

Course I: Introduction to food technology

Food Technology is the branch of science that applies principles of chemistry, microbiology, engineering, and nutrition to the processing, preservation, and distribution of food. This discipline explores both traditional processes (such as fermentation, pasteurization, drying, and canning) and modern innovations (including biotechnology, functional foods, edible films, and novel preservation methods). It integrates knowledge from various scientific fields in order to understand how raw agricultural materials can be transformed into stable, palatable, and marketable products.

I. Food Science and Food Technology

Food science can be defined as the systematic study of the physical, chemical, and biological properties of food, as well as the mechanisms of food deterioration and the principles of food processing. It draws on disciplines such as chemistry, microbiology, engineering, epidemiology, and nutrition to understand food composition, stability, safety, and functionality.

Food technology, on the other hand, refers to the practical application of food science to ensure the safe, large-scale production and distribution of food products. It involves the development of processing, preservation, and packaging techniques that enhance food stability, extend shelf life, and maintain nutritional quality. In practice, food technologists apply multidisciplinary knowledge to transform raw agricultural materials (whether animal, plant, or marine) into safe, convenient, and palatable products for consumers.

II. Basic concepts

II.1. Food Processing

Food processing is the systematic transformation of raw biomaterials into value-added products through unit operations and bioprocesses. It addresses both primary processing (e.g., milling of cereals, pasteurization of raw milk) and secondary/tertiary processing (formulation of cheese, bread, fermented beverages, ready-to-eat meals), this involves:

- Biochemical modifications (protein denaturation, lipid oxidation, enzymatic activity).
- Physicochemical transformations (gelation, emulsification..).
- Engineering principles define the efficiency of processing lines.

II.2. Food Preservation

Food preservation aims to control the growth kinetics of microorganisms and rate of chemical reactions responsible for spoilage. Preservation technologies are based on:

- Microbial inactivation (thermal sterilization, irradiation...).
- Microbial growth inhibition (low-temperature storage, bacteriocins ...).
- Enzyme inactivation and oxidative stability.

II.3. Food Safety and Quality Control

Quality control combines analytical chemistry with statistical process control. Scientific aspects include:

- Microbiological assays to detect pathogens and spoilage organisms.
- Chemical analytics for nutrient quantification, detection of residues, and characterization of bioactive compounds.
- Process validation systems such as HACCP.
- Predictive microbiology and foodomics (metabolomics, proteomics).

II.4. Food Biotechnology

Food biotechnology focuses on:

- Microbial biotransformations (lactic acid fermentation, alcoholic fermentation, biosynthesis of enzymes, organic acids, and flavor compounds).
- Probiotic and prebiotic systems.
- Metabolic engineering and genetic improvement of microorganisms and crops for enhanced yield, stress resistance.
- Functional foods and nutraceuticals.

II.5. Packaging and Storage

Packaging science combines materials engineering and food chemistry to design systems that maintain food integrity. It involves:

- Barrier properties (permeability to oxygen, carbon dioxide, and water vapor).
- Active packaging systems that release or absorb substances (antimicrobials, antioxidants, moisture scavengers).
- Edible films and coatings derived from polysaccharides, proteins, and lipids....

- Smart packaging equipped with biosensors or chemical indicators for real-time monitoring of food quality.
- Storage science to model shelf-life kinetics.

III. Shelf Life of food

Shelf life refers to the period during which a food product can be stored without significant deterioration, provided that recommended storage conditions are respected. It starts from the time of preparation or manufacture and is influenced by several factors such as ingredient composition, processing methods, packaging type, and storage conditions. Shelf life is communicated to consumers through date marking on the product label.

I.1. Shelf life and food safety

Shelf life encompasses both quality preservation (appearance, odor, texture, flavor, and nutritional claims) and microbiological safety. Food must remain safe to eat throughout its declared shelf life. Safety is ensured by implementing HACCP systems, supported by predictive microbiology models and challenge tests to assess pathogen growth.

II.2. Regulations and date marking

All packaged foods with a shelf life of less than two years must carry a date mark. Three main categories are specified:

- **“Use by” date:** applied to highly perishable foods posing a safety risk after this date. Such foods must not be sold or consumed past the marked date.
- **“Best before” date:** used for less perishable foods. They may still be sold after this date, although quality may decline.
- **Special bread labels:** “Baked on” or “Baked for” may be used for bread with a shelf life of less than 7 days.

