POST-HARVEST MANAGEMENT AND VALUE ADDITION OF HORTICULTURAL CROPS

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Scope and importance of post harvest technology (PHT) in horticultural crops in India

Scope in India / Future prospects in India

1. Magnitude of pH losses in fruit and vegetable is still to be minimized by proper cultural operations, harvesting, transportation and storage facilities.
2. Through the establishment of cold storage and other amenities at the growers and retailers level, there is a greaters scope for fruit and vegetable processing industry. Presently mango, pineapple, citrus, grapes, tomatoes, peas, potatoes, cucumber are being processed on a major scale.
3. There are about 4000 small and large scale processing units in the country which process only about 2.5% of the total fruit and vegetable as against 40-85% in developed countries (Eg: Malaysia-83%, Phillippines-78%, Brazil and USA-70%).

General information

- In India, there is a vast scope for growing fruit and vegetable throughout the year in one or other part of the country because the climatic conditions are highly suitable for growing various types of fruits and vegetables.
- Fruit and vegetable are highly perishable but most important commodity for human diet due to their high nutritional value. They are the cheapest and other source of protective food supplied in fresh or processed or preserved form throughout the year for human consumption. Hence the national picture will improve significantly.
- Fruit and vegetable are available in surplus only in certain seasons and availability in different regions.
- In peak season due to improper handling practices, marketing, storage problems around 20-25% fruit and vegetable are spoilt in various stages.
- Fruit and vegetable are living commodities as they respire. Hence, proper post harvest management handling and processing is required in horticulture crops.

4. A variety of fresh fruit and vegetable in India can be made available in plenty due to favourable agro-climatic situations. Hence there is no derth for raw material for processing.

5. Product profile being developed in India at present is limited to few fruit and vegetable. Eg. Mango, Pineapple, Grapes *etc*. But there is a wider potentiality for processing of papaya, sapota, banana, jack, guava, aonla, carambola and other minor fruits.

6. Similarly there is a greater scope for processing cauliflower, carrot, bitter-gourd onion, garlic, watermelon, muskmelon *etc*.

Importance of Post Harvest Technology

1. Proper handling, packaging, transportation and storage reduces the post harvest losses of fruit and vegetables. For every one percent reduction in loss will save 5 million tons of fruit and vegetable per year.
2. Processing and preservation technology helps to save excess fruit and vegetable during the glut season (off season).
3. The technology has become a necessity to improve the food safety and strengthen nations food security.
4. The technology helps to boost export of agricultural commodities in the form of preserved and value added products.
5. Presently mango, pineapple, citrus, grapes, tomatoes, peas, potato and cucumber being processed on a large scale.

Principals and methods of preservation of fruits and vegetables

Preservation:

Preservation means just protect the foods against the spoilage, bt scientifically it may be defined as a science which deals with the process for prevention of decay or spoilage of the food is called preservation.

In other words, just controlling the physical, chemical or microbial changes in the foods is called preservation.

1. **Physical Changes** : Colour, flavour, texture and taste *etc.*
2. **Chemical Changes** : Carbohydrate, fats, proteins, vitamins and minerals.
3. **Microbial Changes** : Mould, yeasts and bacteria

Why do we preserve the food?

1. To supply to increase the shelf life of the food for increasing the supply.
2. To make the seasonal fruits available throughout the year.
3. To add the variety to the diet.
4. To save time by reducing preparation, time and energy by fire.
5. To stabilize the prices of the food in the market.
6. To improve the health of the population.

Principles of Preservation : There are three main principles :

A. Prevention / delay the microbial decomposition of the food.
B. Prevention / delay the shelf decomposition of the food.
C. Prevention of damage by insects, animals, mechanical causes *etc.*

A. Prevention / delay the microbial decomposition of the food :

1. By Keeping out the micro organisms → Asepsis
2. By Removal of micro organisms → Filtration
3. By Hindering the growth and activity of micro organisms → Anaerobic condition
4. By Killing the micro organisms → Exposing at high temperature

1. **Asepsis:** It means preventing the entry of micro organisms by maintaining of general cleanliness, while picking, grading, packing and transporting of fruits and vegetables, increase their keeping quality and the product prepared from them will be superior quality.

2. **Filtration:** Fruits juice, bear, soft drinks, wines *etc.* enter through a bacteria proof filters which is made of Asbestos pad or unglazed porcelain type of materials. These filters contain the micro organisms and allow the water or juice to percolate though with or without pressure.

3. **Anaerobic conditions:** It can be maintained by:
   (i) Replacing the O_2 by CO_2 → carbonation
   (ii) Evacuating the sealed container (fruit juice)
   (iii) Use of oils from top of the food (pickles)

4. **Exposing at high temperature:** Fruits can be exposed by high temperature such as:
   (i) Canning : Food is expose to a high temperature (> 100^0 C) which prevents spoilage and inactivate the enzyme present in the food.
   (ii) Irradiation : In case of irradiation, the food is exposed to the radiations to kill the survive m.o. by ionizing and non-ionizing radiation like α, β and γ rays. Her, food is exposed to electromagnetic or ionizing radiation or various frequencies ranging from low frequency electromagnate to high frequency *i.e.* gamma rays which destroy the micro-organism present in the food.

B. Prevention/delay the shelf decomposition:
   (i) By destruction or inactivate the enzyme – Blanching.
   (ii) Prevention / delay the non-enzymatic chemical reactions – Antioxident

Blanching:

1. It is a primary treatment which have to soften the tissues to facilitate packaging.
2. To preserve the original colour and flavour
3. To destroy the certain enzyme which are undersirable

4. Elimination of the air
5. Mostly for vegetables
6. Remove micro-organisms
7. Remove astringent taste and toxins

Anti-oxidant: Anti-oxidant are substances which are used to protect the food gamma deterioration caused by exposure to the air.

1. BHA – Butylactic Hydroxy Anisole
   BHT – Butylactic Hydroxy Toluene
   } Vegetable oils
2. Gellales: Animal fat, Vegetalbe oil
3. Tocopherols: Animal fat
4. Ascorbic acid: Fruit juices, Citrus oil, Wine, Bears *etc.*
5. Lactic acid : Processed fruits and vegetables, Canned fruits,
6. Phosphoric acid: Vegetable oils, Animal fat and cola drinks

Methods of preservation of fruit and vegetable:

There are two main basic methods:

A. Bacteriostatic methods B. Bactericidal methods

A. Bacteriostatic Methods –

1. Drying of foods
2. Use of chemical preservatives
3. Use of food additive
4. Use of low temperature

B. Bactericidal Methods –

1. Pasteurization
2. Cooking
3. Canning
4. Irradiation

A. BACTERIOSTATIC METHODS: In this method, the environmental conditions are change to prevent the growth of micro organisms, such conditions are called bacteriostic. These are -

1. **DRYING OF FOODS:** Drying is just removal of moisture from the food to a certain level at which micro organisms can not grow is called drying, it can be done by two methods:

(i) Application of heat:

(a) Sun drying (b) Mechanical drying

(c) Vacuum drying (d) Freeze drying

(ii) Binding the moisture in the food:

(a) Use of Sugar (b) Use of Salt

(i) Application of Heat:

a) **Sun Drying:** Sun drying is the method in which food is directly exposed to sunlight. It is generally done in the places where plenty sunshine is available for long period e.g. Rajasthan. The dried product in this method is inferior in quality.

b) **Mechanical drying:** This is a method of drying where application of heat is applied by a mechanical dryer under the controlled conditions of temperature, humidity and air flow.

c) **Vacuum drying:** the temperature of the food and the rate of water removal are controlled by regulating the degree of vacuum and intensity of heat input.

d) **Freeze drying:** In this method, the food is dried by sublimation process, *i.e.,* just converting the food into ice without passing through the liquid form of water by means of vacuum plus heat applied in the drying chamber. In this method, product first frozen then water is removed by vacuum and application of heat which occurs simultaneously in same chamber.

