NAHEP

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PRESERVATION & VALUE ADDITION OF FRUITS & VEGETABLES

IDP-NAHEP

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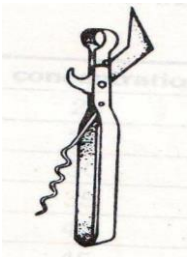
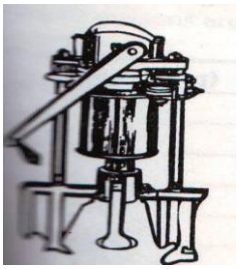
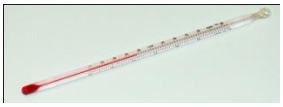
Topic: Identification of equipments and chemical /preservatives use in processing and value addition of fruits and vegetables:

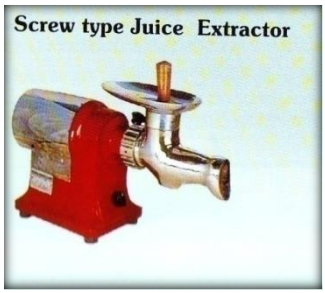
1. Identification of equipments:

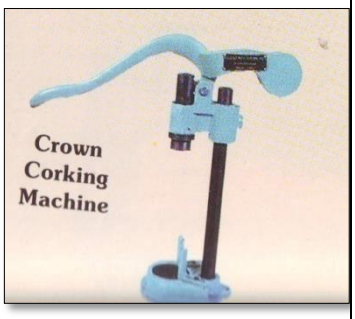
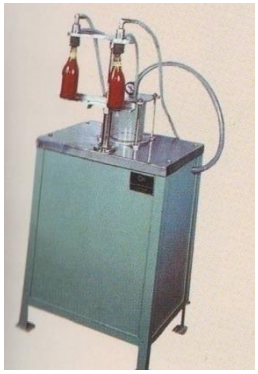
A. Utensils: Various utensils like big bowl, pan, knife, presser cooker, buckets/ steel try, colander, big spoon, funnel/ beaker/ filter items (sieves) use for preparation value added products. These utensils are made by aluminum or steel.

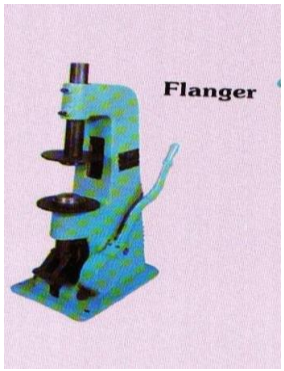
B. Equipments:

S.No.	Name	Figure	Use
1.	**Cutting knife**		Cutting the fruits and vegetable in small pieces
2.	**Peeling knife**		Remove fruit peel
3.	**Pineapple eye remover**		Remove pineapple eyes
4.	**Core and seed remove knife**		Remove the core and seed into the fruits and vegetables
5.	**Lime squeezer**		Squeeze the juice from the fruits
6.	**Juice extractor**		Extract the juice from the fruits

7.	**Weighing machine**		Weighing the chemicals / products
8.	**Can opener or cork remover**		Remove the open end of the cans
9.	**Can Sealer**		Packing or sealing of the open or bottom end of the cans
10.	**Thermometer**		Measuring temperature during preparation of the products
11.	**Jelmeter**		Testing the pectin content during jelly preparation
12.	**Hand refractometer**		Measuring amount of sugar in fruits or products by manual
13.	**Digital refractometer**		Measuring amount of sugar in fruits or products by digital in few seconds

14.	**Steam Jacketted Kettle**		Cooking tomato purees, sauces, ketchup in large scale and that are heated by steam
15.	**Basket press**		Extraction of the juice in thick pulp of fruits
16.	**Hydraulic Juice Press**		Extraction of the juice in pulp of fruits by using hydraulic force
17.	**Screw type Juice extractor**		Hand operated juice extraction machine
18.	**Rosing machine**		
19.	**Pulper**		Remove pulp from the fruits and vegetable (Electrical machine)

20.	**Fruit mill**		Remove juice from the fruits and grind the spices (Electrical machine)
21.	**Crown corking machine**		Fix the crown tightly on the bottle
22.	**Vacuum filling**		Fill the ketchup/jam etc into the bottle by vacuum process
23.	**Cap sealer**		It is use for cap sealing into the bottle
24.	**Double Seamier machine**		It is use for top / bottom portion of can sealing but first can is fixed on this machine

25.	**Rotary falt can**		Rotary flat sieve is a grain cleaning equipment equipped with sieve, which is the main working part, and air separator, which is the supplementary equipment.
26.	**Double seamer machine**		A double seam is a canning process for sealing a tin can by mechanically interlocking the can body and a can end (or lid). Originally, the can end was soldered or welded onto the can body after the can was filled
27.	**Flanger**		*Flange* facing machines are *used* to machine a new sealing surface onto the *flange* by creating a spiral serrated finish.
28.	**Lid Embossing**		This ***machine*** is ***used*** for can ***lid embossing use*** in canning unit for ***embossing*** batch number, manufacture date, etc on the ***lid*** before seaming

29.	**Potato Slicer**		Making the slices of fruits and vegetables
30.	**Solar dryer**		Drying the vegetable and fruits

C. Storage Container: Bottles are made by glass or cans are made by tin. Now days, water proof tetra pack, plastic materials are use for packing

2. CHEMICAL/PRESERVATIVES:

(A) Preservation by use of chemical preservatives-- Chemical or preservatives are substances which are added to food just to retard, inhibit or arrest the activity of micro organisms such as fermentation, pacification and decomposition of the food.

Two types of chemical preservatives:

Class-1 preservatives: common salt, sugar, dextrose, spices, vinegar, Ascorbic acid etc.

Class-2 preservatives : Benzoic acid and its salt, SO_2 and the salts of sulphuric acid, nitrates, ascorbic acid and its salts, propeonic acid and its salts, lactic acid and its salts.

Among the class-2 preservatives, only two chemical preservatives are used in fruits and vegetables preservation:

(i) KMS (Potassium Meta bisulphate) :

- It releases the SO2 and it is unstable.
- It is used for the fruit which have non water solvent pigment (colourless).
- It cannot be used in naturally coloured juices such as phalsa, jamun because they have the Anthocynin pigment.
- It cannot be used in the product which is packed in container because it acts on the tin containers and oil, Hydrogen sulphide (H2S) which has an unpleasant smell and also form a black compound with the base plate of containers.

