Chapter 4
Food preservation

Food preservation refers to any one of a number of techniques used to prevent food from spoiling. The oldest methods of preservation are drying, refrigeration and fermentation. Modern methods include canning, pasteurization, freezing, irradiation and the addition of chemicals. Advances in packaging materials have played an important role in modern food preservation.

Methods of preservation used to extend shelf life includes removal of moisture, temperature control, pH control, use of chemical preservatives, irradiation etc.

Historical methods of food preservation

Primitive and tedious methods used for food preservation are

Drying

Used to preserve fruit, vegetables, meat and fish. Mainly used in the South-warmer climate. Causes the loss of many natural vitamins and texture.

Salting

Used extensively for pork, beef, and fish. Done mainly in cool weather followed by smoking.

Sugaring

Used to preserve fruits for the winter. Jams and Jellies. Expensive because sugar was scarce commodity in early America.

Pickling

Fermenting, used to preserve vegetables. Use of mild salt and vinegar brine. It increases the salt content and reduces the vitamin content of the food. Oldest form of food preservation.

Cold storage

Used extensively in the northern U.S. Root cellars were used to store vegetables at 30-40^{0}F. Root cellars were replaced by ice boxes in the mid 1800's.

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Current preservation methods

Physical	Chemical	Biological
Chilling and cooling	Preservatives	
Freezing	eg: benzoates	Fermentation:
Blanching/cooking	Nitrites	Alcoholic
Pasteurization	Sugar	Acetic
Canning	Salt	Lactic
Freezing	Spices	
Drying/Dehydration	Additives	
Separation/Filtration	eg: antioxidants	
Concentration		
Irradiation		
Modified/Controlled Atmosphere packaging		

Physical methods of preservation

Methods of preserving an array of local products for use throughout the year have been based on traditional methods. More sophisticated techniques such as irradiation may also extend shelf life mainly by the destruction of enzymes and the inactivation of microorganisms.

Chilling and Cooling

Chilling may be referred to as the process that lowers the food temperature to a safe storage temperature between 0^0Cand 5^0C, whereas cooling is a more general term applied to the lowering of a food temperature. Chilled foods can potentially present a greater risk to public safety than frozen foods. Keeping products at a low temperature reduces the rate of microbiological and chemical deterioration of the food. In most processed chilled foods, it is the microbial growth that limits the shelf life, even the slow growth rates that occur under chilled conditions will eventually result in microbial levels that can affect the food or present a potential hazard. This microbial growth can result in the spoilage of the food (it may go putrid or cloudy or show the effects of fermentation), but pathogens if present, may have the potential to grow and may show no noticeable signs of change in the food.

Freezing

Freezing of food doesn't render it sterile, although it can reduce the levels of some susceptible microorganisms that is not significant in the context of the overall microbial equality of the food. Once a frozen food is defrosted, those viable microorganisms present will grow and multiply.

Rapid freezing in blast freezers is desirable to prevent the formation of large ice crystals that will tend to adversely affect the texture of the food by disrupting cell integrity in fruits and vegetables or degrading the muscle proteins of meat, fish and poultry. Apart from enzymatic activity, there are many other chemical and physical changes which may limit the shelf life of frozen food, examples include fat oxidation and surface drying both of which may occur over a period of months depending on the food.

Damage to tissue may also result from ice crystals, particularly in the case where slow freezing occurred. For example, in a domestic freezer. In commercial freezers, where temperature of -40^0C and below are maintained, freezing of the product takes place quickly and the shelf-life is even longer.

Heat Preservation

Microorganism and enzymes are the major causes of undesirable changes in foodstuffs. Both of them are susceptible to heat, and appropriate heating regimes can reduce, inhibit or destroy their activity. The degree of heat treatment required to produce a product of acceptable stability will depend on the nature of the food, its associated enzymes, the number and types of microorganisms, the conditions under which the processed food is stored and other preservation techniques used.

Blanching

Blanching is a process designed to inactivate enzymes and is usually applied immediately prior to other thermal preservation processes either using high temperatures (eg: thermal processing) or low temperatures (eg: freezing). It does not reduce the microbial population on the surface of foods, but it reduces the number of organisms of lower heat resistance such as yeasts, molds and certain bacteria (eg: *Listeria*, *Salmonella*, *E. coli*). Without a blanching step, the shelf life of frozen vegetables would be substantially reduced as a results of chemical break down during storage.

In thermal processing of fruits and vegetables, the objective of blanching is to prevent further enzymatic break down of the foods if delays occur prior to processing the foods. It is mainly used for vegetables by heating the food with steam or hot water to 180-190^oF and cooling in ice water, which prevents bacteria from growing.

