FOOD TECHNOLOGY

1. Introduction

1.1. Definition of Food Technology

Food Technology is the use of science of food for the collection, conservation, processing, wrapping, supply, and use of non-toxic, nourishing, and healthy food.

Food technology has grown in an interdisciplinary zone of functional science and engineering grounded on food science and on chemical engineering. India is principallycentred on agriculture.The request for constantgood quality food throughout the year at distant places has resulted inupgraded food processing technologies. Now, industries related to food have nearly doubled the dimension of chemical industries.

The raw products of present day foods generally originate from two major sources: the plant and animal kingdoms. We still rely on the agricultural lands, lakes, rivers, and the seas for their origin in forests and wildlife, and in many parts of the world they still constitute important sources of food. The plant and animal products that compose our foods and food products may be classified in the following way:

1.2. Food industries can be distributed in the following units:

- Customer food (confectionaries, soft drinks bakery and cocoa products, etc.)
- Grain processing: Corn (maize), wheat, barley, oats, sorghum (kaoliang, jowar), rye, millets (including ragi), rice, adlay, buckwheat
- Pulses: Beans, lentils, peas, navy beans, lima beans, broad beans, cowpea (chickpea), vetch (fitches)
- Marine products
- Dairy products
- Poultry and meat products
- Fruit

1. Tropical fruits banana, plantain, pineapple, papaya, guava, mango, passion fruit, breadfruit, avocado, zapote, cherimoya, naranjilla, surina (Brazil) cherry.
2. Subtropical fruits
   (a) Citrus fruits orange, lemon, tangerine, grapefruit, pomelo, citron, lime, kumquat.
   (b) Other figs, pomegranate, olives, persimmon tunas (cactus figs), peijabe.
3. Deciduous fruits Pome (seed) fruits, Apple, Grapes, Pear, Quince.
4. Stone fruits peach, cherry, plum, apricot.

5. Berries strawberries, raspberries, black raspberries, blackberries, loganberries, boysenberries, cloudberries, blueberries, cranberries, lingo berries (whortleberries), elderberries, black currants, red currants, gooseberries, rose hips.

- Vegetable processing

1. Leaf(y) vegetables cabbage, Brussels sprouts, spinach, celery, artichoke, leeks, lettuce, endive, bamboo shoots, heart of palms, herbs.
2. Root vegetables carrot, radish, parsnip, turnip, rutabaga, salsify.
3. Seeds green peas, green beans, lima beans, okr.
4. Others cauliflower and broccoli, cucumbers, onions, garlic, tomatoes.

- Fats and oils
- Sugar

1.3. Emphasis of food industries

Food industries stress on mainly four operations explicitly food stowage, processing, transportation and conservation.

(i) Food stowage

Food stowagecomprisesof enhancedstoring of food likefreezing cycles, refrigerants, and improvedlining. The raw materials are processed by the food industriesonce they are recuperated. Occasionallybecause ofinevitableconditionslikepromptonsets, inaccessibility andvariation in market price that alter with time, the raw materials need to be stored before processing.

The storagezone should be well aired, sheltered, should use water bathhouses, and if required, cold storingcan be used. Before storing, all damaged, withered, discoloured or fermentedlotsmust be removed.

(ii) Food Processing

Food processing comprisestranslation of tissues of raw plants and animals into eatableconstituents and parting of indigestible and toxic ingredients, their removaland concentration of nutrients, tastes, dyes and other valuableconstituents and exclusion of water.

Group of Operations	Typical Food Processing Operations
Mechanical Transport	Pumping of Fluids Pneumatic Conveying Hydraulic Conveying Mechanical Conveying

Mechanical Processing	Peeling, Cutting, Slicing Size Reduction Sorting, Grading Mixing, Emulsification Agglomeration Extrusion, Forming
Mechanical Separations	Screening Cleaning, Washing Filtration Mechanical Expression Centrifugation
Heat Transfer Operations	Heating, Blanching Cooking, Frying Pasteurization Sterilization Evaporation Cooling, Freezing, Thawing
Mass Transfer Operations	Drying Extraction, Distillation Absorption, Adsorption Crystallization from Solution Ion Exchange
Membrane Separations	Ultrafiltration Reverse Osmosis
Non-Thermal Preservation	Irradiation High Pressure Pulsed Electric Fields
Packaging	Filling, Closing Metallic, Plastic Packages Aseptic Packaging

1.4. Raw Material selection

Definition of Quality

Degree of excellence and include things such as taste, appearance, and nutritional content.

