Chapter 04: Unit Operations in Food Processing

5. Thermal Operations

5.1. Definition
Thermal operations are treatments that use heat to transform, preserve, or stabilize foods.

5.2. Objectives of Thermal Treatments

- Destroy microorganisms
- Inactivate enzymes
- Extend shelf life
- Improve sensory qualities

5.3. Types of Thermal Operations

A. Pasteurization

1. Definition
Pasteurization is a moderate thermal process that consists of heating a liquid to a controlled temperature for a specific time in order to destroy pathogenic microorganisms while preserving as much nutritional and sensory quality as possible.

2. Principle
The liquid is heated to a moderate temperature (e.g., 72°C for milk) for a short time (e.g., 15 seconds for high-temperature short-time treatment), then rapidly cooled to limit deterioration.

Objectives:

- Destruction of pathogenic microorganisms
- Limitation of sensory and nutritional alterations

3. Types of Foods Concerned

- Milk and dairy products
- Fruit juices and nectars
- Beer and fermented beverages

4. Effects on Quality

4.1. Microbiological Quality
- Destruction of pathogens
- Reduction of spoilage microorganisms

4.2. Nutritional Quality
- Preservation of most vitamins and minerals
- Partial loss of heat-sensitive vitamins (C, B1…)

4.3. Sensory Quality
- Minimal changes in taste and aroma
- Color preserved

4.4. Shelf Life
- Extended shelf life without major alteration
- Shorter than sterilization

B. Sterilization

1. Definition
Sterilization is an intensive thermal process aimed at destroying all microorganisms, including spores, to ensure very long preservation of food.

2. Principle
The food is heated to a high temperature (110–130°C depending on the product) for a sufficient time to destroy all bacteria and spores.
This process generally causes greater changes in structure, color, and flavor compared to pasteurization.

3. Types of Foods Concerned

- Canned vegetables and fruits
- Canned meats and fish
- Sterilized dairy products (UHT milk)
- Sterilized fruit purées

4. Effects on Quality

4.1. Microbiological Quality
- Total destruction of microorganisms and spores
- Maximum safety

4.2. Nutritional Quality
- Greater loss of certain vitamins (C, B…)
- Possible reduction of some aromas

4.3. Sensory Quality
- Stable product
- Possible alteration of taste, color, and texture

4.4. Shelf Life
- Very long duration (months to years)
- Not always comparable to fresh products

5. Advantages

- Maximum food safety

- Very long shelf life
- Allows distribution and storage without refrigeration

6. Disadvantages

- Possible alteration of sensory quality
- Loss of certain vitamins
- High energy consumption

C. Cooking

1. Definition

Cooking is a thermal operation that consists of applying heat to food in order to make it edible, safe, and more digestible.

2. Principle of cooking

Cooking is based on heat transfer (conduction, convection, or radiation) to the food, leading to physical and chemical changes.

These transformations include:
• Protein denaturation
• Starch gelatinization
• Water evaporation
• Browning reactions (Maillard reaction)

3. Types of cooking

- **Cooking in water**
  Example: boiling
  • Pasta, vegetables
- **Steam cooking**
  • Vegetables, fish
- **Oven cooking**
  • Bread, cakes
- **Frying**
  • Potatoes, meat

4. Types of foods concerned

Cooking is used for almost all foods:
• Meats
• Vegetables
• Cereals
• Processed foods

5. Effects on quality

5.1. Nutritional quality

- Improved digestibility
- Destruction of some antinutritional factors
- Loss of vitamins (C, B)
- Degradation of some nutrients

5.2. Sensory quality

- Improved taste
- Formation of aromas
- More pleasant texture
- Overcooking → burnt taste
- Texture too soft or too dry

5.3. Sanitary quality

- Destruction of microorganisms
- Improved food safety
- Risk if cooking is insufficient
- Formation of undesirable compounds (e.g., excessive frying)

D. Blanching

1. Definition

Blanching is a thermal operation that consists of subjecting food to short-term heating in hot water or steam, usually followed by rapid cooling.

2. Principle

Blanching is based on applying moderate heat for a limited time in order to inactivate enzymes responsible for food deterioration.

It also helps reduce the microbial load partially.

3. Types of foods concerned

Blanching is mainly used for:
• Vegetables (green beans, carrots, spinach)
• Certain fruits
• Products intended for freezing or drying

4. Examples

• Blanching vegetables before freezing
• Treating tomatoes to facilitate peeling
• Preparing vegetables before canning

5. Effects on quality

5.1. Technological quality

- Enzyme inactivation
- Facilitation of subsequent processes (freezing, drying)

5.2. Nutritional quality

- Loss of water-soluble vitamins (vitamin C, B)
- Leaching of nutrients into water

5.3. Sensory quality

- Color stabilization (green color of vegetables)
- Texture improvement (controlled softening)
- Risk of overcooking if not well controlled

5.4. Sanitary quality

- Reduction of microbial load
- Does not ensure sterilization

Remark

Blanching is a preliminary thermal operation and not a preservation method by itself.

It is often combined with other processes such as freezing or drying.

Comparison

Operation	Temperature	Objective	Main effect
Pasteurization	Moderate	Microbial reduction	Safety ↑
Sterilization	High	Total destruction	Preservation ↑
UHT	Very high (short time)	Rapid sterilization	Better quality preservation
Cooking	Variable	Consumption	Taste ↑
Blanching	Short	Pre-treatment	Enzymes ↓