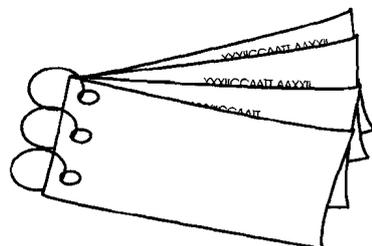


## UNIT 3 FACTORS AFFECTING MULTIPLICATION AND SURVIVAL OF MICROORGANISMS



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- Knowledge of factors that favour or inhibit the growth of microorganisms is essential to understand how food spoils and how it can be preserved.
- In order to eliminate microbes from our foods or at least prevent their growth, conditions of storage and processing need to be adjusted.
- Chief factors influencing microbial activity in a food are hydrogen ion concentration (pH), moisture, oxidation- reduction (O-R) potential, temperature, nutrients and the presence of inhibitory substances or barriers.
- When conditions are not favourable for their growth or survival, microbes slow down their activity i.e. they become dormant. Difficult conditions are countered by forming spores (bacteria, fungi) or cysts (protozoa). Most spores and cysts can survive normal pasteurization and cooking temperatures. Subsequently, if the food is left at room temperature for a long time, the spores may germinate or cysts get activated or and lead to food poisoning.

### 3.1 Factors Influencing Microbial Growth

- Several factors determine survival and growth of microorganisms in a food. Each microorganism has a maximal, optimal and minimal requirement level for each of these factors.
- Optimal levels correspond with maximum growth of the microbe.

### *Hydrogen-Ion Concentration (pH)*

- Every microorganism has a minimal, maximal and optimal pH for growth.
- Food with low pH values (below 4.5) are not readily spoiled by bacteria and are more susceptible to spoilage by yeasts and moulds. Foods may have a low pH because of inherent acidity e.g. fruits or developed acidity as a result of microbial activity e.g. curd.
- Moulds can grow over a wider range of pH values than most yeasts and bacteria and many moulds grow at acidities too great for yeasts and bacteria to survive. Most yeasts do not grow well in alkaline substrates. Most bacteria are favoured by a pH near neutrality.

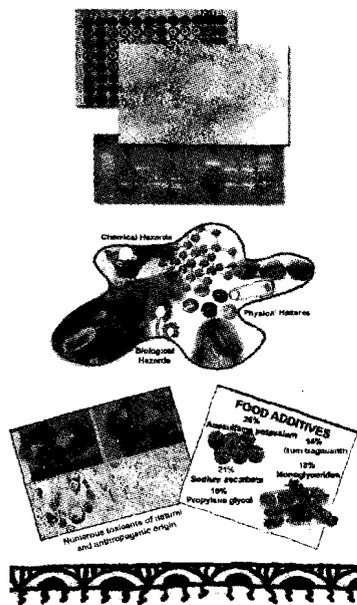
## **3.2 Moisture Requirement and Water Activity**

- Microorganisms have an absolute demand for water, for without water no growth can occur. The exact amount of water needed for growth of microorganisms varies.
- Water requirement is best expressed in terms of available water  $a_w$  calculated by vapour pressure of the solution (of solutes present in foods) divided by vapour pressure of the solvent (usually water). The value for  $a_w$  for pure water would be 1.00 and for a 1.0 M solution of ideal solute  $a_w$  would be 0.9823.
- As  $a_w$  is reduced below the optimal level, there is a decrease in rate of growth and metabolism. Most bacteria grow well in a medium with  $a_w$  approaching 1.00 (at 0.995 to 0.998) They grow best in low concentrations of sugar/ salt though there are exceptions.
- Bacteria require more moisture than yeasts and yeasts more than moulds.  $A_w$  would have to be below 0.62 to stop all chances of mould growth.
- Microorganisms that can grow in high concentrations of solutes e.g. sugar and salt obviously have a low minimal  $a_w$ . Halophilic bacteria require minimal concentrations of dissolved sodium chloride for growth. Osmophilic yeasts grow best in high concentrations of sugar.

### *Oxidation-Reduction (O-R) Potential*

- The oxygen tension or partial pressure of oxygen around a food and the O-R potential or reducing and oxidizing power of the food itself influence the type of organisms which will grow and hence the changes produced in the food. The O-R potential of the food is determined by the oxygen tension of the atmosphere about the food and the access which the atmosphere has to the food.
- High O-R potential favours aerobes but will permit growth of facultative anaerobic organisms. Aerobes require oxygen for growth and can grow when incubated in an air atmosphere. Facultative anaerobes do not require oxygen for growth although they may use it for energy production if available. They are not inhibited by oxygen and usually grow as well under an air atmosphere as they do in the absence of oxygen.

- Growth of an organism may alter O-R potential of a food enough to restrain other organisms. Anaerobes, for example, may lower the O-R potential to a level inhibitory to aerobes.
- Moulds are aerobic, most yeasts grow best aerobically.
- Bacteria may be anaerobic, aerobic or facultative. They can be divided into four groups.
  1. Aerobic bacteria require oxygen for growth and can grow when incubated in an air atmosphere (i.e. 21 percent oxygen).
  2. Anaerobic bacteria do not use oxygen to obtain energy. Moreover, oxygen is toxic for them and they cannot grow when incubated in an air atmosphere. Some can tolerate low levels of oxygen (non-stringent or tolerant anaerobes), but others (stringent or strict anaerobes) cannot tolerate even low levels and may die upon brief exposure to air.
  3. Facultative Anaerobic bacteria do not require oxygen for growth, although they may use it for energy production if it is available. They are not inhibited by oxygen and usually grow as well under an air atmosphere as they do in the absence of oxygen.
  4. Microaerophilic bacteria require low levels of oxygen for growth but cannot tolerate the level of oxygen present in an air atmosphere.



