PRINCIPLES OF PRESERVATION BY HEAT, LOW TEMPERATURE, CHEMICALS AND FERMENTATION

PRINCIPLES OF FOOD PRESERVATION BY HEAT

Application of heat to the foods leads to the destruction of microorganisms. The specific treatment varies with:

i) The organisms that has to be killed.

ii) The nature of the food to be preserved and

iii) Other means of preservation that may be used in addition to high temperature.

High temperatures used for preservation are usually: (1) Pasteurization temperature – below 100^{o}C (2) Heating at about 100^{o}C and (3) Sterilization temperature above 100^{o}C.

a. Pasteurization–below 100^{o}C

Pasteurization is a heat treatment that kills part but not all the microorganisms present and the temperature applied is below 100^{o}C. The heating may be by means of steam, hot H_2O, dry heat or electric currents and the products are cooled promptly after the heat treatments. The surviving microorganisms are inhibited by low temperature (or) some other preservative method if spoilage is to be prevented.

Preservative methods used to supplement pasteurization include (i) refrigeration e.g. of milk (2) keeping out microorganisms usually by packaging the product in a sealed container (3) maintenance of anaerobic conditions as in evacuated, sealed containers (4) addition of high concentration of sugar, as in sweetened condensed milk and (5) presence (or) addition of chemical preservatives e.g. the organic acids on pickles.

Methods of pasteurization

HTST method - High temperature and short time (above 70^{o}C)

LTH method - Low temperature and higher time (or) Holding method (60-70^{o}C)

b. Heating at about 100^{o}C

A temperature of approximately 100^{o}C is obtained by boiling a liquid food, by immersion of the container of food in boiling water or by exposure to flowing steam. Some very acid foods, e.g., sauerkraut may be preheated to a temperature somewhat below 100^{o}C, packaged hot, and not further heat processed. Blanching fresh vegetables before freezing or drying involves heating briefly at about 100^{o}C.

c. Sterilization-above 100^{o}C

By this method all microorganisms are completely destroyed due to high temperature. The time and temperature, necessary for sterilization vary with the type of food. Temperatures above 100^oC can only be obtained by using steam pressure sterilizers such as pressure cookers and autoclaves.

Fruits and tomato products should be noted at 100^oC for 30 min. so that the spore-forming bacteria which are sensitive to high acidity may be completely killed. Vegetables like green peas, okra, beans, etc. being non acidic and containing more starch than sugar, require higher temperature to kill the spore forming organisms. Continuous heating for 30-90 min. at 116^oC is essential for their sterilization. Before using, empty cans and bottles should also be sterilized for about 30 min. by placing them in boiling water.

Difference between pasteurization and sterilization

Pasteurization	Sterilization
1. Partial destruction of microorganism	Complete destruction of microorganism
2. Temperature below 100^oC	Temperature 100^oC and above
3. Normally used for fruits	Normally used for vegetables

Aseptic canning

It is a technique in which food is sterilized outside the can and then aseptically placed in previously sterilized cans which are subsequently sealed in an aseptic environment.

Hot Pack (or) Hot fill

Filling of previously pasteurized or sterilized foods, while still hot, into clean but not necessarily sterile containers, under clean but not necessarily aseptic conditions.

PRESERVATION BY LOW TEMPERATURE

Microbial growth and enzyme reactions are retarded in foods stored at low temperature. The lower the temperature, the greater the retardation. Low temperature can be produced by

(a) Cellar storage (about 15^oC)

The temperature in cellar (underground rooms) where surplus food is stored in many villages is usually not much below that of the outside air and is seldom lower than 15^oC. It is not enough to prevent the action of many spoilage organisms or of plant enzymes. Root crops, potatoes, cabbage, apples, onions and similar foods can be stored for limited periods during the winter months.

(b) Refrigerated (or) chilling (0 to 5^oC)

Chilling temperature are obtained and maintained by means of ice or mechanical refrigeration. It may be used as the main preservative method for foods or for temporary preservation until some other preservative process is applied. Most perishable foods, including eggs, dairy products, meats, sea foods, vegetables and fruits, may be held in chilling storage for a limited time with little change from their original condition. Enzymatic and microbial changes in the foods are not prevented but are slowed considerably.

Factors to be considered in connection with chilling storage include the temperature of chilling, the relative humidity, air velocity and composition of the atmosphere in the store room, and the possible use of ultra violet rays or other radiations.

PRESERVATION BY CHEMICALS

A preservative is defined as only substance which is capable of inhibiting, retarding or arresting the growth of microorganisms.

Microbial spoilage of food products is also controlled by using chemical preservatives. The inhibitory action of preservatives is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes.

Pasteurized squashes, cordials and crushes have a cooked flavour. After the container is opened, they ferment and spoil within a short period, particularly in a tropical climate. To avoid this, it is necessary to use chemical preservatives. Chemically preserved squashes and crushes can be kept for a fairly long time even after opening the seal of the bottle. It is however, essential that the use of chemicals is properly controlled, as their indiscriminate use is likely to be harmful. The preservative used should not be injurious to health and should be non-irritant. It should be easy to detect and estimate.

Two important chemical preservatives are permitted to beverages according to the FPO (1955).

1. Sulphur dioxide and
2. Benzoic acid

Sulphur dioxide

It is widely used throughout the world in the preservation of juice, pulp, nectar, squash, crush, cordial and other products. It has good preserving action against bacteria and moulds and inhibits enzymes, etc. In addition, it acts as an antioxidant and bleaching agent. These properties help in the retention of ascorbic acid, carotene and other oxidizable compounds. It also retards the development of nonenzymatic browning or discolouration of the product. It is generally used in the form of its salts such as sulphite, bisulphate and metabisulphite.