(ii) Binding the Moisture:

a) **Use of Sugar:** The use of high concentration of sugar bindup the moisture and make the food have a certain level of moisture at which micro organisms are not able to grow.

b) **Use of Salt:** The concentration of salt causes the high osmotic pressure and tie up the moisture which inhibit the growth of micro organisms. It dehydrate the food by drying out and tie up moisture as it dehydrate the micro organisms cells. Salt reduces the solubility of O_2 in the food by reducing the moisture. It interfere with the action of proteolytic enzyme. The effectness of NaC1 is varied with the concentration of salt and temperature.

2. USE OF CHEMICAL PRESERVATIVE:

Chemical 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. Chemical preservatives are of two types:

Class-1 preservatives: Common salt, sugar, dextrose, spices, vinegar, ascorbic acid

Class-2 preservatives: Benzoic acid and its salt, SO_2 and the salts of sulphuric acid, nitrates, sorbic 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:

(1) It release the SO_2 and it is unstable.

(2) It is used for the fruit which have non water solvent pigment (colourless).

(3) It can not be used in naturally coloured juices such as phalsa, jamun because they have the Anthocynin pigment.

(4) It can not be used in the product which are packed in container because it acts on the tin containers and oil, Hydrogen Sulphide (H_2S) which has an unpleasant smell and also form a black compound with the base plate of containers.

(5) Best to control moulds than bacteria.

(6) 350 ppm KMS is mostly used in fruit juice products.

(ii) Sodium Benzoate:

(1) It is salt of benzoic acid and soluble in water.

(2) It delays the fermentation in the juices.

(3) It is commonly used in the product which are having natural colour such as anthocynin pigment.

(4) It is more effective against the yeast.

(5) 750 ppm Sodium benzoate is mostly used in fruit juices, squashes and cordials.

3. USE OF FOOD ADDITIVE:

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 (i) sugar, (ii) salt, (iii) acids, (iv) spices.

In case of sugar and salts, they exerts osmotic pressure by water is diffuses from the product through a semi-permeable membrane until the concentration reached equilibrium. They kills the micro organisms or do not allow them to multiplication.

(i) 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.

(ii) Salt: the concentration of salt 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:

1. Causing high osmotic pressure resulting in the plasmolysis of microbial cells.
2. Dehydrating food and micro organisms by tying up the moisture.
3. Ionizing to yield the chloride ion which is harmful to micro organisms, and
4. Reducing the solubility of oxygen in water, sensitizing the cells against CO_2.

(iii) Acids:

1. Many processed foods and beverages needs the addition of acids to impart their characteristic flavour and taste in the final product because acids provides desired flavour and taste.
2. They adjust the sugar and acid ratio in the food.
3. Proper balance flavour of the food.
4. They are also playing the role for controlling the pectin-gel formation.

Main acids are the following

1. Acetic acid (Vinegar)
2. Citric acid (Lime juice)
3. Lactic acid (Lactose)

1. **Acetic acid:** it is commonly used for pickles, chutney, sauce and ketchup, just to inhibit the growth of micro organisms.
2. **Citric acid:** It is used for preparation of jam, jelly, squash, nectar *etc.* just to increase the acidity.
3. **Lactic acid:** It is used for the formation of curd from milk, raw flavour, specific to pickles

(iv) Spices:

(1) Spices are plant products which are used in flavouring the foods and beverages to enhance the food flavour, colour and palatability.

(2) They acts as antibacterial and antifungal activity.

(3) They impart as colour agent.

4. USE OF LOW TEMPERATURE:

Low temperature retards the microbial growth and enzyme reaction because it retards the chemical reactions. This is not a permanent method because some micro organisms can also grow at low temperature.

1. Cellar storage : (Above 15^0C)
2. Refrigerated storage : (0 to 5^0C)
3. Freezing storage : (-18 to -40^0C)

1. **Cellar Storage:** These are the underground room where surplus food can be stored for sometime, only root crops such as potato, onion can be stored for a limited period.

2. **Refrigeration:** Fruits and vegetables can be stored for 2-7 days. Semi-perishable crops, such as potatoes, apples *etc.* can be stored, in the commercial cold storage with proper ventilation, automatic controlled temperature for one year.

3. **Freezing:** It tie up the moisture and increase the concentration of dissolved substances in the food. But, sometimes enzymes are active even below the 0^0C. In this case before freezing, 'Blanching' is necessary for vegetable freezing.

B. BACTERICIDAL METHOD:

In this method, food material is exposed to higher temperature and high temperature helps to killing of the micro organisms due to coagulation of protein. It helps in inactivation of enzyme. Here moist heat is more effective than dry heat. At low pH

high temperature is required than the high pH. High temperature can be employed by following methods:

(i) Pasteurization : Below 100^0C

(ii) Boiling/ Cooking : at 100^0C

(iii) Canning : Above 100^0C

(i) Pasteurization:

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 and filled in bottles, leaving sufficient head space for the expansion of the juice during heating. The bottles are then sealed air-tight and pasteurized.

b) Overflow method

Juice is heated to temperature of about 2.5^0C higher than the pasteurization temperature and then filled in hot sterilized bottles up to the brim, during filling and sealing the temperature of juice should not fall below the pasteurization temperature.

c) Flash pasteurization

The juice is heated rapidly to a temperature of about 5.5^0C higher than the pasteurization temperature and kept at this temperature for about a minute. This method commonly used for canning of natural orange juice, grape and apple juices.

It is a mild heat treatment, by pasteurization milk is pasteurized by HTST at 72^0C for 15 sec. Fruit juices are pasteurized at such temperature and for such periods as would render them sterile, without impairing their flavour. Usually, the juices are pasteurized at about 85^0C for 25-30 min., according to the nature of the juice and

the size of container. Acid fruit juices require lower temperature and less time for pasteurization than the less acid ones.

Juices can be pasteurized in two ways

(1) By heating the juice at a low temperature for a High time (LTHT) and

(2) By heating the juice at high temperature for a short time only (HTST).

(ii) Boiling/Cooking: The primary objective of cooking is to produce a palatable food. Cooking results in:

1. Destruction or reduction of micro organisms and inactivation of undesirable enzymes.
2. Destruction of potential hazard in the foods which are present naturally through micro-organism.
3. Improvement of colour, flavour and texture of the food.
4. It improves the digestibility of food component.
5. Putting the temperature about 100^0C. by this method, food can be preserved for 10-24 hours at low temperature.

(iii) Canning: Canning is done at or above 100^0C. In case of fruits which are acidic, they are canned at 100^0C, while in case of vegetable those are non-acidic, they are canned at above 100^0C. Here, high temperature can be obtained by using steam pressure, time is vary according to the type of foods. Due to anaerobic condition any survivable organism will not grow.

On the basis of Acid, foods are divided into four different groups:

1. Low Acid Foods	5.3 and above	Peas, Corn, Lime beans, Meat, fish, Poultry and Milk
2. Medium Acid Foods	5.3-4.5	Spinach, Asparagus, Beets and Pumpkin

3. Acid Foods	4.5-3.7	Tomatoes, Pears and Pineapple, Sauce
4. High Acid Foods	Below 3.7	Berries and Sauer kraut, Pickle

Other methods of Preservation:

- Preservation by Filtration
- Preservation by Carbonation
- Preservation by Fermentation
- Preservation by Antibiotics
- Preservation by irradiation

Other methods of preservation

Preservation by filtration

In this method 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.

