RAMA UNIVERSITY

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FACULTY OF ENGINEERING & TECHNOLOGY

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1. INTRODUCTION

- Food biotechnology is the application of technology to modify genes of animals, plants, and microorganisms to create new species which have desired production, marketing, or nutrition related properties.

Biotechnology

Any technological application that uses biological systems, living organisms or derivatives to make or modify products or processes for a specific use:

Traditional plant breeding

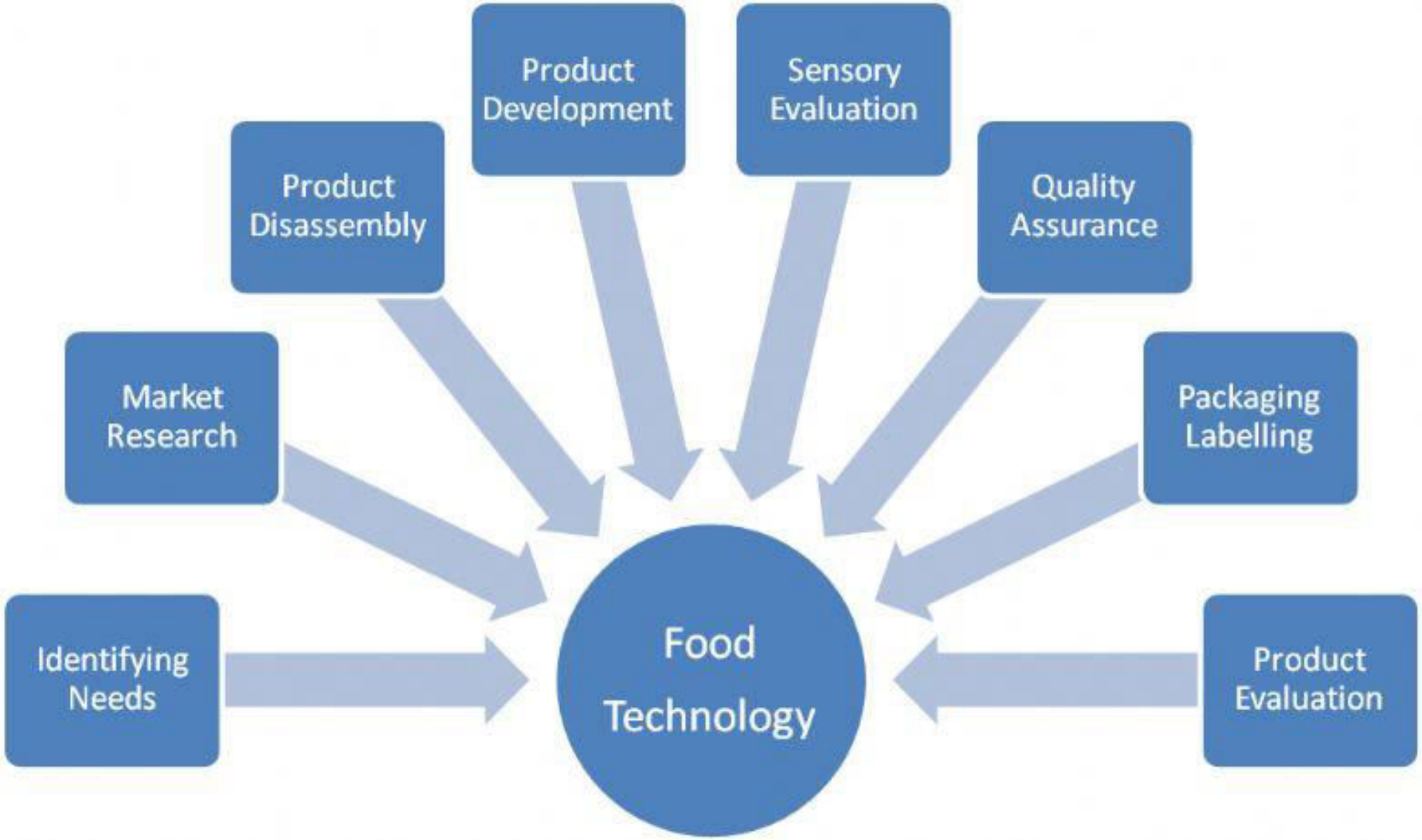
Old biotechnology – tissue culture, fermentation

