

1.1. Introduction

- Food technology applies food science and scientific methods to the selection, preservation, processing, packaging, distribution, and use of foods, in order to ensure food safety, nutritional quality, and desirable sensory properties.
- Food scientists and technologists analyze food composition from physical, chemical, and microbiological perspectives.

1.2. Production System

A production system is a system that enables the conversion of raw materials into finished products.

It is based on physical, chemical, and/or biochemical transformation processes applied to the raw material.



Components of the System

1.3. Food Industry Historically

Food processing has evolved from simple preservation techniques to advanced technological systems aimed at ensuring food safety, stability, and availability. Early methods such as drying, smoking, salting, and fermentation reduced spoilage and extended shelf life. The Industrial Revolution marked a major shift with the introduction of machinery and canning. In the early 19th century, Nicolas Appert pioneered thermal preservation in sealed containers, and Peter Durand later patented metal cans, enabling industrial-scale production and long-distance transport.

Subsequent scientific advancements in the late 19th and early 20th centuries introduced refrigeration, freezing, and pasteurization, significantly improving microbial safety while maintaining sensory and nutritional quality. The mid-20th century saw the expansion of convenience foods and the adoption of technologies such as microwaving, freeze-drying, and advanced packaging. In response to growing demand for fresher and healthier products, modern food processing has incorporated minimal processing techniques, including high-pressure processing and reduced heat treatments.

Today, food technology encompasses a wide range of innovative and sustainable approaches designed to meet global demands for safe, nutritious, and accessible foods.

1.4. Objectives

- **Transformation:** Converts raw, relatively inedible ingredients into edible food products.
- **Stabilization:** Preserves foods during periods of abundance for consumption out of season.

1.5. Principles: food industry is based on four principles:

- ✓ **To transform** products through cooking, fermentation, etc.;
- ✓ **To extract, separate, and purify** the constituents of natural products (sugar production, oil extraction, milling, butter production, etc.);
- ✓ **To perform blends** to achieve the desired flavors and/or textures (for example, in bakery or charcuterie);
- ✓ **To stabilize** agricultural and fishery products (through drying, thermal or cold treatments, salting, smoking, candying, etc.).

The raw materials used in the food industry come from:

- Agriculture (plant and animal production) for the largest part;
- Fishing and the sea (seaweed, sea salt);
- The subsoil, in the case of mineral waters and rock salt;
- The chemical industry (certain additives): limited in quantity, but economically and functionally important.

1.6. Biological Materials

Biological raw materials used in the food industry include:

1. Meat products – such as fresh, processed, or cured meats.
2. Dairy products – including milk, cheese, yogurt, and butter.
3. Cereals – grains like wheat, rice, maize, and their derivatives.
4. Fruits – fresh, dried, or processed fruits.
5. Vegetables – fresh, frozen, or preserved.
6. Beverages – both alcoholic and non-alcoholic drinks.

These materials are characterized by:

- **Variability** – their composition can vary depending on species, origin, and season.
- **Fragility** – they are highly perishable and sensitive to environmental conditions.
- **Complexity** – they contain diverse biological molecules and structures that influence processing and preservation.

1.7. Quality Attributes

The quality attributes considered in the food industry include:

- ✓ **Health attributes:** Factors related to the nutritional value, safety, and overall health impact of the food product.
- ✓ **Sensory attributes:** Characteristics perceived by the senses, such as taste, aroma, texture, color, and appearance.
- ✓ **Process attributes:** Features related to the production process, including consistency, reliability, and compliance with food safety and quality standards.
- ✓ **Convenience attributes:** Factors that affect ease of use, preparation, storage, and consumption, such as ready-to-eat products or packaging design.

1.8. Food preservation

The principles of food preservation encompass a range of techniques and strategies aimed at extending the shelf life of food, ensuring its safety, and maintaining its nutritional quality.

