# FOOD PRESERVATION

## Importance of Preservation

i) Destroy pathogens for safe consumption
ii) Reduce the microbial load to prevent spoilage and extend shelf life of foods
iii) Prevent survivors from growth

## Principles of preservation

Treatments to are intended to inhibit microbial growth (microbistatic), destroy irreversible inactivation, microbicidal), to mechanically remove microorganisms, maintaining asepsis (keeping out microbes), to prevent self-decomposition of foods, inactivation of food enzymes, prevention of oxidation by anti-oxidants and applying one or combination of strategies to achieve reduction in numbers and destroying pathogens to make food safe for consumption.

## Methods of food preservation

1. Asepsis or keeping out microorganisms.
2. Removal of microorganisms.
3. Maintainance of anaerobic condition
4. Use of high temperature
5. Use of Low temperature
6. Drying
7. Irradiation
8. Osmotic pressure
9. Use of chemical preservatives
10. Mechanical destruction of microorganisms.
11. Combination of two or more above methods.

# Chemical Methods of Preservation of Foods

Chemical preservatives are considered as food additives. A food additive is a substance or substances other than the basic food stuff which is present in food as a result of any aspect of production, processing, packaging or storage. Those food additives which are specifically added to prevent microbial spoilage, deterioration and decomposition of food are referred to as chemical preservative.

**Classes of chemical preservatives: -**

1. Antioxidants – They inhibit the process of oxidation of unsaturated fats.
2. Neutralizers – They neutralize the acidity of foods.
3. Antibiotics(Antimicrobials) – They inhibit (microbiostatic) or kill microorganisms (microbicidal).
4. Stabilizers – They prevent physical changes in food.

**Characteristics of an ideal antimicrobial preservative:**

a) It should have a wide range of antimicrobial activity. b) It should be non-toxic to human beings or animals. c) It should be economical. d) It should not have an adverse effect on the flavour, taste or aroma of the original food. e) It should not be inactivated by the food or any other substance in food. f) It should not encourage the development of resistant strains. g) It should kill the microorganisms rather than inhibiting them.

**Types of Chemical Preservatives:**

*Organic preservatives* – Organic acids (like lactic acid, citric acid, propionic acids etc. and propionates, benzoates etc.), formaldehyde, wood smoke (cresols), antibiotics.

*Inorganic preservatives* – Boric acid, nitrogen salts (like nitrates, nitrites), $SO_2$, sulphite, salt, sugar, oxides, ozone etc.

**Factors affecting chemical preservation:** Food antimicrobials are generally bacteriostatic and fungistatic. Factors that influence preservative effect are food product, storage environment, handling and target microorganisms, concentration, stability, solubility, pH and buffering capacity.

**Organic acids**: Acetic, lactic, propionic, sorbic, benzoic, citric, caprylic, malic, fumaric acids are used. Organic acids are inhibitory to *Bacillus*, *Campylobacter jejuni, Clostridium spp., Escherichia coli, Listeria monocytogenes, Pseudomonas, Salmonella, Staphylococcus aureus.*

**Acetic acid and Acetates**: Acetic acid is a primary component of vinegar. Na, K, Ca salts, Na, K, Ca diacetates, dehydroacetic acid are used. Concentration of 0.1% acetic acid in bread, pH 5.1 makes shelf life- 6 days at 30°C and inhibits

*Bacillus subtilis* growth. Sodium acetate 1% increases shelf life of catfish by 6 days at 4$^{o}$C.

**Benzoic acid and Benzoates**: They are used as antifungal agent. para-hydroxybenzoic acid esters (parabens), alkyl esters of benzoic acid are also used. They are antimicrobial. They are more effective against molds and yeasts and to gram positive bacteria. They interfere with function of cell membrane and have permeabilizing effect.

**Lactic acid and Lactates**: Lactic acid is naturally produced by lactic acid bacteria. It is antimicrobial and flavouring agent in food products. Sodium lactate reduce contamination in beef, pork, poultry, fish. At pH 4.0 it is inhibitory to *E. coli*. Sodium lactate inhibits *Clostridium, Yersinia Listeria and Staphylococcus aureus*. Mixtures of sodium and calcium lactates (1.25 to 6%) are effective in inhibiting *L. monocytogenes* in sea foods.