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 life of beverage. Fruit juice beverages are generally bottled with CO2 content varying from 1-8 g/lit though carbon should be avoided as it destroys the flavour of the juice. The keeping quality of carbonated fruit beverages is enhanced by adding about 0.005% sodium benzoate. The level of carbonation is required according to the type of fruit juice and type of flavour.

Preservation by fermentation

This is one of the oldest methods of preservation. By this method the foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of alcoholic beverages vinegars and fermented pickles depends on the presence of alcohol

acetic acid and lactic acid respectively. Wines, beers, vinegar, fermented drinks, fermented pickles are prepared by these processes.

Fermentation is carried out by using acetic acid, lactic acid and alcohol *etc.*

Preservation by Antibiotics

Certain metabolic products of m.os which are found to have a germicidal effect **Nissin** is an antibiotic produced by **Streptococcus lactis** an organism found in milk, curd, cheese and other fermented milk products. It is non toxic and it is widely used in food industry especially for preservation of acid foods.

It is commonly used in canning of mushroom tomatoes and milk products. Nisin suppress the growth of spoilage organisms.

Subtilin – an antibiotic obtained from ***Bacillus subtilis*** is used in preservation of asparagus, corn and peas.

Pimaricin – an antifungal antibiotic used for treating fruits and fruit juices.

Preservation by irradiation

It is a process of preservation of food by exposing them to ionizing energy / radiation which kills most of the spoilage causing organism and also inactivates the enzymes responsible for browning *etc.* This method prevents the sprouting in storage condition (onion, potato *etc.*).

Te irradiation of food can be considered to be a method of "Cold sterilization". Irradiation measured in rads.

Factors affecting ripening of fruits and vegetables

- Respiration
- Transpiration / water loss
- Ripening Ethylene production

- Pathological stresses
- Mechanical stress
- Temperature stresses.

Respiration: It is the oxidative break down of more complex substrates normally present in cells such as sugars, starch and organic acids to simpler molecules CO_2 and H_2O.

Transpiration / water loss: Fruit an vegetables contain more than 87-95% water and the presence of moisture inside the tissue is responsible for maintenance of turgidity and succulence. Loss of moisture is direct loss to the traders. Hence, the fruit and vegetable are sold by weight.

Ripening: Ripening is associated with physical and biochemical irreversible process which leads to senescence and finally leads to death.

Ethylene: Ethylene is naturally produced gaseous plant growth regulator that has numerous effect on growth, development… and storage life of many fruits, vegetable and ornamentals.

Pathological stresses: Disease play major role. Fruit and vegetable affected with disease spoil early and minimize keeping quality/ shelf life.

Mechanical stress: Mechanical damage also affects fruit and vegetables.

Temperature: Temperature like chilling or freezing maximum temperature also affects the fruit and vegetables quality.

Maturity and ripening process

Mature and ripe means the same when describing fruit. But in PHT mature can be defined as the stage at which a commodity has reached a sufficient stage of development after harvesting and post harvest handling (including ripening where required) its quality will be at least minimum acceptable to that consumer.

Maturity is of two types

a) Physiological maturity
b) Commercial maturity / Horticultural maturity

a) **Physiological maturity:** Refers to the development of an organ (e.g. fruit, leaf) or organism (e.g. ornamental plant). Incase of fruit, ripening can be considered the next development stage (senescence stage).

b) **Commercial / Horticultural maturity:** Is the characteristic stage of a plant organ required by the consumer.

Eg: Beans – early stages of development
Cucumber – during maturation
Tomato – ripening

Determination of maturity

If the stage of maturity at which a fruit or vegetable should be harvested is important for its subsequent quality, storage and marketable life. Determination of maturity can be grouped into physical, chemical, physiological, computation, electronic *etc.* based on the principles used for measuring the various parameters.

Physical method

Skin cbolour: change of skin colour of many fruits at maturity (Toamto, Papaya, litchi, mango) colour charts are used for apple, tomato, peach *etc.* Instruments are also available for measuring colour of fruits and this is mostly used in harvested fruits.

Shape: the shape of fruit and vegetable can change during maturation. Eg.: Banana becomes less angular

Size: Size is frequently used to determine at harvest. It is related to market requirement.

Firmness: As fruits mature and ripen the tissues become soften. The softening can be estimated by the finger feel of commodity (Firmness can be measured by penetrometer). (weight of fruit).

Specific gravity: It is measured through weight of solids or liquids. As fruits mature their specific gravity increases. This method is rarely practiced.

Aroma: Most fruits synthesis volatile chemicals as they ripen. Based on this we can determine whether fruit is ripe.

Chemical method: a) Sugars, b) starch, c) acidity

a) **Sugar:** As the fruit ripens. Starach is broken down to sugars. Measurement of sugars indicate the stage of maturity or ripeness, sugar constitute the major portion of soluble solid of the fruit juice. Measurement of TSS is done on refractometer.

b) **Starch:** Starch content in developing fruit of pear and apple provides harvest maturity.

c) **Acidity:** The acidity of many type of fruit changes during maturing and ripening. In citrus, mango, pineapple and many stage other fruits acidity progressively decrease as the fruit matures on the tree.

Physiological methods

Climacteric fruits in which there is a distinct rise in respiration during ripening, can be sampled and kept at high temperature and respiration rate is measured. By this way we can predict the number of days will take for ripening stage if left on the tree.

Climacteric fruit: harvested at full maturity stage and ripen after harvest. Maximum respiration starts immediately after harvest. Long shelf life (6-8 days) no need of sophisticated packing material as fruits are hard.
Eg: Apple, Apricot, Avocado, Banana, Blue berry, Kiwi fruit, Mango, Papaya, Passion fruit, Peach, Peas, Muskmelon, Watermelon and tomato.

Non-climacteric fruits: Harvested at full ripening (90-95%) complete colour development. Rate of respiration is less than climacteric fruit. Difficult to transport need sophisticated packing material as fruits are soft and ripened. Difficult to transport.
Eg: Cherry, cucumber, grapes, lemon, pineapple, mandarins *etc.*

Computation method

The time required between flowering and fruit being ready for harvesting may be measured by 'heat units' or degree days in a particular environment.

Electronic and other methods

Electronic colour sorter: used in packing houses to sort-out fruits on the basis of colour.
Eg: Apple, orange *etc.*

Aconsting and vibration test

The sound of fruit when tapped with knuckle of the finger, the sound heard changes during maturation and ripening- Eg: Watermelon and jack fruit.

Ripening

The sequence of changes in texture, colour and flavour as a result of physiological and biochemical change that makes the fruit ready for consumption.

Artificial ripening – climacteric fruits are picked relatively green and subsequently ripened by introducing ethylene or acetylene gas (calcium carbide) Eg: Banana, Mango, Pear and Avocado.

On the basis of the respiratory pattern and ripening behavior fruits are carried into two classes *viz.*, climacteric fruits and non-climacteric fruits.

Changes occur during maturation and ripening (physiological and Biochemical)

1) **Water:** After harvest, during storage and ripening, fruit and vegetable lose water as a result of respiration transpiration and exchange of gas, resulting in water loss. Loss of H2O depends upon the RH, temperature, anatomical structure and the rate of transpiration and respiration. When the loss is more than 5-10% fruit and vegetable start shrivel and become unusable.

2) **Colour:** The most common change is loss of green colour. It is due to degradation of chlorophyll structure. The degradation is due to pH, oxidative systems. The disappearance of chlorophyll is associated with the synthesis of pigments ranges from yellow to red.

3) **CHO:** CHO are important in attaining pleasing fruit flavours through sugar to acid balance, attractive colour and whole some texture.

4) **Organic acids**: the nonvolatile organic acids are among the major cellular constituents undergoing changes during the ripening of fruits. As the fruit ripens the acid content minimize and converts it in to sugar.

5) **Proteins**: Proteins are free amino acids, minor constituents of fruit and not have much role in determining eating quality.