- Best to control moulds than bacteria.
- 350 ppm KMS is mostly used in fruit juice products.

(ii) Sodium Benzoate:

- It is a salt of benzoic acid and soluble in water.
- It delays the fermentation in the juices.
- It is commonly used in the product which are having natural colour such as anthocynin pigment.
- It is more effective against the yeast.
- 750 ppm Sodium benzoate is mostly used in fruit juices, squashes and cordials.

(B) Preservation by use of food additives (Sugar, Salt, acids and vinegar):

Food additives are substances or mixture of substances other than basic foodstuffs, which are present in the foods as reagent of any aspects of production, processing, storage, packaging etc. Food additives are (a) **sugar**, (b) **salt** (c) **acids**, (d) **spices and condiments**

(a) Sugar: The concentration of 68-70% is used for preparation of jam, jelly, marmalades etc. Sugar act as a preservative by osmosis and not as a true poison for micro organisms. It absorbs most of the available water, so little water available for the growth of micro organisms.

(b) Salt: The concentration of 15-20% is used for the preparation such as pickles. Salt inhibits enzymatic browning and discolouration and also acts as an anti-oxidant. It exerts its preservative action by:

- Causing high osmotic pressure resulting in the plasmolysis of microbial cells.
- Dehydrating food and micro organisms by tyeing up the moisture.

- Ionizing to yield the chloride ion which is harmful to micro organisms, and
- Reducing the solubility of oxygen in water, sensitizing, and the cells against CO2.

(c) Acids: Many processed foods and beverages need the addition of acids to impart their characteristic flavor and taste in the final product because acids provide desired flavor and taste. They adjust the sugar and acid ratio in the food .proper balance of flavor of the food. They are also playing the role for controlling the pectin-gel formation. Example - Acetic acid (Vinegar), Citric acid (Lime juice) and lactic acid.

Acetic acid: It is commonly used for pickles, chutney, sauce and ketchup, just to inhibit the growth of micro organisms.

Citric acid: It is used for the preparation of jam, jelly, squash, nectar etc. just to increase the acidity.

Lactic acid: It is used for the formation of curd from milk.

(C) Preservation by oil- A layer of oil on the surface of any food produces anaerobic conditions which prevent the growth of moulds and yeasts. Eg., pickles

(D) Preservation by fermentation- Decomposition of carbohydrates by microorganisms or enzymes is called fermentation. 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. In wines – 14% alcohol acts as a preservative. About 2% acetic acid prevents spoilage in many products.

(E) Preservation by Carbonation - Carbonation is the process of dissolving sufficient CO_2 in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste. Fruit juice beverages are generally bottled with CO_2 content varying from 1 to 8 g/ l, it is sufficient for supplementing that effect of acidity on pathogenic bacteria. The keeping quality of carbonated fruit beverages is enhanced by adding about 0.005% sodium benzoate. The level of carbonation required varies according to the type of fruit juice and type of flavor.

(F) Preservation by Antibiotics- Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics. Nisin is an antibiotic produced by *Streptococcus lactis*. Commonly found in milk, curd, cheese and other fermented milk products. It is non-toxic.

TOPIC: TOMATO PRODUCTS

1) **Tomato Juice**
2) **Tomato puree and paste**
3) **Tomato sauce**
4) **Tomato ketchup**
5) **Tomato chutney**
6) **Tomato Soup**
7) **Tomato chilli sauce**

A) Sauces: Sauce is a product similar to ketchup, prepared from pulps of tomato or other fruits / vegetables having TSS not less than 15% and cooked to a suitable consistency with added sugar, salt, spices and vinegar (acetic acid). Sugar, salt, spices, acetic acid all act as partial preservatives. According to the FPO fruit should have a minimum of 15% TSS and 1.2% acidity. To ensure its keeping quality the sauces should contain 3% acetic acid. The sugar content may vary from 15-30% according to the kind of sauce made. Preservative and colours may also be added in sauces for increasing storability. Sauces may or may not be prepared from tomato, but ketchups are essentially prepared from tomato.

Examples: Tamarind sauce, pumpkin sauce, chilli sauce, Soya sauce

B) Ketchup: It is a product made by concentrating tomato juice or pulp without seeds and skin, with added spices, salt, vinegar, onion, garlic etc.so that it contains not less than 12% tomato solids and generally 28% or more total solids (not less than 25% TSS as per FPO specifications)

1. **Selection of fruits:** Select sound ripe tomatoes having deep red colour. Remove all green and yellow portions. Green fruits make the ketchup inferior in colour and flavour.

2. **Preparation of pulp:** Take the selected tomatoes in an aluminum or stainless steel vessel and crush thoroughly with a wooden handle. Cook the crushed mass for 5 minutes and mash it well while cooking. While it is sufficiently soft. Strain through the fine mosquito net cloth or 1mm mesh stainless steel sieve. Discard the sheds and skins.

3. **Cooking:** To the pulp add about 1/3rd of sugar given in the receipe. Place the spices (onion, garlic, cloves, cardamom, black pepper, jeera, mace, cinnamon and chili powder) in a muslin cloth bag (Jelly bag) and immerse it into the pulp. Heat the pulp till it thickens and is reduced to about 1/3rd of its volume. Remove the bag and squeeze it well to extract the aroma and flavour of the spices.

Add vinegar, salt and the remaining sugar. Heat the mass for a few minutes so that the volume of the finished product is about 1/3rd of the original pulp.

4. **Addition of preservatives:** To a small quantity of finished product, add the preservative sodium benzoate, at the rate of 295mg/kg of finished product and mix thoroughly. This can be increased up to 885 mg/kg as per specifications of FPO, 1955.Transfer the dissolved preservatives to the rest of the product and mix thoroughly.

5. **Cooling and Mixing:** Pour the finished product into a medium size sterilized bottles, seal them air tight with crown cork and pasteurize in boiling water for 30 minutes. Cool the bottle in air and store in a cool dry place.