- a) **Traditional and Modern Preservation Methods:** Traditional preservation methods are those that have been used for centuries or even millennia to prevent food from spoiling or becoming unsafe for consumption. Some examples of traditional preservation methods are:
- **Drying:** This method involves removing the moisture from food by exposing it to sun, air, or artificial heat. Drying prevents the growth of microorganisms and enzymes that cause spoilage. Dried foods can last for a long time and are easy to store and transport. However, drying can also reduce the nutritional value, flavor, color, and texture of food.
 - **Salting:** This method involves adding salt to food to create an environment that is unfavorable for microbial growth. Salting can also enhance the flavor and texture of food, as well as prevent oxidation. Salting is commonly used for preserving meat, fish, cheese, and vegetables. However, salting can also increase the sodium intake of consumers, which may have negative effects on health.
 - **Smoking:** This method involves exposing food to smoke from burning wood or other materials. Smoking can impart a distinctive flavor and aroma to food, as well as inhibit microbial growth and oxidation. Smoking is often used for preserving meat, fish, cheese, and spices. However, smoking can also produce harmful substances such as polycyclic aromatic hydrocarbons (PAHs) and nitrosamines, which may increase the risk of cancer.
 - **Pickling:** This method involves preserving vegetables, fruits, and meat in vinegar, lemon juice, or oil. Spices, salt, and sugar are added to the mix to give the pickles their distinct

flavour. Pickles can be made with a wide variety of ingredients, such as mangoes, lime, gooseberries, carrots, and onions.

- **Fermenting:** This method involves preserving food by allowing it to sit in a solution of salt or sugar water. The bacteria in the solution break down the sugars in the food, creating lactic acid, which acts as a natural preservative. Fermentation is commonly used to preserve dairy products, such as yogurt and buttermilk, as well as vegetables, such as pickles and sauerkraut.
- **Curing:** This method involves preserving meat by adding salt, sugar, nitrites, or nitrates to it. Curing can also enhance the flavour and colour of meat, as well as prevent the growth of harmful bacteria. Curing is often used for preserving ham, bacon, salami, and sausages.

b) **Modern Preservation Methods:** Modern preservation methods are those that use advanced technology and science to prevent food from spoiling or becoming unsafe for consumption. Some examples of modern preservation methods are:

- **Pasteurization:** This method involves heating liquid food, such as milk or juice, to a high temperature for a short time and then cooling it rapidly. Pasteurization kills most of the harmful microorganisms and extends the shelf life of the food. Pasteurization was invented by Louis Pasteur in the 19th century.
- **Freezing:** This method involves lowering the temperature of food to below 0°C (32°F) to stop microbial growth and enzyme activity. Freezing can preserve the nutritional value, flavor, color, and texture of food for a long time. Freezing is suitable for preserving almost any type of food. However, freezing requires electricity and freezer space, and may cause freezer burn or ice crystals if not done properly.
- **Drying:** This method involves removing the moisture from food by exposing it to hot air or other sources of heat. Drying can reduce the weight and volume of food and make it resistant to microbial spoilage. Drying is suitable for preserving fruits, vegetables, meat, fish, and grains. However, drying can also reduce the nutritional value, flavor, color, and texture of food.
- **Vacuum Packing:** This method involves sealing food in an air-tight plastic bag or container and removing the air from it. Vacuum packing prevents oxygen from reaching the food and inhibits microbial growth and oxidation. Vacuum packing can extend the shelf life of food and retain its quality. Vacuum packing is often used for preserving meat, cheese, nuts, and dried fruits.

- **Irradiation:** This method involves exposing food to ionizing radiation such as gamma rays or X-rays. Irradiation can kill microorganisms and insects, delay ripening, prevent sprouting, and extend shelf life. Irradiation is suitable for preserving fruits, vegetables, meat, fish, eggs, and spices. However, irradiation may also alter the chemical composition, flavor, color, and texture of food.
- **Biopreservation:** This method involves adding beneficial microorganisms or their metabolites to food to inhibit the growth of spoilage microorganisms. Biopreservation can enhance the safety, quality, and shelf life of food. Biopreservation is commonly used for preserving dairy products, such as yogurt and cheese, as well as meat products, such as salami and ham.
- **Hurdle Technology:** This method involves combining two or more preservation methods to create multiple barriers or hurdles for microbial growth. Hurdle technology can improve the safety, quality, and shelf life of food while minimizing the adverse effects of each individual method. Hurdle technology is often used for preserving ready-to-eat meals, such as soups and salads.
- **Modified Atmosphere Packaging (MAP):** This method involves replacing the air in a package with a gas mixture that is optimal for preserving the food. MAP can slow down the respiration rate of fresh produce, inhibit microbial growth and oxidation, and maintain the color and flavor of food. MAP is widely used for preserving fruits, vegetables, meat, fish, bakery products, and cheese.
- **High-Pressure Processing (HPP):** This method involves applying high pressure (up to 600 MPa) to food in a sealed container for a few minutes. HPP can inactivate microorganisms, enzymes, and toxins, and preserve the freshness, flavor, color, and texture of food. HPP is suitable for preserving liquid or semi-solid foods, such as juices, sauces, soups, meats, and seafood.
- **Pulsed Electric Field (PEF):** This method involves applying short pulses of high voltage (up to 80 kV/cm) to food placed between two electrodes. PEF can damage the cell membranes of microorganisms and enzymes, and extend the shelf life of food. PEF is suitable for preserving liquid or semi-solid foods, such as milk, juice, eggs, and mashed potatoes.
- **Ultraviolet (UV) Light:** This method involves exposing food to UV light of a specific wavelength (254 nm) for a short time. UV light can kill or inactivate microorganisms and