6) **Flavouring compounds:** Aroma plays an important part in the development of optimal eating quality of fruit and vegetables. This is due to the synthesis of many volatile organic compounds during the ripening phase.

7) **Enzymes:** Many of the chemical and physical effects that occur during ripening of fruits are attributed to enzyme action.

Pre and post harvest factors affecting quality in post harvest shelf life of fruits and vegetables

The quality and condition of fresh produce can not be improved after harvest. The adoption of good practices is advisable before and after harvest of fruit and vegetables.

Pre-harvest factors

- **Cultivar and root stack genotype:**

  It plays an important role in determining the taste, quality, yield, nutrient composition and post harvest life of fruit and vegetable.

- **Water supply (irrigation)**

- Excess rain or irrigation, leads to brittle and easy damage in leafy vegetables and to reduced tendency to decay.
- Lack of rain or irrigation leads to low juice content and thick skin in citrus fruit.
- Dry condition followed by rain or irrigation leads to growth cracks in tomato or secondary growth in potatoes.

- **Soil fertility and use of fertilizers**

  Lack of nutrients in the soil can seriously affect the fresh produce at harvest. Too much of fert…… can harvest the development of post harvest condition of some produce.

- **Mineral nutrition**

  Deficiencies or excess or imbalance of various nutrients are known to result in disorders that can limit the storage life of many fruit and vegetables.

- **Foliar nutrient spray**

  Ca is often considered to be the most important mineral dement in determining fruit quality, especially in apples and pears where it has been demonstrated to reduce metabolic disorders, maintain firmness and reduce decay.

- **Cultivation practices:**

  Good management practices is very much important in achieving good yields and quality of fresh produced 9weed control, crop hygiene, pesticides and herbicides, growth regulating chemicals).

Post harvest factors

- **Perishability and produce losses:**

  All fruits and vegetables and root crops are living plant parts containing in 65-95% water and they continue their living processes after harvest. Their post harvest life depends on their stored food and water loss.

- **Physiological deterioration**

  High temperature, low atmospheric humidity and physical injury maximize the rate of natural deterioration.

- **Mechanical damage (Physical injury)**

  Careless handling of fresh produce causes internal injury, which results in abnormal physiological damage.

- **Pest and Diseases**

  Fresh produce can become infected before or after harvest by diseases widespread in the air, soil and water. Pest damage also play major role.

Chemicals used for hastening and delay of ripening of fruit and vegetables

Chemicals that hasten ripening

1) **Ethylene:** Ethylene related compounds –

   CEPA-2 Chloro ethyl phosphoric acid

   CPTA-2,4 Chloro phenyl friethyl amine

   Used for pre and postharvest treatments of fruits.

2) **Acetylene and calcium chloride:** Calcium carbide treatment to generate acetylene to hasten fruit ripening in banana.

3) **Smoke treatment:** Burning and releasing smoke from leaves, twigs or straw will also hasten ripening in mango.

4) **2,4-D:** 2, 4 dichlorophenoxy acetic acid is used in ripening of Guava

   2,4,5-T-2,4,5-trichlorophenoxy acetic acid used in Sapota.

Chemicals that delay ripening

1) **Cytokinins and Kinetins:** Delays chlorophyll degradation and senescence of leafy vegetable.

2) **Gibberellins:** Post harvest treatments with GA_3 retard ripening of tomato and bananas GA_3 lowers respiratory rate, retards in climacteric fruits and delays the process of colour changes.

3) **Growth retardants:**
   a) **MH** – prevents sprouting of onion bulbs and potato tubers. Also delays ripening of mango.
   b) **Alar**: Reduce…. Fruit firmness fruit colour development and early maturation. It is applied before harvest. In lettuce it reduces senescence.
   c) **CCC** (Cycocel)-2 chloroethyl – trimethyl ammonium chloride used in delaying of senescence of vegetables.

4) **Delaying ripening process by skin coating (waxing):**
   Edible waxes are coated on fruits which prevents transportation losses and minimize respiration rate.
   a) Sugar wax along with emulsifier is melted and then boiling water is poured slowly to melted ingredients and prepare emulsion.

Emulsifying agents: TEA (Triethylene amine), TBZ – Tribenzoate, fungicides – SOPP (Sodium ortho phenyl phenate) for control of pencillium in oranges (Take the emulsion in large basins and dip the fruit or basket containing fruits for 30 seconds.

Thiourea – is used for control of penicillium and deplodium on oranges.

Study of different storage structures

Storage of fruit and vegetables in very much essential, because of their highly perishable nature.

Improved / Advanced / modern storages.

a) **Refrigerated / cold storage:** If fruits and vegetables are stored at low temperature they remain fresh and nutritious for a longer time, low temperature reduces physiological activities like respiration, transpiration, ethylene production and other biochemical reactions responsible for rapid ripening and senescence. It also minimizes attack of pest and diseases and prevents product dryness.

b) Control / atmosphere storage

- It is an advance technology for storage of fruit and vegetables. In this system, the storage environment is different than the normal, in controlled atmosphere (CA) storage oxygen is reduced (minimized) fro 21% to 25% and CO_2 is maximized to 0.03 to 1-5%. This results slew down of physiological activity of fruit and vegetables such as rate of respiration ethylene production and other biochemical reaction. In CA storage atmospheric components are precisely adjusted to specific concentration.

- CA storage is used for warehouse storage of whole fruit and vegetables or bulk controlled atmosphere road or sea-frieght transport of perishable foods. Atmospheric components can be adjusted to specific concentration.

- **Modified atmosphere storage (MA)** – Modified atmosphere inside the package or sealed hermacefically.

- Inside the package O_2 minimize and CO_2 maximize with the uptake of O_2 and release of CO_2 – In MA storage a very low degree of control gas concentration is possible atmospheric components can not be adjusted because it has been hermatically sealed.

c) **Ice Bank cooler:** Cooled air passes over the stored fruits and vegetables at a very high velocity as a result desiccation of the crop takes place. To avoid this, various methods of humidifying the cooling air have been developed.

d) **Hypobaric storage:** Fruit and vegetables can be stored under less than atmospheric pressure. Fruits were held at about 0.2-0.5 atmosphere pressure at 59-75^{0}F and humidified air was passed through the chamber to maintain humidity and to remove ethylene and other volatile compounds given off by the fruits and vegetables.

Lowest storage (Traditional storage)

Low cost storage structures are the best attractive for rural areas, where electric facility is not available. It is easy to install and run by unskilled people. There low cost storage is of natural cooling, ecofriendly and also energy saving.

Clamps: It is an old traditional method. The clamps vary in design and commonly used for potatoes, turnips, beets *etc.* An area is not susceptive to water logging is selected. The width can be any convenient, normally ranges between 3'-7.5' and it can be at any suitable length. The dimensions are marked out and the vegetable are piled on the ground (Occasionally straw is put on the ground before the vegetable). The height of the pile

should be 1/3 of its width. The pile is covered with rice straw to about 6.8" thick, when fully compressed, after two weeks the clamp is covered with a layer of soil.

Pits: Pits or trenches are dug at the edges of the field where the crop is grown. These pits/trenches should be at higher pints particularly in high Rainfall areas. These are lined with straw or any other organic matter before filling the commodities. The straw / organic matter is covered with layer of soil. Sometimes the boards are placed on the surface before the soil is put on.

Cellar: Cellars are underground or partly underground structures usually below the house. Cellar provides good insulation and protected from excessively low temperature in cold climates. There are used for years as storage for fruits and vegetables. The crops are usually spread out thinly on shelves to ensure good air circulation. The doors of the cellars are kept open at night to maintain low temperature.

