

# INFLUENCE OF POST-HARVEST OPERATIONS, PACKAGING AND STORAGE ON THE QUALITY OF FRUITS

Dr. Susanta K. Roy, Professor Emeritus

## IMPORTANCE OF QUALITY

- The word quality is used in various ways with reference to fresh fruits such as (i) market quality (ii) edible quality, (iii) shipping quality, (iv) table quality, (v) nutritional quality, (vi) internal quality and (vii) appearance quality.
- Quality of fresh fruits is a combination of characteristics, attributes and properties that give the commodity value to human food.
- Producers are concerned that their commodities have good appearance and few visual defects, but for them a useful variety must score (i) high on yield, (ii) disease resistance, (iii) ease of harvest, and (iv) shipping quality.
- To receivers and market distributors, appearance quality is most important; they are also keenly interested in firmness and long storage life.
- Consumers consider good quality fruits to be those that look good, are firm and offer good flavour and nutritive value. Although consumers buy on the basis of appearance and feel, their satisfaction and repeat purchases are dependent upon good edible quality.

## Pre and Post Harvest Factors on Quality of Fruits

- Genetic factors -Selection of variety, rootstocks
- Pre-harvest environmental factors climatic temperature, humidity light, wind, rain fall, snow/chilling, pollutants. Cultural conditions: soil type, nutrient and water supply, mulching, pruning, thinning, agricultural chemicals, time and method of harvest.
- Harvesting -Stage of maturity, ripeness, physiological age.
- Post- harvest treatments
- Post Harvest Environmental factors (e.g., temperature, relative humidity, atmospheric composition), handling methods, duration between harvesting and consumption

## HARVESTING TECHNIQUE

- Successful harvest is possible if harvesting stage and technique/method are adopted appropriately. The ideal stage of harvesting is when the fruit attains the optimum maturity.
- Maturity is best defined as completion of natural growth and development that will ensure proper completion of the ripening process.
- The maturity of harvested fruit has an important bearing on the way in which they are handled, transported and marketed. The quality of fruits after harvest cannot be improved but it can be preserved or maintained.
- Good quality is obtained when harvesting is done at the proper stage of maturity. Immature fruits when harvested will give poor quality and erratic ripening.
- The objective of harvesting is to pick the fruits at the proper stage of maturity, with a minimum damage, as rapidly as possible and at a minimum cost.

**Hand Harvesting** : It is the most advantageous method. It offers several advantages:

- Selection of proper stage of maturity is accurate.

- Humans can handle fruits with minimum damage.
- Multiple harvesting is possible.
- Requires less capital investment.

### **Mechanical Harvesting :**

#### **It has certain advantages:**

- It is a quicker method.
- Problem associated with labour management is less.

#### **The disadvantages are:**

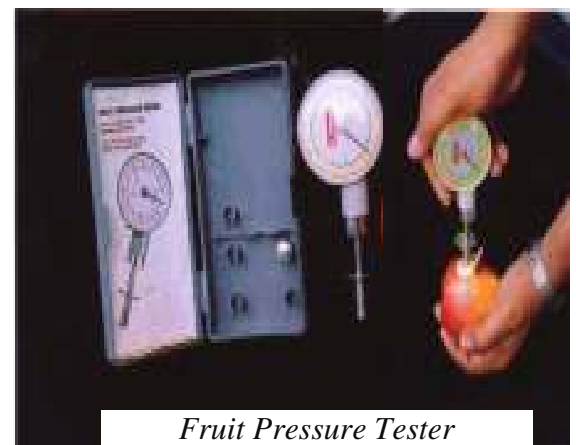
- It damages perennial crops (e.g. damage to bark by a tree shaker)
- There may be a lack in processing and handling capacity to handle high rate of harvest.
- There is less chance of selection of fruits.
- Damage due to mechanical injury is more.
- It is more expensive.

### **ROLE OF MATURITY**

- Present practice of determining maturity is generally by visual means: Skin color, size, persistence of a part of style, presence of dried outer mature leaves, fullness of fruits etc.
- There are various methods of determining maturity of fruits such as measurement of respiration and ethylene production but the most common and convenient methods are:
  - Days from full bloom to harvest,
  - Fruit firmness,
  - TSS (total soluble solids), and
  - Starch content (in case of apple)
- Standard calendar date i.e. the number of days from full bloom to harvest is considered to be the most reliable index of harvest maturity and is largely practiced by farmers and fruit growers.