Date marking must be clear, uncoded, and follow chronological order:

- **Day and month** for products with shelf life ≤ 3 months.
- **Month and year** for products with shelf life > 3 months.

II.3. Storage conditions and post-opening instructions

Labels must also provide storage instructions necessary to maintain the declared shelf life. These conditions must be practical across distribution, retail, and household use. Special attention is

required for products packaged under vacuum or modified atmospheres, since the packaging strongly influences stability. For example, vacuum-packed sliced ham may last one month under refrigeration, but only 3–4 days once the package is opened.

II.4. Factors Influencing Shelf Life

The shelf life of a product cannot be defined by a single duration, as all foods spoil at different rates. Spoilage is influenced by both microbial and non-microbial factors.

a. Microbial growth

- Bacteria, yeasts, and moulds may cause spoilage or foodborne illness.
- The rate of microbial growth depends on:
 - Initial microbial load at production.
 - Contamination during handling, packing, or storage.
 - Food type and composition (moist foods spoil faster than dry foods).
 - Storage temperature and time.

b. Non-microbial spoilage

- Moisture changes: lead to nutrient loss, rancidity, or browning; dry foods absorbing moisture may become microbially unstable.
- Chemical changes: off-flavors, color changes, nutrient degradation.
- Light exposure: induces rancidity, vitamin loss, and fading of colors.
- Temperature fluctuations: accelerate spoilage processes.
- Physical damage: bruising of produce or compromised packaging (e.g., pinholes in cans, torn films) increases susceptibility to spoilage.
- External factors: infestation by insects/rodents, absorption of foreign odors, or deliberate product tampering.

II.5. Determination of Shelf Life

a. Direct Method

Step 1. Identify potential spoilage factors

- Product-related: raw material quality, formulation, water activity, pH, oxygen availability, use of preservatives.
- Process-related: processing methods (heating, freezing, fermentation, sterilisation), consistency of operations, hygienic packaging, and storage conditions (temperature, humidity, light, handling).

The objective is to list all possible causes of deterioration and factors that may prolong shelf life.

Step 2. Select appropriate tests

Tests must be chosen according to the product and its risks:

1. Sensory evaluation : monitoring changes in smell, flavor, appearance, and texture.
2. Microbiological tests : quantifying spoilage organisms and detecting pathogens (e.g., *Listeria monocytogenes*).
3. Chemical tests : measuring indicators such as pH, volatile nitrogen, free fatty acids, or gas composition.
4. Physical tests : assessing texture, packaging integrity, transport stability, and performance under real-life distribution conditions.

Step 3. Plan the study

- Define tests, sampling intervals, and study duration.
- Conduct trials under the most challenging season (e.g., summer).
- Use replicate samples, ensure consistent product and process, and keep detailed written records.

Step 4. Conduct the study

Store samples under controlled and representative conditions. At predefined times, test and record results systematically, noting any anomalies.

Step 5. Establish shelf life

Determine the point at which the product fails to meet quality or safety standards. The shorter of the two defines the official shelf life. A safety margin should be included to account for real-world variability and potential misuse.

Step 6. Monitor and adjust

Continue monitoring products throughout distribution and retail. Shelf life must be re-evaluated if:

- Changes occur in ingredients, processing, or packaging.
- Customer complaints suggest early spoilage.
- Limiting factors are modified to extend stability.

Accurate records and ongoing verification are essential for product safety and reliability.

b. Indirect Methods

Indirect methods are approaches that estimate shelf life without conducting full-length storage trials, making them particularly useful for products with long shelf lives. The two main techniques are:

1. Accelerated shelf Life studies (ASLT): Shelf life is predicted by increasing the rate of deterioration, typically through elevated storage temperatures. Results are extrapolated to normal storage conditions.
2. Predictive modelling : Uses mathematical equations and databases to predict microbial growth and product deterioration under specific conditions. It requires data on product composition, packaging, and expected changes during spoilage. Examples include the USDA Pathogen Modelling Program, Growth Predictor, and FORECAST (CCFRA).