enzymes, and prevent spoilage and discoloration of food. UV light is suitable for preserving solid or liquid foods, such as fruits, vegetables, meat, fish, milk, and water.

1.9. Food processing technologies

Food processing technology encompasses a wide range of methods and techniques used to transform raw agricultural materials into safe, convenient, and marketable food products. This multidisciplinary field integrates science, engineering, and culinary arts to ensure the quality, safety, and sustainability of food production.

a) **Thermal Processing in Food Technology:** Thermal processing is a fundamental aspect of food technology, utilizing heat to alter the properties of food products, enhance safety, and extend shelf life. Several key thermal processing methods are commonly employed:

□ **Cooking:** Cooking is a broad term encompassing various methods such as boiling, frying, grilling, roasting, and steaming. It uses heat to make food more palatable, eliminate pathogens, and enhance flavors and textures. For example, grilling a steak not only cooks it to a safe temperature but also imparts a desirable charred flavor.

□ **Blanching:** Blanching involves briefly immersing food items, usually vegetables, in boiling water or steam, followed by rapid cooling. This process is primarily used to deactivate enzymes that can cause food deterioration, such as browning or loss of

nutrients. It also helps preserve color and texture before freezing.

□ **Baking:** Baking is a dry-heat cooking method primarily used for bread, cakes, pastries, and other baked goods. It involves exposing food to controlled temperatures in an oven. Baking provides products with desirable textures, flavors, and aromas due to the Maillard reaction and caramelization.

Each of these thermal processing methods serves unique purposes in food preparation and preservation, contributing to both the safety and sensory quality of food products. Understanding the principles and techniques of thermal processing is essential for food technologists to create safe and appealing foods for consumers.

b) **Non-Thermal Processing in Food Technology:** Non-thermal processing methods in food technology are innovative techniques that do not rely primarily on heat for food preservation and processing. These methods are increasingly important because they can maintain the sensory and nutritional qualities of food products while ensuring safety. Here are two notable non-thermal processing methods:

High-Pressure Processing (HPP): HPP involves subjecting packaged food products to extremely high pressures, typically between 100 to 800 megapascals (MPa). This pressure disrupts the cellular structure of microorganisms, enzymes, and pathogens, effectively sterilizing the food. Unlike traditional thermal processing, HPP preserves the fresh-like qualities of foods, including taste, texture, and nutritional content. It is used for products like fruit juices, guacamole, deli meats, and seafood.

Pulsed Electric Fields (PEF): PEF is a non-thermal technique that exposes food to short bursts of high-voltage electrical pulses. These pulses create tiny holes in the cell membranes of microorganisms, leading to their inactivation and, ultimately, food preservation. PEF is used for liquid and semi-liquid products, such as fruit juices, dairy products, and liquid eggs. Like HPP, it preserves the sensory attributes and nutrients of food.

Non-thermal processing methods are gaining popularity due to their ability to extend the shelf life of products while retaining their quality. They are particularly valuable for the growing demand for minimally processed and fresh-like foods, meeting consumer expectations for both safety and sensory appeal. Food technologists continually explore and develop new non-thermal processing techniques to enhance the quality and safety of food products.