Q 2. Write in brief the importance & scope of fruit & vegetable preservation in India?

Ans.

❖ Importance

1. India is the 2nd largest producer of fruits after Brazil & 2nd largest producer of vegetables after china
2. India's total annual production is 70million tons which includes 25tons fruits & 45tons vegetables
3. India produces world's 10% fruits % vegetables
4. We are producing 53% mango , 17% banana , 11% onion in the world
5. India ranks 1St in pomegranate production
6. Area under vegetable production in India is 78.03 lakh per ha
7. In Maharashtra area under fruit cultivation is 14lakh per ha while vegetables is 4.50 lakh per ha
8. India export 40 different types of fruits all over the world
9. India export 70% of onion ,23% green Chili , 20% of other vegetables
10. India is one of the major producer of mango, banana ,pineapple
11. Value addition done by various countries is UK 188 , Philippines 45%, China 23%, India 7%
12. Indian farmers get 25% of total consumer prize
13. 35-40% losses of vegetables due to soft rot bacteria
14. As per ICMR every one should consume 90gm fruits per day & vegetables 280-300 gm per day

❖ Scope

1. There is a tremendous production of fruits & vegetables in a shorter period
2. Post harvest losses can be avoided to increase substantial returns to process for off season consumption
3. Availability of cheaper Labour ,Govt subsidy for cold storage & processing units
4. Convince of roads increase for marketing and processing unit
5. With availability of cans ,bottle and other equipment at cheap rate ,there is a tremendous scope for export of processed product like jam jelly marmalade pickles
6. With investment of Rs 1000 crore in the food industry ,it employed 54000 people , 25000 paper industry , 48000 people in textile
7. To increase the value addition from 7% to 35% there is need to be investment of Rs 140000 crore
8. To increase processing of fruit & vegetables with investment of Rs 140000 crore it generates 77lakh direct employment and 3 crore indirect employment

Q4. Enlist the different post harvest handling operations of fruits & vegetables?

Ans.

1. Curing
2. Degreening
3. Pre-cooling
4. Washing & drying
5. Sorting & grading
6. Disinfection
7. Post harvest treatment
8. Waxing
9. Ripening
10. Pre-packing in plastic films

Q5. Define post harvest technology & write its scope & importance with suitable examples?

Ans.

❖ **Postharvest technology:**

Defined as the branch of agriculture that deals with all the operations right from harvesting or even the pre harvest stages till the commodity reaches the consumer, either in fresh or processed form and utilization of the wastes in a profitable manner

❖ **Scope & importance of Post harvest technology**

1. **Reduction In Post Harvest Losses** : Post harvest technology ensures reduction of losses in what has already been produced. So reduction of post harvest losses is an alternative way of increasing production of agricultural & horticultural crops
2. **Reduction Of Cost, Of Production**: Post harvested technology reduces cost of production, packaging, storage, transportation, marketing and distribution, lowers the price for the consumer and increase the farmer's income.
3. **Reducing Malnutrition**: Proper post harvest technology ensures availability of sufficient food to all thus reducing malnutrition & ensuring healthy growth of the nation . It also extends the season of availability of a particular commodity.
4. **Economic Loss Reduction** : reduces economic Losses at grower level, during marketing and at consumers end.
5. **Availability** : post harvest technology makes the availability of fruits & vegetables as & when are required due to the availability of the transport facilities thus increasing export s of fruits & vegetables have become possible only by the interventions made in post harvest technology
6. **Employment Generation** :-food processing industries ranks 1st in terms of employment generation with 15 lakh persons employed. With investment of Rs 1000 crore in the food industry ,it employed 54000 people , 25000 paper industry , 48000 people in textile .
7. **Export Earning** :- export of fresh & processed horticultural commodities also attract valuble foreign exchange

Q6. What is ripening?. Describe natural factors affecting ripening of fruits & vegetables?

Ans.

