

Controlling microorganisms in foods

I. Methods for controlling microorganisms in foods

Avoiding or retarding spoilage of raw and processed foods but at the same time preserving the sensory and nutritional characteristics of foods is a great challenge for the industry. The methods used for controlling microbial spoilage include **preventing access of the organisms to the foods, removing their cells or spores, inhibiting their growth**, and using **thermal and nonthermal methods to inactivate them** (table)

Table 4 Methods for controlling the microorganisms involved in food spoilage

<i>Principle of preservation</i>	<i>Methods</i>
Prevent access of the microorganism to the food	Good agricultural practices Good manufacturing practices Appropriate hygienic and sanitary conditions
Microorganism removal	Washing of surfaces Centrifugation Filtration by membranes
Growth inhibition	Cooling or freezing Reduce water activity (drying and addition of solutes) Food acidification Addition of inhibitors (weak organic acids, nitrites, nitrates, sulfites, and bacteriocins) Microbial competition Atmosphere modification (vacuum or modified atmosphere packaging)
Microbial inactivation	Thermal treatments (pasteurization, sterilization, blanching, and thermization) Radiation High hydrostatic pressures Pulsed electric field processing Ultrasound

A. Physical methods

1. Temperature control:

- **Low-temperature storage:** refrigeration (0-5°C) slows growth; freezing (-18°C or below) halts growth but may not kill microbes.
- **Heat treatment:**
 - **Blanching:** mild heat (e.g., 70-100°C) to inactivate enzymes and reduce surface microbes on vegetables.
 - **Pasteurization:** destroys vegetative pathogens and extends shelf life (e.g., HTST: 72°C/15s for milk; UHT: 135-150°C/1-2s for shelf-stable milk).
 - **Sterilization/canning:** commercial sterility (12d process) to destroy *C. botulinum* spores (e.g., >121°C for several minutes).

2. **Irradiation:** use of ionizing radiation (gamma rays, x-rays, electron beams) to disrupt microbial DNA. Used for spices, grains, and some fruits/vegetables. Measured in kilograys (kgy).
3. **High-pressure processing (HPP or pascalization):** uses isostatic pressure (400-600 mpa) to inactivate vegetative microbes while minimally affecting food quality. Ideal for juices, guacamole, ready-to-eat meats.
4. **Dehydration/drying:** reduces a_w to inhibitory levels (e.g., sun-drying, spray drying, freeze-drying/lyophilization).
5. **Filtration:** physical removal of microbes using membranes (common for wine, beer, clear juices, and air in aseptic processing).
6. **Ultrasound and pulsed electric fields (PEF):** emerging non-thermal technologies that disrupt microbial cell membranes.

B. Chemical methods

1. **Direct antimicrobial additives (preservatives):**
 - **Organic acids & their salts:** sorbic acid/potassium sorbate (molds, yeasts), benzoic acid/sodium benzoate (yeasts, molds, some bacteria), propionic acid/calcium propionate (molds, rope in bread).
 - **Nitrites and nitrates:** in cured meats, inhibit *C. botulinum* and contribute to color/flavor.
 - **Sulfur dioxide and sulfites:** antimicrobial and antioxidant in wines, dried fruits.
2. **Indirect additives:**
 - **Acidulants:** lower pH (e.g., citric, lactic, acetic acid).
 - **Antioxidants:** prevent oxidative rancidity which can create compounds that support microbial growth.
3. **Modified atmosphere packaging (MAP):** replaces air with gases like CO₂ (primary antimicrobial), N₂ (inert filler), and low O₂. Extends shelf life of fresh meats, pasta, cheese.
4. **Surface sanitizers and disinfectants:** used on equipment and contact surfaces (chlorine compounds, quaternary ammonium compounds, iodophors, peroxyacetic acid).

C. Biological methods (biocontrol/biopreservation)

1. **Fermentation:** intentional use of lactic acid bacteria, yeasts, or molds to produce acids, alcohol, and bacteriocins that inhibit competitors.
2. **Bacteriocins:** proteinaceous toxins produced by bacteria to inhibit closely related species.
 - **Example:** nisin (produced by *Lactococcus lactis*), used globally to inhibit gram-positive spoilage and pathogenic bacteria in cheese, canned foods, and cured meats.

3. **Protective cultures:** direct addition of live, non-pathogenic, antimicrobial-producing bacteria (e.g., *Lactobacillus sakei* against *Listeria* in meats).

II. The integrated food safety system: HACCP and prerequisite programs

Control is not a single step but a **system**.

- **Prerequisite programs (PRPs):** foundational practices (GMPs, sanitation, pest control, supplier approval, training).
- **Hazard analysis critical control point (HACCP):** a systematic, preventive approach.
 1. Conduct hazard analysis.
 2. Determine critical control points (CCPs).
 3. Establish critical limits for each CCP.
 4. Establish monitoring procedures.
 5. Establish corrective actions.
 6. Establish verification procedures.
 7. Establish record-keeping and documentation.

III. Current challenges and future directions

- **Biofilms:** microbes in protective matrices on surfaces are highly resistant to sanitizers.
- **Antimicrobial resistance (AMR):** transfer of resistance genes from environmental and foodborne bacteria.
- **Consumer trends:** demand for "clean-label," minimally processed, additive-free foods drives innovation in physical and biological methods.
- **Climate change:** may alter the geographic distribution of pathogens and pests.
- **Advanced diagnostics and predictive modeling:** use of whole-genome sequencing for traceback and predictive software to model microbial growth under various conditions.