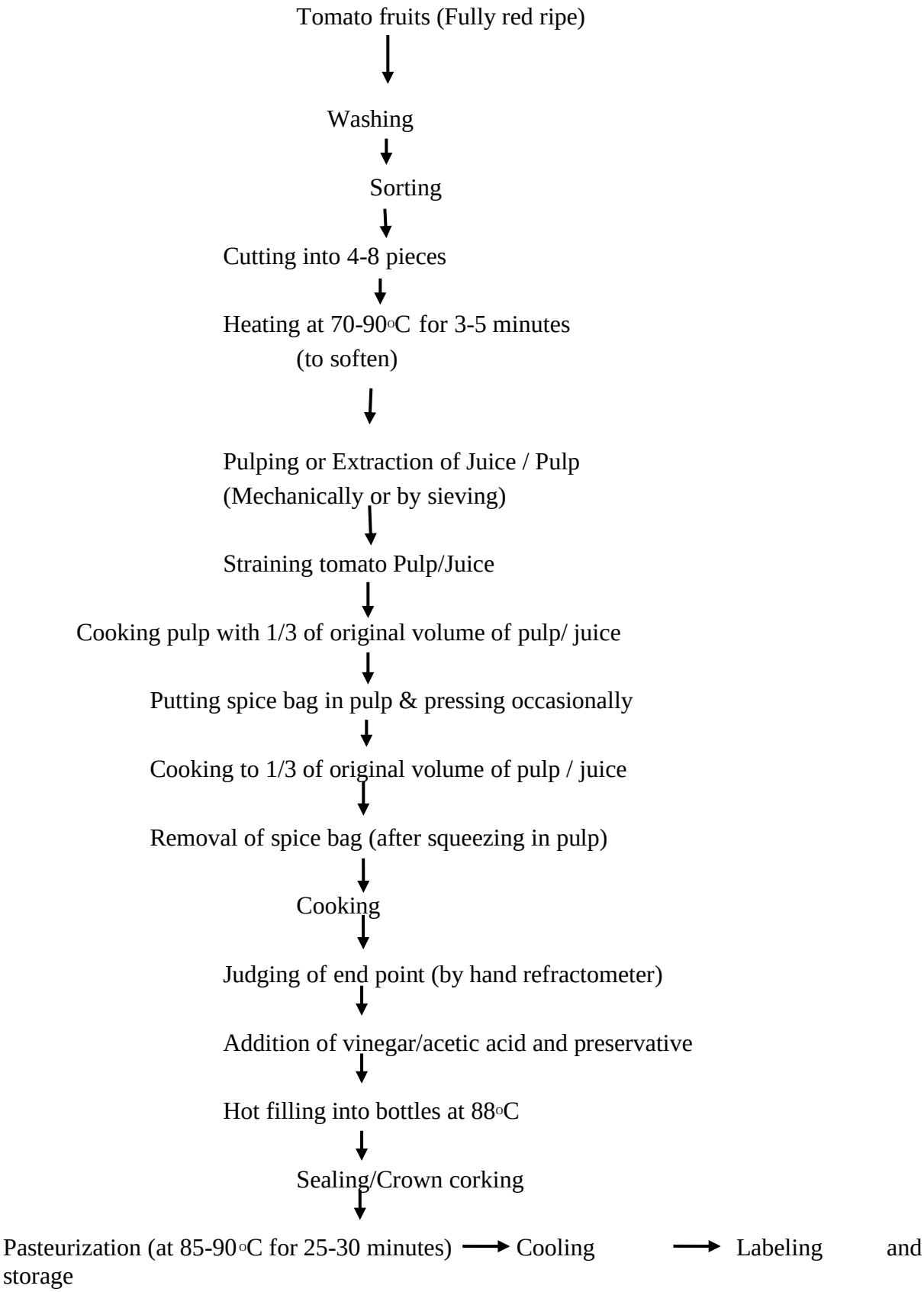
Judging end point: End point is determined by hand refractometer.when TSS reaches desired level (28-30%) sauce or ketchup is considered ready. Judging end point by volume is very simple and common in practice. The volume is measured by stick. If the volume of the produce remains 1/3rd of its original volume sauce/ketchup is considered ready.

Note:

- Chilly powder, spices, onion, ginger and garlic should be tied loosely in a muslin cloth bag.
- Vinegar and colour may be added towards the end of boiling.
- 1/3rd of sugar may be added in the beginning to preserve the red colour of pulp.
- Instead of clove, cinnamon and cardamom, their essences may be added more conveniently. Garlic may or may not be added, depending upon consumer's acceptance.

C) Tomato Puree: Tomato pulp without skin and seeds, containing not less than 8.37% of salt free from tomato solids is called as "medium tomato puree". It is further concentrated to 12% solids to form heavy tomato puree. Pulp is extracted and concentrated in open cookers or vacuum pans and packing is done in glass bottles or cans.

Flow Chart (Tomatoes sauces/ketchup)



Principles and Methods of Preservation

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.

Principles of food preservation:

A. Prevention or delay of microbial decomposition

1. by keeping out microorganisms (asepsis);

2. by removal of microorganisms, e.g., by filtration;

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

4. by killing the microorganisms, e.g., by heat or radiation.

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

1. by destruction or inactivation of enzymes. e.g., by blanching.

2. by prevention or delay of chemical reactions. e.g., prevention of oxidation by means of an antioxidant.

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

The methods of food preservation:

1. **PREVENTION OR DELAY OF MICROBIAL DECOMPOSITION**

1.1. by keeping out microorganisms (asepsis):

Asepsis means preventing the entry of microorganisms.

- Maintaining of general cleanliness while, picking, grading, packing and transporting of fruits and vegetables.
- Washing or wiping of the fruits and vegetables before processing.

1.2. by removal of microorganisms, e.g., by filtration:

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

1.3. by hindering the growth and activity of microorganisms:

1.3.1. 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 15°C),

(ii) refrigeration or chilling (0 to 5°C), and

(iii) freezing (-18 to -40°C).

1.3.1.1. Cellar **storage (about 15^0C)** :

- The temperature in cellars (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°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.

1.3.1.2. 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 0°C but his varies with the product and is fairly specific to it.
- **1.3.1.3. 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.
- 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.
- 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.
- This method is particularly useful in the case of juices whose flavour is adversely affected by heating.
- Properly frozen juice retains its freshness, colour and aroma for a long time.
- Juice can be kept in good condition for a long time in frozen form at -12 to -17°C by excluding air.

1.3.2. Preservation by chemicals:

- 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, salt petre, alcohol, spices, essential oils or any other substances added to the food by the process of curing.