Ripening :- it is the most dramatic events in a life of a fruit which transforms / physiological matured but unedible fruit into visually attractive , olfactory & taste sensation

❖ **Natural Factors Affecting Ripening Of Fruits & Vegetables**

1. **Temperature**: fruits picked up at right time generally ripens at any temperature between two critical limits. In certain cases fruits may require a cold treatment being placed in the temperature limit for ripening. Temperature affects the synthesis of specific pigments and their final concentration in the fruit.
2. **Carbon dioxide** :- high levels of CO_2 will inhibit ripening of fruits due to decrease in respiration rate & in other case increase the rate of respiration in its absence
3. **Radiation**: may act as inhibitors or stimulators of ripening. Grapes ripen quickly under treatment with 'infrared' radiations. Banana irradiated with 'X' exhibited a decrease in softening but an increase in skin blackening.
4. **Air humidity**: The relative humidity and velocity of the air in the vicinity of the influence the maturity, especially in the evolution of flavour. Saturated air hinders development of good flavour in pears. Apples show blackening of the core.
5. **Volatiles:** Non-ethylene volatiles can stimulate ripening . Air purification activated carbon, H_2SO_4 and NaOH slowed down the ripening of pre-climatic apples in a recirculation system Carbon (activated) reduces the effect in both cases.
6. **Growth regulators**: These sometimes stimulate ripening of gathered fruits. It sets that the treatment is effective especially when the application made very, early, after the picking. Ste of bananas immersed in solution containing 1000 ppm soak 2,4-D, 2,4,5 -Tor Para- chlo phenoxy acetic acid showed that ripening accelerated. 2,4,5-T and to some extent 2,4-D wh spayed in a wax emulsion delayed the yellow colour in the rind of lemons during stora storage life increases.
7. **Harvest**: The extent to which certain fruits are pre-climacteric post-climacteric the time harvest is an factor affecting ripening detachment accelerates ripening in fruits like avocado apple. After the harvesting respiration increases in fruit & they sudden show ripen symptoms.

Q9. Enlist the methods of storage of fruits & vegetables. Describe zero energy cool chamber.

Ans.

❖ **Methods Of Storage Of Fruits & Vegetables**

1. **Ambient storage**
2. **Cold storage**
3. **Controlled atmospheric storage**
4. **Sub atmospheric storage**
5. **Modified atmospheric storage**
6. **Cold chamber storage / evaporated cold storage / zero energy cool chamber**

❖ **Zero Energy Cool Chamber**

- Cool Chamber is simple structure made out of bricks and sand cud closed with thatched coconut leaves and gunny cloth or even with grass
- It is a double wall brick structure. The space between two walls is filled with sand
- This structure, is required to be watered in the morning and in the evening every day
- in this structure the relative humidity remains more than 95 % and the temperature is reduced by 6 to 10^0 C than the ambient temperature
- It has been reported that the cool chamber retards the ripening process and thus, increases of the shelf life of both .fruits and vegetables
- The fruits and vegetables in the cool chamber remain turgid showing almost no symptoms of shriveling. This structure is also called as "Zero energy cool chamber" and can be built at the farm as well as at the market place

❖ **Advantages of Cold chamber:**

1. Ripening produce in the Cool chamber is uniform and fruits are much firmer compared with those ripened under ambient conditions. Example: Shelf life of find ripe mangoes, ber could be increased to 8 and 10 days, respectively in cool chamber compared with four days outside in both the fruits. In case of Grape fruits and Orange could be increased to 60-90 days compared with 8-1 5 days in ambient
2. The growers can avoid the clutches of the middle man and need not have to make any distress sale by keeping the produce in cool chambers
3. The cool chambers do not require any energy & would to long way in solving the handling problems of fresh fruits

Q10. Describe the post harvest handling operations of fruits & vegetables for increasing the post harvest life?

Ans

1. Curing
2. Degreening
3. Pre-cooling
4. Washing & drying
5. Sorting & grading
6. Disinfection
7. Post harvest treatment
8. Waxing
9. Ripening
10. Pre-packing in plastic films

A. Curing

1. It is the suberization of outer tissue formed by the development of wound periderm which acts as an effective barrier against infection & water loss.
2. In sweet potato, tills condition is most rapid at 33°C and relative humidity of 95 %. Potato tubers are held at 18°C for 2 days and then at 7 °C - 10°C for 10-12 days at 90 % relative humidity
3. Curing also, reduced the moisture content especially, in-onion and garlic
4. Drying of superficial leaves of onion bulbs protects them from microbial infection in storage
5. Maximum safe temperature for onion curing at field is 37.8 DC for 3-5 days.
6. Artificial curing of onions In crates at 40 DC for 16 hours reduces rot losses in storage