Principles of Quality Control

- Raw Material Control
- ➢ The application of decent and complete raw material is of key importance for the accomplishment of the requisite end product of steadyclass.
- Process Control
- ➢ Finished Product Inspection

The composite of characteristics that have significance and make for acceptability

- Quality Factors in Foods

a) *Appearance Factors*

- Include such things as;
- ✓ Size
- ➢ Approximated by weight after rough grading
- ➢ Ex. Determining the weight of dozen eggs
- ✓ Shape
- ➢ Have more than visual importance
- ➢ The grades of certain types of pickles include the degree of curvature
- ✓ Colour and Gloss
- ➢ Colour is commonly an index of ripeness and spoilage:
- ➢ Potatoes darken in colour as they are fried
- ➢ Blenching of dried tomato powder on storage
- ✓ Consistency
- ➢ May be considered a textural quality attribute
- ➢ Measured by viscosity of food:
- ▪ Higher viscosity – higher consistency
- ▪ Lower viscosity products – lower consistency

b) *Texture Factors*

- ✓ Texture Refers to those qualities of food that we can feel either with the fingers, the tongue, the palate or the teeth.
- ✓ A departure from an expected texture is a "quality defect".
- ✓ Expected texture
- ➢ Chewing gum should berubbery
- ➢ Crackers and potato chips should becrunchy

c) *Flavour factors*

- ✓ Flavour is a combination of both taste and smell
- ✓ Largely subjective
- ✓ Hard to measure because of difference of opinion:
- ✓ People differ in
- ➢ Their sensitivity to detect different tastes and odours
- ➢ Their preference
- ➢ Their cultures

d) *Nutritional quality*

- ✓ Can be assessed by chemical or instrumental analyses for specific nutrients, Animal feeding tests or equivalent biological tests must be used in many cases. Particularly common in evaluating the quality of
- ➢ protein sources
- ➢ Interacting variables of
  - ▪ protein level
  - ▪ amino acid composition
  - ▪ digestibility
  - ▪ absorption of amino acid

e) *Sanitary Quality* usually measured by counts of bacteria, yeast, mould, and insect, fragments sediment levels

1.5. Scope of Food Technology

- Food Technology established as a discipline to scientificallyconsolidate and connect the numerouskinds of data which is required to enlightenthe activities of human in food management, treatment, supply and promotion.
- Food Technology spread over:

1. The ideologies and perceptions of engineering to handle the complications of food management and processing, and
2. Trains the interrelationships amongst the characteristics of materials and the fluctuatingapproachesinvolved in their manufacturing and controlling.

1.6. Components of Food Technology

- Food analysis and chemistry
- Food Quality Factors and their Measurement
- Nutritive characteristics of food ingredients and effect of treatingand processing

- Food microbiology, mycology, and toxicology
- Food processing and engineering

1.7. Emerging trends in Food Technology

Augmentedapprehension about the nutritive content of technicallydeveloped foods is stated by both customers and nutritionists.

- Dietary recommendations and nourishmentknowledgeemphasis on moderatelyswitching refined foods with those of legumes,whole grains, and other such types of foods which preserve their biochemical property.
- Apprehension about food safety concerns is very stout. Food scientists are reacting to these dietary and securityanxieties in a number of ways,
- Amplified attention towards food interactions and bioavailability of food nutrients,
- Improved analytical and detection methods, and research and education in food safety.
- New development of the product, predominantly in the area of low-fat and low-calorie products is projected. New processing techniqueslike high energy electrical pulse processing, hydrostatic pressure processing and freeze concentration show promise.
- Biotechnology is a growing area.

1.8. Effect of improvements in other technologies on Food Technology

For the sake of inclusiveness it needs to be revealed that expansion of food technology dependsseverely on developments of other technologies, like in steel, tinplate, glass, aluminium, plastics, engineering, instrumentation, electronics, chemicals, and agriculture.