Recently: Modern biotechnology:

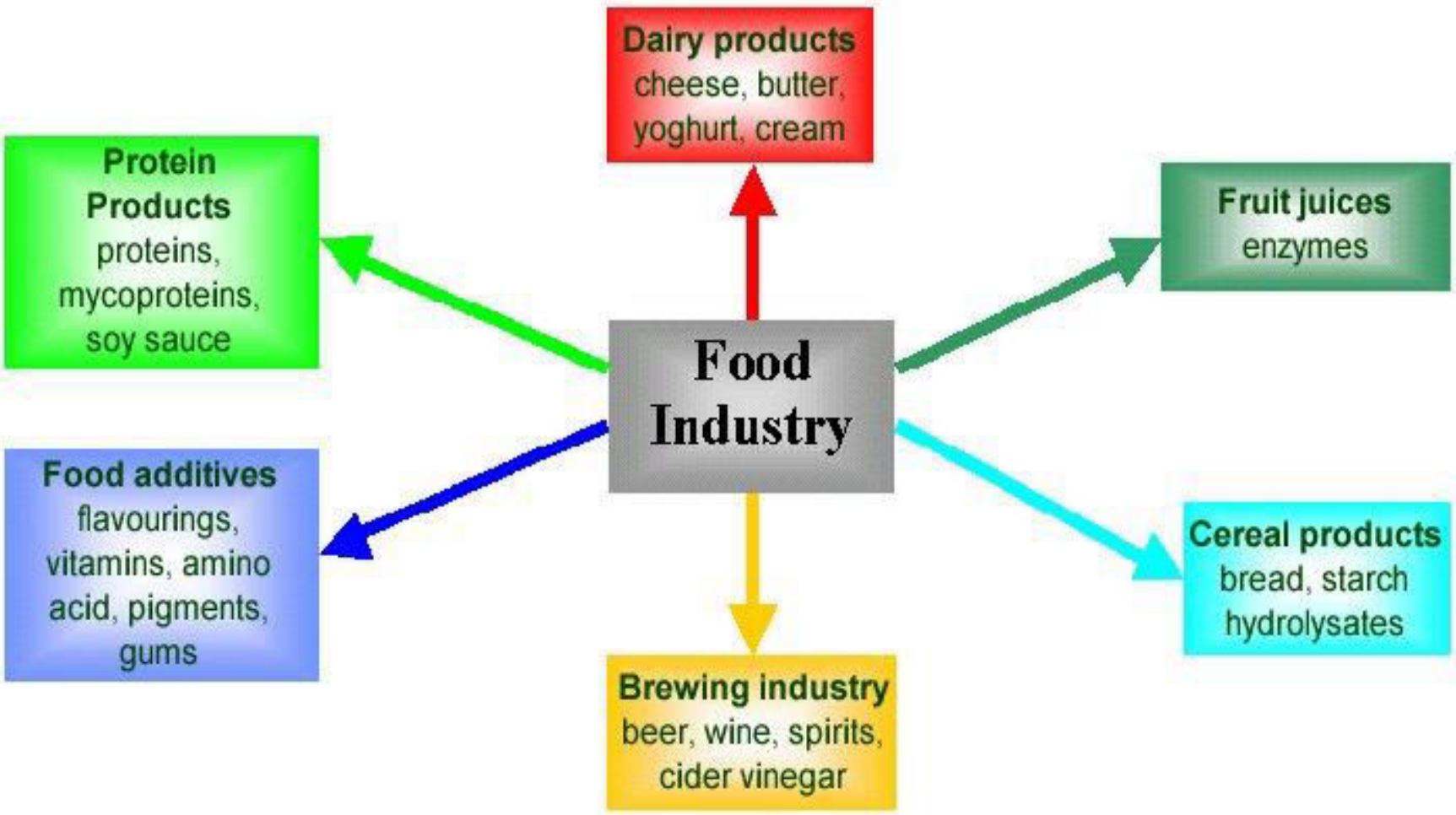
In vitro nucleic acid techniques including