B. Degreening

1. It is the process of decomposing of green pigments (chlorophyll) by applying ethylene
2. Degreening is earned out in special treating rooms with controlled temperature and humidity in which low concentration of ethylene (20 ppm) 15 applied
3. The ethylene should be supplied from a gas cylinder
4. These rooms are thoroughly ventilated to keep the CO2 level below 1 % which does not allow higher colouring If kerosene fumes are placed outside the degreening room, they enter the room through ducts by forced ventilation.
5. The best degreening temperature is 27° C, higher temperatures delay Degreening
6. The relative humidity should be 85-90 %. Higher humidity levels cause condensation during degreening and are associated with slow degreening and increase in decay degreening

C. Precooling

1. It is the removal of field heat , so as to increase its keeping quality
2. Peas and okra which deteriorate fast need prompt cooling. Sometimes stage of ripening and level of field heat of produce also determine the need for pre-cooling.

3. Peas are cooled at 15 ^{0} C
4. In air cooling, cool air can be obtained from cold storage. Temperature should not be less than 1 °C to avoid freezing. Where night temperatures are low, doors of the store rooms can be opened for cooling in the night.
5. In water cooling (hydrocooling), field heat is removed quickly. It is used for leafy vegetables to retain their texture and freshness. Ice can be added to bring down the temperature
6. Grapes are pre-cooled at 0^0 C
7. Mangos are pre-cooled at 12 to 15 °C

D. Washing & drying

1. Most of the fruits and vegetables are washed after harvesting to improve their appearance, prevent wilting and remove primary inoculum load of microorganisms
2. Hence a fungicide / bactericide should be used washing water
3. Washing improves shelf-life of bananas by delaying their ripening
4. After washing, excess of water should be removed which would other
5. Encourage microbial spoilage. Root and tuber crops arc often washed to remove the soil adhering to these

E. Sorting and grading:

1. Immature, diseased and badly bruised fruits and vegetables are sorted out
2. Most of the countries have their own set of standards of domestic trade and for international trade, standards have also been defined
3. Grades are based on. size, weight, colour and shape.
4. Grading is done manually or mechanically

F. Disinfestation:

1. Papaya, mango melon and other fruits are susceptible to fruit fly attacks
2. Disinfestations is done either by vapour heat treatment at 43 °C with air saturated with later vapour for 6-8 hours by ethylene dibromide fumigation (18-22 g of EBD / cubic meter for 2-4 hours
3. Residues of inorganic bromide must not exceed 10 kg/g) or by cold treatment (exposure of fruits to near freezing temperature for a specified period).

G. Post-harvest treatments:

1. Post-harvest application of Bavistin (Q.I %) and Topsin (0 1 %) controls storage diseases in mango
2. In Nagpur mandarins, hot water treatment with Imazalil (0.1 %), Bavistin (0.1 %) and Benlate (0.1 %) is most effective.
3. A complete inhibition of sprouting of cool chamber (evaporatively cooled) stored potatoes for 4 months and 5 months is achieved by spraying them with an aqueous emulsion of CIPC @ 50 mg and 100 mg/kg of tubers respectively, before completion of dormancy period

H. Waxing

1. Fruits and vegetables have a natural waxy layer on their outer surface which is partly removed by washing
2. Waxes are the esters of fatty acids with monohydric alcohols
3. Waxes can be grouped in different categories like vegetable waxes, mineral waxes, petroleum waxes, bee waxes, shellac waxes
4. There are two types of waxes that are wax O 12, wax W 12
5. Waxes can be given with fungicide treatments —capton 0.2-1%, sodium hypochlorite 0.1 – 1%, sodium benlate 0.1%
6. Fruits are dipped into wax solution for 30 to 60 sec , drained & dried under fan or shade
7. Advantages--decrease (transpiration, respiration, scaled injury, physiological activity, shriveling losses, mold growth) --increase (storage life, quality control)

I. Ripening

1. It is the most dramatic events in a life of a fruit which transforms / physiological matured but unedible fruit into visually attractive, olfactory & taste sensation
2. It marks, the completion of development and commencement of senescence with life of a fruit
3. Ripening can be achieved by the application of ethylene
4. A concentration of CO2 about 1 % delays ripening. Hence through ventilation is essential
5. By use -of ethephon commercially known as ethrel or CEPA. Making it alkaline using caustic soda (3g of caustic soda for 20 ml of ethephon)