2.Characteristic of Microorganisms

Microorganisms are minute, commonly single-celled organisms proficient enough of prompt reproduction under appropriate conditions for growth. Those microorganisms that have vital role in the food industry comprise of bacteria, viruses, yeasts, moulds, and protozoans.

- Most of them are supportive and aid valuable tasks like making breads to rise, fermenting sugars present in food to alcohol, supporting in the making of cheese from milk and milk products, and rotting organic matter to replace nutrients of the soil.
- Some microorganisms can also result in spoilage of food and turn them inedible. Spoilage causing organisms cost the loss of millions of dollars to the food industry each year.
- Microorganisms can also be dangerous. These are termed as pathogens. These living forms, are so tiny in size that even if 25,000 of them would be positioned end to end, they would not cover more than an inch.

2.1. History

- *Antony van Leeuwenhoek* and others revealed through their simple microscopes some "very little animalcules' that were present in rain water. Now, we know that these microorganisms are present everywhere on our skin, in the air, soil, and on almost all objects present in our surroundings.
- Till Louis Pasteur demonstrated that the microorganisms can be eradicated from the system, like from a can of food, and wrapped up (hermetically wrapped). This man found out how to control the microorganisms present in his environment.

2.2. Terminology

- Bacteria: Bacteria are one-celled microbes present in almost all natural environments. External appearances of the bacterial cell like its size, figure, and organization is mentioned as its morphology.
  - Bacteria range in size from $0.2-2\mu$m in diameter, and $0.5-5.0\mu$m in length.
  - Morphologically they are divided into the broad classes of spherical (cocci), cylindrical (rods) and spiral. The coccican be classified further depending on trends of cluster. Those that attach in pairs are diplococci, those that attach in chains are streptococci, those that appear like bunch of grapes are staphylococci, and those that have cuboidal arrangement are arcinae. Some bacteria like

Corynebacterium, have many shape and lack a single shape and are called pleomorphic.
- ➢ Bacterial cells comprise of definite characteristic structure. They comprise of the cell wall, plasma membrane, cytoplasm, and nuclear structures.
- ➢ Some of the bacteria also own hair like appendages for motion known as flagella. Fimbriae help in fastening, and cytoplasmic and membranous inclusions involved in regulating the life processes.

- *Viruses*: Viruses are awfully small sized parasites. They need living cells of plants, or animals, or other microorganisms for their growth. They cannot grow on their own. The virus is generally a pack of genetic material that can to be replicated within the host only.
- *Yeast and moulds*: Yeast and mould are fungi which do not contain chlorophylls.
    - ➢ Their size range from one-celled organisms to huge mushrooms.
    - ➢ While some can be multi celled, they are not distinguished in roots, stems and leaves. The true fungi yield masses of filamentous hyphae which produce the mycelium.
    - ➢ Subject to the organism, they can replicate via fission or by budding as in yeasts or through the spores endured on the fruiting structures of mould.
- Protozoa: Protozoa are one-celled organisms like amoeba. They can be the reason for diseases in humans and animals. They own cell structure which is more similar to advanced and complex organisms.

2.3. Nomenclature

Microorganisms are denoted by their scientific names that are very evocative themselves. The first half of the name implies the genus, whose first letter is capitalized such as *Streptococcus* (which are spherical cells and occur in chains), *Lactobacillus*(which are rod-shaped cells and found in milk), and *Pediococcus*(which are spherical cells involved in fermentation of pickles). The first letter of the second half of the name is not capitalized and adds further information. Both the parts of the name are either underlined or italicized, for example the name of yeast that is involved in fermentation is written as *Saccharomyces cerevisiae*.