- The inhibitory action of preservatives is due to their interferance with the mechanism of cell division, permeability of cell membrane and activity of enzyme.
- 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.
- A number of chemicals such as hydrogen peroxide, formaldehyde, halogenated acetic acid, salicylic acid, etc., which were used as preservatives some years ago, have now been banned in many countries.
- In recent years, except KMS and sodium benzoate, sorbic acid and tylosin, etc., are being tried.
- The two important chemical preservatives permitted in many countries are sulphur dioxide (including sulphites), and benzoic acid (include benzoates).

a) Sulphur dioxide

- It is generally used in the form of its salts such as sulphite, bisulphite and metabisulphite.
- Potassium meta-bi-sulphite ($K_2O.2S0_2$ or $K_2S_2O_5$) commonly used as a stable source of sulphur dioxide.
- According to Indian Fruit Product Order, the maximum amount of sulphur dioxide allowed in fruit juice is 700 ppm, in squash, crush and cordial 350 ppm and in RTS and nectar 100ppm.

The advantages of using sulphur dioxide are:

- 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 non enzymatic browning or discolouration (after killing the enzyme) of the productIt is fairly stable in neutral or alkaline media but decomposed by weak acids.
- When added to fruit juice or squash it reacts with the acid in the juice forming the potassium salt and sulphur dioxide, which is liberated and forms sulphurous acid with the water of the juice.

- It has a better preserving action than sodium benzoate against bacterial fermentation,
- It helps to retain the colour of the beverge for a longer time than sodium benzoate,
- Being a gas, it helps in preserving the surface layer of juices also,
- Being highly soluble in juices and squashes, it ensures better mixing and hence their preservation, and
- Any excess of sulphur dioxide present can be removed either by heating the juice to about 71°C or by pasing air through it or by subjecting the juice to vacuum.

The major limitations of sulphur dioxide are:

- It cannot be used in naturally coloured juices like phalsa, jamun, pomegranate, strawberry, coloured grapes, plum, etc., on account of its bleaching action,
- It cannot 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
- 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.

(b) Benzoic acid:

- It is only partially soluble in water hence its salt, sodium benzoate, is used. 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 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.
- 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, phalsa, jamun. pomegranate, plum, watermelon, strawberry, coloured grapes, etc.

1.3.3. 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).
- 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.

1.3.4. 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 asafoetida 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.

1.3.5. Preservation by Antibiotics:

Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics.

- Nisin
- Subtilin
- Pimaricin

Nisin:

- It is an antibiotic produced by *Streptococcus lactis*,
- 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.
- suppresses the growth of spoilage organisms, mainly the gas-producing, spore-forming bacteria and toxin-producing *Clostridium botulinum.*

Subtilin:

- It is an antibiotic obtained from certain strains of *Bacillus subtilis*,
- *It* 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 & 20ppm of subtilin respectively were found to be free of microorganisms.
- **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.

1.4. By killing the microorganisms:

1.4.1. 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.
- High temperatures used for preservation are usually: (i) pasteurization temperature (below 100°C), and

(ii) sterilization temperature (100°C or above).

1.4.2. Preservation by Irradiation

- Sterilization of food by ionizing radiations is a recently developed method.
- It is known as "cold sterilization", i.e., food is free of microorganisms without high temperature treatment.
- 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.
- During foods preservation, the radiation dose must be carefully controlled.
- The longer the food is exposed to radiation, the more radiation will it absorb.
- The WHO and the International Atomic Energy Agency have recommended that radiation dose of up to 1 Mrad is not hazardous.
- Different organisms are sensitive to radiation to different extents, e.g., a dose of 10^3 to 10^7 rad kills microorganisms, 10^3 to 10^6 rad kill insects and 10^2 to 10^3 rad are lethal to humans.
- Sprouting of potatoes, onions, carrots, etc., are inhibited by 10^3 to 10^4 rad.
- The unacceptable flavour of some irradiated foods and the fear of radioactivity might be hurdle in the way of its greater use.
- **2. PREVENTION OR DELAY OF SELF DECOMPOSITION OF FOOD:**
- **2.1. Destruction or inactivation of enzymes by blanching:**
- It is also known as scalding, parboiling or precooking. Blanching is usually done in case of vegetables by exposing them to boiling water or steam for 2 to 5 minutes, followed by cooling.
- **Advantages:**

- Inactivates most of the plant enzymes which cause toughness, discolouration (polyphenol oxidase), mustiness, off-flavour (peroxidase), softening and loss of nutritive value.
- Reduces the area of leafy vegetables such as spinach by shrinkage or wilting, making their packing easier.
- Reduces the number of microorganisms by as much as 99%.
- Enhances the green colour of vegetables such as peas, broccoli and spinach.
- Removes saponin in peas.
- Removes undesirable acids and astringent taste of the peel, and thus improves flavour.
- Removes the skin of vegetables such as beetroot and tomatoes which helps in their peeling.

Disadvantages

- Water-soluble materials like sugar and anthocyanin pigments are leached by boiling water.
- Fruits lose their colour, flavour and sugar.

2.2. By prevention or delaying of chemical reactions:

2.2.1. Preservation by Carbonation

- Carbonation is the process of dissolving sufficient CO_2 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. It is sufficient for supplementing the effect of acidity on pathogenic bacteria.
- carbonation is the removal of air thus creating an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning (14.6 g/litre).
- Moulds and yeasts require oxygen for their growth and become inactive in the presence of carbon dioxide.

2.2.3. Preservation by salt

- Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products.
- It inhibits enzymatic browning and discolouration 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.

2.2.4. Preservation by Fermentation

- ❖ Decomposition of carbohydrates by microorganisms or enzymes is called ‘fermentation’.
- ❖ 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 depend upon the presence of alcohol, acetic acid and lactic acid, respectively.
- ❖ About 2 per cent acetic acid prevents spoilage in many products.

2.2.5. Preservation by Acid

- ➢ Acid conditions inhibit the growth of many microorganisms hence organic acids are added to or allowed to preserve food.
- ➢ Acetic acid (vinegar), citric (lime juice) and lactic acids are commonly used for preservation.
- ➢ About 2 percent acetic acid prevents spoilage of many products.

3. PREVENTION AND MINIMIZING DAMAGE BY INSECT PESTS & DISEASES:

- ➢ By undertaking proper packing insect pests damage can be prevented.
- ➢ To prevent damage due to diseases require special attention that the humidity should be low in produce as well as in storage condition.