J. Pre-packaging in plastic films

1. Pre-packaging increases the shelf life by creating a modified atmosphere with an increase in concentration of CO2 in the package
2. The packaging material, used should provide reasonable access to oxygen, for this breathing films like polystyrene and cellulose acetate are used. But tougher LOPE films which have high O2 and CO2 transmission rates are more durable. The pouches must have perforations to transmit oxygen and carbon dioxide rapidly enough for the respiration of fresh produce
3. The pouch used reduces bruising, facilitates inspection, reduces moisture loss (weight loss) and prevents dehydration. It also creates modified atmosphere.
4. In pre-packaging, leaves, stalk, stem etc are trimmed; washed cleaned and weighed quantities are put in pouches. Ethylene absorbents may be added to the package wherever required to retard the ripening process. Hydrated lime (Calcium hydroxide) inserts may also be beneficial in controlling CO2 concentration within the film package.

Q12. What are the different pre harvest factors affecting post harvest quality of fruits & vegetables write in brief about environmental factors?

Ans.

Pre Harvest Factors

1. Selection of varieties

It is qualitative change occured in fruit after ... which it become edible. (Ripening).

1. Selection of variety
2. Cultural factors (pruning, thinning, rootstocks, irrigation, growth regulators)
3. Environmental factors (temp, light , rainfall, relative humidity, wind velocity & hail)
4. Pre harvest treatments
5. Maturity factors
6. Harvesting factors

❖ **Environmental factors**

1. **Temperature** - High & low temperature affects maturity, colour, sugar, acidity etc of the fruits and vegetables. high temperature reduces the quality e. g. radish. spinach, cauliflower, etc. and low temperature causes chilling and freezing injury.
2. **Light**- Essential for anthocyanin formation. Exposed to sunlight develop lighter weight. thinner peel, lower juice, acids and higher TSS than shaded fruit. E.g. citrus, mango, etc. Exposure of potato to light causes greening (solanine formation), which has toxic properties. High sunlight intensity causes sunscald in citrus and tomatoes ,and reduces the pure white colour of cauliflower. Low light intensity causes thin and large leaves in leafy vegetables.
3. **Rainfall**- Causes cracking in grape's, dates, pomegranate, lime, lemon, tomato etc It reduces appearance and sweetness. Increases incidence and intensity of fungal diseases and pests.
4. **Relative humidity**- High humidity reduces the colour and TSS and increases acidity in citrus, grapes, tomato, etc .. But ell other hand it is needed for better quality of banana , litchi & pine apple
5. **Wind velocity** :- causes brushing, scratching & corky scar on the fruits
6. **Hail**- several hail injuries to fruits like apple, grapes, banana, guava etc.

Q13. Define Ripening. Write in brief about important physiochemical changes that take place during ripening of fruits?

Ans.

Ripening :- it is the most dramatic events in a life of a fruit which transforms / physiological matured but unedible fruit into visually attractive , olfactory & taste sensation

❖ **Physiochemical Changes That Take Place During Ripening**

1. **Change in colour**
   - Green colour (chlorophyll) into yellow colour (xanthophyll)
   - Anthocyanin-----pomegranate
   - Lycopin------tomato
   - Capsicin------chili
   - All colouring pigments act as antioxidants
2. **Maturation of seed**
   - As the seed reaches to its physiological maturity, seed also reaches to its maturity

3. **Change in softness**
    - Softening is due to the conversion of insoluble propectin into soluble pectin

4. **Change in rate of ethylene production**
    - As the fruit is becoming more ripen, its rate of ethylene production is also increased

5. **Change in rate of Respiration**
    - Rate of respiration is associated with two terms i.e. climacteric fruits & non climacteric fruits
    - Climacteric fruits – show sudden increase in rate of respiration after harvesting e.g. papaya, grapes, custard apple
    - Non-climacteric fruits—do not shoe sudden increase in rate of respiration after harvesting e.g. grape, pineapple, banana

6. **Change in organic acid**
    - Different organic acid content gets decreased as the fruit matures
7. **Change in starch content**
    - During ripening starch is converted into sugar
    - In banana before maturity 22 to 25% starch & 1-2 % sugar is present, after maturity starch is 1-2 % & sugar is 15 to 20 %
8. **Change in phenolic compounds**
    - Decrease in 'Astringency compounds because of decrease in phenolic compounds

9. **Change in flavouring compounds**
    - Due to increase in sugar content fruits shows different sweet flavour & lumpish taste

10. **Change in protein content**
    - Proteins are dehydrolised into peptones, proteases & finally into amino acids

11. **Development of wax layer**
    - Fruits and vegetables have a natural waxy layer on their outer surface
    - Wax protects fruit from tiny injuries, wounds

Q23. Enlist factors affecting respiration & transpiration in fruits & vegetables. Explain in brief two?