During hot water blanching, some soluble constituents are leached out: water-soluble flavors, vitamins (vitamin C) and sugars. With potatoes this may be an advantage as leaching out of sugars makes the potatoes less prone to turning brown.

Blanching is a delicate processing step. Time, temperature and the other conditions must be carefully monitored. Sodium bicarbonate is added to the blanching water when okra, green peas and some other green vegetables are blanched. The chemical raises the pH of the blanching water and prevents the fresh green color of chlorophyll being changed into pheophytin which is unattractive brownish green.

If products are over-blanched (boiled for too long) they will stick together on the drying trays and they are likely to have a poor flavor. Green beans, carrots, okra, turnip and cabbage should always be blanched. The producer can choose whether or not potatoes need blanching. Blanching is not needed for onions, leeks, tomatoes and sweet peppers. Tomatoes are dipped into hot water for one minute when they need to be peeled but this not blanching. As a rule fruit is not blanched.

Benefits of blanching

1. It helps clean the material and reduce the amount of micro organisms present on the surface
2. It preserves the natural color in the dried products
3. It shortens the soaking and/or cooking time during reconstitution
4. Destroys enzymes in the food.

Pasteurization

Pasteurization is a process in which water and certain packaged and non packaged foods (such as milk and fruit juice) are treated with mild heat, usually to less than 100°C (212°F) to eliminate pathogens and extend shelf life.

The actual degree of heat process required for an effective pasteurization will vary depending on the nature of the food and the types and numbers of microorganisms present. Milk is the most widely consumed pasteurized food, and the process was first introduced commercially in the UK during the 1930s, when a treatment of 63°C for 30 minutes was used. Modern milk pasteurization uses an equivalent process of 72°C for 15 seconds.

Pasteurization is used extensively in the production of many different types of food, including fruit products, pickled vegetables, jams and chilled ready meals. Food may be pasteurized in a sealed container (analogous to a canned food) or in a continuous process (analogous to an aseptic filling operation). It is important to note that pasteurized foods are not sterile and will usually rely on other preservative mechanisms to ensure their extended stability for the desired length of time. Once the food product is exposed to temperatures of 60-70°C, microbial growth stops and enzyme inactivation starts. As the temperature is increased (80-90°C), the vegetative forms of microorganisms are destroyed and the rate of enzyme inactivation increases. Heat processing of acid products, such as fruits and fruit juices is usually done at higher temperature (100°C), for short times (10-15 seconds).

Heat processing requirements - dependent on product acidity

Acidity class	**pH value**	**Food item**	**Heat and processing requirements**
Low acid	6.0	Peas, carrots, beets, potatoes, asparagus, poultry, meat, sea foods, milk etc.	High temperature processing 116-121°C (240-250°F)
	5.0	Tomato soup	
Medium acid	4.5	Tomatoes, pears, apricots, peaches	Boiling water processing 100°C (212°F)
Acid	3.7	Jams, sauces, fruits, Sauerkraut, apple,	Temperature of 93-100^{o} C, (200-212^{o} F)
High acid	3.0	Pickles	

Canning

Frenchman Nicholas Appert is credited as the further of modern-day canning. It is a preservation method involves placing foods in jars or similar containers and heating them to a temperature that destroys microorganisms that cause food to spoil. During this heating process air is driven out of the jar and as it cools a vacuum seal is formed. This vacuum seal prevents the air from getting back into the product bringing with it contaminating microorganisms. Canning is suitable for low and high acidic foods, prevents contamination and it also enhances the shelf life. Canning process involves the following steps.

- Cleaning usually involves passing the raw food through tanks of water or under high pressure water sprays, after which vegetable or other product is cut, peeled, cored, sliced, graded, soaked and pureed and so on.
- Almost all vegetables and some fruits require blanching by immersion in hot water or steam.
- The filling of cans are done automatically by machines
- The filled cans are then passed through a hot-water or steam bath in an exhaust box, this heating expands the food and drives out the remaining air.
- The exhausted cans are then immediately closed and sealed

- Sealed cans are then sterilized i.e., they are heated at temperatures high enough and for a long enough time to destroy all microorganisms.
- The cans are than cooled in cold water or air, after which they are labelled.

Canning methods

Hot water canning methods

Here the food jars are submerged in boiling water (212^{0}F at sea level) and cooked for a specified amount of time. Hot water canning can be used for high acidic foods such as fruits, pickled vegetables etc.

