

Chapter 1: Preliminary treatment by thermal preservation (heat)

Thermal treatment is often applied to foods as a **final preparation step before consumption**. This includes **heat-based destruction processes** such as **pasteurization, sterilization, blanching**, and others.

- **Pasteurization** is applied when heating is **below 100 °C**, while
- **Sterilization** is applied when heating is **above 100 °C**.

The objectives of thermal treatment are to:

- **Destroy microorganisms**
- **Stop product deterioration** caused by **endogenous enzymes** (lipolytic or proteolytic)
- **Improve organoleptic quality** (e.g., **nitrosomyoglobin**: pink color of cooked ham, or **Maillard reaction** producing nitrosamines responsible for the brown color of bread)
- **Stabilize the structure** of certain products (through **protein denaturation**)

I. Heat-based processes

A. Pasteurization

Pasteurization is a **mild thermal treatment** developed by **Louis Pasteur in 1863**. It consists of heating foods to a temperature **below 100 °C**, followed by **rapid cooling**.

- Not all microorganisms are destroyed during this process; the goal is to **slow the growth of remaining germs**.
- All microorganisms **sensitive to heat** are killed.
- Pasteurized foods are usually **stored under refrigeration** (+4 °C).

This process aims to **preserve as much as possible the physical, biochemical, and organoleptic characteristics** (taste and aroma) of the food. Examples include: **milk and dairy products, fruit juices, vinegar, honey**, and more.

Several types of pasteurization exist, depending on the **time-temperature combination**. These determine the **pasteurization value** (see Table 3).

Table 3: Different types of pasteurization and pasteurization scale

	Pasteurisation basse	Pasteurisation haute	Flash pasteurisation
Température	63 à 65°C	82 à 88°C	90 à 95°C
Temps	20 à 30 minutes	Quelques dizaines de secondes	Quelques secondes
Aliments	Bières Ovo-produits	Glaces Semi-conserves	Lait, Jus de fruits (évite la dégradation des vitamines)
Cas particulier		Lait : 15 secondes à 72°C	

The **time-temperature combination** is the **pasteurization schedule** applied during the pasteurization process.

Pasteurization is carried out in a device called a **pasteurizer**, which is essentially a **heat exchanger**. The food product passes continuously between **heated plates or through pipes**, or it is **heated to the desired temperature for a set period of time**. After heating, the product undergoes **rapid cooling**.

The **shelf life** of pasteurized foods is:

- **Up to 14 days when unopened**
- **2 to 3 days once opened**

It should be noted that pasteurization is chosen only in certain specific cases. This process is applied when the food presents low bacteriological risks due to its intrinsic characteristics, such as the acidity of fruit juices, or when the objective is to eliminate only a limited number of pathogenic microorganisms, such as *Mycobacterium tuberculosis* in milk.

A longer treatment at a higher temperature may lead to the deterioration of the product's organoleptic properties, including taste, aroma, and texture.

Operation of a Plate Pasteurizer

A plate pasteurizer consists of metal plates that are more or less corrugated or channeled and assembled together. Between these plates circulate two different fluids:

- the heating medium (steam or hot water),
- the food product to be treated (Figure 2).

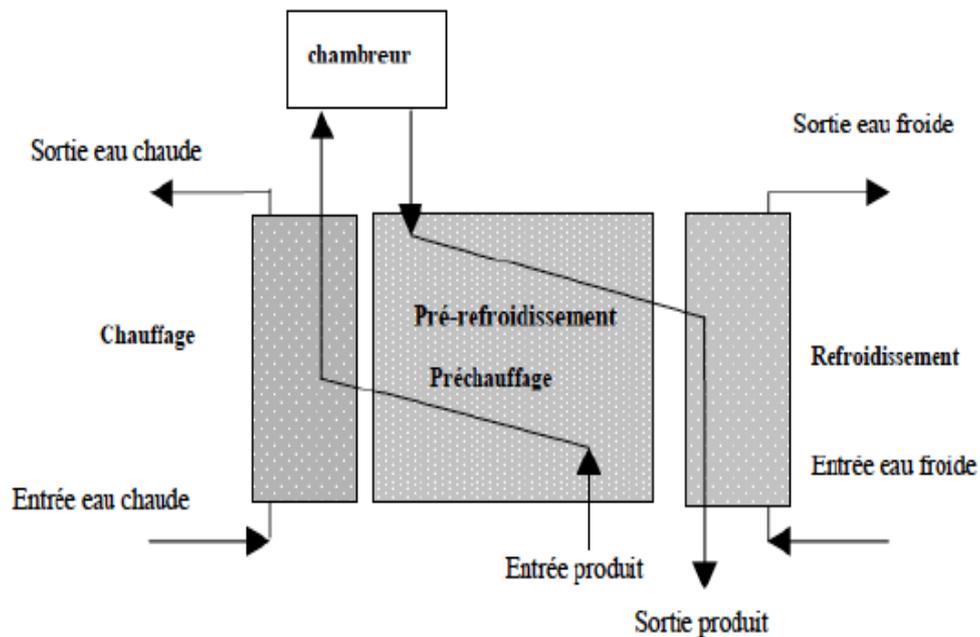
This type of equipment is generally composed of three main sections (Figure 3):