### **Fruit Pressure Tester**

- This instrument works on the principle of maximum force required to rupture / penetrate into the sample. Maximum force required to penetrate the sample can be measured by pushing a metal probe.
- Collection of sample fruits from different locations of a tree of several trees, as random sample will be more representatives.
- Take an apple and peel off some portion.
- Place the penetrometer perpendicular and apply force while resting hard with sample on a firm surface.
- Penetrometer reading is noted.
- It measures the pressure necessary to force a plunger of specified size into the pulp of the fruit.
- Such a pressure is measured in pounds or kilograms.



*Fruit Pressure Tester*

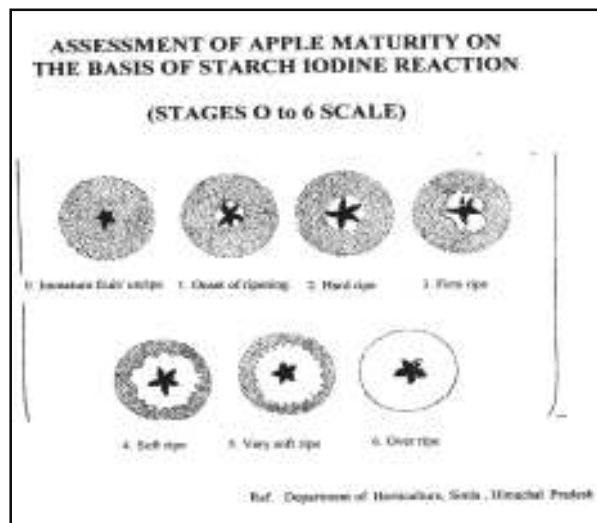
### Total soluble solids (TSS)

- TSS is measured with hand refractometer. This primarily indicates the concentration of water-soluble matter in apple juice that mainly includes sugars, organic acids and water-soluble polysaccharides.
- In general high TSS means high degree of sweetness and vice versa.
- The refractometer is calibrated by using two drops of distilled water on the prism of the refractometer, the lid is covered and the reading is viewed through the eyepiece.
- If the demarcation line between the light and dark coincides to 0 of the scale then the instrument needs no calibration.
- If the demarcation line does not coincide to 0 then the calibration knobs are adjusted and setting to 0 is done.
- Apple juice is extracted and two drops are put on the prism and the value is read.



### Starch Estimation

- Early harvested fruits will contain significant levels of starch that will be converted into sugars during storage. Late harvested fruits will contain little starch.
- The best method for starch estimation is the iodine test.
- The apple is cut in half and a cut cross section is dipped in an iodine potassium iodide solution for one minute.
- The apple surface turns mostly black the apple has a high starch content.
- The solution for starch testing is prepared by dissolving 58.1g of potassium iodide and 14.5 g of iodine in 2 litres distilled water.



## POST HARVEST OPERATIONS :

All the operations, such as washing, sorting, grading and waxing are undertaken before packaging done in packing house/station, where the fruits are assembled after harvest.

### Washing:

- The main purpose of washing is to meet the demand of the consumer for a clean product, free from external dirt. Fruits are washed after harvesting in order to:
  - a. Improve the appearance,
  - b. Reduce the primary load of microorganisms and
  - c. Remove spray residues before the produce is ready for the fresh market.
- Low concentration of chlorine is widely used in wash water in order to prevent the spread of diseases. Chlorine has the advantage of leaving no chemical residue on the fruit.
- Drying is an essential step after washing and must be followed in order to remove the excess of surface water from the apples that would otherwise encourage microbial spoilage.



*Washing*

### Sorting:

- Sorting is almost entirely a manual operation because only vigilant human sight can detect the unwanted fruits for fresh market.
- This is not satisfactorily achieved in ordinary machines. Only highly sophisticated equipment with an electronic eye can do this job.
- The fruits for sorting generally move over a belt or roller conveyer.
- A roller conveyer that turns the fruits as it moves forward is preferable to a belt conveyer because it allows the sorter to see all sides of the fruits.
- Sorting is generally accomplished in a central packing shed where the purpose is to remove apples that are obviously unsuitable for sale, such as fruits with severe mechanical injury, decay, or not of a typical shape or colour for the particular variety being sorted for fresh marketing.



*Sorting*

### Grading:

- Grading is necessary to get suitable returns by marketing uniform quality of fruit. Most countries have their own set of standard for domestic and international trade.
- The main outlet for fruit is usually the fresh market. Acceptability depends on the size, attractiveness and organoleptic quality of the particular variety.
- Fruits show considerable variations in quality primarily due to genetic, environmental and agronomic factors. Grading may be done manually or mechanically.
- Grades are based on: soundness, firmness, cleanliness, size, shape, weight, colour, maturity, free from diseases, mechanical injury, insect damage etc. Sizing is primarily done in order to achieve uniformity in the contents.