**Propionic acid and Propionates: Upto 1% propionic acid is naturally produced** in Swiss cheese by *Propionibacterium freudenreichii*. It is used to inhibit molds mainly; and to inhibit yeasts and bacteria. Added to bread to prevent *Bacillus subtilis* causing ropiness. It is used for preservation of baked foods and cheeses.

**Sorbic acid and Sorbates**: Sorbic acid and sorbates are used as antimicrobial additive in foods as spray, dip, coating on packing materials. They are widely used in cheeses, baked items, beverages, fruit juices, dried fruits, pickles, margarine. they inhibit yeasts and molds; less effective against bacteria.

**Fatty Acid Esters**: Glyceryl monolaurate is active against gram positive bacteria like Bacillus, Micrococcus, L. monocytogenes. They inhibit spores of Bacillus at100 µg/ml concentration.

**Nitrites:** They are used as curing solutions for meats. Nitrite decomposes to nitric acid and forms nitrosomyoglobin with heme pigments in meats. So stable red color is imparted. Nitrites react with amines to form nitrosamines (carcinogenic). They are inhibitory to *Clostridium botulinum* and used for preservation of bacon, ham. Sodium nitrite and potassium nitrite are employed and nitrates have limited effect and not considered as good chemical preservatives and act probably as reservoirs for nitrites.

**Sulfur dioxide and Sulfites**: They are used as disinfectants. Salts of $SO_2$ like potassium sulfite and sodium sulfite are used for preservation of fruits and vegetables by controlling spoilage and fermentative yeasts and molds in wine, acetic acid bacteria and malolactic bacteria. It is used to inhibit E. coli, yeasts and fungi like Aspergillus.

**Ethylene and Propylene Oxides**: Ethylene oxide exists as gas. It acts as an alkylating agent and employed as fumigant. It is applied to dried fruits, nuts, spices etc. Hydroxyl ethyl group blocks reactive groups within microbial proteins and inhibits them.

**Preservation by Salt:**

Salt acts as preservative when its concentration is increased above 12 per cent. Salt levels of about 18 to 25 per cent in solution generally will prevent all growth of microorganisms in foods. However, this level is rarely tolerated in foods except in the case of certain briny condiments. **Salt exerts its preservative action by plasmolysis of microbial cells due to high osmotic pressure, drawing moisture from microbes, ionizing to yield chloride ion, which is harmful to microorganisms, reducing the solubility of oxygen to water,** sensitizing the cells against carbon dioxide and interfering with the action of proteolytic enzymes.

Salting is being done in case of meat and fish preservation. Dry salting is used in India for the preparation of preserved tamarind, raw mango, aonla, fish and meat. The preservation of food in common salt or in vinegar is known as pickling. Fruits and vegetables are preserved by pickling.

**Preservation by Salt:**

Sugar in high concentrations acts as a preservative due to osmosis. Sugar attracts all available water and water is transferred from the microorganisms into the concentrated sugar syrup. The microflora is dehydrated and cannot multiply further.

The concentration of sugar in sugar preserved products must be 68 per cent or more, which does not allow microorganisms to grow. Lower concentrations may be effective but for short duration unless the foods contain acid or they are refrigerated. The critical concentration of sugar required to prevent microbial growth varies with the type of microorganisms and the presence of other food constituents.

Some of the most popular preserves with sugar are jelly, jam and marmalade. These are the stable gels. Pectin, a natural component of fruits, forms a gel only in the presence of sugar and acid. Sugar prevents spoilage of jams, jellies, and preserves even after the container is opened.

**Antibiotics**: They are secondary metabolites produced by microorganisms. They inhibit and kill wide spectrum of other microorganisms. Molds and filamentous bacteria (Genus Streptomyces) are main producers.

Two antibiotics approved for use in food: Nisin and Natamycin. Former is produced by Lactococcus lactis. It is a bacteriocin (antibiotic like) and latter is produced by Streptomyces natalensis. Aureomycin and tetracyclines are also used.

**Nisin:** It is a polypeptide. It was first used in cheese to prevent spoilage by Clostridium butyricum. It is heat stable and storage stable. No off flavors are imparted but has narrow spectrum of antimicrobial activity. It is used as heat adjunct in canned foods and typical levels incorporated in foods are 2.5 to 100 ppm. It s mode of action is prevention of germination of spores and act on cell membrane lipids. It inhibits gram positive bacteria.