Pressure canning method

In pressure canning method, food jars are placed in 2-3 inches of water in a special pressure cooker. Which is heated to a temperature of at least 240^{0}F. This temperature can only be reached using the pressure method. Pressure canning can be used for low acidic foods such as metals, sea food, poultry, dairy products, vegetables etc.

Use of ionizing radiation

Food irradiation (the application of ionizing radiation to food) is a technology that improves the safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects. There are 3 sources of radiation approved for use on foods. They are gamma rays, X-rays and electron beam.

Mode of action

- Affects on bacteria, yeasts & molds
- Main sites of damages: nucleic acids & lipids of the cell membrane
- Membrane lipid degradation
- Change the permeability of the cell membrane
- Inhibition of DNA replication
- Leach out of cell components.

Use of Non ionizing radiation

Microwave radiation

- Two frequencies used in food processing are 2450 MHz and 915 MHz
- Domestic microwave ovens use 2450 MHz which is less penetrating than the lower frequency.

Mode of action

- Microwave act indirectly on microorganism through the generation of heat
- Destruction of microorganism is accomplished through the denaturation of protein & nucleic acids.

Light energy in food preservation

UV radiation

- Used to inactivate microorganisms on the surface of foods and thin films of liquid
- Used extensively in disinfection of equipment, glassware & air
- The optimum wavelength is 260 nm

Mode of action

- UV light is absorbed by proteins and nucleic acids, in which photochemical changes are produced.
- It disrupts the DNA molecules, produce lethal mutations and thereby prevent cell replication.
- Degradation of bacterial cell wall also cause the germicidal effect

Physical methods of food preservation also involves Pulse electric fields and Modified atmosphere.

Pulse electric fields

- Involves the application of short pulses of high electric fields to foods placed between two electrodes.
- No significant detrimental effect on heat labile components present in foods such as vitamins.
- High initial investment is the major disadvantage of this method
- Gram-negative bacterial cells more sensitive than gram-positive or yeasts
- By increasing the intensity of electric field and number of pulses, greater microbial destruction can be achieved.
- Destruction of bacterial & fungal spores require a higher voltage & longer period of time.

Mode of action

- Pulse electric field causes the cell death by the disruption of cell membrane function

- When microbial cells are exposed to pulse electric field, a potential difference occurs between outside &inside cell membrane. Because of this difference, pore formation occurs in the membrane, causes the destruction of membrane function & cell death.

Modified atmosphere

Three different procedures are used:

Modified Atmosphere Packaging (MAP)

Bulk or retail pack is flushed with a gas mixture usually containing a combination of carbon dioxide, oxygen and nitrogen. It does not require a control of gaseous environment during the entire storage period. The composition of the gaseous atmosphere changes during storage as a result of product & microbial respiration.

Controlled Atmosphere Packaging (CAP)

Here the atmosphere in the storage facility is altered and continually monitored the gas levels. A constant product environment is maintained throughout storage. It is used for long term storage of fruits & vegetables for maintaining their freshness.

Vacuum packaging

Air is removed from the packages and the packages are then sealed hermetically.

Mode of action

Growth of aerobes (mold, yeast, aerobic bacteria) are prevented in products. However anaerobic & facultative anaerobic bacteria can grow unless other techniques are used to control their growth.

Natural Food Preservatives

In the category of natural food preservatives comes the salt, sugar, alcohol, vinegar etc. These are the traditional preservatives in food that are also used at home while making pickles, jams and juices etc. Also the freezing, boiling, smoking, salting are considered to be the natural ways of preserving food. Coffee powder and soup are dehydrated and freeze-dried for preservation. In this section the citrus food preservatives like citrus acid and ascorbic acid work on enzymes and disrupt their metabolism leading to the preservation.

Sugar and salt are the earliest natural food preservatives that very efficiently drops the growth of bacteria in food. To preserve meat and fish, salt is still used as a natural food preservative.

Chemical Food Preservative

Chemical food preservatives are also being used for quite some time now. They seem to be the best and the most effective for a longer shelf life and are generally fool proof for the preservation purpose. Examples of chemical food preservatives are:

- Benzoates (such as sodium benzoate, benzoic acid)
- Nitrites (such as sodium nitrite)
- Sulphites (such as sulphur dioxide)
- Sorbates (such as sodium sorbate, potassium sorbate)

Antioxidants are also the chemical food preservatives that act as free radical scavengers. In this category of preservatives in food comes the vitamin C, BHA (butylated hydroxyanisole), bacterial growth inhibitors like sodium nitrite, sulfur dioxide and benzoic acid.

