Food Preservation by Chemical Methods

Food preservation by chemical methods is a technique that involves adding **authorized chemical substances** to food in order to inhibit the growth of microorganisms (bacteria, yeasts, and molds) and **extend the shelf life** of food products

1. Modification of Water Activity (Aw) by Addition of Chemical Products

These processes, considered **indirect methods**, consist of **binding the available water in food by adding chemical agents that reduce water activity (Aw)**.

Water activity–reducing agents do not belong to any specific chemical family. **Water activity depends on the nature and the quantity of substances dissolved in the aqueous phase of the food product (or solution).**

The **most commonly used Aw depressants in the food industry** are **salts**, particularly **sodium chloride (NaCl)**, and **carbohydrates**, especially **mono- and disaccharides**.

The table below gives some **Aw values of solutions with different concentrations of NaCl and sucrose measured at 25 °C**.

Table 1: *Water activity (Aw) of NaCl and sucrose solutions (concentration in g/100 g of water, Aw measured at 25 °C)*

AW	***NaCl***	***Saccharose***
0,99	1,75	11
0,96	7,01	25
0,94	10,34	93
0,92	13,5	120
0,90	16,5	144
0,85	23,6	208

The use of **salts and sugars** is among the **simplest and least expensive methods** for reducing the **water activity (Aw)** of a food and thus improving its **preservation**. However, this method can only be considered in the case of **special preparations** where salt or sugar plays an important role in the **organoleptic characteristics** of the food. This is the case, for example, for **salted anchovies, salted capers, syrups, and confectionery products**.

A. SALTING

- **Preservation by salt**, or **salting**, consists of subjecting a food product to the action of salt:

- Either by spreading salt directly on the surface of the food (dry salting):
In this operation, a salt concentration of about **15% of the weight of the food product** is added to cause **dehydration**.

- Or by immersing the product for a certain period in a saltwater solution (brining):
The food is placed in a **brine** composed of **salt, water, and various additives** (spices, sugars, nitrates, etc.).
The brine acts by **osmosis**, meaning that **part of the salt migrates into the food**, and the **salt concentration in its tissues becomes balanced with that of the brine**.

- Both methods reduce the water activity (Aw) of the product and slow down or stop microbial growth.

- Salt acts as an antimicrobial agent, neutralizing the microorganisms responsible for **spoilage or putrefaction**.

Salt is used in **different doses depending on preservation needs**. At **2%**, it slows the growth of certain microorganisms and gives a **salty taste**. However, at **high concentrations**, it destroys **almost all microorganisms**.

-This process is mainly applied in **cheese making, cured meats (charcuterie), and for preserving certain fish species** (such as **herring and salmon**). It is sometimes **combined with smoking**.

-Food products preserved by **salting** carry a **DLUO (Best Before Date)**, which means **Optimal Use-By Date**.

B. CANDYING OR SUGARING

-Sugaring, also called **candying**, is a process widely used in the **food industry**. It is carried out by **adding sugar, especially sucrose, to the food product while heating**. The cooking of the food in the presence of sugar occurs **slowly**: a **sugar syrup penetrates the fruits by osmotic effect**.

-Thanks to its **hygroscopic property** (the tendency to bind several water molecules), **sugar absorbs the available water in the food**, reduces **water activity (Aw)**, and consequently **inhibits bacterial growth**.

-The **sugars contained in foods** can also combine with **bacteria** to produce **acids** (such as **lactic acid and propionic acid**) with **antibacterial properties**. This occurs in foods such as **sauerkraut and pickles** (lactic fermentation), and **grapes and apples** (alcoholic fermentation).

-Sugar, added as an ingredient, is generally used to **improve the taste, color, and/or texture** of certain food products such as **beverages and sauces (e.g., ketchup)**.

-The **candying process is effective only at very high concentrations (65–67%)**.

-The **sugaring process** is used for the preservation of:

- **Glucose syrups**
- **Canned fruits**
- **Jams and jellies**
- **Candies**
- **Fruit pastes**
- **Candied fruits**

✓ Food products preserved by **sugaring** also carry a **DLUO (Best Before Date)**.

