Traditional Methods of Food Preservation

Food Preservation

- Foods are composed of edible biochemical.
- Application of food processing, storage and preservation methods helps prevent outbreak of foodborne illnesses.
- Food preservation is an action designed to maintain foods at a desired level of quality.
- Novel preservative techniques are developed to satisfy current demands of market and consumer satisfaction in safety, nutritional and sensory aspects.

Why Preservation?

- Vital for the continuous supply of food during season and off-season.
- To produce value-added products and to provide variety in diets.
- Minimize the food deterioration by environmental factors (temperature, humidity, O_2 and light) as well as from microbial effects.
- Preserve quality and nutritive value of food.
- Eliminate wastes.

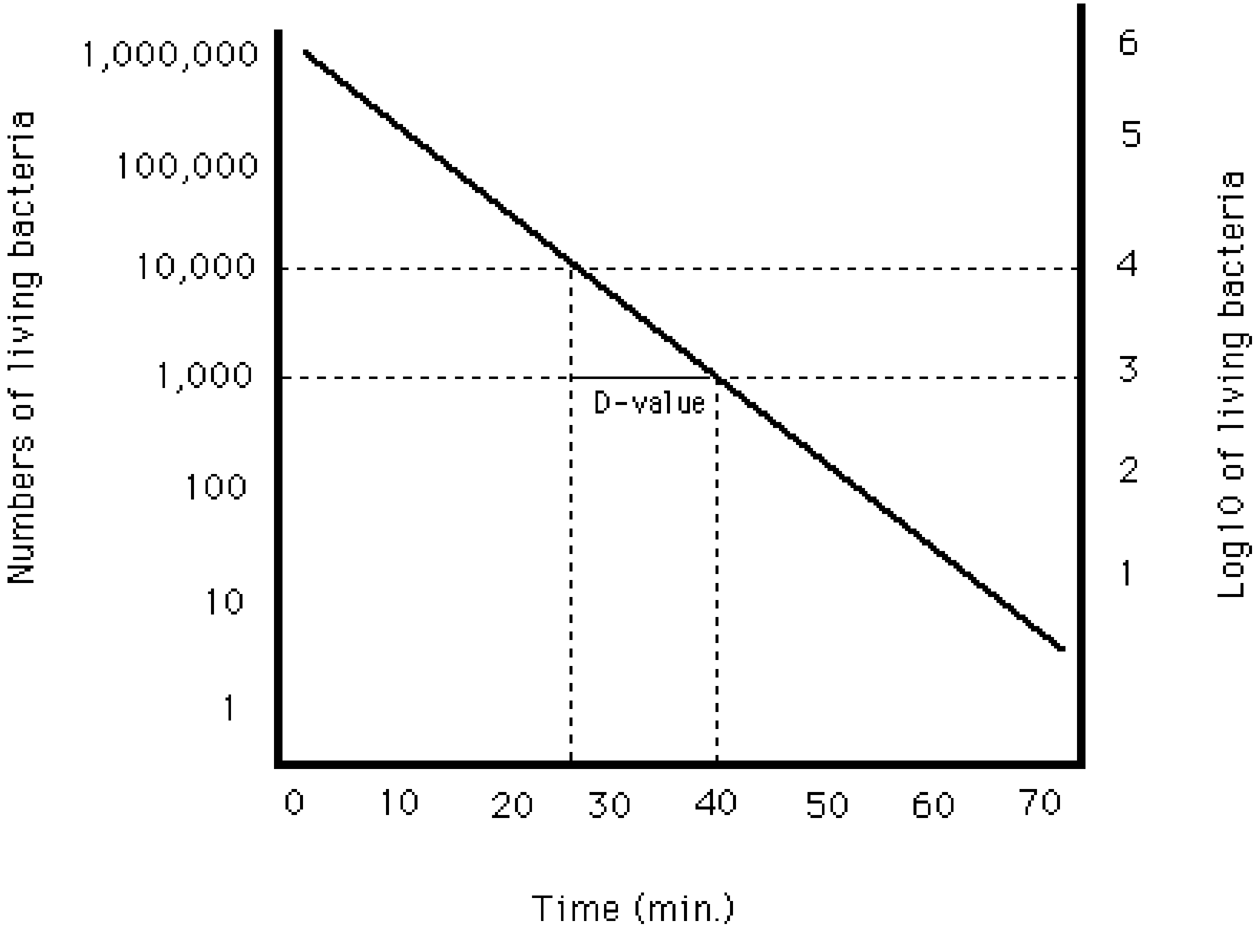
Food Preservation by Heat Treatment

- The most commonly used method of food preservation.
- There are various degrees of preservation by heating like pasteurization, sterilization, cooking and extrusion.
- These processes must be carried out under a combination of strict temperature and time control to ensure the killing of pathogenic and non-pathogenic microorganisms.
- Causes thermal inactivation of food enzymes and some destruction of food constituents.

Food Preservation by Heat Treatment

- The time of heating required to kill all vegetative cells of microorganisms is called the thermal death time.
- Microorganisms are killed by heat at a rate that is proportional to the number of cells of a specified organism present in the system being heated.