Recombinant DNA technology – direct injection of DNA into cells or organelles, fusion of cells beyond taxonomic family -→ overcome natural physiological, reproductive or recombination barriers….. Not used in traditional breeding & selection

Food Technology



Food Production



- **History of food industry can be traced by developments w.r.t**
  - **Food preservation techniques**
  - **Food Microbes**
  - **Food poisoning**
  - **Food Laws**

Food Preservation Techniques

- **1843 - Sterilization by steam was first attempted by I. Winslow in Maine.**
- **1853—R. Chevallier-Appert obtained a patent for sterilization of food by autoclaving.**
- **1855-Grim wade in England was the first to produce powdered milk.**

-A patent was issued to H. Benjamin in England for freezing foods by immersion in an ice and salt brine.

- **1917—Clarence Birdseye in the United States began work on the freezing of foods for the retail trade.**

Food Preservation Techniques

- 1929—A patent issued in France proposed the

use of high-energy radiation for the processing of foods.

- 1954— The antibiotic nisin was patented in England

for use in certain processed cheeses to control clostridial defects,

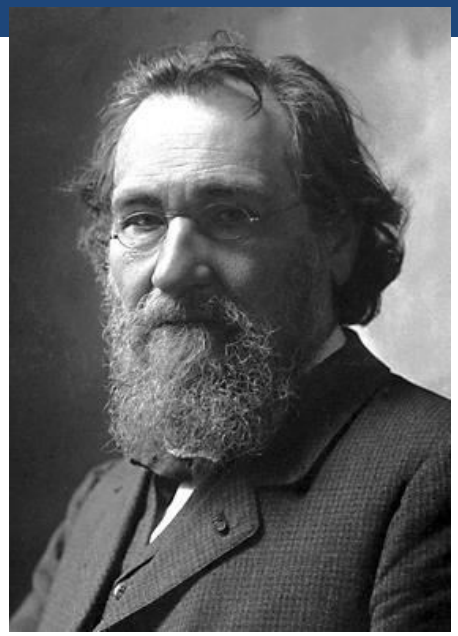
- 1955—Sorbic acid was approved for use as a food preservative.
- 1988—Nisin accorded GRAS (generally regarded as safe) status in the United States.
- 1997—Ozone was declared GRAS by the U.S. Food and Drug Administration for food use.

Food Microbes

- **1659— Kircher demonstrated the occurrence of bacteria in milk**
- **1780— Scheele identified lactic acid as the principal acid in sour milk.**
- **1857— Pasteur showed that the souring of milk was caused by the growth of organisms in it.**
- **1867—Martin advanced the theory that cheese ripening was similar to alcoholic, lactic, and butyric fermentations.**
- **1873— Lister was first to isolate *Lactococcus lactis* in pure culture.**
- **1876— Tyndall observed that bacteria in decomposing substances were always traceable to air, substances, or containers.**

Food Microbes

- **1878—Cienkowski reported the first microbiological study of sugar slimes**
- **1907—E. Metchnikoff and co-workers isolated and named one of the yogurt bacteria, *Lactobacillus bulgaricus*.**
- **1915—*Bacillus coagulans* was first isolated from coagulated milk by B. W. Hammer.**
- **1917—*Bacillus stearothermophilus* was first isolated from cream-style corn by RJ. Donk.**



"Father of natural immunity"

In particular, Mechnikov is credited with the discovery of macrophages in 1882. Mechnikov received the Nobel Prize in Medicine in 1908, shared with Paul Ehrlich, for his work on phagocytosis.

Metchnikoff thus attributed health benefits to lactic-acid producing bacteria, suggesting that “oral administration of cultures of fermentative bacteria would implant the beneficial bacteria in the intestinal tract.”