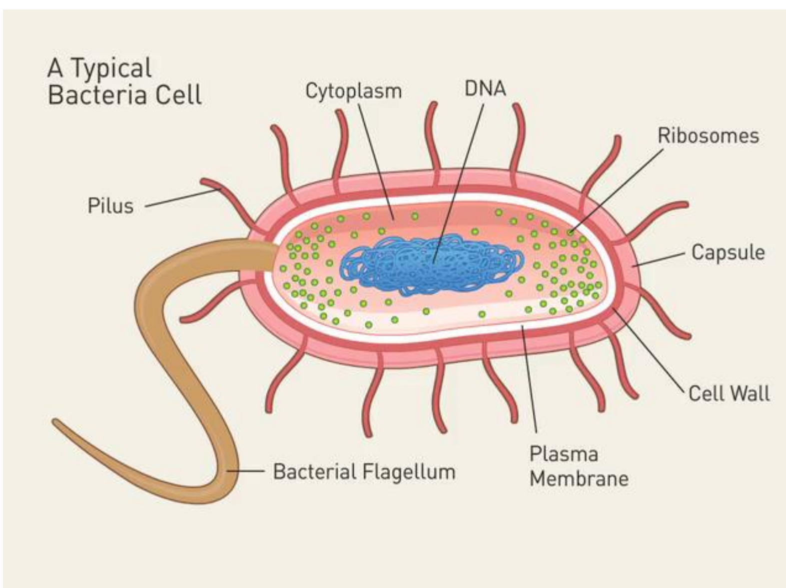
2.4. The Cell

The cell is the elementary part of our life. Our bodies have been made up of billions of cells, these we are multicellular. However, most of the microorganisms are one celled beings. Cells are mainly bundles of living matter enclosed by plasma membranes or cell walls. Inside the cell lies number of organelles that regulate life processes for the cell like ingestion of nutrients, energy production, release of waste materials, and replication.

- Growth of the cell usually involves reproduction. Bacteria and related microorganisms reproduce via binary fission that means division of a cell into two.
- The regulator centre for the bacterial cell lies inside its nuclear structure. The genetic material is present inside it, this genetic material is replicated and is relocated to daughter cells during the process of reproduction. Then, these daughter cells may divide all over again to yield four cells from one.
- The time a new cell takes to form from a new generation of these daughter cells is termed as generation time. Under optimal growth situations, some microorganisms have a generation time of only 15 minutes.
- Under antagonistic situations, some bacteria can defend the genetic material of the cell by spore production. These are enormously sturdy capsules of their genetic materials. Nonetheless in the spore, there is no visible life processes, but under appropriate sporulation circumstances, a sustainable, duplicating cell will sprout from it.

2.4.1. Structure of Bacteria

A prokaryotic cell has five essential structural components: a nucleoid (DNA), ribosomes, cell membrane, cell wall, and some sort of surface layer, which may or may not be an inherent part of the wall.



Summary of characteristics of typical bacterial cell structures:

Structure	Function(s)	Predominant chemical composition
	Cell wall	
Gram-positive bacteria	Prevents osmotic lysis of cell protoplast and confers rigidity and shape on cells	Peptidoglycan (murein) complexed with teichoic acids
Gram-negative bacteria	Peptidoglycan prevents osmotic lysis and confers rigidity and shape; outer membrane is permeability barrier; associated LPS and proteins have various functions	Peptidoglycan (murein) surrounded by phospholipid protein-lipopolysaccharide "outer membrane"
Plasma membrane	Permeability barrier; transport of solutes; energy generation; location of numerous enzyme systems	Phospholipid and protein
Capsules (includes "slime layers" and glycocalyx)	Attachment to surfaces; protection against phagocytic engulfment, occasionally killing or digestion; reserve of nutrients or protection against desiccation	Usually polysaccharide; occasionally polypeptide
Flagella	Swimming movement	Protein
Pili		
Sex pilus	Stabilizes mating bacteria during DNA transfer by conjugation	Protein
Common pili or fimbriae	Attachment to surfaces; protection against phagotrophic engulfment	Protein
Ribosomes	Sites of translation (protein synthesis)	RNA and protein
Inclusions	Often reserves of nutrients; additional specialized	Highly variable; carbohydrate, lipid,

	functions	protein or inorganic
Chromosome	Genetic material of cell	DNA
Plasmid	Extra-chromosomal genetic material	DNA

2.5. Enumeration of Cells

We can estimate the number of microorganisms depending on their cell counts, cell mass, or activity of cell.