Nighttime cooling: It is also called as air cooled storage system. This method consist of an insulating room from all the sides with air inlet and outlet for exchange of air. During night open these pores inlet and allow the cool air to come inside. By putting exhaust fan at outlet will maximum the efficiency of nighttime cooling. During day time both inlet and outlet are kept clored. The trapped air will keep the produce cool.

Naturally formed ice: This is an old method of refrigeration and very useful for cold countries where, lakes, ponds are frozen in winter season. This ice is harvested stored in insulated houses and used for pre-cooling, storage and transpiration of horticultural commodities.

High altitude cooling: It is also a source of cold. Air temperature minimize by 10^0C (18^0F) every 1km maximize in attitude. It is not possible in low attitude.

Underground storage: It is also an old method of storage which has been used for years for storage of fruit and vegetable. The temperature inside storage is approximately equal to the average annual air temperature cool underground spaces work well for already cooled produce but not for removing field heat.

Ventilated storage/ onion storage structure: It is conventional storage structure in India for onion, which is made of bamboo or plant material with a thatch on top.

Evaporative cooling / on farm storage/ pusa zero energy cool chambers

This is low cost storage structure, based on the principles of evaporative cooling. Low cost technology is applied by utilizing locally available material. It can be installed by low skill persons as it does not require any specialized skill. Only the place / site should have permanent source of water. The floor is made with a single layer of bricks and the side wall are made with a double layer of bricks upto a height of 67.5 cm leaving a cavity gap approximately 7.6 cm space in between the two layers of bricks. The raw material required for the construction of cool chamber are bricks, river bed sand, bamboo, straw, gunny bag *etc.* Its construction is very simple.

- The cavity gap is filled with river bed sand free from stines and other materials.
- The top cover is made with straw / guny bag in a bamboo frame structure.
- About 400 bricks are required to built a cool chamber for 1 quintal of fruit and vegetable.
- After construction of wall, floor sand and top cover should be wetted fully by water.
- To achieve desired temperature and RH, water should be done twice daily. Stone the fruits and vegetable in this chamber by keeping in perforated plastic crates, cover these crates with a thin polythene sheet.
- These cool chambers should be reinstalled once in three years with new bricks.

Various packaging methods for storage and transportation and export purpose

The main objective of packaging is to keep the fruits, vegetable and root crops in good condition until it is sold and consumed.

1) **Plastic film bags –** widely used for consumer size packs in fruit and vegetables marketing.
   Retain water vapour so as to reduce H_2O loss from the content.
2) **Plastic boxes –** they are rigid containers most suited for packaging soft and delicate commodities.
3) **Net / mesh bags –** widely used for packing fruits like apple, citrus, guava, sapota *etc*.
4) **Sleeve packs –** Immobilization of packed fruits, superior visibility that gives a good sales appeal.
5) **Cling film –** Ideal packaging for low water vapour transmission rate, high gas permeability.
6) **Shrink film or stretch film –** Stretching the film under controlled temperature and tension, the film which is wrapped over the produce, stretches and then contract by cooling.
7) **Active packaging –** Also called as smart packaging. It is actively involved with food products or interacts with internal atmosphere to extend shelf life by maintaining quality and safety.
8) **Antimicrobial packaging –** Incorporating antimicrobial agents into polymer surface coating sand surface attachments.
9) **Wooden packaging –** used for packing fruits and vegetable. Similar to plastic crates.
10) **Modified atmosphere packaging –** It is the packaging of a perishable products. The modified atmosphere surrounding the produce beings about the beneficial effects and extends shelf life a products.

11) **Vacuum packaging –** packaging the products in film of low oxygen permeability and sealing it after evacuating the air.
12) **Teltrapackaging:** It is used to store the fruit beverages and RTS beverages
13) **Bamboo mat holed boxes:** Suitable for transportation of apple
14) **Polypropelene boxes:** Highly suitable fro long markets it can be reused
15) **Corrugated fibre board:** Suitable for fruit and vegetable and most economical.

For processed fruit and vegetable products

Aluminium cans, Tin containers, collapsible tubes, glass containers, plastic containers – low density polyethylene (LDPE) HDPE, PP (Polypropylene), PVC (Polyviny), chloride, polytysrons (PS), biodegradable plastics, Phetodegradable plastics, laminate, coextruded films, retortable pouch, bulk packaging, aseptic packaging, *etc.*

Canning and freezing

Appert is Knewn as father of canning fruit and vegetable are canned in the season when the raw material is available in plenty. The canned products are sold in the off-season and give better returns to the grower.

Caning is a process of sealing food stuffs hermatically in containers and sterilizing them by heat for long storage is known as canning.

Principle and process of canning

Principle: Destruction of spoilage organism within the sealed container by means of heat.

Process: (Flow chart for canning process)

1) Selection fruits and vegetable

a) Fruit and vegetable be fresh

b) Fruits should be ripe, but firm and uniformly matured, over-ripe fruits should be rejected before they are infected with m.o. and give poor quality product. Unripe fruits should be rejected before they generally shrivel and toughen on canning.

c) All vegetable should be tender, except tomato
d) Tomatoes should be firm, fully ripe and should be deep red colour
e) Fruits and vegetable should be free from dirt
f) They should be free from blemishes, insect damage or mechanical injury.

Flow chart for canning process

1. Selection of fruit and vegetable → Grading → washing →peeling → cutting → blanching → cooling →filling and syruping brining →exhausting →sealing → processing →cooling → storage.

2. **Grading:** Selected fruit and vegetable are graded according to size and colour to obtain uniform quality. This is done by hand or machines such as screw grader and roller grader.

3. **Washing:** It is important to remove pesticide spray residue and dust from fruits and vegetables.

4. **Peeling:** Peeling is to remove the outer layer. It is done in various ways.

a) **Hand peeling:** It is done in case of fruits of irregular shape. Eg: Mango and Papaya where mechanical peeling is not possible.

b) **Steam peeling:** Peaches are steam peeled in different ways, potatoes and tomatoes are peeled by steam or boiling H_2O.

c) **Mechanical peeling:** This is done in case of apples, peaches, pineapples and cherries and also for root vegetable like carrots, turnips and potatoes.

d) **Lye peeling:** fruits like peaches, apricots, sweet oranges, mandarin oranges and vegetable like carrots and sweet potatoes are peeled by dipping them in 1-2% boiling caustic soda solution (lye) for 30 second – 2 minute depending on their nature and maturity.

e) **Flame peeling:** It is used only for garlic and onion which have a papery outer covering. This is just burnt off. Vegetable like peas are shelled, carrots are scraped, and beans are snipped or trimmed.

5. **Cutting:** Pieces of the size required for canning are cut, seed, stone and core are removed.

6. **Blanching:** It is also knewn as scalding, parboiling or precooking, usually done in vegetable by exposing them to boiling water or steam for 2-5 minute followed by cooling.

This heat treatment helps in

a) Inactivate most of the plant enzymes which cause toughness, discolouration, mustiness, off flavour, softening and loss of nutritive value.
b) Reduces the area of leafy vegetables such as spinach by shrinkage or wilting, making their packing easier.
c) Removes tissue gases which reduces sulphides.
d) Reduces the number of m.o.s upto 99%
e) Enhances the green colour of vegetable such as peas, broccoli and spinach.
f) Removes saponin in peas
g) Removes undesirable acids and astringent taste of the peel and thus improves flavour

7. **Cooling:** After blanching the vegetable are dipped in cold water for better handling and keep them in good condition.

8. **Filing:** Before filling cans are washed with hot H_2O and sterilized. But in developing countries these are subjected to a jet of steam to remove dust and foreign material. Automatic large can filling machines are used in advanced countries. After filling covering with syrup or brine in done and this process is called syruping or brining.

9. **Exhausting:** The process of removal of air from cans is knewn as exhausting. After filling and lidding / clinching, exhausting is essential.