Ans.

Internal factors

1. **Stage of development:**

During organ development the rate *of* respiration variation occurs when fruits become bulky i.e maturation stage degree of respiration rate decreases as compared to initial development stage diametric fruit the rate of respiration is minimum a 1 maturity stage put when ripening is about to after harvest , the respiration rate will increase to climacteric peak

2. **Stage at which the fruits are to be harvested:**

At ripening stage increases in respiration rate is few higher than the maturity stage. In non-climac fruits, fruits ripen on the plant If the fruits removed from [he plant the respiration rate slowly incre e.g. in Strawberry. In apples the respiration is more due to more sugars

3. **Moisture content:**

If the moisture is more, respiration is less because of dimension of sugar content. Transpir is more water loss is more so concentration of sugar is more which leads to higher respiration More water loss lead to desiccation rather than more accumulation of sugar.

4. **Size of fruit:**

Small sized fruits have more expose surface compared to bulky fruits, so respiration rate is mo small fruits

5. **Coating on surface of fruits:**

More thickness of coating less the respiration rate.

6. **Type of tissue:**

Young tissues have more respiration rate

❖ **External factors**

1. **Temperature:**

At 0 to 35°C temperature respiration rate is increased at rate of 2 to 25 for every 2°C temperature raising. The biological and chemical processes are affected. When level of CO2 is more under this condition rate is low even at higher temperature.

2. **Ethylene:**

Application of ethylene can shift the time as to reach climacteric peak.

3. **Availability of O2:**

If Oxygen is supplied more to produce, like carrots, the respiration rate is increased to certain level.

4. **CO2:**

Proper CO2 concentration prolongs the storage life by less respiration.

5. **Growth regulator application:**

Maliec hydrazide (MK) application inhibits or accelerates the respiration rate act to the purpose of application.

6. **Fruit injury**

Tins mechanical injury is also responsible for stimulating respiration rat

7. **Respiration drift:**

The fruit exhibit more respiration rate at ripening is called climacteric fruit.

Other fruits not showing such pattern are called non-climacteric fruits but rnany non-climacteric fruits show respiration rate with rise of ethylene production, Respiration rate increases sometimes.

Young citrus fruits produce more respiration rate and ethylene like climacteric fruits. This is nothing but respiration drift

8. **Transpiration factors :**

Nature of skin, coating of skin, irradiation, wax coating, low temperature, high R.H. are factors responsible for transpiration.

Q 25. Describe different types of maturity indices to judge the maturity of fruits & vegetables with examples.

Ans.

There are five types of maturity indices to judge the maturity of fruits.

1. Visual means
2. Physical means
3. Chemical analysis
4. Computation
5. Physiological method

1) **Visual means:**

Skin, colour, size, persistence of the style portion, drying of outer leaf, ripe fruit.

e.g. Loss of green colour in citrus and red colour in tomato.

2) **Physical means:**

Firmness, easy separation / Abscission, specific gravity, weight of the fruit.

e.g. Musk melon should be harvested at the formation of abscission layer.

In cabbage and lettuce should be harvested at firmness stage.

3) **Chemical analysis:**

T.S.S , Acids, Starch, Sugar etc.

e.g. In papaya T.S.S at hsrvest should be minimum 11 to 12 %

4) **Computation**

Days of harvesting fruits from fruit set till maturity.

e.g. Guava: Fruits mature in 140 to 160 days after flowering.

5) **Physiological method:**

Respiration rate, internal ethylene evolution.

it is a stage, which will allow fruits / vegetables at its peak condition when it reaches to the consumers and develop acceptable flavour or appearance and having adequate shelf life.

e.g In most of the fruits changes from dark green to pale green or yellow colour

i.e Mango Banana

Q.26 Define ripening. Write in brief important physico- chemical changes occurring during ripening.

Ans.

Definition : it is the most dramatic events in a life of a fruit which transforms / physiological matured but unedible fruit into visually attractive , olfactory & taste sensation.

