Food preservation can be defined as the science which deals with the methods of prevention of decay or spoilage of food, thus allowing it to be stored in a fit condition for future use. It is better if the following directions are kept in mind to **control the spoilage**.

1. Raw materials should be thoroughly examined and handled hygienic conditions to avoid microbial spoilage.

2. Equipment must be cleaned every time before use.

3. The cans should be carefully filled and exhausted sufficiently to produce a good vacuum.

4. Processing should take place as soon as possible after sealing of cans or bottles. The cooling process should also be done in such a manner that the cans are left sufficiently warm to dry off surplus moisture but not hot enough to cause "stack" burning.

5. Use of contaminated water should be avoided.

6. The finished products after canning or bottling should be stored in well- ventilated rooms in a cool and dry place. High storage temperature should be avoided.

Freshly prepared products are highly attractive in appearance and possess good taste and aroma, but deteriorate rapidly if kept for some time. This is on account of **several reasons** such as. fermentation caused by moulds, yeasts and bacteria, enzymes present in the product may affect the colour and flavour adversely, e.g. apple juice turns brown due to the activity of oxidative enzymes in it, chemicals present in the pulp/juice may react with one another and spoil its taste and aroma, air coming in contact with the product, may react with the glucosidal materials present in it and render the product bitter, e.g., Navel orange and sweet lime juices often turn bitter when they are exposed to air even for a short time. And traces of metal from the equipment may get into the product and spoil its taste and aroma.

In the preservation of foods by various methods, the following principles are involved:

1. Prevention or delay of microbial decomposition

(a) by keeping out microorganisms (asepsis);

(b) by removal of microorganisms, e.g., by filtration;

(c) by hindering the growth and activity of microorganisms, e.g., by low temperature, drying, anaerobic conditions, chemicals or antibiotics; and

(d) by killing the microorganisms, e.g., by heat or radiation.

2. Prevention or delay of self-decomposition of the food

(a) by destruction or inactivation of enzymes, e.g., by blanching;

(b) by prevention or delay of chemical reactions, e.g., prevention of oxidation by means of an antioxidant.

3. Prevention of damage by insects, animals, mechanical causes, etc.

To retain the natural taste and aroma of a product, it is necessary to preserve it soon after preparation, without allowing it to stand for any length of time.

Various methods of preservation are employed and each has its own merits. The methods generally used are as under:

1. Asepsis (Absence of infection)

Asepsis means preventing the entry of microorganisms. Maintaining of general cleanliness while, picking, grading, packing and transporting of fruits and vegetables increases their keeping quality and the products prepared from them will be of superior quality. Washing or wiping of the fruits and vegetables before processing should be strictly followed as dust particles adhering to the raw material contain microorganisms and by doing so the number of organisms can be reduced considerably.

2. Preservation by High Temperature

Coagulation of proteins and inactivation of their metabolic enzymes by the application of heat leads to the destruction of microorganisms present in foods. Further, heating can also inactivate the enzymes present in the food. Heating food to high temperatures can, therefore, help to preserve it. The specific treatment varies with:

Acid fruit juices require a lower temperature and less time far pasteurization than the less acid ones. Juice can be pasteurized in two' ways: (i) by heating it at a law temperature for a long period, or (ii) by heating at a high temperature for a short time only (HTST method). There are three methods of pasteurization.

(a) Bottle or 'Holding' pasteurization: This method is commonly used for the preservation of fruit juices at home. The extracted juice is strained or clarified as the case may be, and filled in battles, leaving sufficient head space far the expansion of the juice during heating. The battles are then sealed air tight and pasteurized.

(b) Overflow method: Juice is heated to' a temperature about 2.5°C higher than the pasteurization temperature, and then filled in hat sterilized battles up to' the brim, taking care that during filling and sealing the temperature of juice does not fall below the pasteurization temperature. The sealed battles are pasteurized at a temperature 2.5°Clower than the filling and sealing temperature and then cooled. This method is very suitable for grape juice because it minimizes the adverse effect of air and the quality of the juice.

(c) Flash pasteurization: The juice is heated rapidly to' a temperature of about 5.5°C higher than the pasteurization temperature and kept at this temperature for about a minute. The method has been developed specially for the canning of natural orange juice but can also be used for grape and apple juices. It has the following advantages:

(a) loss of flavour is minimum,

(b) vitamins are not destroyed

(c) effects economy of time and space.