Advantages of exhausting is

a) Corrosion of tinplate and pin-holing during storage is avoided
b) Minimizes discolouration by preventing oxidation.
c) Retention of vitamin-C
d) Reduces chemical reaction between the container and the contents
e) Prevents development of excessive pressure

10. **Sealing:** Immediately after exhausting the cans are sealed airtight by means of can sealer. In case of glass jars a rubber ring should be placed between the month of the jar and the lid, so that it can be sealed airtight, during sealing the temperature should not fall below 74^0C.

11. **Processing:** Heating of foods for preserving is knewn as processing. In canning technology processing means heating or cooling of canned foods to inactivate bacteria. Many bacterial spores can be filled by either high or low temperature. Processing time and temperature should be adequate to eliminate all bacterial growth. Almost all fruit and acid vegetable can be processed satisfactorily at a temperature of 100^0C *i.e.* in boiling water.

12. **Cooling:** After processing, the cans are cooled rapidly to about 39^0C to stop the cooking process and to prevent stack-burning. Cooking is done by the following methods.
    a) Dipping or immersing the hot cans in tanks containing cold water (Generally this method is used)
    b) Letting cold water in to pressure cooker specially in case of vegetable
    c) Spraying cans with jets of cold water
    d) Exposing the cans to air.

13. **Storage:** After labeling the cans, they should be packed in strong wooden cases or corrugated cardboard cartons and stored in a cool and dry place. Storage of cans at high temperature should be avoided as it shortens the shelf-life of the product.

Containers for packing of canned products

Both tin and glass containers are used in the canning industry. But tin containers are preferred.

Freezing

Freezing is a preservation method probably it was done by prehistoric people during cold weather. Naturally occurring show and ice were used to freeze foods outside. With the development of mechanical refrigeration n and quick freezing techniques and the frozen food industry has expanded rapidly.

- Highly expensive
- Commonly followed in Europe before they are unable to grow fruit and vegetables.
- Expensive equipments, which required lot of power
- Slewer rate of chemical reaction
- Retard m.o's multiplication
- Without adding chemicals preservation can be done for longer time
- Not popular in India
- Nutritional property will not be altered
- Rancidity will not occur
- Normally freezing temperature is -18^0C

Freezing is cheaper than canning and frozen products are of better quality than canned products.

Flow chart for freezing of fruits and vegetables

Fruit and vegetables (fully mature) → Washing → Trimming → Cutting in to pieces → Scalding / blanching → Keeping syrup/ Brine (Except strawberry which is packed after freezing → packing freezing.

Methods of freezing

1) **Sharp freezing (slew freezing):** Commodities are expored to -150C to -290C. it required 3-72 hrs. Here the thawed tissue cannot regain its original water content. The ice crystals formed are large and rupture the cells. The thawed tissue cannot regain its original H_2O content.

   THAWING → the frozen products are kept out side to bring it into room temperature before consuming / cooking.

2) **Quick freezing:** It is quick and fast process the food attains the temperature of max ice cryetal formation (0 to -4^0C) in 30 min or less. Such a speed results in formation of very small ice crystals and hence minimum disturbance of cell structure most foods are quick frozen by one of the following methods.

   a) **By direct immersion:** Since liquid are good heat conductors food can be frozen rapidly by this method in a liquid such as brine or sugar solution at low temperature.
   b) **By indirect contact with refrigerant:** It is defined as freezing by contact of the product with a metal surface which is it self cooled by freezing brine or other refrigerating media. This is an old method of freezing in which the food or package is kept in contact with the passage through which the refrigerant at -18 to -46^0C flows.
   c) **Air blast freezing:** It is a vigorous circulation of cold air to freeze the product.

   Freezing is done by placing the foodstuffs on trays or on a belt and then passed slowly through an insulated tunnel containing air in it. Here the air

temperature is approximate -18 to -34^{0}C or even lower. This process is economical and a variety of sizes and shapes can be accommodated.

a) **Fluidized bed freezing:** This is modification of air blast freezing the foodstuff is fluidized to form a bed of particles and then frozen.

b) **Plate freezing:** In this method, food products are placed in contact with a cold surface. The cooling temperature of the metal surface is by using cold brine or vaporizing refrigerants. This process is suitable for packaged food products.

3) Cryogenic freezing

Most foods retain their quality when quick frozen by the above methods (Mushrooms, sliced tomatoes, whole straw berries and raspberries) a few require ultrafast freezing. Such materials are subjected to cryogenic freezing. It is defined as freezing at low temperature 9below -60^{0}C). The refrigerants used at present in cryogenic freezing are liquid N_2 and liquid CO_2.

4) Dehydro-freezing: this is a process where freezing is followed by partial dehydration. In some fruits and vegetable about 50% of the moisture is removed by dehydration prior to freezing.

5) Freeze - drying

In this process food is first frozen at -18^{0}C on trays in the lower chamber of a freeze drier and then frozen material dried (initially at 30^{0}C for 24 ours and then at 20^{0}C) under high vacuum in the upper chamber. The product is highly hygroscopic, excellent in taste and flavour.

Eg. Mango pulp, orange juice cone, passion fruit juice and guava pulp are dehydrated by this method.

Drying / Dehydration

The terms Drying and dehydration means the removal of water.

Drying - is done by using non-conventional energy sources like sun and wind.

Dehydration – means the process of removal of moisture by application of artificial heat under controlled conditions of temperature humidity and air flow.

Various factors that affect the rate of drying of horticulture produce

a) Composition of raw material
b) Size, shape and arrangement of stacking of produce
c) Temperature, humidity and velocity of air
d) Pressure (barometric or under vacuum)
e) Heat transfer to surface (conductive, convective / irradiative)

Several types of driers and drying methods, each method better suited for a particular situation, are commonly used to remove moisture from a wide variety of food products including fruit and vegetables.

Sun drying is followed in certain crops such as prunes, figs, apricots, grapes and dates.

There are three basic types of drying process

- Sun drying / solar drying
- Atmospheric drying including batch (Kiln, tower and cabinet driers) and continuous (tunnel, belt, belt-through, fluidized bed, explosion puff, foam mat, spray, drum and microwave).
- Sub atmospheric dehydration (Vacuum shelf / belt and freeze driers)

Common driers types used for liquid and solid foods

Drier types		Food types
a) Air convection driers		
1) Kiln	→	Pieces
2) Cabinet, tray or pan	→	Pieces, purees, liquid
3) Tunnel	→	Pieces
4) Continuous conveyor belt	→	Purees, liquids
5) Belt through	→	Pieces
b) Drier type		
a) Air lift	→	Small pieces granules
b) Fluidized bed	→	Small pieces, granules
c) Spray	→	Liquid purees
c) Drum or roller driers		
a) Atmospheric	→	Purees, liquids
b) Vacuum	→	Purees, liquids
d) Vacuum driers		
a) Vacuum shelf	→	Pieces, purees, liquid
b) Vacuum belt	→	Purees, liquids
c) Freeze driers	→	Pieces, liquids

Drying techniques / methods

A) Fruit and vegetable natural drying –

1) **Sun or solar drying:** Surplus production and specially grown crops may be preserved by natural drying for use until the next crop can be grown and harvested. These can be cheaply distributed t areas where there are permanent shortages of fruit and vegetables.

2) **Shade drying:** It is done for products which can lose their colour and or turn brown if put in direct sunlight.
   Eg: Herbs, Green and red sweet peppers, chillies, green beans and okra.

3) **Osmotic dehydration:** Here the prepared fresh material is soaked in a heavy or thick liquid sugar solution or strong salt solution and then the material is solar dried.