**Natamycin**: This antibiotic is a polyene produced by Streptomyces natalensis. It is effective against yeasts and molds at 1 to 25 ppm levels and control growth of fungi in strawberries and raspberries. Mode of action is it binds membrane sterols and induces distortion of selective membrane permeability. Bacteria are insensitive to natamycin due to lack of membrane sterols.

Other antibiotics tried for food applications include tetracyclines: chlor- and oxytetracyclines as approved by FDA at 1 to 7ppm level in uncooked refrigerated poultry to control bacterial spoilage.

**Antifungal Agents for Fruits**: Compound - Thiabendazole is used for preservation of Apples, pears, pineapples.

Biphenyl are used for preservation of Citrus fruits. They are applied to fresh fruits after harvest on surface at 0.5 to 1 g/L levels.

# Food preservation by use of Low Temperature

Low temperature are used to retard the chemical reaction and the action of food enzymes or to stop the growth & activities of microorganisms in the food.

At low temperature since the biochemical reactions are slowed down, it is microbiostatic in nature. Temp. around 0˚C or even low is microbiostatic & prevents the microbial spoilage of food.

Low temperature preservation is nearly attained by employing three different temperature conditions. They are --

- **Refrigeration temperature**: Keeping foods at 5 ~ 10 $^{0}$C. These temperatures are suitable for storage of vegetables and fruits such as potatoes, limes, cucumber etc.
- **Chilling temperature:** keeping foods at 0 - 5$^{0}$C. These temperatures are suitable for storage of large number of perishable foods. These includes various vegetables, fruits, dairy products like butter, cheese, eggs, meat, poultry and fish.
- **Freezer temperature**: Storage of foods at or below -18$^{0}$C. These temperatures are able to prevent the growth of all microorganisms.

**The following methods are employed in the preservation of food by low temp.--**

1. Common or cellar storage method.
2. Cold storage or chilling.
3. Frozen storage or freezing.

1. **Common or cellar storage method:-** In this method , the temp. used is in the range 15 to 25˚C for storage. Various foodstuffs like potatoes , cabbage, apples ,root crop & similar food can be stored for a limited period .Common or cellar storage method is commonly employed for storage of food for limited period (10 -15 days) since temp. is not very low. This method is usually followed in those situations where refrigeration facility is not available

2. **Cold storage or chilling:-** In this method of preservation the temperature is kept just above the freezing point. It usually involves either cooling by ice or by mechanical refrigeration. Chilling means keeping the food at very cold or at very low temperature. Factor that influence chilling process involves-
   i) Temp. of chilling ii) Air velocity
   ii) Composition of atmosphere in store room.

In food industries food is chilled by holding the food just above freezing point i.e. at $0^0$C. Chilling is microbiostatic in nature. Physical texture, colour, and flavor of food is not altered by this method hence food remains tasty for few days.

- **Freezing or frozen storage :-** It involves lowering of temperature of food to $-20^0$C and storage at same temperature. At this temperature the water in food as well as in microorganism is converted to ice crystals which affect fluidity of cell. The non-availability of water makes the environment unsuitable for microbial growth and activity. This ensures prolonged shelf-life as microbial activity is completely stopped at this temperature condition.

**Selection and preparation of foods for freezing:**

The freezing method is considered one of the simple and safe method for the preservation of various kinds of foods, provided following points are considered-

i) Careful selection, washing, blanching.
ii) Proper packaging condition.
iii) Freezing at -18˚C with a minimum fluctuation in temperature
iv) Avoidance of too long storage.

**Blanching :** Scalding or blanching is done by immersing the food material into hot water or exposing to live steam for a brief period of time. Blanching serves the following purpose- 1) it inactivates the enzymes present in the food responsible for causing undesirable changes during freezing storage. 2 ) it sets colour (enhances or fixes the green color of certain vegetables). 3) it displaces the entrapped air in the food material. 4) it reduces the number of microorganisms in the food. 5) it facilitates the packing of leafy vegetables by including wilting and making the food softer.

**Methods of Freezing: Freezing is achieved by**

- **Quick freezing**: Also called as fast or rapid freezing. Here the temperature of food is lowered to -23$^0$C( in the range of -17.8 to -34.4$^0$C) within 30 min. Here the food is usually frozen in small packets.