Then there is ethanol that is a one of the chemical preservatives in food, wine and food stored in brandy. Unlike natural food preservatives some of the chemical food preservatives are harmful. Sulfur dioxide and nitrites are the examples. Sulfur dioxide causes irritation in bronchial tubes and nitrites are carcinogenic.

Artificial Preservatives

Artificial preservatives are the chemical substances that stops of delayed the growth of bacteria, spoilage and its discoloration. These artificial preservatives can be added to the food or sprayed on the food.

Types of Artificial Preservatives Food

- Antimicrobial agents
- Antioxidants
- Chelating agent

In antimicrobial comes the Benzoates, Sodium benzoate, Sorbates and Nitrites. Antioxidants include the Sulfites, Vitamin E, Vitamin C and Butylated hydroxytoluene (BHT) Chelating agent has the Disodium ethylenediaminetetraacetic acid (EDTA), Polyphosphates and Citric acid

Harmful Food Preservatives

Although preservatives food additives are used to keep the food fresh and to stop the bacterial growth. But still there are certain preservatives in food that are harmful if taken in more than the prescribed limits.

Certain harmful food preservatives are:

Benzoates

This group of chemical food preservative has been banned in Russia because of its role in triggering allergies, asthma and skin rashes. It is also considered to cause the brain damage. This food preservative is used in fruit juices, tea, coffee etc.

Butylates

This chemical food preservative is expected to cause high blood pressure and cholestrol level. This can affect the kidney and live function. It is found in butter, vegetable oils and margarine.

BHA (butylated hydroxyanisole)

BHA is expected to cause the live diseases and cancer. This food preservative is used to preserve the fresh pork and pork sausages, potato chips, instant teas, cake mixes and many more.

Caramel

Caramel is the coloring agent that causes the vitamin B6 deficiencies, genetic effects and cancer. It is found in candies, bread, brown colored food and frozen pizza.

In addition to this there are many other harmful food preservatives. These are Bromates, Caffeine, Carrageenan, Chlorines, Coal Tar AZO Dies, Gallates, Glutamates, Mono- and Di-glycerides, Nitrates/Nitrites, Saccharin, Sodium Erythrobate, Sulphites and Tannin.

Preservatives Food Additives

All of these chemicals act as either antimicrobials or antioxidants or both. They either inhibit the activity of or kill the bacteria, molds, insects and other microorganisms. Antimicrobials, prevent the growth of molds, yeasts and bacteria and antioxidants keep foods from becoming rancid or developing black spots. They suppress the reaction when foods comes in contact with oxygen, heat, and some metals. They also prevent the loss of some essential amino acids some vitamins.

Some common preservatives and their primary activity

Chemical Affected	Organism(s)	Action	Use in Foods
Sulfites	Insects & Microorganisms	Antioxidant	Dried Fruits, Wine, Juice
Sodium Nitrite	*Clostridia*	Antimicrobial	Cured Meats
Propionic Acid	Molds	Antimicrobial	Bread, Cakes, Cheeses
Sorbic Acid	Molds	Antimicrobial	Cheeses, Cakes, Salad Dressing
Benzoic Acid	Yeasts & Molds	Antimicrobial	Soft Drinks, Ketchup, Salad Dressings

Biological preservation

Biopreservation is the use of natural or controlled microbiota or antimicrobials as a way of preserving food and extending its shelf life. Beneficial bacteria or the fermentation products produced by these bacteria are used in biopreservation to control spoilage and render pathogens inactive in food.

Lactic acid bacteria

Lactic acid bacteria have antagonistic properties which makes them particularly useful as biopreservatives. When lactic acid bacteria compete for nutrients, their metabolites often include active antimicrobials such as lactic acid and acetic acid, H_2O_2 & peptide bacteriocins. Some lactic acid bacteria produce the anti microbial nisin which is a particularly effective preservative. Lactic acid bacteria (LAB) & propionibacteria have been extensively studied for their efficacy against spoilage causing yeasts & molds in food spoilage.

Yeasts

In addition to LAB, yeasts also have been reported to have biopreservation effect due to their antagonistic activities relying on the competition for nutrients, production and tolerance of high concentration of ethanol, as well as the synthesis of a large class of antimicrobial compounds exhibiting large spectrum of activity against food spoilage microorganisms but also against plant, animal & human pathogen.

Bacteriophage

Bacteriophages are viruses which infect bacteria. Bacteriophages have recently received a Generally Recognised As Safe (GRAS) status because of their lack of toxicity & other detrimental effects to human health for application in meat products in U.S.A. Phage preparations specific for *Listeria monocytogenes*, *E. coli* 0157:H7 & *Salmonella enterica* serotypes have been commercialized and approved for application in foods.

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