B) Common driers used for drying / dehydration

a) Air convection driers: All air convection driers have some root of insulated enclosure, a means of circulating air through the enclosure and a means of heating this air –

1. **Kiln drier:** It is the simplest kinds of air convection drier. These are generally used to for large pieces of material. Eg: apple and Potatoes.

2. **Cabinet, tray and Pan driers:** Advanced method, the food is loaded on trays or pans in a thin layer. Hot air is blown across the food trays. It is used for small scale operations.

3. **Tunnel and continuous belt driers:** These driers are most commonly used for dehydrating fruit and vegetable. Here also hot air is blown across the trays.

4. **Belt through driers:** the belt is usually of metal mesh and heated air is blown up through the mesh. The belt moves continuously keeping the food pieces in through. All products can not be dried by this method.

5. **Air lift driers:** These are generally used to finished dry materials that have been partially dried by other methods.

6. Fluidized bed drier: In fluidized bed drying, heated air is blown up through the food particles with just enough force to suspend the particles in a gentle boiling motion. Eg: grains and peas.

7. Spray driers: Are used for liquids and low riscority pastes and purees. Atomization in to minutes droplets results in drying in a matter of seconds with common inlet air temperature of about 200^0C.

b) **Drum or roller driers:** In drum or roller drying, liquid foods, purees, pastes and mashes are applied in a thin layer on to the surface of revolving heated drum. While revolving the dried product is scraped from the drum.

c) **Vacuum drier:** In this method highest quality product can be obtained. In vacuum drying the temperature of the food and the rate of H_2O removal are controlled by regulating the degree of vacuum and the intensity of heat input.

1. **Vacuum shelf driers:** Liquids like concentrated fruit juices are dried, the concentrated juice puffs as it loses water vapour.

2. **Continuous vacuum belt driers:** It is used commercially to dehydrate high quality citrus juice crystals, instant tea and other delicate liquid foods.

3. **Freeze drying:** It is highly advanced method. It can be used to dehydrate sensitive and high value liquid foods such as coffee and juices, but it is especially suited to drying solid foods of high value such as strawberries. Whole shrimp, chicken dice, mushroom slices *etc.*

Difference between conventional and freeze drying

Conventional Drying	Freeze drying
1) Successful for easily dried foods such as seeds, fruit and vegetables	Successful for most foods but usually limited to those not successfully dried by other methods.
2) Not satisfactory for meat products	Successful for cooked and raw animal products
3) Continuous processing	Batch processing
4) Temperature between 37-93^{0}C is used	Low temperature is used to prevent thawing
5) Drying tie may be short *i.e.* < 12 hrs	Drying time between 12 and 24 hrs
6) Solid dried particles	Porous dried, highly hygroscopic particles
7) Higher density than the original food	Lower density than the original food
8) Odour frequently abnormal	Odour usually natural
9) Slow rehydration usually incomplete	Rapid, complete rehydration possible
10) Colour usually darker	Colour usually natural
11) Flavour may be abnormal	Flavour generally natural
12) Storage stability good, tendency to darken	Storage stability excellent
13) Costs generally low	Costs generally high

Flow sheet for drying / dehydration of fruits and vegetables

Fruit and vegetable

(Mature and free from insects and disease)

↓

Washing

↓

Peeling

↓

Preparation

↓

Blanching

↓

Spreading on flat-wooden trays

↓

Sulphuring

(usually @ 1.8-3.6 kg/ton of fruits)

↓

Drying/ Dehydration

(with occasional stirring)

↓

Sweating

↓

Packing

(air tight container or polythene bags)

↓

Storage

(at ambient temperature in dry place)

Fermentation methods

Decomposition of CHO by M.os or enzymes is called fermentation. Fermentation of food results in the production of organic acids, alcohol *etc.* which not only help in preserving the food but may also produce distinctive new food products.

Fermentation methods

A) Acetic acid fermentation (A.a)

The production of vinegar (a. acid) from the for juice is perhaps one of the oldest organic acid fermentation known. A.a is produced by the oxidation of ethyl alcohol by bacteria such as *Acetobacter aceti, A. orleansis* and others.

B) Lactic acid fermentation (L.a)

L. a fermentation is an anaerobic intra-molecular oxidation reduction process. Both homo-fermentative and hetero-fermentative lactic acid bacteria participate in food fermentation.

In some cases, yeasts and moulds also participate along with L.a bacteria L.a bacteria is most active at 30^0C temperature.

C) Alcoholic fermentation

Ethyl alcohol can be produced by fermentation of any CHO containing a fermentable sugar or a polysaccharide that can be hydrolyzed to a fermentable sugar.

Factors to be considered to start small scale processing industry in India

I. Availability of raw material

- Most of fruits and vegetables are required
- Raw material should be available at cheaper rates and required varieties
- Availability of raw material highly fluctuates in India because of maturation of different fruits in different time.

II. Selection of site and construction of building

- It should be located in nearby places of fruits growing to give adequate level
- The site should have adequate water supply
- Their should be good scope for expansion of industries
- If there are any other industries nearby fumes will contaminate the product and hence should avoid such places.
- Building should be constructed according to plan having different sections with enough place.
- The floor of building should be slip-proof should be ware and tare and resistant to chemicals.
- Well drainage facility should be there
- Provision for washing, peeling *etc.*

III. Availability of labour

- Number of workers depends on site of industry type of product and degree of mechanization
- Training of labour are required skillfulled

IV. Duration of canning

- Canning process will be affected by seasonal fluctuation
- Hence ideal time can not be fixed effectively and profitability goes down
- To reduce unit cost alternative produce should be manufactured during off season.

V. Water supply

- continuous water supply should be available for washing of raw materials, preparation of brine, syrup solution, blanching, cooling and also to sun steam generated.
- Water should not be contaminated
- High salt content water not recommended to use.

VI. Disposal of cannery waste

- Here large quantity of waste is produced but contains more starchy material like skin and peel and colloidal starch material can also profitabaly utilized to make by products.

VII. Transport facility

- Should be located near road, which connects important cities and towns.

Hygienic conditions of the processing unit

a) Cleanliness of walls, floors and ceiling

- Walls, floors and ceilings should be constructed so as to be easy to clean. It should have smooth, hard surfaces which are easy to clean.
- Adequate sewage disposal and plumbing improper sewage disposal can cause serious illness and out breaks of food poisoning.

  Sewage must never be allowed to contaminate food, equipment and prepared product.
- Pluming: cross connections between pipes carrying drinking water and pipes carrying non drinking water
- Drainage stoppage
- Avoid overhead leakage
- Backflow of sewage into drains from refrigerator drains, dishwater drains.

b) Good lighting:

Good lighting is particularly needed in these areas *i.e.,*

- Kitchens, food storage rooms *etc.*

c) Good ventilation

- Good ventilation removes hot, stale, odorous moist, greasy, smoky, while has developed during cooking and dishwashing.

- Prevents deposit of droplets of moisture on walls and ceilings, further avoids growth of m.o's on preparation surface, equipment *etc.*

d) Adequate hand – washing facilities

- Hand washing facilities should be made available in several locations. They are
- Adjacent to toilet rooms
- Dressing rooms
- Areas where food is prepared

Hand washing facilities should consists of

- A washbowl equipped with hot and cold water
- Liquid / powdered soap / detergent
- Individual towels / other hand drying devices to be put.

e) Dressing or locker rooms and toilet facilities

- Dressing rooms, locker rooms should be available so food service personal may change heir clothes and store their belongings,
- Toilet facilities should be provided in areas separate from those where food is prepared, stored and served,
- Hand washing facilities should be available next to dressing rooms and lockers.

f) Sanitary Garbage disposal

- Provide garbage containers of durable materials that do not leak and do not absorb liquids and provide them in sufficient numbers.
- Provide tight fitting covers for the cans or a special, enclosed, vermin-proof and cool garbage room.
- A refrigerated garbage room aids in preventing rapid decay garbage is the development of bad odour resulting from decay.
- After cans are emptied, clean them thoroughly inside and outside with the help of brushes, detergent and plenty of hot water for this job. In large operation steam cleaning devices can be used.

g) Control of rodents and insects

- The presence of rodents such as rats, and insects (flies and cock roaches) is a menace to a food-service operation.
- Rodents and insects may transmit disease by contaminating food, food preparation equipment and utensils. Hence their entry may be restricted and killed.

h) Separate storage area for cleaning materials, utensils and equipments

- Cleaner such as detergent, soaps, ammonia polishes and other materials must be stored separately and not in the kitchen.
- Cleaning equipments and utensils must also be stored separately.

i) Regular and adequate cleaning facility

- Cleaning of the food-service facility is a fundamental and important part of the operation.
- Routine checks are made by food inspectors, to ensure the high standards in sanitations are maintained.