❖ **Changes during Fruit Ripening**

1. Cell Wall Changes

Cell wall consists of pectic substances and cellulose as the main components along with small amounts of hemicelluloses and non-cellulosic polysaccharides. In cell wall, the changes particularly in the middle lamella which is rich in pectic polysaccharides are degraded and solubilized during ripening. During this softening, there is a loss of neutral sugars (galactose and arabinose-major components of neutral protein) and acidic pectin (rhamnogalacturonan) of all cell wall. The major enzymes implicated in the softening of fruits are pectine1asterase, polygalacturonase cellulase and b- galactosidase.

2. Starch

During fruit ripening sugar levels within fruit tend to increase due to either increased sugar importation from the plant or to the mobilization of starch reserves within the fruit, depending on the fruit type and whether it is ripened on or off the plant. With the advancement of maturity, the accumulated starch is hydrolyzed into sugars (glucose, fructose or sugars) which

are known as a characteristic event for fruit ripening. Further breakdown of sucrose into glucose and fructose is probably mediated by the action of inverts. In vegetables like potato and peas on the other hand, the higher sucrose content which remains high at fresh immature stage, converts into starch with the approach of maturity.

3. Organic Acids

With the onset of fruit ripening there is downward trend in the levels of organic acids. The decline in the content of organic acids during fruit ripening might be the result of an increase in membrane permeability which allows acids to be stored in the respiring cells, formation of salts of malic acid, reduction in the amounts of acid translocated from the leaves, reduced ability of fruits to synthesize organic acids with fruit maturity, translocation into sugars and dilution effect due to the increase in the volume of fruit.

4. Colour

With the approach of maturation, the most obvious change which take place is the degradation of chlorophyll and is accompanied by the synthesis of other pigments usually either anthocyanin or carotenoids. They can give rise to a wide range of colours (from red to blue). The chloroplasts in green immature fruit generally lose chlorophyll on ripening and change into chromoplast which contain carotenoid pigments. Carotenoids are normally synthesized in green plant tissue a major product being 3-carotene. However, in many fruits additional - carotene and Lycopin is synthesized during ripening.

5. Flavouring Compounds

Although fruit flavour depends on the complex interaction of sugars, organic acids, phenolic and volatile compounds but the characteristic flavour of an individual fruit or vegetable is derived from the production of specific flavouring volatile. These compounds are mainly esters, alcohols, Aldehyde, acids and Ketones. At least 230 and 330 different compounds in apple and orange fruits have been indicated respectively.

6. Ascorbic Acid

L-ascorbic acid (Vitamin C) is the naturally occurring ascorbic acid in fruits. A reduced amount of ascorbic acid is noticed in pome, stone and berry fruits at the time of harvest. An increase in ascorbic acid content with the increase in fruit growth has been and the levels declined with the advancement of maturity and onset of fruit ripening in pear, sweet potatoes, potato, asparagus and okra during the course of post harvest handling.

7. Phenolic

The phenolic content of most fruits declines from high levels during early growth to low levels when the fruit is considered to be physiologically mature and thereafter susceptible to the induction of ripening.

8. Amino Acids and Proteins

Decrease in free amino acid which often reflects an increase in protein synthesis. During senescence the level of free amino acids increases reflecting a breakdown enzymes and decreased metabolic activity.

9. Ethylene Production and Respiration

Ethylene production

In climacteric fruits such as mango, banana, ethylene production increase and causes:

- Rise in respiration
- Rise in temperature
- Rise in activity of hydrolytic enzymes.

Ethylene is produced from an essential amino acid — methionine.

Rise in respiration

Respiration is required for releasing energy and the substrate for synthesis of several organic compounds required in the ripening process. During ripening in climacteric fruits, there is rise in respiration called climacteric. The clirnacteric peak is obtained very fast when temperature is relatively high. Respiration is a most deteriorating process of the harvested fruits and vegetables which leads to the oxidative breakdown of the complex materials (carbohydrates or acids) of cell into simple molecules (CO_2 and water) with the concurrent production of energy required by the cell for the completion of chemical reactions. In brief, the process of respiration can be summed up with the following reaction:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

1. Marketing linking to product on centres
2. Infrastructures are necessary to be developed.
3. Self groups and cooperative societies are also required to be formed for organizational work.
4. Development of contact farming is necessary to get assured business so as to have better linkages.
5. Training and demonstration are necessary to educate the factors.

7.4 Post Harvest Losses

Fruits and vegetables are perishable commodities and they begin to spoil shortly after the harvest and every year considerable quantity is loss. These losses are known as post harvest losses and occur at different stages in chain of harvesting, storage, transport and marketing.