- The *direct count* of cells can be done through inspection of a known amount of cell suspension below a microscope. This technique is prompt and involves nominal equipment. This technique will not differentiate living cells and dead cells and could be somewhat tiresome. The use of some stains can make morphological characteristics of the organism noticeable which help in the identification.
- Perhaps the most communal technique of cell enumeration is the *plate count*. A known amount of a diluted specimen is put on the agar present in a petri dish. Supposing that in the dilute solution, each organism will replicate till it cultivates a visible mass of cell or colony. The colonies can be calculated and increased by the application of dilution factor to evaluate the number of cells present in the original sample. This technique is grounded on the supposition that a colony forming unit (CFU) is considered as a single organism. This will not hold accurately correct in case of chains or clumps of cells. Sub-lethally damaged organisms might not grow. The culture environments might not be constructive for the growth of some types of fastidious organisms like anaerobes.
- To quantity the development of a culture in a clear broth, variations in the turbidity could be detected and can be related with numbers or organism. This technique is comparatively easy and quick. Number of commercial formations has established application of the technique.

2.6. Identification of Cell

As many types of cells look similar in morphology and produce similar colonies, it becomes necessary to identify the organisms by their biochemical characteristics.

- Biochemical testing requires pure cultures isolated from a single colony from a plate count or streaked plate made for isolation purposes. Isolates are grown in an enriched broth to produce large cell numbers.

- Various media can then be inoculated with the culture and then growth can be observed by carefully formulating the various media, the biochemical and growth characteristics of the organism can be determined.
- Previously determined morphological characteristics can be combined with biochemical data to properly classify the organism.
- Newer methods more rapidly identify organisms of interest using other characterization such as monoclonal antibodies and DNA.

Characteristics	**Moulds**	**Yeasts**	**Bacteria**
Size	5-12 μ dia up to 25 μ length	5-12 μ	1-2 μ
Reproduction	Slow asexual-spores sexual cycle	Intermediate budscars-limit sexual-ascus zygote	Fast binary fission infinite
Diversity (types)	High	Moderate	High
End products (1^o, 2^o metabolites)	Greatest	Least	Very high
Substrate utilization	High	Low	Highest
pH	Acid tolerant 3-8	Acid tolerant 4-8	Neutral 5-10
Oxygen	Aerobic	Facultative	Aerobic-anaerobic
Moisture tolerance	Very dry	High level of water	High level of water
Food Spoilage	Low pH foods dryer foods	Low pH foods high H_2O content	Neutral pH foods high H_2O content

2.7. Staining Methods of Bacteria

Bacteria have nearly the same refractive index as water, therefore, when they are observed under a microscope they are opaque or nearly invisible to the naked eye. Different types of staining methods are used to make the cells and their internal structures more visible under the light microscope.

- Gram staining is used to determine gram status to classify bacteria broadly. It is based on the composition of their cell wall. Gram staining uses crystal violet to stain cell walls, iodine as a mordant, and a fuchsin or safranin counter stain to mark all bacteria. Gram status is important in medicine; the presence or absence of a cell wall will change the bacterium's susceptibility to some antibiotics. Gram-positive bacteria stain dark blue or violet. Their cell wall is typically rich with peptidoglycan and lacks the secondary membrane and lipopolysaccharide layer found in Gram-negative bacteria.
- Additional differential staining method is acid-fast technique that distinguishes Mycobacterium spp. from other bacterial spp. Because of the presence of special cell wall in Mycobacterium species, they resist the outcome of the acid-alcohol that act as decolorizer and thus preserve the colour obtained from the primary stain of carbolfuchsin and dyes the acid fast cells in a bright red colour. Other non-acid bacteria lose the stain and undertake the succeeding colour of the methylene blue stain which is a counter dye and dye the cells blue in colour.
- Endospore staining is a distinct staining method. It is used to detect bacterial spores. In this method, bacterial spores take the colour of the Malachite green dye which is a primary stain, whereas the safranin which act as counter stain, give pink colour to the non-spore developing bacteria.
- Some explicit stains like nigrosine and Indian ink help to picture those bacterial strains that cannot be stained through the common staining methods.
- The characteristic feature of *Cornybacteriumdiphtheriae*is the presence of metachromatic granules. They can be discriminated from other bacterial cells by the method of Albert staining.
- Flagella are the very thin and gentle structure that bacteria use for their motility. The thin organizations of the flagella make it quite hard to observe them under bright field microscope. Some distinctive stains and mordents like stain of Leifson is essential for staining the bacterial flagella.