Technology for preparation of jam, jelly, RTS, beverage, nectars, squash, marmalade, syrup and tomato products and pickles.

Spoilage of canned products

- Spoilage is due to two reasons

A) Physical and chemical changes

B) Micro-organisms

A) Spoilage is due to physical and chemical changes

1) Swell: The swell / bulge is due to the positive internal pressure of gases formed by microbial or chemical action.

a) Hydrogen swell: This is due to the H_2 gas produced by the action of food acids on the metal of the can.

b) **Flipper:** The can will appears normal, but when struck against a table top one or both ends becomes convex and springs or flips out, but it can be pushed back to normal condition by little pressure. Such can is termed as 'flipper'.

c) **Springer:** A mild swell at one or both ends of a can is called 'Springer'. It is due to insufficient exhausting or overfilling of the can. The bulged ends can be pressed back to the original position, but again it will become bulge.

d) **Soft swell:** At a more advanced stage swell develops at both ends of the can it can e pressed and returned to normal position, but springs back when the pressure is removed

e) **Hard swell:** This is the final stage of well, the bulged ends cannot be pressed back to normal position and the cans ultimately burst.

Precaution are necessary to prevent formation of H_2 swell

- Good quality tin plate should be used
- Plain cans are less susceptible
- Lacquering is more essential
- Addition of 0.5% citric acid to syrup will lower the acidity
- Before placing the lid maintain proper head space (0.6-0.9 cms)
- The lid should placed firmly or clinched before exhausting to ensure a high vacuum in the can.
- Can should be exhausted for a fairly long time, but without affecting the quantity of product.
- The sealing temperature should not be below 74^0C.
- At high storage temperature hydrogen formation will be more, hence canned products should be stored under cool and dry condition.

2) **Overfilling:** During retorting, over filled cans become strained due to expansion of the contents, and in the absence of vacuum in them swelling takes place.

3) **Faulty retort operation**

   When the steam pressure is reduced rapidly at the end of processing, high pressure develops inside the cans resulting in their distortion and the cans when cooled look like swells.

4) **Under exhausting:** Can are exhausted to remove most of the air present in the product. This helps in proper filling of fruit and vegetables and also creates a good vacuum.

5) **Paneling:** Generally seen in large sized cans that the body is pushed inward due to high vacuum inside.

6) **Rust:** rust formation can be checked if the cans are extremely lacquered.

7) **Foreign flavours:** During preparation, filling, storage or even transportation, condition may become unhygienic and the products develops foreign flavour.

8) **Damage:** Cans show signs of leakage or revere distortion they must be rejected.

9) **Undesirable texture:** Texture is another important characteristic like flavour and colour.

10) **Corrosion of cans:** Cans become corrode or perforate due to the acidity of the contents.

11) **Leakage:** It is due to defective seaming / sealing, nail holes, excessive internal pressure due to microbial spoilage sufficient to burst the can, internal or external corrosion, mechanical damage during handling.

12) **Breathing:** There may be very tiny leak in the can through which air can pass in destroy the vacuum.

13) **Bursting:** It is caused by the excess pressure of gases produced by decomposition of the food by m.o's.

14) **Buckling:** Due to improper cooling, it resembles like swell.

15) **Discolouration:** It can be detected by visual examination of the can and its contents. Discolouration is due to biological causes like enzymatic and non-enzymatic browning or metallic contamination (Iron and copper salts).

16) **Stack burning:** If processed cans are not allowed to cool down sufficiently before storing, the contents remain hot for a long time. This is knewn as stack burning.

B) Microorganisms / microbial spoilage

1) Pre-processing spoilage

This spoilage is due to time gap between filling and heat processing of the containers. Processing checks the growth of organisms the gas already present in the can causes swelling and flipping. Hence, delay between filling and processing must be avoided.

2) Under-processing spoilage

Under-processing of canned foods result in their spoilage by thermophilic bacteria and mesophilic organisms and this is termed as 'under processed spoilage'.

a) Thermophilic bacteria

These bacteria can thrive at a high temperature of 100^0C. If cans are stored without adequate cooling. Some thermophiles produce hydrogen and some other hydrogen sulphide gas which blackens the contents. The only way to avoid bacterial contamination is to clean and wash the raw material thoroughly before canning.

Three types of spoilage are caused by

1) **Thermophiles**

   i. Flat sour: This occurs mostly in non-acid foods like vegetable and is caused by thermophilic spp. Of Bacillus such as *B. coagulans, B. Sterothermophilus* which produce acid without formation of gas. The product has a sour odour and its acidity is much higher than that of normal product. It is not fit for consumption.

   ii. Thermophilic acid (TA) spoilage;

   The case of TA spoilage, the cans swell due to production of CO2 and H2. Spoilage mostly occur in low and medium acid foods, and develops in cans stored in hot condition.

   iii. Sulphide spoilage: It develops in low-acid foods.

   b) Mesophilic organisms: Spoilage by mesophylic organism such as some spp. of clostridium, Bacillus, yeast and fungi is also indicative of under-processing.

3) **After processing**

   A large number of cans after processing show signs of microbial spoilage due to leakage of can seams. Cans which are water cooled are more likely to leak than air cooled ones. For reducing this type of spoilage the bacterial level of the cooling water should be low and the cans should be properly exhausted to reduce the seam strain.

Technology for preparation of jam, jelly, RTS beverage, nectars, squash marmalade, syrup, tomato products, pickles.

Microbial spoilage of fruit and vegetables

Spoilage of fresh fruits and vegetables usually occurs during storage, transportation and during processing. They also get contaminated with spoilage organisms either from each other or from the containers.

Mechanical injuries during harvesting and transportation further aggravates the deterioration process.

Spoilage is mainly of two types:

a) Abiotic spoilage
b) Biotic spoilage

a) Abiotic spoilage: It is due to different physical and chemical changes in the product *i.e.* hydrolytic action of enzymes, oxidation of fats, putrification of proteins, browning reaction between proteins and sugars and physical changes are – wilting control, caking, melting *etc.*

Biotic spoilage: This includes the microbial action associated with bacteria yeasts and molds on vegetable and fruits.

There are two types of microbial spoilage

a) Spoilage caused by plant pathogen which attack various parts of the plant used as foods.
b) Spoilage caused by saprophytes.

Among the microorganism spoilage can be caused by bacteria, molds or yeast.

Bacteria: Various groups of bacteria can attack different fruit and vegetable depending upon their composition such as, lactic acid bacteria, acetic acid bacteria, caliform bacteria and spore forming bacteria.

Yeasts: Yeasts are widely found in the environment including the surface of the fruits, leaves and flowers *etc.* yeasts degrade, starch, pectins and sugars, thus degrades the food product by changing the composition.

Molds: Molds are associated with food products. Many of the molds secrete toxic compounds like aflatoxins, patulin *etc.*