1. **Heating section,**
2. **Chilled water cooling section,**
3. **Heat exchange and recovery section.**

The heating section raises the temperature of the product to a specified value for a defined period, known as the *holding time*, using steam or hot water.

The cooling section rapidly cools the product with chilled water in order to prevent recontamination after heat treatment.

Finally, the heat exchange and recovery section allows the incoming product to be preheated while simultaneously pre-cooling the outgoing product, thereby improving the overall energy efficiency of the process.



This process consists of the complete destruction of all microorganisms and reproductive spores present in food by prolonged boiling for 15 to 20 minutes at a temperature ranging between 100 °C and 120 °C. The sterilization operation uses a time–temperature combination that is higher than that of pasteurization. In other words, it may range from 15 minutes at 121 °C to a few seconds at 140 °C. Among sterilized foods, milk, fruits, and vegetables can be cited.

The sterilization temperature varies according to the characteristics of the food, such as its composition, pH, and initial microbial load. In fact, the more acidic a food is, the more rapidly microorganisms are destroyed by heat. For example, in fruit juice with a pH lower than 4.5, all microorganisms are destroyed, whereas in products with a pH higher than 4.5 (such as meat products), microorganisms resistant to temperatures above 100 °C are not eliminated. In this case, such products are referred to as *semi-preserved foods*.

The major drawback of this treatment is the loss of about 30% of vitamins and the alteration of flavor. However, its main advantage lies in the ability to preserve foods for several months, or even several years, without deterioration, provided they are stored away from excessive heat.

The sterilization process is carried out in hydrostatic sterilizers. These are continuous-pressure autoclaves used for the production of canned foods (Figures 4 and 5).



Figure 4: Pilot Autoclave

- **Safety:** On every autoclave, a safety valve is adjusted to open before the pressure exceeds the maximum allowable limit of the equipment.
- **Condensates:** A valve allows the regular removal of condensed steam (condensates) after it has transferred its heat to the product.
- **Cooling water:** At the end of the treatment, product cooling is ensured by spraying refrigerated water.
- ☐ **Compressed air:** At the beginning of the cooling phase, the pressure inside the chamber drops suddenly due to the stoppage of steam admission and the temperature decrease caused by cold water. However, the product at the core of the cans remains at a high temperature. This creates a risk that the water contained inside may vaporize and cause the cans to burst. To prevent this, compressed air is injected into the chamber in order to maintain the set pressure until the temperature of the products is uniformly below 100 °C

C. APERTIZATION

This process was developed by Nicolas Appert in 1810 for the preservation of fruit juices. Apertization is a food preservation method that consists of placing perishable foods of animal or plant origin in a hermetically sealed container and subjecting them to heat treatment in order to destroy or inactivate enzymes, toxins, and microorganisms—both pathogenic and non-pathogenic—that are capable of growing in foods under normal storage and distribution temperatures, without refrigeration.

After sealing the containers and depending on the nature of the food product, it is heated under the following conditions: 30 minutes at 110 °C, 3 minutes at 120 °C, 20 seconds at 130 °C, or 2 seconds at 140 °C. This treatment allows food to be preserved for several months, or even several years.

- Among apertized foods, one can cite fruits, vegetables, meats, fish, and ready-to-eat meals, among others.
- Apertization helps preserve the organoleptic and nutritional qualities of food products.

Description of a Simple Static Batch Autoclave (Figure 7)

The autoclave is the conventional equipment used in apertization. It consists of a hermetically sealed chamber (vessel) that allows food products to be sterilized at high temperatures under pressure ($T > 100\text{ }^{\circ}\text{C}$). Heating is achieved using saturated steam or superheated water. The pressure is either solely related to the temperature increase or additionally regulated by the injection of compressed air (counterpressure).