2.8. Factors Affecting Growth

Microorganisms, like other living organisms, are reliant on their surroundings to deliver them their basic needs. Antagonistic conditions can modify their rate of growth or execute them.
Rate of growth of microorganisms can be influenced by monitoring:

- Nutrients available
- Oxygen
- Water
- Temperature
- Acidity and pH
- Light
- Chemicals

2.8.1. *Nutrients*

- Nutrients like carbohydrates, fats, proteins, vitamins, minerals and water, as needed by human beings are also required by the microorganisms for growth.
- Microbes vary in their capabilities to take substrates as their source of nutrients. Their enzyme systems are made accessible depending on their genetic code. They differ in their skill to take nitrogen sources to yield amino acids and, consequently, proteins.
- Some need amino acids which are brought by the substrate. When microorganisms need distinct substances delivered by the environment, they are termed as fastidious.
- Alteration in the application of nutrients and the production of waste products are significant in distinguishing between different organisms.

2.8.2. *Oxygen*

- Microbes also have different needs for the amount of oxygen.
- For aerobic organisms presence of free oxygen is must in order to cultivate and grow, while anaerobic organisms cultivate in the complete absence of free oxygen.
- Facultative bacteria can cultivate both with and without oxygen, whereas microaerophilic bacteria cultivate in the presence of small amount of oxygen.

2.8.3. *Water*

- Water is required by the microbes in order to grow; nevertheless they cannot cultivate in presence of pure water.

- Some volume of water is not accessible to them. A measurement of the availability of water is called a_w or water activity. For pure water the value of a_w is 1.0,but that for a saturated salt solution is 0.75.
- Most of the spoilage bacteria need a lowest a_w of 0.90. And, some bacteria are able to tolerate the swell above 0.75 and so does some yeasts and most moulds.
- Most of the yeast needs water activity to be around 0.87. A a_w of about 0.85 or less suppresses the microbial growth.

2.8.4. *Temperature*

- Microorganisms are able to grow in a wide range of temperatures. As they rest on water that works as a solvent for nutrients, thus frozen water and boiling water constrains their growth.
- General terminology is applied for the organisms depending on their rate of growth at different temperatures:
  - Most organisms cultivate finest at or near room and body temperature. These are known as mesophiles.
  - Those organisms that grow at a temperature of 40˚C or above are called thermophiles.
  - While, those organisms that grow at a temperature of 5˚Cor below are called psychrotrophs.

2.8.5. *Acidity*

- The pH of a solution describes its acidity or alkalinity.
- The scale of the pH varies from 0, strongly acidic, to 14, strongly basic.
- Neutral solutions have a pH of 7for example, the pH of pure water. Most bacteria need neutral circumstances for their optimal growth and their minimums and maximums lies between 4 and 9.
- Many microorganisms can alter the pH of the substrate on which there are feeding by generating by-products during their growth. Thus, it can alter the surroundings such that they no longer upkeep their growth.
- Yeasts and moulds are somewhat more forbearing to lower pH than the bacteria and might expand more than them under similar conditions.

2.8.6. *Light & Chemicals*

- The growth of microorganisms can also be affected by the ultraviolet light and the presence or absence of chemical inhibitors.

- Application of chemicals like hydrogen peroxide and chlorine can execute or harm microbes.

2.8.7. *Growth*

- Characteristic growth designs of microorganisms can be demonstrated on a graph. A selected region of the normal growth curve is stated as the logarithmic growth phase.
- When cells initiate to grow, a period of no ostensible growth is observed, it is referred as the lag phase. This happens because in this period cell make required adjustments to acclimatise.
- Then, a phase of the rapid growth called the log phase is observed. As the cell mass enlarges, nutrients are used up completely and metabolic by-products are collected.
- Growth starts to narrow down and the population remains persistent for a time. This is stated as the stationary phase of growth.
- With no interference in the system the populace will pass in the death phase and total numbers of organisms will drop.