pH),
- moisture content,
- nutrient content of the food,
- antimicrobial substances ad
- biological structures.

# 1. Hydrogen ion concentration (PH)

- “ Most bacteria grow best at neutral or weakly alkaline pH usually between 6.8 and 7.5.
- “ Some bacteria can grow within a narrow pH range of 4.5 and 9.0, e.g. salmonella
- “ Other microorganisms especially yeasts and molds and some bacteria grow within a wide pH range, e.g. molds grow between 1.5 to 11.0, while yeasts grow between 1.5 and 8.5.

## Table 2: pH values of some food products

Food type	Range of pH values
Beef	5.1 - 6.2
Chicken	6.2 – 6.4
Milk	6.3 – 6.8
Cheese	4.9 - 5.9
Fish	6.6 - 6.8
Oyster	4.8 - 6.3
Fruits	< 4.5 (most < 3.5)
Vegetables	3.0 – 6.1

- “ Microorganisms that are able to grow in acid environment are called **acidophilic microorganisms**.
- “ These microorganisms are able to grow at pH of around 2.0.
- “ **Yeasts** and **molds** grow under acid conditions.
- “ Other microorganisms such as *vibrio cholerae* are sensitive to acids and prefer **alkaline conditions**.
- “ **Most bacteria** are killed in strong acid or strong alkaline environment except Mycobacteria.

**Table 3: Minimum and maximum pH for growth of some specific microorganism**

Microorganism	Minimum	Maximum
<i>Escherihia coli</i>	4.4	9.0
<i>Salmonella typhi</i>	4.5	8.8
All bacteria	4.0	9.0
Molds	1.5	11.0
Yeast	1.5	8.5

## 2. Moisture content

- “ The effect of moisture is in terms of water activity: -the amount of free water in a food medium.
- “ The amount of free water is important for growth of microorganisms.
- “ If there is lack of this free water microorganisms will not grow.
- “ Water activity is defined as the vapour pressure of a food substance to that of water at the same temperature. ( $A_w = \frac{VP_{Food}}{VP_{Water}}$ )

# Moisture content

- “ The water activity is therefore equal to 1.0.
- “ Food products have a water activity of less than 1.0.
- “ A saturated salt solution has a water activity of 0.75.
- “ Salting and drying reduces the water activity of a food product.



## Table 4: Water activity of some food products.

Food Product	Water activity
Raw meat and milk	0.99- 1.0
Luncheon meat	0.95
Boiled ham, sliced bacon	0.90
Dried grains	0.80

# Water activity levels

- “ Growth of microorganisms is greatly affected by the level of water activity( $A_w$ ) in the food.
- “ Inhibition of growth occurs if the water activity for food is lowered beyond an organism's minimum level of water activity that is necessary for growth.
- “ Microorganisms have varied minimum water activity requirements that supports their growth in food.

**Table 5: Minimum water activity that supports growth of some microorganisms**

Microorganism	Water activity
Clostridium botulinum,	0.95
Bacillus cereus,	0.95
Pseudomonas aeruginosa,	0.95
Salmonella spp.	0.95
Staphylococcus aureus (anaerobic), Candida spp., Saccharomyces	0.90
Staphylococcus aureus (aerobic)	0.86
Penicillium spp.	0.82
Most spoilage yeast	0.88
Most spoilage molds	0.80
Osmotic yeast	0.70

## 3. Nutrients content of the food

- “ Microorganisms require proteins, carbohydrates, lipids, water, energy, nitrogen, sulphur, phosphorus, vitamins, and minerals for growth.
- “ Various foods have specific nutrients that help in microbial growth.
- “ Foods such as milk, meat and eggs contain a number of nutrients that are required by microorganisms.
- “ These foods are hence susceptible to microbial spoilage.

# Antimicrobial substances

- “ Antimicrobial substances in food inhibit microbial growth.
- “ Various foods have inherent antimicrobial substances that prevent (inhibit) microbial attack.
- “ Such inhibitors are like **lactinin** and **anti-coliform factors** in milk and **lysozyme** in eggs.

# Biological structures

- “ Some foods have biological structures that prevent microbial entry.
- “ For example, meat has fascia, skin and other membranes that prevent microbial entry.
- “ Eggs have shell and inner membranes that prevent yolk and egg white from infection.

## **(b). Extrinsic factors**

- ” Are factors external to the food that affect microbial growth. They include:
1. Temperature of storage,
  2. Presence and concentration of gases in the environment
  3. Relative humidity of food storage environment.