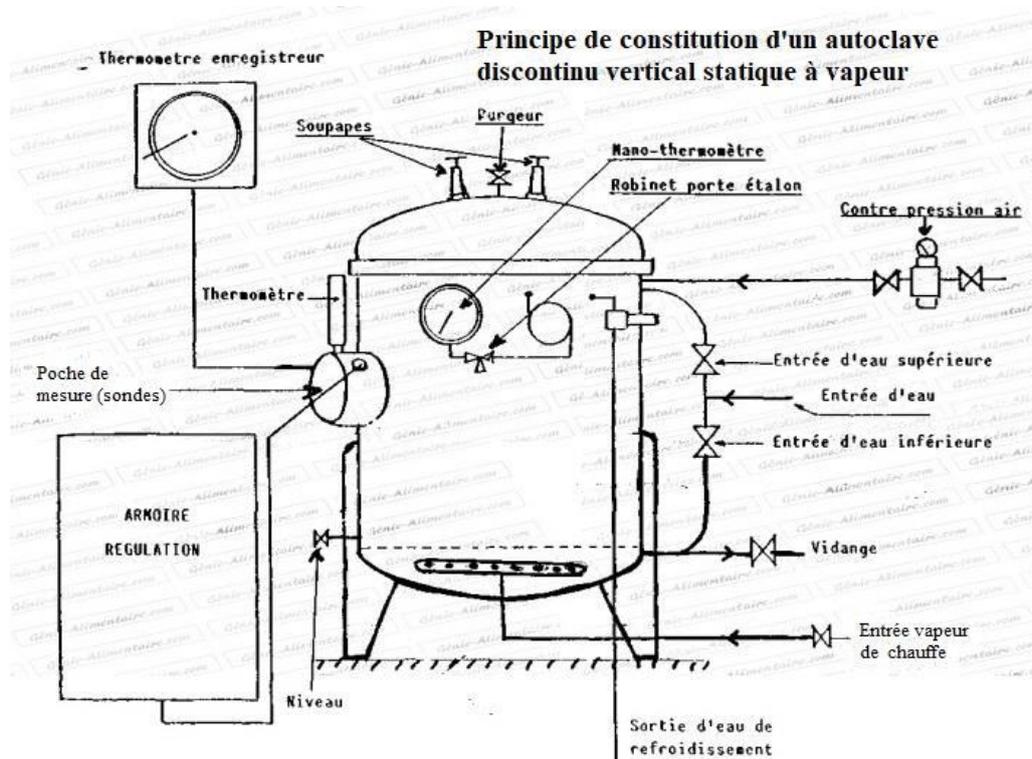


Figure 7: Diagram of a Retort (Autoclave) for Canning

D – SEAMING

Seaming of food cans is a critical step in the canning (appertization) process, a thermal preservation method developed by Nicolas Appert. This operation ensures the hermetic sealing of the container before heat treatment, guaranteeing microbiological safety and long-term stability of the product during storage.

Seaming allows:

- Prevention of microbial and external contamination
- Maintenance of internal vacuum after heat processing

- Extension of shelf life
- Preservation of sensory quality (taste, texture, aroma)

D.1. The Seaming Process

Seaming is a mechanical operation that joins the can body and the lid (end) to form a hermetic double seam. This process is carried out using a seaming machine equipped with seaming rolls.

The operation includes several steps:

1. Preparation of the Can and Lid

Cans are manufactured from tinplate steel or aluminum sheets.

The lid is pre-formed with a curled edge containing a sealing compound (gasket) that ensures airtightness after compression.

2. Filling

Cans are filled with pre-treated food products (washed, blanched, partially cooked).

A headspace is left to allow product expansion during thermal processing.

3. Seaming (Sealing)

The lid is placed on the filled can.

Seaming is performed in two main operations:

- **First operation:** The edges of the can body and lid are interlocked by folding to form the initial seam.
- **Second operation:** The seam is compressed and tightened to create a strong, hermetic double seam.

The double seam is formed by the interlocking and compression of the body hook and cover hook.

4. Inspection and Quality Control

Each sealed can is inspected to verify:

- Seam thickness and height
- Seam tightness and compactness
- Absence of defects (leaks, false seams, excessive wrinkles)

Destructive testing (cutting and examining the seam cross-section) may be performed to evaluate internal seam integrity.