Preparation of Jam and their Problems

Jam: Jamis a product made by boiling fruit pulp with sufficient sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position.Apple , sapota apricot loquat peach,papaya karonda carrot plum mango, are used for preparation of jam. It can be prepared from one kind of fruit or from two or more kinds.

Jam contains 0.5 to 0.6 per cent acid and invert sugar should not be more than 40 percent

Fruit	Ingredients for one kg pulp		
	Sugar (Kg)	Citric acids (g)	Water
Apple	0.75	2.0	150 ml
Aonla	0.75	-	100
Grapes	0.70	1.0	50
Mango	0.75	1.5	50
Plum	0.80	-	150
Peach	o.80	3.0	100
Pear	0.75	1.5	100
Sapota	0.80	2.5	100
Raspberry	0.75	2.0	100

Flow sheet for Processing of Jam

Ripe Firm Fruit ---- Washing-----Peeling------Pulping(Remove seed and core)----- Addition of sugar

(Add water if necessary)------- Boiling(with continous stirring)--------- Addition of citric acid --------

Judging of end point by further cooking upto 105^0C or 68-70 % TSS or By sheet test---- Filling hot into sterilized bottles----- cooling-----waxing-----capping------ storage (at ambient temperature).

Judging of end point

1. **Sheet test**:- A small portion of jam is taken out during boiling,in spoon or wooden ladle and cooled slightly. It is then allowed to drop. If the product falls off in the form of a sheet of flakes instead of flowing in a continous stream or syrup,It means that end point has been reached and the product is ready,otherwise, boiling is contined till the sheet test is positive.
2. **Drop test**:- A drop of the concentrated mass is poured into a glass containing water. Settling down of the drop without disintegration denotes the end point.

3. **Temperature test** :- A solution containing 65 percent total soluble solids boil at 105^0C. Heating of the jam to this temperature would automatically bring the concentration of soilds to 65 percent. This is the easiest way to ascertain the end point.

Problems in jam production

I) **Crystallization**: - The final product should contain 30 to 50 per cent invert sugar. If the percentage is less than 30, cane sugar may crystallize out on storage and if it is more than 50 the jam will become a honey like mass due to the formation of small crystals of glucose.

II) **Sticky or gummy jam:** -Because of high percentage of total soluble solids.gam tend to because gummy or sticky. This can be solved by addition of pectin or citric acid or both.

III) **Premature setting**: - This is due to low total soluble solids and high pectin content in the jam and can be adding more sugar. If this cannot be done a small quantity of sodium bicarbonate is added to reduce the acidity and thus prevent pre-coagulation.

IV) **Microbial spoilage** :- Sometimes mould may spoil the jam during storage but they are destroyed if exposed to less than 90 per cent humidity. Hence jam should be stored at 80 per cent humidity. Mould growth can also prevented by not sealing the filled jar covering the surface of jam with a disc of waxed paper because mould does not grow under open conditions as rapidly as in a closed space. It is also advisable to add 40 ppm sulphur dioxide in the form of KMS. In the case, sulphur dioxide should not be added to the jam as it causes blacking of the internal surface of the cane

Harvest indices of fruit and vegetables

Maturity Standards

Growth & development of fruits involves a series of changes in their physical, chemical & physiological characters from fruit set until full maturation.

Maturity indices are the sign or indication the readiness of the commodity for harvest.

It is the basis for determining harvest date.

The maturity of harvested perishable commodities has an important bearing on their storage life and quality and may affect the way they are handled, transported and marketed.

Horticultural maturity

Horticultural maturity is the stage of development at which a plant or plant part possesses the prerequisities for use by consumers for a particular purpose.

Physiological maturity

Physiological maturity refers to the stage in the development of the fruits and vegetables when maximum growth and maturation has occurred.

Horticulture maturity is a development state of the fruit on the tree, which will result in a satisfactory product after harvest. Quality of the latter is predestined by the level of maturity at the time of harvest. During growth and development many physical & chemical changes occurs in the fruits. These changes are gradual & continuous. Fruits like mango & banana are harvested when they are mature, other like citrus pineapple, grapes are ripened on the plant itself. Several parameters have been suggested to judge & harvest maturity of different fruits such as firmness, T.S.S., Acid/sugar ratio, Flesh colour, starch content, pulp/peel ratio, days after fruit set. But now of these appear to be adopted in practice. Traditionally maturity is determined by the colour, shape, size, development of aroma disappearance of astringency etc.

Determination of Harvest Maturity – The principle which dictate at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage & marketable life & quality.

These may be defined in terms of either physiological maturity or either horticultural maturity and are based on the measurement of various qualitative and quantitative factors.

Harvesting maturity should at

i. Be at a stage which will allow it to be at its peak condition when it reaches the consumer.
ii. Be at a maturity that allows it to develop an acceptable flavor or appearance.
iii. Be at a size required by the market.

iv. Not to toxic
v. Have an adequate shelf life.

1. **Skin Colour: -** This factor is commonly used in fruits where the skin colour changes as the fruits ripens or matures. In papaya and other some fruit turns from green to yellow during ripening. If the fruit is harvested when it is still green, it may be possible to develop the colour after harvest but not all the flavor characteristics. If the fruit is harvested just as the yellow colour begins to show in the funicles of the fruit, the fruit can eventually ripen to as acceptable flavor. The colour of the spin terns and the skin is used as a guide to harvest maturity in rambutan. The assessment of harvest maturity of skin colour changes usually depends of the judgment of the harvester but colour charts are used for some cultivars of apple, tomato, peach, chilli, pepper etc.
2. **Optical methods: -** Light transmission properties can be used to measure the degree of maturity of fruits. These methods are based on the chlorophyll content of the fruit, which is reduced during maturation. The fruit is exposed to a bright light, which is then switched off so that the fruit is in total darkness. Next, a sensor measures the amount of light emitted from the fruit, which is proportional to its chlorophyll content and thus its maturity. diffuse light transmission in the range of 380-730 nm through cherries and apricots. These measurements were compared with organdeptic measurement of ripeness in individual fruit.
3. **Shape: -** The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops on the plant. Mangoes also change shape during maturation. As the mango matures on the tree the relationship between the shoulders of the fruit and the point at which the stalk is attached may change. The shoulders of immature mangoes slope away from the fruit stalk; however, on more mature mangoes the shoulders become level with the point of attachment, and with even more maturity the shoulders may be raised above this point.
4. **Size:** - The changes in size of a crop as it is growing are frequently used to determine when it should be harvested. In crop such as green beans, okra and asparagus this may be related to size.
5. **Aroma:** - Most fruits synthesize volatile chemicals as they ripen. These may give the fruit its characteristics colour and can be used to determine whether it is ripe or not. Guavas have a strong aroma which develops during ripening. Beta-caryophyllene was identified as an important volatile associated with the aroma of guava.
6. **Fruit opening: -** Some fruits may develop toxic compounds during ripening, such as ackee tree fruit, which contains toxic levels of hypoglycine. The fruit splits when it is fully mature, revealing black seeds on yellow arils. At this stage, it has