Food Preservation by Heat Treatment



Thermal destruction of microorganisms

Food Preservation by Heat Treatment

Temperature ^0C	Time (min.)
100	330
104	150
110	36
116	10
118	5.27
121	2.78
124	1.45
127	0.78

Effective time-temperature relationships for destruction of *Clostridium botulinum* spores

Food Preservation by Heat Treatment

- In containers, time required to sterilize food is influenced by;

- ✓ pH of the food.
- ✓ The size of the container.
- ✓ Physical state of the product.
- ✓ Mechanism of heat exchange.
- ✓ Heating method.
- ✓ Initial product temperature.
- ✓ Temperature of sterilization.
- ✓ State of container during sterilization (static, shaking, vibrating).
- ✓ Microbial cell concentration.

Food Preservation by Low Water Activity (a_w)

- a_w can be reduced by partial removal of the water via drying, reverse osmosis, concentration or by adding substances which increase the osmotic pressure of the food or media such as sugars, ethanol, glycerol and salts.

- Microorganisms are sensitive to the water status in their immediate environment and they can remain metabolically active only in a narrow range of high water activities.

- Low water activity limit the growth of microorganisms.

Food Preservation by Low Water Activity (a_w)

- Microorganisms that are tolerant to low a_w also tolerant of very high osmotic pressures.

- The nature of the solute added to increase osmotic pressure affects the growth of microorganisms.

Eg. Ionic solutes such as NaCl and KCl are more inhibitory than non-ionic solutes such as sugars.

Solutes such as glycerol rapidly permeate most bacteria but not yeast.

Food Preservation by Low Water Activity (a_w)

- Lowering the a_w by various means may influence the rate of enzymatic and chemical changes in foods.

Eg. Enzymatic reactions causing food spoilage continue.

Lipid oxidation accelerates.

- All microbiological growth is completely stopped below about a_w = 0.6

Food Preservation by Low pH and Organic Acids

- Foods are classified according to their acidity.

Group	pH
Non acidic	7.0-5.3
Low / medium acidic	5.3-4.6
Acid I	4.6-3.7
Acid II	3.7 and lower

Food Preservation by Low pH and Organic Acids

- Microorganisms have a characteristic range of pH values within which they can grow.

Organism	Characteristic pH range
Heterotrophic bacteria	4.0-9.0
Yeast	1.5-8.0
Mould	1.5-11.0
Saccharomyces cerevisiae	2.35-8.6
Acetobacterium sp.	2.8-4.3
E.coli	4.4-8.7
Bacillus acidocaldurius	2.0-5.0

Food Preservation by Low pH and Organic Acids

- Usually the growth rate decreases as the pH drops below the optimum value.
- The degree of inhibition increases as pH decreases.
- Many foods are preserved by the addition of relatively low concentrations of organic acids and their esters.
- Lowering of cytoplasmic pH is probably the major cause of inhibition of growth by weak acids used as food preservatives.

Food Preservation by Low pH and Organic Acids

Name of the compound	Remarks
Acetic acid	An effective preservative. Effective at concentration range 0.04% - 2.4%.
Lactic acid	Excellent inhibitor of spore-forming bacteria at pH 5.0. Ineffective against yeast and mould. Aflatoxin and sterigmatocytin formation is prevented.
Sorbic acid	More effective against mould and yeast than bacteria.
Benzoic acid	Use commonly against yeast (20 to 7000 ppm), mould (20 to 10 000 ppm) and bacteria (50 to 1800 ppm).
Parabens	Esters of p-hydroxybenzoic acid. Effective at significantly lower concentrations.

Preservation by Carbon Dioxide and Sulphite

Carbon Dioxide

- Has a major role in modifying microbial growth.
- Modified atmospheres enriched with CO_2 use to extend the shelf life of a variety of non-sterile refrigerated foods.
- Elevated CO_2 levels are effective against the psychotropic microorganisms which cause spoilage of chilled foods.
- Causes inhibition of the decarboxylation reaction in living cells.

Preservation by Carbon Dioxide and Sulphite

Sulphite

- SO_2, sulphite ($[SO_3]^{2-}$), bisulfite ($[HSO_3]^{-}$) and metabisulphite ($[S_2O_4]^{2-}$) are used as preservatives in wine, fruit juices, sausages and other foods.
- Used to inhibit enzymatic and non-enzymatic browning.
- Bisulfite ion has greater inhibitory activity towards bacteria and fungi than the sulphite ion.

Preservation by Modified and Controlled Atmospheres

- Used mainly for larger storage of fresh and partly processed food including meat, fish, fruits and vegetables.

- Includes three different methods;

1. Controlled atmosphere
2. Gas packaging
3. Vacuum packaging

Preservation by Modified and Controlled Atmospheres

Controlled atmosphere	Used for bulk storage or transportation of fruits, vegetables, meat and other foods. The gas composition, humidity and temperature is controlled.
Gas packaging	Used for bulk storage and retail packs. Gas mixtures are used (CO_2, O_2 and N_2). Gas mixtures change subsequently due to pack permeability, biological activities of packed product, and chemical reactions.
Vacuum packaging	Used for retail packs. The original air atmosphere is evacuated and the atmosphere, which develops during storage, is mainly the result of biological activities of the products.