# 1. Temperature

- “ The growth of microorganisms is affected by the environmental temperatures.
- “ Various microorganisms are able to grow at certain temperatures and not others.
- “ Bacteria can therefore be divided into the following groups depending upon their optimum temperature of growth.



## (i). Psychrophilic microorganisms

- “ These grow best at about 20°C but also down to -10°C in unfrozen media.
- “ Psychrophilic bacteria can cause food spoilage at low temperatures.
- “ Several of the microorganisms found in the soil and water belong to this group.

## (ii). Mesophilic bacteria

- “ These organisms grow between 25°C and 40°C, with an optimum growth temperature close to 37°C
- “ Some such as *Pseudomonas aeruginosa* may grow at even lower temperatures between 5-43°C
- “ None of the mesophilic bacteria are able to grow below 5°C or above 45°C.
- “ Most pathogenic bacteria belong to this group.

## (ii). Thermophilic bacteria.

- “ These grow at temperatures above 45°C. Often their optimum growth temperatures is between 50°C and 70°C.
- “ Growth of some bacteria occur at 80°C.
- “ Bacteria in this group are mainly spore formers and are of importance in the food industry especially in processed foods.

## Note that:

- “ The effect of temperature on microbial growth also depends upon other environmental conditions such as:
  - Growth factors in the nutrient medium,
  - pH of the food, and
  - Water activity.

## 2. Concentration of gases in the environment

- “ 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 (microaerobic) or absence of oxygen (anaerobic).
- “ Some microorganisms may grow either in high oxygen tension, or in the absence of oxygen (facultative anaerobes).

# Foods affected by various groups

- “ **Anaerobic** or **facultatively anaerobic** sporeformers are most likely to grow in canned foods .
- “ **Microaerophilic bacteria** are most likely to grow in vacuum packed foods since they have low oxygen tension, while
- “ **Aerobic bacteria** are likely to grow on the surface of raw meat.
- “ **Aerobic molds** will grow in insufficiently dried or salted products

### 3. Relative humidity

- “ 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 mold spoilage.

# Food preservation

- “ Food preservation is a process through which physical and /or chemical agents are used to prevent microbial spoilage of food.
- “ Food preservation aims at treating food in a manner to prolong its storage life
- “ In food preservation, efforts are made to destroy organisms in the food,or
- “ Increase the period taken by microorganism to adapt to the food environment before they start to spoil the food.



# Food preservation principles

- “ Two general principles are employed in food preservation.
- “ (1). Inhibition principle
- “ (2). Killing principle

# (1). Inhibition principle

- “ In this principle, food preservation is achieved by inhibition of growth and multiplication of microorganisms.
- “ The inhibition principle can be achieved by any of the following methods:
  - “ (a). Reduction of water activity e.g. By drying and salting
  - “ (b). Reduction in pH e.g. by fermentation and addition of acids.
  - “ (c). Use of preservatives, e.g. sodium benzoate
  - “ (d). Use of low temperatures (chilling or freezing)
  - “ (e). Smoking – which has a drying and preservative effect

# Inhibition methods

- “ Preservation of food by inhibition methods does not necessarily imply the destruction of organisms,
- “ On removal of the inhibiting influence, the food will undergo spoilage as the microorganism present will grow and multiply to cause spoilage.

# Food preservation by lowering pH

- “ Many food products can be preserved by lowering pH so that the growth of spoilage and pathogenic bacteria is prevented.
- “ The lowering of pH can be achieved by **addition of acids** and **fermentation**
- “ Fermentation is the breakdown of carbohydrates under anaerobic conditions into alcohol or lactic acid and carbon dioxide.

# Food preservation by lowering water activity

Lowering of water activity can be achieved by:

- “ **Addition of high content of salt:** Sodium chloride and sometimes nitrates and nitrites
- “ **Addition of high content of sugar**
- “ **Drying:** sun/air drying; electrical drying or freeze drying.

# The salting procedure

The salting procedure can be performed in four ways:

1. **Dry cure** in which the meat or fish is rubbed with salt
2. **Pickling**: The products are immersed in pickle of brine, usually containing about 15% salt.
3. **The injection cure**: concentrated salt injected to muscles
4. **Direct addition method**

## Preservation of food by addition of high content of sugar

- “ **Monosaccharides** such as glucose(dextrose) and fructose are more effective in reducing the water activity than disaccharides like sucrose.
- “ Thermophiles are more susceptible to the action of sugar than than other bacteria.
- “ Osmophilic yeasts are able to tolerate very high concentrations of sugar and cause food spoilage.