Mechnikov himself consumed daily sour milk fermented with the bacteria he called “Bulgarian Bacillus” (later described as Lactobacillus delbrueckii subsp. Bulgaricus) and physicians began prescribing the sour milk diet for their patients. Probiotics were born.

Food poisoning

- **1820—The German poet Justinus Kerner described "sausage poisoning" (which in all probability was botulism) and its high fatality rate.**
- **1857—Milk was incriminated as a transmitter of typhoid fever by W. Taylor of Penrith, England.**
- **1894—T. Denys was the first to associate staphylococci with food poisoning.**
- **1904—Type A strain of C. *botulinum* was identified**

by G. Landman.

- **1906— *Bacillus cereus* food poisoning was recognized**

Food poisoning

- **1938-Outbreaks of *Campylobacter* enteritis were traced to milk in Illinois.**
- **1945— McClung was the first to prove the etiologic status of *Clostridium perfringens (welchii)* in food poisoning.**
- **1960—Type F strain of C. *botulinum* identified by Moller and Scheibel.**
- **1960— The production of aflatoxins by *Aspergillus flavus* was first reported.**
- **1969— *C. perfringens* enterotoxin was demonstrated by CL. Duncan and D.H. Strong.**

Food poisoning

- **1975—*Salmonella* enterotoxin was demonstrated by L.R. Koupal and R.H. Deibel.**
- **1983—*Campylobacter jejuni* enterotoxin was**

described by Ruiz-Palacios et al.

- **1986—Bovine spongiform encephalopathy**

(BSE) was first diagnosed in cattle in the United Kingdom.

Food Laws

1939- The new Food, Drug, and Cosmetic Act became law.

2006- The Food Safety and Standards Authority of India (FSSAI) has been established under Food Safety and Standards Act, 2006.

Various central Acts like Prevention of Food Adulteration Act, 1954 , Fruit Products Order , 1955, Meat Food Products Order , 1973, Vegetable Oil Products (Control) Order, 1947,Edible Oils Packaging (Regulation)Order 1988, Solvent Extracted Oil, De- Oiled Meal and Edible Flour (Control) Order, 1967, Milk and Milk Products Order, 1992 etc was repealed after commencement of FSS Act, 2006.

Current Status and Future

- Genetically modified foods
- Probiotics
- Novel Food products (HFCS, QUORN)
- Advanced enumeration and detection techniques
- Sequencing of genomes

ROLE AND SIGNIFICANCE OF MICROORGANISM IN FOODS

Introduction

- Food supply consists basically of plants and animals or product derived from them.
- it is understandable that our food supply can contain microorganism in interaction with food.
- These microorganisms use food supply as a source of nutrients for their own growth.

These will cause 2 possibilities:

- Either – Result in deterioration of food ("spoil")

- OR These interactions between microorganisms and food give beneficial to human.



How microorganisms can cause deterioration of the food?

- When they utilize the nutrients of the food, it involved changes in the food compound like:

- synthesis a new compound that cause spoiling of the food.

or

- produced enzymatic changes and contributing off-flavours by mean of breakdown of product.

What are the importance of microorganisms in food?

Good (desirable)	Bad (undesirable)
Food bioprocessing	Foodborne disease
Food biopreservation	Food spoilage
Probiotics	

GOOD (DESIRABLE)

- Food bioprocessing

means: Foods produce by using **biological process**.

- In this process, food-grade microorganisms are used to produce different types of fermented food using raw materials from animal and plant sources (this process known as “starter culture”).
- Besides, microbial enzymes are also being used to produce food and food additives.