- **Slow freezing**: Here temperature is lowered to -23$^0$C ( in the range of -15 to -29$^0$C ) within 3 - 72 hours.

Quick freezing is accomplished by one of the three methods---1)direct immersion of food or packaged food in refrigerant, 2) by passing the food through a passage where refrigerant is flowing at -17.8 to -34.4$^0$C or 3)by **air blast freezing** where frigid air at -17.8 to -34.4$^0$C is blown across the food material being frozen. For **Dehydrofreezing,** fruits and vegetables have about half moisture removed before freezing.

- Quick freezing is more advantageous than slow freezing

| **Quick freezing** | **Slow freezing** |
|---|---|
| Time required is 30 min or less.<br>Small ice crystals formed.<br>Temp. range is -17.8 to-34.4˚C | Time required is 3 – 72 hours<br>Large ice crystals formed<br>Temp. range is -15 to -29˚C |
| Suppresses microbial metabolism | Break down of metabolic rapport and causes cell damage |
| Brief exposure to adverse conditions | Longer exposure to injurious factors |
| No adaptation to low temperature | Gradual adaptation |

| | |
|---|---|
| Causes thermal shock to microbes | No thermal shock effect |
| No protective effect. | Accumulation of concentrated solutes with beneficial effects. |
| Quick frozen food thaw to a condition more like that of original. | Return of food to original form after thawing is less. |

## Effect of freezing on microorganisms

- Freezing causes sudden mortality .i.e. microbes die immediately on freezing, varying with microbial species
- The surviving microorganisms die when stored in frozen condition
- Decline in microbial number is rapid at temperature below freezing point (-$2^0$C) than at lower temperature, and is slow below -$20^0$C
- Bacteria differ greatly in their capacity to survive during freezing
- Cocci are more resistant than Gram negative bacteria
- Food poisoning bacteria are less resistant to freezing while, microbial endospores and toxins are not affected by freezing.

## Changes during Storage:

Improper freezing or storage of foods may result in detrimental quality changes. When foods with high amounts of water are frozen slowly, they may experience a loss of fluid, called drip, upon thawing. This fluid loss causes dehydration and nutrient loss in frozen food products.

During frozen storage, the ice crystals present in foods may enlarge in size, producing undesirable changes in texture. This phenomenon is commonly observed when the storage temperature is allowed to fluctuate.

Improperly packaged frozen foods lose small amounts of moisture during storage, **resulting in surface dehydration commonly called freezer burn.** Frozen meats with freezer burn have the appearance of brown paper and quickly become rancid. Freezer burn can be minimized by the use of tightly wrapped packages and the elimination of fluctuating temperatures during storage.

## Thawing:

**The process of bringing back the frozen food to normal temperature is called thawing.** Thawing frozen food correctly is important for keeping food safe to eat. The FDA Food Code states that the temperature of food should not exceed 41 °F during the thawing process. Freezing food keeps most bacteria from multiplying, but it does not kill them. If food is allowed to enter the temperature danger zone of 41 °F–135 °F, bacteria will grow rapidly.

When ice crystals in frozen foods melt, the liquid either is absorbrd back into the tissue cells or leaks out from the food. Slow well- controlled thawing usually results in better return of moisture to the cells and results in more like the original food than rapid thawing. **The pink or reddish liquid that comes out from meat on thawing is called drip or bleeding.** The liquid that oozes out from fruits and vegetables on thawing is called leakage. During thawing the rate of action of enzymes in the food will increase, but the time for action will be comparatively short if the food is promptly utilized.

**If thawing is done rapidly and food is used promptly, there is no trouble with growth of microorganisms as the temperature is too low for their growth. But if thawing is very slow or when thawed food is allowed to stand at room temperature there will be considerable amount of micro-organisms growth and activity.** The kinds of microorganisms growing depend on temperature of thawing and the time the food was allowed to stand after thawing.

Some foods like meat, fish or poultry products: some bakery products, fruits and vegetables are cooked before freezing. The precooking is usually enough to kill most pathogens but if toxins are present they may not be destroyed. **If these precooked frozen foods are kept at warm temperature for long time after thawing, there may be growth and toxin production by food-poisoning organisms.**

**Hence thawed food should be consumed as early as possible or refrozen or kept at cold temperatures.**