Importance of Seaming

Improper seaming may result in:

- Microbial contamination
- Can swelling (spoilage)
- Product deterioration
- Serious health risks to consumers

Therefore, seaming is a critical control point in the canning (appertization) process and must be carefully monitored to ensure food safety and product stability.



.2. Advantages of Metal Cans

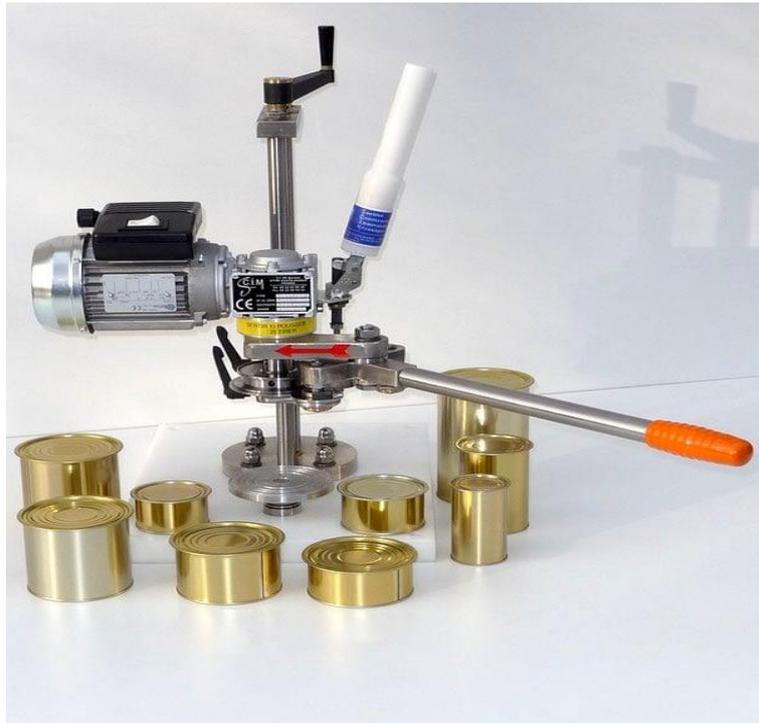
- **Preservation of Freshness:**
The hermetic double seam prevents air and microorganisms from entering the container, thereby maintaining the freshness, flavor, and nutritional quality of foods over an extended period.
- **Food Safety:**
Airtight sealing significantly reduces the risk of contamination by pathogenic microorganisms. Combined with thermal processing (appertization), it ensures microbiological safety.
- **Durability and Strength:**
Metal cans are highly resistant to impact, pressure, and perforation, making them suitable for transportation, handling, and long-term storage.

- **Reduction of Food Waste:**

Thanks to their long shelf life, canned foods help reduce food spoilage and minimize food waste throughout the supply chain.

- **Environmental Sustainability:**

Metal cans are a sustainable alternative to plastic packaging because they are fully recyclable. Steel and aluminum can be recycled multiple times without significant loss of quality, contributing to resource conservation and reduced environmental impact.



E – MICROWAVE PRESERVATION

Thanks to its high thermal efficiency and shorter processing time, microwave treatment generally provides better preservation of the organoleptic properties (taste, texture, color, aroma) of food and cosmetic ingredients.

Microwave preservation is based on the use of electromagnetic waves (frequency ≈ 2450 MHz) that cause agitation of polar molecules, mainly water. This agitation generates rapid internal heating, leading to:

- Inactivation of microorganisms
- Destruction or reduction of enzyme activity responsible for food spoilage

Microwaves act through:

- **Dipole rotation** (water, salts, sugars)
- **Molecular friction**, producing heat
- **Rapid temperature increase** to levels lethal for microorganisms

This technology can be used alone or combined with other preservation techniques.

E.1. Applications in Food Preservation

Microwave technology is used for:

- **Blanching** (pre-treatment before freezing or dehydration)
- **Pasteurization** (destruction of pathogenic microorganisms)
- **Microwave-assisted sterilization**
- **Rapid thawing**
- **Microwave drying or vacuum microwave drying**

In addition, microwave thermal treatment can serve as an alternative to certain pesticides and chemical preservatives that are restricted or prohibited in organic agriculture. It helps extend shelf life without the use of synthetic chemicals.

Microwave preservation is a modern and promising technology, especially when combined with other processes (microwaves + vacuum, microwaves + freezing). It allows effective food preservation while maintaining good nutritional quality. However, strict process control is essential to ensure microbiological safety and uniform heating.