(d) keeps the juice uniformly cloudy, and

(e) juice is heated uniformly and thus its cooked taste is minimum.

(ii) Sterilization

Sterilization by definition means the destruction of all viable microorganisms. Heat sterilization is the most effective process of food preservation. It has c severe effect on heat liable nutrients, particularly vitamins and mainly through Maillard reaction, the nutritional quality of proteins is reduced. 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. Fruit and tomato products should be heated at 100°C for 30 minutes 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 to 90 minutes at 116°C is essential for their sterilization. Before using, empty cans and bottles should also be sterilized for about 30 minutes by placing them in boiling water. Temperatures above 100°C can only be obtained by using steam pressure sterilizers such as pressure cookers and autoclaves.

3. Preservation by Low Temperature

Microbial growth and enzyme reactions are retarded in foods stored at low temperatures. The lower the temperature, the greater the retardation. Low temperatures can be produced by (i) cellar storage (about l5°C), (ii) refrigeration or chilling (0 to 5°C), and (iii) freezing (-18 to -40°C).

(i) Cellar storage (about 15°C) : The temperature in cellars (under- ground rooms) where surplus food is stored in many villages is usually not much below that of the outside air and is seldom lower than l5°C. It is not low enough to prevent the action of many spoilage organisms or of plant enzymes. Decomposition is, however, slowed down considerably. Root crops, potatoes, onions, apples and. similar foods can be stored for limited periods during the winter months.

(ii) Refrigeration or chilling (0 to 5°C): Chilling temperatures are obtained and maintained by means of ice or mechanical refrigeration. Fruits, vegetables and their products can be preserved for **a few** days to many weeks when kept at this temperature. The best storage temperature for many foods is slightly above O°C but his varies with the product and is fairly specific to it. Besides temperature, the relative humidity and the composition of the air can affect the preservation of the food. Commercial cold storages with proper ventilation and automatic control of temperature are now used throughout the country (mostly in cities) for the storage of semi-perishable foods such as potatoes and apples. This has made such foods available throughout the year and has also stabilized their prices.

(ii) Freezing (-18 to -40°C): Freezing method is the most harmless method of food preservation. Microbial growth is inhibited and the rate of chemical reactions is slowed down at low temperatures. In commercial frozen storage the activity of meat enzymes is stopped while plant foods have to be blanched before freezing to avoid undesirable quality changes. At temperatures below the freezing point of water (-18 to - 40°C) growth of microorganisms and enzyme activity are reduced to a minimum. Most perishable foods can be preserved for' several months if the temperature is brought down quickly (quick freezing) and the food kept at these temperatures. Foods can be quick frozen in about 90 minutes or less by: (i) placing them in contact with the coil through which the refrigerant flows, (ii) blast freezing in which cold air is blown across the food, and {iii) dipping in liquid nitrogen. Quick frozen foods maintain their quality and freshness when they are thawed (brought to room temperature) because only very small ice crystals are formed when foods are frozen in this manner. Many microorganisms can survive this treatment and become active and spoil the food if it is kept at higher temperatures. Frozen foods should, therefore, always be kept at temperatures, below -5°c. Enzymes in certain vegetables can continue to act even after being quick frozen and so such vegetables have to be given a mild heat treatment called blanching (above 80°C) before they are frozen to prevent development of off-flavours.

The best way of preserving pure fruit juice is by freezing. Properly frozen juice retains its freshness, colour and aroma for a long time. This method is particularly useful in the case of juices whose flavour is adversely affected by heating. The juice is first deaerated and the vacuum filled with nitrogen gas. It is then transferred into containers which are hermetically sealed and frozen. Moulds are sometimes not affected by this technique. Juice can be kept in good condition for a long time in frozen form at -12 to -17°C by excluding air. It is defrosted before consumption.

4. Preservation by Chemicals

Microbial spoilage of food products is also controlled by using chemical preservatives which do not include salt, sugar, acetic acid, oils, alcohols, etc., but only microbial antagonists. 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.

According to the British Food and Drug Act of 1928 **a "preservative"** is any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food, but does not include common salt (sodium chloride), saltpeter (sodium or potassium nitrate), sugar, acetic acid or vinegar, alcohol or potable spirits, spices, essential oil or any other substance added to the food by the process of curing known as smoking.