Poor planning in production, lack of modern markets, short falls in storage capacities, unsatisfactory transport, lack of organizational set up, absence of processing industries are the most important factors responsible for post - harvest losses.

7.5 Nature of Losses -

In India loss occur at different places like farmer's field (15-20%), packaging time (15-20%), During transportation (30-40%) and in market itself (30-40%). At present it is a need of hour to minimize these losses occurring at different sites. Nature of losses noticed in fruits and vegetables are as under.

i) **Loss in weight** - Leafy. Vegetables, Onion, Potato and also many fruits get suffered due to transpiration and reduce the weight considerably.

ii) **Shrinking and wilting** - Many fruits shriveled, leaf vegetables wilts.

iii) **Change in colour** - Change in colour is observed due to high temperature or hot and dry conditions. E.g. Litchi, becomes brown, spinach and Lettuce become yellow while cauliflowers change to yellow.

iv) **Change in texture**-Many fruits and tomato becomes soft due to over ripening.

v) **Change in taste** - Some fruits gives flat, sour and bad odour.

vi) **Bruising** - Fruits and vegetables get bruised due to defective harvesting handling packing transport and storage.

vii) **Sprouting** - This is great problem in Onion, Garlic, ginger, potato if not stored at proper temperature and humidity.

viii) **Toughening** - Green beans, sweet corn become tough due to appearance of spongy tissues in prolonged storage.

ix) **Greening** - Potatoes, sweet potatoes, if exposed to light during storage cause green tissues due to solanine, a toxic chemical.

x) **Rotting** - There are some diseases & pest brings rotting in many fruits and vegetables. Fungi are most common factor to post harvest losses.

7.6 Causes of the Losses and their control -

There are many number of factors responsible for the losses of fruits and vegetables during different stages of the handling. They are classified broadly into three major groups as described below -

1. Physical injuries
2. Physiological disorders
3. Pathogenic disorders

1. Physical injuries :

These type of injuries are caused in fruits and vegetables during harvesting, grading, packing, transportation and storage is source of entrance of micro-organisms which cause spoilage and losses. Improper physical handling can result injuries due to following.

I) **Abrassion** - It can occur during harvesting, packing and transport. Rough containers or stacking packed containers permit the individual fruits to rub against each other or against containers surfaces and causes abrassion.

II) **Compression** - Packing more produce into little container or staking them higher than their design strength cause this type of damage.

III) **Impact** - Careless handling of crates of fruits and vegetables like dropping of crates on concrete floor, careless dumping of produce which causes abruse or cracks.

Iv) **Punctures** - Punctures are some times caused by stem or pedicle in egg plants, cucumber, tomato etc.

v) **Tears** - It is most common in leafy vegetablels, exposed tissues lead rapid dehydration, descolouration and decay.

The important disease pathogens which then enter through the injuries and spoil the product.

Control measures -

i) Careful handling in all operations to prevent injuries.

ii) Removal of injured fruits in time to avoid probable infection of various diseases.

iii) Chemical protection is given to the fruits as soon as possible after harvest, chemicals used are Benomyl (0.1 %) which will minimize the problems.

2. Physiological Disorders -

These are the abnormalities which may be non-parasitic, metabolism which usually shorten the post harvest life of fresh fruits and vegetables. Such disorders inherited at harvest or other develop later. They cause lossen and affects marketability of fruits and vegetables.

a) **Pre harvest period causing post harvest physiological Disorders -**

I. **Water relations or Imbalance** - Fluctuation of moisture during growth and

ripening causes fruit splitting of lime, Grapes, Litchi, fig, Pomegranate & tomato.

ii) High temperature - High temperature during growth period causes spot of grapes, plums, scald in fig, Pomegranate, Potato, tomato.

iii) Low temperatures - Low temperature causes cold injury which is called as chilling injury in chill sensitive crops like tomato and freezing injury in citrus fruits during winter.

iv) Mineral nutrition deficiency-Several physiological disorders of fruits and vegetables are attributed to like deficiency of mineral nutrients, calcium being the most important. It causes bitter pit in apple, blossoms end rot in tomato. Boron deficiency causes internal cork of apple and necrosis in Aonla. Exanthem or rind browning in citrus in dim to copper deficiency. These are some examples of these types of disorders,

b) Post harvest Period -

i) Senescent Period (Ageing)- Senescent fruits and vegetables are more susceptible to microorganisms due to decreased level of microbial inhibitors such as tannin, 3-4 dehydroxy benzol dehyde, methyl mullein etc.