# Food preservation by use of low temperatures

- “ Two methods are employed to arrest microbial growth and multiplication.
- “ These are **chilling** (cold storage) and **freezing**.
- “ Chilling is keeping food at temperatures between 0-15°C. The common chilling temperatures ranges between 4-5°C.
- “ Freezing is keeping food at temperatures between 0°C and -35°C.



# Effect of low temperatures

- “ Low temperatures are used to retard chemical reactions and actions of food enzymes and to slow down or stop the growth and activity of microorganisms in the food.
- “ A low enough temperature will prevent growth of any microorganisms.
- “ Spores are not usually injured at all by freezing. However, most parasites are killed by freezing.

## **(2). Killing principle**

“ In this principle, spoilage microorganisms are destroyed (Killed) in the food, and the food protected against subsequent contamination by being enclosed in an air tight container.

# Methods employed to achieve the killing principle

- 1. Heat treatment:** through **pasteurization** or **sterilization**
- 2. Irradiation** with either ionizing or electromagnetic radiation e.g gamma rays, cobalt 60 radioactive particles. Radiations kill microorganisms by destruction of DNA and by creating toxic reactive compounds in a medium and in microbial cells
- 3. Use of gases:** by use of ethylene oxide or ozone. The gases destroy both vegetative cells and spores.

# Pasteurization

- “ Is the process of heat treatment at specific temperatures and times.
- “ Pasteurization is aimed at destroying all pathogenic microorganisms without affection the nutritive value of the food.

# Three methods of pasteurization

- a. Low temperature long time (63°C for 30 min)
- b. High Temperature short time (72°C for 15 seconds)
- c. Flash method (80°C for 1-2 seconds)

# Sterilization

- “ Is the use of physical or chemical means to destroy all microorganisms that are present in the food.
- “ Sterilization can be achieved by:
  - a. Heating at high temperatures, e.g. 100-140°C
  - b. Irradiation: Irradiation kills bacteria, spores, and insects as well as inactivates enzymes.

# Applications

- “ In practice, often a combination of inhibition and killing principles and the various methods are used depending on the food type. e.g.
  - . use of pasteurization and chilling of milk,
  - . lowering of water activity and low temperature storage,
  - . use of preservatives and low temperature etc.

# Important terminologies on use of heat in food preservation

“D- value

“Z- value

“F-value



## Decimal reduction Time (D-Value)

- “ Is the time required at any temperature to destroy 90% of the spores or vegetative cells of a given organism.
- “ The higher the temperature, the faster is the rate of destruction and the shorter it takes to kill 90% of the cells.
- “ For example, D-value for *Clostridium sporogenes* in a given food at 120°C is 1 minutes, at 115°C is 4 minutes, at 110°C is 10 minutes.

## D-Value cont..

- “ The larger the initial number of vegetative cells or spores, the longer it will take to destroy 90 % of the cells at a given temperature.
- “ D- value is numerically equal to the number of minutes required for the survivor curve to trasverse one log cycle.
- “ If the intial number is one million per ml, one log cycle will reduce this number to 100 per ml.

# Z-value

- “ **The Z value:** Is the number of degrees the temperature has to be increased in order to reduce the thermal death time tenfold.
- “ The z value is relatively constant and depends very little upon the environment.
- “ For spores of bacteria, the z - value used is 10°C.

## Z- value

- “ The spore killing effect of a heat treatment can be expressed as a function of temperature and the time the material has been exposed to that heat.
- “ For example, when it takes 1 min to kill 90% of the remaining spores at 120°C, it will take 10 min to obtain the same effect at 110°C, and it will take 100 min at 100°C.

# F-value

- “ **F-value.** The F-value express the time taken to expose food to the same amount of heat required to destroy spores and vegetative cells of a particular organism using different temperatures.
- “ For example, food heated at 121.1°C for 2 minutes will give a value  $F=2$ . To get the same F-value of 2 using 111.1°C, one needs to heat the food for 20 min.

# F-value

- “ Heating such a food at 111.1°C for 2 minutes will give F value of  $2/10 = 0.2$ .
- “ This means that one can obtain the same killing effect of spores and /or vegetative cells at a lower temperature, provided the time of exposure is longer.
- “ Thus, F-value shows the heat treatment given to a food product to destroy bacteria.

# F-value

“ As far as spore killing is concerned,  $F=1$  is equal to 1 min at  $121^{\circ}\text{C}$  (or 10 min at  $111.1^{\circ}\text{C}$  or 100 min at  $101.1^{\circ}\text{C}$ .)

THANK YOU FOR  
LISTENING