The two important chemical preservatives permitted in many countries are:

(i) sulphur dioxide (including sulphites), and

(ii) benzoic acid (include benzoates)

These two are also allowed in India according to the Fruit Product Order (F.P.O.) of 1955.

(i) 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 (after killing the enzyme) of the product. It is generally used in the form of its salts such as sulphite, bisulphite and metabisulphite.

The advantages of using sulphur dioxide 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 sulphur dioxide present can be removed either by heating the juice to about 71°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.

The major limitations of sulphur dioxide are: (a) it cannot oe used in the case of some naturally co loured juices like those of phalsa, jamun, pomegranate, straw- berry, 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 hydrogen sulphide 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) sulphur dioxide gives a slight taste and odour 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 water 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 part of benzoic acid is soluble in 100 parts of water. Sodium benzoate is thus nearly 1170 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 carbon dioxide and acid, e.g., *Bacillus subtilis* cannot survive in benzoic acid solution in the presence of carbon dioxide. 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 to 4.0, which is the range of a majority of fruit juices, addition of 0.06 to 0.10 per cent of sodium benzoate has been found to be sufficient. In case of less acid juices such as grape juice at least 0.3 per cent is necessary.

5. Preservation by Drying

Microorganisms need moisture to grow so when the concentration of water in the food is brought down below a certain level, they are unable to grow. Moisture can be removed by the application of heat as in sun-drying or by mechanical drying (dehydration). Sun drying is the most popular and oldest method of preservation. In 'these days, mechanical drying has replaced sun-drying. This is a more rapid process as artificial heat under controlled conditions of temperature, humidity and air flow is provided and fruits and vegetables, e.g., green peas, cauliflower, mango, mahua, etc., are dried to such an extent that the microorganisms present in them fail to survive. In this method, juices are preserved in the form of powder. The juice is sprayed as a very fine mist into an evaporating chamber through which hot air is passed. The temperature of the chamber and the-flow of air are so regulated that dried juice falls to the floor of the chamber in the form of a dry powder. The powder is collected and packed in dry containers which are then closed airtight. The powder when dissolved in water makes a fruit drink almost similar to the original fresh juice. Fruit juice powders are highly hygroscopic and require special care in packing. All juices cannot, however, be dried readily without special treatment. Mango juice powder is prepared by this technique but the method is very expensive and not popular in India.

6. Preservation by Filtration

In this method, the juices are clarified by settling or by using ordinary filters, and then passed through special filters which are capable of retaining yeasts and bacteria. Various types of germ-proof filters are used for this purpose. Recently this method has come into use in U.S.A., Germany, etc., for preserving apple and grape juices. It is not used in India. This method is used for soft drinks, fruit juices and wines.

7. Preservation by Carbonation

Carbonation is the process of dissolving sufficient carbon dioxide in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste. Carbonation adds to the life of a beverage and contributes in some measure to its tang. Fruit juice beverages are generally bottled with carbon dioxide content varying from 1 to 8 g per litre. Though this concentration is much lower than that required for complete inhibition of microbial activity (14.6 g/litre), it is sufficient for supplementing the effect of acidity on pathogenic bacteria. Another advantage of carbonation is the removal of air thus creating 'an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning. Moulds and yeasts require oxygen for their growth and become inactive in the presence of carbon dioxide. In ordinary carbonated drinks, the oxygen which is normally present in solution in water in sufficient amount to bring about fermentation is displaced by carbon dioxide. Although carbonated beverages contain sugar much below 66 percent, the absence of air and the presence of carbon dioxide in them help to prevent the growth of moulds and yeasts. High carbonation should, however, be avoided as it usually destroys the flavour of the juice. The keeping quality of carbonated fruit beverages is enhanced by adding about 0.005 per cent sodium benzoate. The level of carbonation required varies according to the type of fruit juice and type of flavour.

8. Preservation by Sugar

Syrups containing 66 per cent or more of sugar do not ferment. Sugar absorbs most of the available water with the result that there is very little water for the growth of microorganisms hence their multiplication is inhibited, and even those already present die out gradually. Dry sugar does not ferment. Thus sugar acts as a preservative by osmosis and not as a true poison for microorganisms. Fruit syrup, jam, jelly, marmalade, preserve, candy, crystallized fruit and glazed fruit are preserved by sugar.