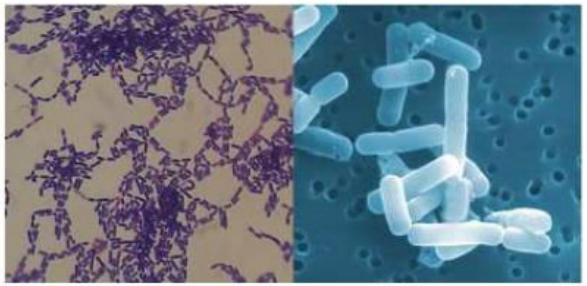
- Food biopreservation

  Is a food biological preservative by using antimicrobial metabolites (taken from certain microorganisms in order to control pathogenic and spoilage microorganisms in foods)

- In biopreservation, beneficial bacteria are used to prevent food spoilage and get rid of harmful pathogens.

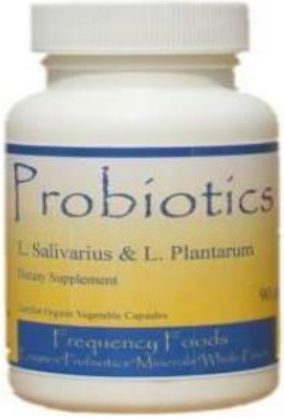
- Lactic acid bacteria (LAB) are the most commonly used due to their unique properties and because they are harmless to humans.

- LABs release antimicrobials(such as lactic and acetic acid, hydrogen peroxide, and peptide bacteriocins) that stop spoilage and inhibit the growth of potentially harmful pathogens.



- Probiotics

Is a concentrated supplement of beneficial live cells of bacteria (friendly bacteria) culture taken orally intended to improve our health by promoting our body's natural immunity and improving digestion system.



The example of probiotics in food

- Milk- baby nowadays is added with *Lactobacillus acidophilus* and *Bifidus* bacteria.
- Yogurt- rich with live bacteria culture such as *Lactobacillus bulgaricus* and *Streptococcus thermophillus.*
- Cheese- friendly bacteria that is added in cheese is Lactobacillus.

- **BAD (UNDESIRABLE)**
- Foodborne disease

Is a disease cause by consumption of contaminate during various stage of handling between production and consumption by many pathogenic microorganisms (bacteria, molds and viruses).

- Food spoilage.

is a condition of contaminate food due to:

growth of microorganisms in food

OR

The action of microbial heat stable enzymes

-Spoilage leads to wastage of food and economic loss.

Factors influencing growth of microorganisms in foods

(a) Intrinsic factors:

These are inherent in the food. They include:

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

1. Hydrogen ion concentration (PH)

- Most bacteria grow best at neutral or weakly alkaline pH usually between 6.8 and 7.5.

- 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 : 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

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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.

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 egg-white 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:

  - Temperature of storage,
  - Presence and concentration of gases in the environment
  - Relative humidity of food storage environment.

1. Temperature

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

(i). Psychrophilic

- 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.
- Bacteria of the genera

  - *Achromobacter, Flavobacterium, Pseudomonas*, and *Micrococcus are psychrophiles*

  - moulds of the genara *Penicillium,Cladosporium* and *Mucor* are psychrophiles.

(ii). Mesophilic

- These organisms grow between 25°C and 40°C, with an optimum growth temperature close to 37°C .
- None of the mesophilic bacteria are able to grow below 5°C or above 45°C.
-
- Most pathogenic bacteria belong to this group.

(iii). Thermophilic

- 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.

- *Bacillus stearothermophilus* can survive ultra-high-temperature treatment (UHT)of milk(135°C for 2 seconds).

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).

Microorganisms can be grouped into categories based on their requirement to oxygen:

1) Aerobes

- Grow in the presence of air that contains molecular oxygen.
- Obligate aerobes require oxygen for growth and carry out aerobic respiration.

2) **Microaerophiles**

- Grow only at reduced concentrations of molecular oxygen - 5%

3) Facultative anaerobes

- Can grow in the presence or absence of air. If oxygen is not available, they will carry out anaerobic respiration.

4) Anaerobes

- Do not require oxygen for growth, therefore grow only in the absence of air.
- Strict anaerobes are sensitive to oxygen and even to a brief exposure to oxygen will kill such organisms e.g. Clostridium spp

3. Relative humidity

- Relative humidiy 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.