### 3.3 Temperature

- All processes of growth are dependent on chemical reactions, the rates of which are influenced by temperature.
- On the basis of temperature preferences, bacteria are divided into three main groups.
  1. Psychrophiles are able to grow at 0 °C or lower, though they grow best at higher temperatures, the maximum temperature being 20 °C.
  2. Mesophiles grow best within a temperature range of approximately 25 to 40 °C. For example, all bacteria that are pathogenic for humans and warm-blooded animals are mesophiles, most growing best at about body temperature (37 °C).
  3. Thermophiles grow best at temperatures above 45 °C. Some thermophilic bacteria have been detected in hot water or sulphur springs also. These bacteria are surviving at very high temperatures.
- Knowledge of the maximum temperature which can be tolerated by the microbe is important in using cooking methods to destroy microbes and their spores.

### 3.4 Nutritive Content

- Nutrients in food, their kinds and proportions are important in determining the organism most likely to grow.

- Carbohydrates (especially sugars) are most commonly used as the source of energy. When carbohydrates are unavailable, some microbes are able to utilize fats and proteins as an energy source.
- Organisms requiring special accessory growth substances might be prevented from growing if one or more of these vitamins or minerals were lacking.
- When nutrients are in short supply the growth of microbes is naturally restricted.
- Moulds can utilize many more kinds of food compared to bacteria. This is because most common moulds possess a variety of enzymes with the help of which they are able to digest simple and complex substances.

### 3.5 Others

- Phototrophic bacteria need light as a source of energy.
- Bacterial growth may be influenced by hydrostatic pressure.
- Presence of inhibitory substances in food such as lysozyme in egg white, lactenins and anticoliform factor in freshly drawn milk. Chemical preservatives are sometimes added to foods to retard growth of microbes e.g. potassium metabisulphite, sodium benzoate.
- A microorganism growing in a food may produce one or more substances inhibiting growth of other microbes e.g. propionic acid produced by bacteria in Swiss Cheese inhibits growth of moulds.
- Heating or other forms of food processing may result in formation of inhibitory compounds in foods e.g. oxidation products when fat is heated. Furfural is produced on browning concentrated sugar syrups.
- Protective covering on some foods determines the kind of microbes that can survive. Increase in exposed surface may facilitate the spoilage microbes.

### 3.6 Food Safety Implications

- By modifying the environment in which the microbes are growing, we can either kill the microbes or at least restrict their growth.
- We can slow down the rate of growth by suitably changing pH of food. Lowering pH i.e. making food acidic usually restricts growth of most harmful bacteria.
- Unfavourable  $a_w$  will result not only in a reduction in rate of growth but also in a lowered maximal yield of cells. The more unfavourable the  $a_w$  of the substrate, the greater the delay in initiation of growth or germination of spores. This often is as important in food preservation as reduction in rate of growth of the organism. Hence, reducing the moisture content of foods by drying or adding solutes like sugar or salt in high concentrations can help in food preservation.
- Heating food to high temperatures can destroy microbes which cannot tolerate high temperatures. Storing food at low temperatures of the refrigerator or freezing slows down growth of most organisms.

- Making the gaseous environment unfavourable by either removal or addition of oxygen also helps, depending on the type of microbe. The growth of an aerobic microbe is restricted by restricting the supply of oxygen e.g. packaging food in a vacuum or in a nitrogen environment. Increasing the concentration of oxygen is detrimental for growth of anaerobic microbes.
- Organisms might be prevented from growing if one or more of nutrients like carbohydrates, proteins and vitamins were lacking. Addition of inhibitory substances like preservatives will also achieve desired results.



### Key Terms

**Aerobic:** Organism requiring free oxygen for survival.

**Anaerobic:** Organism growing best in the absence of free oxygen.

**Facultative:** Organism growing well either aerobically or anaerobically.

**Halophilic:** Organism requiring minimal concentrations of dissolved sodium chloride for growth.

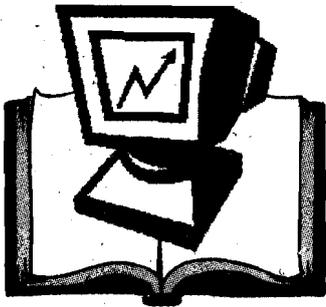
**Mesophile:** Organism growing best within a temperature range of approximately 25 to 40 °C.

**Microaerophilic:** Bacteria which require low levels of oxygen for growth but cannot tolerate the level of oxygen present in an air atmosphere.

**Osmophilic:** Organism growing best in high concentrations of sugar.

**Psychrophiles:** Microbes able to grow at 0 °C or lower.

**Thermophiles:** Organism growing best at temperatures above 45 °C.



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