9. Preservation by Fermentation

Decomposition of carbohydrates by 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 de-pends upon the presence of alcohol, acetic acid and lactic acid, respectively. Care should be taken to seal the fermented products from air to avoid further unwanted or secondary fermentation. 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 per cent acetic acid prevents spoilage in many products.

10. Preservation by salt

Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products. It inhibits enzymatic browning and discoloration and also acts as an antioxidant. Salt in the form of brine is used for canning and pickling of vegetables which contain very little sugar and hence sufficient lactic acid cannot be formed by fermentation to act as preservative. It exerts its preservative action by (i) causing high osmotic pressure resulting in the plasmolysis of microbial cell! (ii) Dehydrating food as well as microorganisms by drawing out and tying up the moisture by ion hydration, (iii) ionizing to yield the chloride ion which is harmful to microorganisms, (iv) reducing the solubility of oxygen in water, sensitizing the cells against carbon dioxide, and interfering with the action of proteolytic enzymes.

11. Preservation by Acids

Low acid foods are spoilt rapidly. Highly acidic environment inhibits the growth of food spoilage organisms. Lowering the protein of certain foods be anaerobic fermentation, action on carbohydrates producing lactic acid is one the methods of food preservation. The same spoilage inhibitory effects can be produced by acidic additives such as vinegar or citric acid. Nutrient losses through fermentation are small. In fact, in certain cases, the nutrient levels are increase, particularly through microbial vitamin and protein synthesis. Acids are added to or allowed to form in foods to preserve them. Acetic (vinegar), citric (lime juice) and lactic acids are commonly used for preservation. About 2 per cent acetic acid prevents spoilage of many products. Onions are bottled in vinegar with a little salt. Vinegar is also added to pickles, chutneys, sauces and ketchups. Citric acid is added to many fruit squashes, jams and jellies to increase the acidity and prevent mould growth.

12. Preservation by Oil and Spices

A layer of oil on the surface of any food produces anaerobic conditions which prevent the growth of moulds and yeasts. Thus pickles in which enough oil is added to form a layer at the top can be preserved for long periods. Spices like turmeric, pepper, and asafetida have little bacteriostatic effect and their ability to prevent growth of other microorganism is questionable. Their primary function is to impart their characteristic flavour to the food.

13. Preservation by Antibiotics

Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics. Their use in medicine for control- ling certain disease producing organisms in the body is well known. Some antibiotics are also used to preserve fruits, vegetables and their products. Nisin is an antibiotic produced by Streptococcus lactis, an organism commonly found in milk, curd, cheese and other fermented milk products. It is non- toxic and has no adverse effect on the sensory qualities of food. It is widely used in the food industry especially for preservation of acid foods in which it is more stable. It is commonly used in canning of mushrooms, tomatoes and milk products. 'Nisin suppresses the growth of spoilage organisms, mainly the gas-producing) spore-forming bacteria and toxin-producing *Clostridium botulinum*. Subtilin, an antibiotic obtained from certain strains of *Bacillus subtilis*, is used in preservation of asparagus, corn and peas. It is most effective against gram-positive bacteria and spore-forming organisms. Canned peas and tomatoes containing 10 and 20 ppm of subtilin respectively were found to be free of microorganisms. Subtilin and nisin effectively reduce the thermal process requirements necessary to control the spoilage of several food products. Pimaricin, an antifungal antibiotic, can be used for treating fruits and fruit juices. At present the above three antibiotics are permitted only in such foods as are cooked prior to use and in the process of cooking the residual antibiotic is expected to be destroyed.

14. Preservation by Irradiation

Sterilization of food by ionizing radiations is a recently developed method of preservation which has not yet gained general acceptance. The unacceptable flavour of some irradiated foods and the fear that radioactivity might be induced in such food has come in the way of its greater use. The harmful effects on the human body of radiation from nuclear explosions have given rise to such apprehension in the minds of many people.

When gamma rays or electron beams pass through foods there are collisions between the ionizing radiation and food particles at atomic and molecular levels, resulting in the production of ion pairs and free radicals. The reactions of these products among themselves and with other molecules result in physical and chemical phenomena which inactivate microorganisms in the food. Thus irradiation of food can be considered to be a method of "cold sterilization", i.e., food is free of microorganisms without high temperature treatment.