been shown to contain minimal amounts of hypoglycine or none at all. This creates a problem in marketing; because the fruit is so mature, it will have a very short post-harvest life. Analysis of hypoglycine 'A' (hyp.) in ackee tree fruit revealed that the seed contained appreciable hyp. at all stages of maturity, at approximately 1000 ppm, while levels in the membrane mirrored those in the arils. This analysis supports earlier observations that unopened or partially opened ackee fruit should not be consumed, whereas fruit that opens naturally to over 15 mm of lobe separation poses little health hazard, provided the seed and membrane portions are removed. These observations agree with those of Brown et al. (1992) who stated that bright red, full sized ackee should never be forced open for human consumption. In crops such as cauliflower and flowering broccoli the curd may have unpleasant flavour and texture if it are over developed at harvest.

7. **Leaf Changes:** - This is a characteristic which is used in fruit and vegetables to determine when they should be harvested. In root crops the condition of the leaves can indicates the condition of the crop below ground.
8. **Abscission:** - As part of the natural development of fruit an abscission layer is formed in the pedicel e.g. Cantaloupe melons.
9. **Firmness:** - Fruit may change in texture during maturation and especially during ripening when they may rapidly become softer excessive loss of moisture may also effect the texture of crops. These textural changes may be detected by touch and the harvester may simply be able to gently squeeze the fruit and judge where to harvest it.
10. **Juice content:** - The juice content of many fruits increase as they mature on the tree.

Type of citrus fruit	Minimum juice content
Naval orange	30%
Othe oranges	35%
Grape fruites	35%
Lemons	25%
Mandarins	33%
Clementines	40%

11. **Oil content and dry matter percent:** - Oil content can be used to determine the maturity of fruits, such as avocados. According to the Agricultural Code in California, avocados at the time of harvest and at any time thereafter, shall not contain in weight less than 8% oil per avocado, excluding skin and seed (Mexican or Guatemalan race cultivars). Thus, the oil content of an avocado is related to moisture content. The oil content is determined by weighing 5-10 g of avocado pulp and then extracting the oil with a solvent (e.g., benzene or petroleum ether)

in a destillation column. This method has been successful for cultivars naturally high in oil content (Nagy and Shaw, 1980).

12. **Sugars:** - In climacteric fruit carbohydrates are accumulated during maturation in the form of starch as the fruit ripens starch is broken down to sugars. In non-climacteric fruit sugars tend to be accumulated during maturation. In both cases if follows that measurement of sugars in the fruit can provide an indication of the stage of ripeness or maturity of that fruit.
13. **Computation:** - The time between flowering and fruit being ready for harvest may quick constant. For many fruits crops grown in temperate climates, such as apples the annual optimum harvest date may very little from year to year, even though the weather conditions may be quite different.
14. **Acoustic and Vibration tests:** - The sound of a fruit as it is tapped sharply with a finger knuckle on change during maturation and ripening. This method of testing fruit is sometimes used by consumer when purchasing fruit soar such as melons, they may be tapped in the field to judge whether they are ready to be harvested. This method may also be used post harvest determine their maturity. Commercial audio speakers have been used as vibrational exciters, with the response of the fruit (mutsu apple & nijitsu-seiki pears) measured on a computer controlled strain gange.
15. **Electrical properties:** - Studies have been carried out passing electrical currents through fruit some correlations have been shown between different characteristics of the fruit, some of which are related to fruit ripening and may the currants passes through the fruit.
16. **Electromagnetic methods:** - Nuclear magnetic resonance (NMR) has been developed in human pathology to provide real time images of the inside of the body. It can be used for detaching and the variation and binding state on water & oil such equipment can be used to provide similar micro-images of the internal structure of fruits.

    NMR has also been shown to correlate well with the sugar content of bananas and apples and the oil content of avocados.
17. **Near infra-red reflectance: -** NIR can be used for measuring moisture content using light-emitting diodes. There operate at water absorbing wavelengths and may find application in rapid online determination of soil moisture, mild and feed composition.
18. **Condiation:** - Both X and gamma rays have been used assess quality and maturity characteristics of fresh produce. A lettuce harvester was developed which used x-rays to determine which heads were sufficiently mature for harvesting.
19. **Physiological methods:** - For fruits which pass through a distinct climacteric rise in respiration during ripening. It may be possible to sample the fruit keep it at a

relatively high temperature (for apples in Britannia temp. of about 20 c would be appropriate) and measure its respiration rate. By doing this it may be possible to predict the number of days the fruit would have taken to commence the climacteric rise if left on the tree.

20. **Some measures of maturity example-**
    - Peel colour-Citrus, papaya, pineapple, grapes, mango, strawberry
    - Pulp colour-Mango, apple
    - Size- Citrus, apple, pear
    - Shape- Banana, pineapple, litchi, mango
    - Drying of plant parts-Banana
    - Surface characters- Melon, mango
    - Ease of separation from plants- Musk melon, grapes, mango
    - Tapping –Watermelon
    - Aroma- Jack fruit
    - Specific gravity-Mango pineapple, guava
    - Firmness – Melon, apple, pear
    - Sugar –Melon and grapes
    - TSS- Grapes, sweet oranges, papaya
    - Acidity –Citrus, mango, pineapple
    - Starch index-Apple, pear, banana
    - Juice content-Citrus
    - Heat unit- mango, grapes, apple pear
    - Days from anthesis- Melon, pineapple
    - Days from full bloom-Mango, citrus, apple, pear
    - Days from fruit set-Banana, mango.