5 . OTHER PRESERVATION METHODS

A. FERMENTATION

- It was **Louis Pasteur** who, in **1857**, established the **microbial origin of the fermentation process**. In this process, food undergoes a **chemical and biological**

(biochemical) reaction that occurs between the **organic matter it contains** and **specific microorganisms in the environment** (yeasts or bacteria).
The fermentation process is accompanied by the formation of **characteristic products such as alcohols, acids, or ketones**. These organic products allow **better preservation of the food product**.

- The **fermentation process** is usually **combined with other preservation methods**, such as **controlled salting or candying (sugaring)**.
- The **three main types of food transformations by fermentation** are:

1. Alcoholic fermentation (grapes, apples – cider):
This is an **anaerobic process** (i.e., in the absence of oxygen) in which **monosaccharides are broken down by yeasts** through a chain of **enzymatic reactions called glycolysis**.
As products of glycolysis, **two molecules of ethanol (C_2H_5OH)** are formed at the end of the process.

2. Lactic fermentation (sausages, sauerkraut (cabbage), pickles, cheeses, yogurt):
In **anaerobic fermentation**, **glucose ($C_6H_{12}O_6$)** or **lactose ($C_{12}H_{22}O_{11}$)** reacts with specific microorganisms such as **Lactococcus lactis**, **Lactobacillus salivarius subsp. bulgaricus**, or **Lactobacillus fermentum** to form **lactic acid (OH-CH(CH_3)-COOH)**.

3. Acetic fermentation (vinegar):
This is an **obligatory aerobic process** starting from **ethyl alcohol (ethanol)**. It occurs in the presence of the bacterium **Acetobacter aceti** and leads to the formation of **acetic acid (ethanoic acid, CH_3COOH)**.

Desired Impact on Microbial Growth

The goal is to **take advantage of the microorganisms present on or in the food** in order to:

- **Improve product preservation**,
- **Enhance its nutritional qualities**,
- **Increase its organoleptic qualities** (taste, aroma, texture).

Fermentation processes **modify the taste of food and enrich the range of flavors**, but they produce a product that is **no longer identical to the original product**.

B. MODIFICATION OF THE ATMOSPHERE

-The principle of this **preservation process** is based on **modifying the composition of the atmosphere surrounding the food**, such as the levels of **oxygen (O_2), nitrogen (N_2), or carbon dioxide (CO_2)**. In fact:

-By decreasing the oxygen (O_2) level, the **ripening and oxidation reactions** responsible for the **growth of aerobic bacteria** and **flavor deterioration of foods** (such as **fat rancidity**) are slowed down.

-By increasing the concentration of carbon dioxide (CO_2) up to **5% or even 10%**, the **respiration rate decreases**, producing **bacteriostatic and fungistatic effects** and even **inhibiting certain enzymatic reactions**.

-By replacing air or oxygen with nitrogen (N_2), an **inert gas** (a process known as **vacuum preservation**), the **development of insects and toxic molds is stopped**, in addition to **inhibiting oxidation reactions** and producing a **bacteriostatic effect**.

- Foods preserved under a **modified atmosphere** are indicated by a **label carrying their corresponding E-number**. The most important **E-numbers for gases** are:
    - **Carbon dioxide:** E 290
    - **Oxygen:** E 948
    - **Nitrogen:** E 941
- **Some advantages of atmosphere modification:**
    - **Extended shelf life and better quality:** Foods preserved under a **protective atmosphere deteriorate much more slowly**.

The **preservation and freshness of the food product** (preservation of **nutritional and organoleptic properties**) are **maintained for a longer period of time**.

- **Fewer preservatives:** This method can **reduce or even completely stop the use of preservatives**. Consumers obtain products that **do not contain artificial additives**.
- **Less waste:** A **longer shelf life** consequently reduces **food waste** caused by spoiled products in many cases.
- Although this **preservation process is much more effective in maintaining food quality**, it is **more expensive**.
- Food products preserved using this method include:

- **Meat**
- **Dairy products**
- **Bread**
- **Fruits and vegetables**
- **Fish**