Preservation by Modified and Controlled Atmospheres

- CO_2 alone or in mixture with N_2 and/or O_2 is most important for food preservation.

- Elstar apples were stored almost a whole year without unacceptable quality loss by combining ultra low level of O_2 (0,5-1%), 2-3% CO_2 at 1-2˚C.

Preservation by Irradiation

- Biological materials are directly and indirectly affected by ionizing radiation.

- Chemical events occur as a result of energy deposition by the radiation in the target molecule (direct effect).

- Diffusible free radical forms from the radiolysis of water, such as, the hydroxyl radical (OH^-), a hydrated electron, hydrogen atom, hydrogen peroxide and hydrogen.

Preservation by Irradiation

- Irradiation is used for;

✓Disinfection (0.15-0.50 kGy) to prevent insect damage in grains.

✓Self-life extension by inhibiting sprouting of potatoes, onions and garlic at 0.2-0.15 kGy.

✓Delaying ripening and senescence of banana, avocado, papaya and mango at 0.12-0.75 kGy.

✓Delaying microbiological spoilage of fruits and vegetables.

✓Product quality improvement in soya beans at 7.5 kGy.

Preservation by Irradiation

- Ionization irradiation affects bacteria, yeast and mould by causing lesions in the genetic material of the cell.

- Factors that affect the susceptibility of microorganisms to irradiation are dose level, temperature, atmosphere composition, state of food and type of organism.

Preservation by Low Temperatures

- Cooling and freezing are the oldest methods of food preservation.
- Chilling is used to reduce the rate of biochemical and microbiological changes and hence to extend the shelf life of fresh and processed foods.
- Chilling reduces the rate of enzymatic and microbiological changes and retards respiration of fresh foods.
- Temperature has a strong influence on the rate of respiratory activity.

Preservation by Low Temperatures

- A reduction in temperature below the minimum necessary for microbial growth extends the generation time of microorganisms and prevents reproduction.

- Chilling prevents the growth thermophilic and many mesophilic microorganisms.

Preservation by Low Temperatures

- Freezing reduces the food temperature below its freezing point.
- A proportion of the water form ice crystals.
- Reduces the water activity (a_w) and pH values.
- Preservation is achieved by a combination of low temperatures, reduced water activity, pre-treatment by blanching and retarded growth of microorganisms.

Novel Methods of Food Preservation

Pulsed Electric Fields

- The inactivation of microorganisms is achieved by pulsed electric fields which causes formation of highly reactive free radicals from various chemical species in the food.
- An increase in the electric field intensity and number of pulses lead to an increase in the inactivation of microorganisms.
- Formation of pores in cell membranes kills microorganisms.
- Treatment temperature, pH, ionic strength and conductivity of the medium containing the microorganisms affect the success of the process.

High Pressure

- Use high hydrostatic pressure (100-600 MPa) at or around room temperature.

- Vegetative microbial forms are inactivated by pressure between 400 and 600 MPa but spores of some sp. may resist pressures higher than 1000 MPa at ambient temperature.

- Gram-positive bacteria are more pressures resistant than gram-negative ones.

- High pressure can inactivate also enzymes.

High Pressure

- Type and number of microorganisms, magnitude and duration of high pressure treatment, temperature and composition of the suspension media affects the success of the process.

- Jams, fruit dressing, fruit sauce (topping), fruit jelly by the following processing conditions: 400 MPa, 2-20 min, 20˚C.
- Grapefruit juice, 120-400 MPa, 2-20 min, 20˚C
- Mandarin juice, 300-400 MPa, 2-3 min, 20˚C.

Ultraviolet Radiation

- Contains bactericidal action.
- Low-level radiation at carefully applied doses can extend the shelf life of foods without damaging quality.
- The wavelength for maximum germicidal effect is 260 nm.
- Spores of bacteria are generally more resistant to UV light than vegetative bacteria.
- Moulds are more resistant than vegetative bacteria.

Ultraviolet Radiation

- Affects bacteria and fungi such as *Penicillium* and *Aspergillus* in grapes and oranges.

- UV irradiated onions show a reduction in post-harvest rot Sprouting is also controlled.

- UV radiation dose of $1.50 \times 10{-}3$ J/mm^2 controls soft and dry rot diseases of potato tubers.

Application of Bacteriocins

- Bacteriocins is a protein that has a bactericidal action against a limited range of microorganisms, which are mostly closely related.
- Bacteriocins produced by pathogenic bacteria are not suitable for food application.
- Interesting sources of bacteriocins are the lactic acid bacteria.
- These microorganisms have been used in food fermentation (sauerkraut).

Application of Bacteriocins

- The inhibitory agent was later termed nisin.
- Nisin is used to lower the heat processing of tomato juice.
- Pediocin produced by *Pediococcus* inhibited the growth and acid production of *Lactobacillus plantarum* in mixed brine cucumber fermentation.