ii) High temperature - Heat or high temperature during storage speed up the Physiological process in stored fruits and vegetables. It also causes excessive transpiration with resultant of shriveling / wilting, cracking of stored fruits and vegetables. There is water loss and such water loss is loss of weight of saleable weight and thus is direct loss in marketing. 5 % such loss causes the shriveling in the commodities. The fruits & vegetable become more succeptible to microorganisms also. High temperature is also causing failure of ripening in Banana (above 30°C) which ceases ethylene production. Tomato do not develop proper colour red / pink due to high temperature. Some time fruits in storage may get blemishes, spotting rosseting and scalding e.g. Apple, Potato etc.

iii) Low temperature - Extremely low temperature causes numerous physiological disorders as chilling and freezing injuries.

a. **Chilling injury** - It reduces the quality of the product and shortens the shelf life. Low temperature breakdown is the major physiological disorders of tropical fruits. This is major problem in post harvest handling of these fruits which are more susceptible. Chilling injuries differs from freezing injury and it occurs at temperature which are low but above freezing points of the tissues. It is responsible for large economic loss during storages. It occurs at 0-12.8°C in many fruits like mango, banana, citrus, apple and vegetables like Potato, oninon, tomato injuries etc. Various injuries caused by chilling are pitting in rind, discolouration of rind, failure of ripening in banana and browning of flesh of apple and plum, blackening of seeds of brinjal.

b. **Freezing injury** - This type of injury results when temperature drops below the freezing point of the fruits and vegetables in storage. It occurs in many fruits such as banana, mango, citrus, grapes apple and vagetables such as potato, onion, tomato etc. It occurs at 1.5° C to 1° C causing soft break down and browning/ discolouration of fruits and vegetables.

iv) Humidity - Relative humidity is best known term for expressing the humidity of moist air. It is defined as the ratio of water vapour pressure in the air to the saturation vapour pressure at same temperature expressed as percentage.

Most of the fruits and vegetables require 85-90 % relative humidity during storage. Both high and low humidity causes spoilage of fruits and vegetables. High humidity causes growth of fungus and causes spoilage e.g. Botrytis rots in grapes, low humidity causes shrinkage and loss in weight in many fruits and vegetables. Dehydration injury occurs when humidity of storage house falls below normal & due to this potato, sweet potato, apples and stone fruits become soft and wrinkled with effect on quality.

v) Volatile compounds -

These compounds are produced in fruits and vegetables during storage. They are ethylene, esters, ketones, hydrocarbons etc.

a) Easters accumulation causes scale in apple, it is serious problem in storages.

b) Ethylene produced by many fruits during storage and its accumulation increases the rate of respiration, faster ripening, fruit softening and spoilage and they are highly susceptible to microorganisms e.g. stem end rot and anthracnose in citrus.

vi) High CO_2 and Low O_2 - Respiration of fruits and vegetables is affected by level of CO_2 and O_2. If CO_2 level is high during storage then anaerobic respiration starts which leads to many physiological disorders such as off flavor, internal discolouration in citrus and brown heart in apple, black heart of potato red heart of lettuce are some good examples of such disorders induced by unfavourable Oxygen relationship.

vii) Refrigerant (chemical) injury –

a) **Sulphur diozide (SO_2) injury** - SO_2 causes bleaching of skin pigment in apple, banana, mango, grapes and citrus. Surface pitting and water break down in potato, discolouration of pigments in Onion, Bleaching and Skin break down in tomato.

b) **Ammonia injury** - Ammonia causes discolouration, browning and break down in apple, banana, grape, citrus, mango, potato, onion, tomato etc. These refrigent injuries predispose fruits and vegetables to decay organisms.

Control measures -

I) **Measures During Pre harvest Period -**

a) Maintain proper moisture condition during growth and maturation period with irrigation level and timing.

b) Control high temperature or field with irrigation and low temperature with smoke.

c) Nutritional balance with proper application of mineral nutrients.

II) Measures at Harvest - Harvesting of fruits and vegetables at right stage of maturity since harvesting at immature stage causes shriveling and at advanced stage of ripening causes fast spoilage of fruits and vegetables.