Food Preservation: Significance, Causes of Spoilage and Preservation Techniques

Food preservation is the science and practice of preventing food spoilage and extending the shelf life of perishable materials. It involves various physical, chemical, and biological methods.

Thus the purpose of food preservation includes: Prevention of spoilage, control or eliminate microorganisms, delay enzymatic deterioration, maintain nutritional and sensory quality. prolongation of shelf life and food safety and public health

Causes of Food Spoilage

Food spoilage refers to undesirable changes in the appearance, flavor, odor, texture, or nutritional quality of food, making it unsuitable for consumption. Spoilage occurs due to several biological, chemical, and physical factors.

1. Microbial Activity
    - Caused by bacteria, yeasts, and molds that grow on food under favorable conditions of temperature, pH, and moisture.
    - Examples:
        - Lactobacillus souring of milk
        - Penicillium, Aspergillus spoilage of bread, fruits
2. Enzymatic Reactions
    - Naturally occurring enzymes in food can cause undesirable changes such as browning in cut fruits or softening in vegetables.
3. Chemical Reactions
    - Oxidation of fats leads to rancidity.
4. Insect and Rodent Infestation
    - Grains and stored foods may be attacked by pests, causing contamination and nutrient loss.
5. Environmental Factors
    - High temperature, humidity, and exposure to air accelerate spoilage by creating favorable microbial conditions.

Principles and Techniques of Food Preservation

The main objective of food preservation is to delay or prevent microbial and enzymatic spoilage while maintaining the desired quality of food.

All food preservation methods are based on one or more of the following principles:

- Removal or reduction of microorganisms (e.g., drying, filtration)
- Inhibition of microbial activity (e.g., refrigeration, addition of preservatives)
- Destruction of microorganisms (e.g., heating, irradiation)
- Avoidance of contamination (e.g., aseptic packaging, sealing)

1. Asepsis (Preventing Contamination)

Asepsis refers to keeping food free from contamination by microorganisms.

It involves:

- Maintaining clean and sterile conditions during handling, processing, and packaging.
- Sealing food in airtight containers or sterile packaging materials.
- Use of aseptic processing in modern industry, where sterilized food and packaging are combined under sterile conditions.

Examples:

Pasteurized milk packed in tetra packs, sterile fruit juices.

2. Removal of Microorganisms

Microorganisms can be removed from food or food media by filtration or centrifugation, especially in liquid foods.

- Filtration: Uses fine filters to remove bacteria and spores without affecting the flavor or nutrients.

  Example: Filtration of fruit juices, beer, or water.
- Clarification and centrifugation: Removes suspended solids and microbial cells.

This method is particularly useful when heating would damage the sensory or nutritional quality of the product.

3. Maintenance of Anaerobic Conditions

Microorganisms generally require oxygen for growth. Hence, excluding or reducing oxygen helps in preservation.

- Vacuum sealing or Modified Atmosphere Packaging (MAP) replaces oxygen with CO_2 or N_2.
- Oil covering or syrup immersion creates oxygen-free environments.
- Fermentation by lactic acid bacteria or yeasts naturally develops anaerobic conditions.

Examples:

Pickles, jams, fermented vegetables, and sealed canned foods.

4. Special Methods of Food Preservation

a. Preservation by Drying

Principle: Removal of water prevents microbial growth since microorganisms need moisture to survive.

- Natural drying: Sun or air drying (used for cereals, fish, fruits).

- Mechanical drying: Use of controlled heat and airflow.
- Freeze drying (lyophilization): Water is removed by sublimation under vacuum, preserving color, flavor, and nutrients.

Examples: Dried fruits, powdered milk, and spices.

b. Preservation by Heat Treatment

Heat is used to destroy microorganisms and inactivate enzymes.

1. Pasteurization:
    - Involves heating food (e.g., milk) at 60–80°C for a short time followed by rapid cooling.
    - Kills most non-spore-forming pathogens.
    - Example: Pasteurized milk, fruit juices.
2. Sterilization and Canning:
    - Food is heated to 115–121°C under pressure, destroying all microorganisms including spores.
    - The sterilized food is then sealed in airtight containers to prevent recontamination.
    - Example: Canned vegetables, meat, soups.
3. Blanching:
    - Mild heating (80–90°C) to inactivate enzymes and reduce microbial load before freezing or drying.
4. Canning: It is one of the most effective methods for long-term preservation.

    It involves heating food to a specific temperature to destroy spoilage microorganisms and sealing it in airtight containers to prevent recontamination. The process includes blanching, filling into cans, sealing, thermal sterilization (usually at 121°C under pressure), and cooling. Properly canned foods can be stored safely for several months to years. Examples: Canned fruits, vegetables, meat, fish, soups, and beverages.

c. Preservation by Low Temperature Storage

Principle: Low temperatures slow down or stop microbial metabolism and enzymatic activity.

- Refrigeration (0–5°C): Delays spoilage for short-term storage.

  Example: Dairy products, vegetables.
- Freezing (-18°C or below): Stops microbial growth completely, used for long-term preservation.

Example: Meat, fish, frozen fruits.

Food should be thawed properly to avoid quality loss and bacterial contamination.

d. Preservation by Chemicals (Food Additives)

Principle: Use of safe chemical preservatives or additives to inhibit microbial growth and chemical reactions.

i. Natural Preservatives

- Salt: Create high osmotic pressure, withdrawing water from microbes.
  - Salting: Used in fish, meat, and pickles. It may be dry salting (rubbing salt directly onto food) or brine salting (soaking food in salt solution). Examples: Salted fish, meat, and pickled vegetables.
  - Pickling is the preservation of food in acidic or saline environments. It involves immersing vegetables, fruits, or meat in solutions containing vinegar (acetic acid), brine (saltwater), or both. The high acidity and salt concentration inhibit bacterial growth, while desirable lactic acid bacteria may ferment the food to produce flavor and aroma.
- Sugar
  - Sugaring: Used in jams, jellies, and syrups.

ii. Acidic Preservatives

- Vinegar (Acetic acid): Used in pickling to lower pH and inhibit microbial growth.
- Citric acid: Prevents browning and rancidity in fruits.

iii. Chemical Additives

- Sodium benzoate, potassium metabisulfite, sorbic acid, nitrates, and nitrites are widely used in beverages, fruit juices, meats, and bakery products.

iv. Antioxidants and Antimicrobials

- Ascorbic acid (Vitamin C) and butylated hydroxyanisole (BHA) prevent oxidation.
- Sulphur dioxide (SO_2) inhibits microbial spoilage in dried fruits and wines. The use of additives is regulated by agencies like FSSAI, FAO, and WHO to ensure safety and permissible limits.

Food preservation is a cornerstone of global food security and public health. By understanding the causes of spoilage and applying effective preservation techniques—including asepsis, removal of microorganisms, anaerobic conditions, and specialized physical or chemical methods.