VALUE ADDED PRODUCTS

1. **Fruit Juice:** It is a natural juice obtained by pressing out the fruits. Fruit juices may be sweetened or unsweetened.
2. **RTS:** It is prepared from fruit juices which must have atleast 10 per cent fruit juice and 10 percent total sugar.
3. **Fruit Juice Powder:** The fruit juice is converted into highly hygroscopic powder. These are kept freeze dried and used for fruit juice drinks by reconstituting their composition.
4. **Fermented fruit beverages:** These are prepared by alcoholic fermentation by yeast of fruit juice. The product thus contains varying amounts of alcohols e.g.; Grape wine, orange wine and berry wines from strawberry, blackberry etc.
5. **Jam:** Jam is a concentrated fruit pulp processing a fairly heavy body form rich in natural fruit flavour. It is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency to hold tissues of fruit in position
6. **Jelly:** Jelly is a semi solid product prepared by cooking clear fruit extract and sugar.
7. **Marmalade:** It is usually made from citrus fruits and consists of jelly containing shreds of peels suspended
8. **Tomato Ketchup:** It is prepared from tomato juice or pulp without seeds or pieces of skin. Ketchup should contain not less than 12 per cent tomato solids and 28 per cent total solids.
9. **Pickles:** Food preserved in common salt or in vinegar is called pickle. Spices and oil may be added to the pickle.

   Blanching: Most vegetables and some fruits are blanched before drying to inhibit enzyme activity and to help preserve the colour. The material is cut into appropriate sized pieces and plunged into boiling water for up to 5 minutes. They should be blanched in small batches to ensure that each piece is properly heated through. If too many pieces are put into the water at one time, the water temperature will drop and prolong the blanching time. After blanching for the required time, vegetables are rapidly cooled by plunging into cold (or iced) water.

Exhausting: Removal of air into the products or into the bottle or cans.

Precaution and problems:

- Sanitization, Cleaning and hygiene is required during manufacturing, packaging, storage and marketing is requires.
- Use steel or aluminium utensils or equipments

Some important methods for maintain asepsis conditions

(i) Pasteurization: below 1000C

(ii) Boiling/Cooking: at 1000C

(iii) Canning: above 1000C

Problems during Canning:

1. Swell: In swelled can, the ends are tightly bulged due to the formation of CO2 or other gas inside the can as a result of decomposition of the contents by micro-organisms. The decomposed food in the can has an offensive and sour odour and is discoloured. It is not fit for consumption and even may contain toxins produced by bacilli like Clostridium botulinum.
2. Hydrogen swell: Hydrogen formed by the action of the acids present in the fruit on the tin plate causes the can to bulge at both the ends. In such cases, the food remains free from harmful micro-organisms and is still fit for consumption.
3. Springer: A mild swell at one or both ends of a can is called a 'Springer'. It may be an initial stage of hydrogen swell or may be caused by insufficient exhausting or by over filling of the can. Food generally remains fit for consumption.
4. Flipper: The cans appear normal, but when struck against a table top one or both ends become convex and spring or flip out, but can be pushed back to normal condition by a little pressure. Such a can is termed as 'flipper'. It may be an initial stage of swell or hydrogen swell, but does more frequently, owe to over filling or under exhausting.
5. Flat sour: it is caused mostly in non-acid foods like vegetables by micro-organisms like thermophilic bacteria (B. coagulens and B. sterothermophilus) which produce acid without formation of gas. The thermophilic bacteria thrive at a high temperature of 100OC.If cans are stored without adequate cooling, the contents remain at a temperature favourable for incubation of such bacteria for fairly long time, which results in their multiplication and spoil the product. It is therefore difficult to detect from the external appearance. It may be due to by under sterilization (processing). Therefore, the thermophilic bacteria would be of significance. The product has a sour odour, and its acidity much be higher than that of the normal product. It is not fit for consumption.
6. Leakage: A leaking can is known as leaker. A very small leak may appear in the can owing to (1) defective seaming, (2) nail holes caused by faulty nailing of cases while packing (3) excessive internal pressure due to microbial spoilage sufficient to burst the can (4) internal or external corrosion (5) mechanical damage during handling.
7. Breathing (Breather): There may be a very tiny leak in the can through which air may pass in and destroy the vacuum but not the micro-organisms. Consequently, the vacuum in the can is always nil, and the pressure inside the can is equal to that of atmosphere. The damage to food is usually owing to rusting of the can caused by oxygen in the air but still the food remains fit for consumption.

8. Bursting of the can: Cans may sometimes burst. This may be due to excess of pressure caused by the gas inside, produced by the decomposition of the food by micro-organisms, or by hydrogen gas formed by chemical action of acids of the food on the tin plate. Thus, the canned product becomes a total loss.

Problems during Jam, jelly preparation:

1. Cloudy /foggy Jelly: It might be due to use of non-clarified extract, use of immature fruits (immature fruits contain starch which is insoluble in juice), Over cooking and cooling, non-removal of skum, faulty pouring (when jelly poured from a great height, air get trapped in bubbles form and jelly become opaque) and premature gelation is also a reason for cloudy or foggy jelly.
2. Weeping /syneresis Jelly: The phenomenon of spontaneous exudation of fluid from a gel is called synersis or weeping of jelly. It is caused by following factors:

- Excess of acid: Addition of excess of acid results in the breakdown of jelly structure due to the hydrolysis or decomposition of pectin.
- Too low concentration of sugar or soluble solids: This causes the network of pectin to hold more liquid than it possibly can do under normal conditions.
- Insufficient pectin: This results in the formation of a pectin network which is not sufficiently dense and rigid enough to hold the sugar syrup.
- Premature gelation: Gelation is caused due to breakdown of pectin during pouring of jelly into the containers. The jelly becomes weak and remains broken.
- Fermented jellies: Fermentation usually takes place in those jellies in which synersis has taken place.

3. Failure of jellies to set: Sometimes the jellies do not set due to the following reasons:

- Lack of acid or pectin: A jelly may fail to set due to lack of acid or pectin in the fruit from which it is made. It may also fail to set due to insufficient cooking of the fruit resulting in inadequate extraction of pectin and acid.
- Addition of too much sugar: If sugar is added in excess of the required quantity, a syrupy or highly soft jelly results. It can be corrected by adding fresh clarified juice rich in pectin.
- Cooking below the end point: If the cooking is stopped before the concentration of sugar reaches 65 percent, the jelly may fail to set and may remain syrupy and highly soft.
- Cooking beyond the end point: If heating is continued beyond the end point, the jelly becomes tough due to over-concentration. This occurs when the juice is rich in both acid and pectin and enough sugar has not been added. If the acid is in excess, the pectin breaks down and forms syrup like jelly.