Potassium metabisulphite (K_2O 2So2 (or) $K_2S_2O_5$) is commonly used as a stable source of So2. Being a solid, it is easier to use than liquid (or) gaseous So2.It is fairly stable in neutral (or) alkaline media but decomposed by weak acids like carbonic, citric, tartaric acid and malic acids. When added to fruit juice (or) squash it reacts with the acid in the juice forming the potassium salt and So2, which is liberated and forms sulphurous acid with the water of the juice. The reactions involved are as follows

$$\text{Potassium meta bisulphate} + \text{Citric acid} \longrightarrow \text{Potassium Citrate} + \text{Sulphur dioxide} + H_2O$$

$$SO2 + H_2O \longrightarrow H_2SO_3 \text{ (Sulphurous acid)}$$

SO2 has a better preservative action than sodium benzoate against bacteria and moulds. It also retards the development of yeasts in juice, but cannot arrest their multiplication, once their number has reached a high value.

It is well known that fruit juices with high acidity do not undergo fermentation readily. The preservative action of the fruit acid its due to is hydrogen ion concentration. The pH for the growth of moulds ranges from 1.5 to 8.5, that of yeasts from 2.5-8.0, and of bacteria from 4.0 to 7.5.As fruit beverage like citrus squashes and cordials have generally a pH of 2.5 to 3.5, the growth of moulds and yeasts in them cannot be prevented by acidity alone. Bacteria, however, cannot grow. The pH is therefore, of great importance in the preservation of food product and by regulating it, one or more kinds of microorganisms in the beverage can be eliminated.

The concentration of So2 required to prevent the growth of mirgroorganism at different pH levels are as under.

pH	**S.ellipsoideus (yeasts)**	**Mucor (mold)**	**Penicillium (mold)**	**Mixed bacteria**
2.5	200	200	300	100
3.5	800	600	600	300
7.0	Above 5000	Above 5000	Above 5000	Above 1000

The toxicity of So2 increases at high temperature. Hence its effectiveness depends on the acidity, pH, temperature and substances present in fruit juice.

According to FPO, the maximum amount of So2 allowed in fruit juice is 700 ppm, in squash, crush and cordial 350 ppm and in RTS and nectar 100 ppm. The advantages of using So2 are a) It has a better preserving action than sodium benzoate against bacterial fermentation b) it helps to retain the colour of the beverage for a longer time than sodium benzoate (c) being a gas, it helps in preserving the surface layer of juices also (d) being highly soluble in juices and squashes, it ensures better mixing and hence their preservation and (e) any excess of So2 present can be removed either by heating the juice to about 71^{o}C or by passing air through it or by subjecting the juice to vacuum. This causes some loss of the flavouring materials due to volatilization, which can be compensated by adding flavours.

Disadvantages (or) limitations

a. It cannot be used in the case of some naturally coloured juices like those of jamun, pomegranate, strawberry, coloured grapes, plum etc. on account of its bleaching action.

b. It cannot also be used for juices which are to be packed in tin containers because it not only corrodes the tin causing pinholes, but also forms H_2S which has a disagreeable smell and reacts with the iron of the tin container to form a black compound, both of which are highly undesirable and

c. So2 gives a slight taste and colour to freshly prepared beverages but these are not serious defects if the beverage is diluted before drinking.

II. Benzoic acid

It is only partially soluble in H_2O hence its salt, sodium benzoate is used. One part of sodium benzoate is soluble in 1.8 parts of water at ordinary temperature, whereas only 0.34 parts of benzoic acid is soluble in 100 parts of water. Sodium benzoate is thus nearly 170 times as soluble as benzoic acid, pure sodium benzoate is tasteless and odourless.

The antibacterial action of benzoic acid is increased in the presence of Co_2 and acid e.g. *Bacillus subtilis* cannot survive in benzoic acid solution in the presence of Co_2. Benzoic acid is more effective against yeasts than against moulds. It does not stop lactic acid and acetic acid fermentation.

The quantity of benzoic acid required depends on the nature of the product to be preserved, particularly its acidity. In case of juices having a pH of 3.5-4.0, which is the range of a majority of fruit juices, addition of 0.06 to 0.10% of sodium benzoate has been found to be sufficient. In case of less acid juices such as grape juice atleast 0.3% is necessary. The action of benzoic acid is reduced considerably at pH 5.0. Sodium benzoate is excess of 0.1% may produce a disagreeable burning taste. According to FPO its permitted level in RTS and nectar is 100 ppm and in squash, crush and cordial 600 ppm.

In the long run benzoic acid may darken the product. It is, therefore, mostly used in coloured products of tomato, jamun, pomegranate, plum, watermelon, strawberry, coloured grapes etc.

Preservation by fermentation

Decomposition of carbohydrates of microorganisms or enzymes is called fermentation. This is one of the oldest methods of preservation. By this method, foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of alcoholic beverages, vinegars, and fermented pickles depends upon the presence of alcohol, acetic acid and lactic acid respectively. Wines, beers, vinegar, fermented drinks, fermented pickles etc., are prepared by these processes.

Fourteen per cent alcohol acts as a preservative in wines because yeasts, etc., cannot grow at that concentration. About 2% acetic acid prevents spoilage in many products.