4. Formation of crystals: Crystals in the jelly may be formed due to addition of excess sugar.
5. Stiff or tough : Overcooking, Too much pectin in fruit and Too little sugar which requires excessive cooking

Preservatives and Colours permitted and prohibited in India.

The acceptance of a food depends to a large extent upon its attractive colour. The characteristic colour of raw food is due to the pigments naturally present in it. Sometimes, artificial colour is added during the preparation and processing of foods to make them more attractive.

The colours or dyes used in food products should be pure and free from all harmful impurities. They should not contain more than 10ppm of copper, 20ppm of chromium,1ppm of arsenic and 10ppm of lead and should satisfy government regulations. In the selection of dyes, it is desirable to choose those which have high solubility in order to obtain a concentrated solution of a particular colour. Colours are generally available in the form of powders or to use solutions. The powder should first be made into a paste with a little cold water and the requisite quantity of almost boiling water is added to the paste with constant stirring. The solution is allowed to stand still cool and any sediment formed is removed by filtration. To prevent sedimentation glycerin is usually added to the solution to increase its density. isopropyle alcohol also helps in increasing the solubility of the powder. Dye solutions can be preserved by addition 10% alcohol (V/V), 25% glycerin for short period storage or 50% glycerin for prolonged storage. The amount of any permitted coaltar dye or mixture of permitted dyes which may be added to any fruit product should not exceed 0.2g per kg of the final product.

Although colours are added to the attractiveness of food products, it is better to avoid their use as far as possible and educate the consumer to use products not containing colourents. Colours can often be used to cover defects in the natural products. A number of naturally occurring substances are used for colouring foods. According to the fruit products order, India (1955),the following natural colouring matters, whether isolated from a natural source or synthesized, are permitted to be added to any article of food. Caramine, Carotene and carotenoides, Chlorophyll, Lactoflavin, Caramel, Annato,

Ratanjot, Saffron and Curcumin.

Industry Scenario: The Processed food market is expected to grow to $543 bn by 2020 from $322 bn in 2016, at a CAGR of 14.6%. Food processing has an important role to play in linking Indian farmers to consumers in the domestic and international markets. The Ministry of Food Processing Industries (MoFPI) is making all efforts to encourage investments across the value chain. The industry engages approximately

1.93 mn people in around 39,748 registered units with fixed capital of $32.75 bn and aggregate output of around $158.69 bn. Major industries constituting the food processing industry are grains, sugar, edible oils, beverages and dairy products. Govt of India further sanctioned over 134 food processing projects during 2020 across different states. Out of which there were 21 Agro-Processing Clusters, 47 Cold Chain, 43 Food processing unit, 8 Backward and Forward Linkages, 3 Operation Greens and 12 Food Testing Laboratories across various states. Moreover, this is going to create additional processing and preservation capacity of agricultural produce of 38.3 lakh MT per annum. These new 134 sanctioned projects are expected to leverage private investment of INR 2,026.32 cr and generated direct and indirect employment for 77,330 persons.

LEADING INSTITUTE IN INDIA

CFTRI, Mysore : CSIR−Central Food Technological Research Institute (CFTRI), Mysore (A constituent laboratory of Council of Scientific and Industrial Research, New Delhi) came into existence during 1950 with the great vision of its founders, and a network of inspiring as well as dedicated scientists who had a fascination to pursue in-depth research and development in the areas of food science and technology.

CPHET, Ludhiana : ICAR-Central Institute of Post-Harvest Engineering and Technology (CIPHET) was established on 3rd October 1989 at the PAU Campus, Ludhiana, Punjab, India as a nodal institute to undertake lead researches in the area of the Post-Harvest Engineering and Technology appropriate to agricultural production catchment and agro-industries. The institute’s second campus was established on 19 March 1993 at Abohar, Punjab, India. Which is primarily responsible for conducting research and development activities on fruits and vegetables, and commercial horticultural crops. ICAR-CIPHET is also headquarters for two All India Coordinated Research Projects (AICRPs) viz. AICRP on Post-Harvest Engineering and Technology (PHET) at 31 Centres and AICRP on Plasticulture Engineering & Technology (PET) at 14 Centre's.

 Central food Labs: 1. Central Food laboratory, Kolkata 2. Food Research and Standardization Laboratory, Ghaziabad 3. Public Health Laboratory, Pune 5.Central Food Technology Research Institute, Mysore

Act:

Food product Order (1955): Department of Food, Ministry of Food Processing Industries under the powers vested in the Government under the Essential Commodities Act to ensure the quality of fruits and vegetable products.

Prevention of Food Adulteration Act 1954 and Rules 1955 (PFA Act) : Primarily intended to check adulteration of foodstuffs available in the country.

Agricultural Produce (Grading and Marketing) Act 1937 (AGMARK) : This is one of the oldest Food laws promulgated in the country to provide for quality control of agricultural produce through grading and marketing.

Sugar (Control) order 1956 : The Directorate of sugar, Ministry of Agriculture and Rural Development is the operating authority of this order.

Standards of weights and Measure Act 1976:

Food Safety and Standards Act, 2006 No. 34 OF 2006

Symbols: Green for Vegetarian and Red for Non-vegetarian

Major Food Preservation and its related Industry:

1. M/s Camlin Ltd., Camlin House, Andheri (E), Mumbai
2. M/s Amba Chemicals, Western India House, Fort, Mumbai
3. M/s FMC Food Tech., Shivaji Housing Society, Pune
4. M/s Mather and Platt (India) Ltd., Ansal Bhawan, New Delhi
5. M/s Foram Foods Pvt. Ltd. Swami Vivekanand road, Vile parle (W), Mumbai
6. M/s Geeta Food Engineering, Plot C-7/1, Thane-Belapur Road, Navi, Mumbai
7. M/s Hershey India Pvt. Ltd, Plot No.5 New Industrial Area, Raisen (M.P.)
8. M/s Jadli Foods India, 219, R G Complex-II, Plot No-5, Sector 14, Rohini, Delhi
9. M/s ABC Fruits - Manufacturers of Mango & Guava pulp & concentrate, Bengaluru - Chennai Hwy, Bargur, Tamil Nadu 635104