*Grading*

### Waxing:

- Most of the fruits have a natural waxy layer on the outer surface that gets partly removed during the washing process.
- An extra discontinuous layer of wax is applied artificially to replace natural wax and reduce the water loss during shipment and storage.
- This gives a cosmetic appeal to the consumers and covers up the minute injuries caused during post harvest handling.
- It acts as a carrier of fungicide/ inhibitor for better shelf life.



*Waxing*

### RECOMMENDATION FOR IMPROVEMENT

- Harvest only when fruits reach maturity.
- The fruit should be removed from the tree with the stalk.
- Avoid dropping to reduce incidence of damaged fruit.
- Fruits should be sorted, graded and placed in the ventilated plastic crates and pre-cooled.
- Precaution should be taken to see that the vent holes of the boxes are not closed or blocked.
- To avoid overfilling use ventilated CFB box with ventilated partition.
- The packing sheds should be located near road head for easy shipment.
- Boxes ready for shipment should be stacked in a ventilated shed to avoid temperature rise.
- There should be minimum time gap between packing and shipping.
- The boxes should not be over stacked in the truck
- Palletisation and refrigerated transportation are essential.
- Container Corporation of India Limited (CONCOR) can provide cool chain facility

## PACKAGING:

- The increase in production of fruits will have significance only when it reaches the consumer in good condition at a reasonable price.
- Packaging of fruits is undertaken primarily to assemble the produce in convenient units for marketing and distribution, therefore the package must reduce undue damage during handling and transportation.
- The existing post harvest losses of fruits could be considerably reduced by adopting improved packaging.
- Economy and protection are both considered in selecting packaging materials for fruits.
- There are a few general rules to be considered such as the life of package must exceed the life of the product, the package must give protection and prevent microbial damage and must minimize the physiological and biochemical changes and losses in weight.
- The other important considerations in choosing a packaging material are
  - i. product shelf life,
  - ii. systems of storage,
  - iii. handling, transport and mechanization,
  - iv. product display,
  - v. consumers attitude and
  - vi. need for recycling, re-use and disposal.

### Wooden Boxes:

- The present method of packaging fruits have been evolved out of consideration such as the local availability of materials which could be converted into suitable containers and also the prevailing methods of handling and transport.
- Wood on account of its favourable properties has remained the main packaging material for fruit. In order to maintain ecological balance the need for conserving timber has assumed critical importance. There is an urgent need for alternative packaging.



*Wooden Box*

### Corrugated Fiberboard (CFB) Boxes:

- Wooden boxes consume two to three times as much wood as required for similar size corrugated fiberboard (CFB) container.
- On account of severe shortage of fuel wooden boxes to a large extent find their way for use as firewood while all the CFB cartons are recycled as pulp or paper.
- The CFB boxes can also be fabricated from kraft paper made from bamboo, long grasses, agricultural residues like bagasse, paddy and wheat straw, cotton stick, jute stick and re-cycled paper and cardboard.



*Tray packed apple in CFB box*

- There are many advantages of using CFB boxes.
  - minimum bruising damage,
  - easy to handle and stack
  - transportation economical
  - can be turned quickly into highly precise sizes,
  - can be appropriately punched for ventilation,
  - printed at low cost,
  - made pilfer proof and reveal tampering at a glance,
  - most acceptable packaging in the international market,
  - collapsible and occupy less volume for storage of empties.
- In order to reduce pressure on wood the immediate answer lies with switching over from wooden to CFB boxes for packaging of fruits.
- These boxes can also be used under cold storage condition after giving waterproof treatment; can be made stronger by reinforcing with hessian or nylon fibre.



Ventilated CFB box with ventilated partitions

#### **Cushioning materials:**

- The cushioning materials used in wooden boxes for packaging of fruits mainly consists of paddy straw and newspaper.
- Unlike in wooden boxes no cushioning material is required in CFB boxes. For example in the case the apples are placed in paper pulp trays having standard fruit cavity without wrapping. Generally 5 to 6 trays are used in boxes depending on the grades of apples.
- It has been observed that such type of packaging offer great protection to the fruits during handling and transportation.

The other packaging materials that can be used to meet the local demands are:

#### **Stretch / Cling Film:**

- This is actually a polyethylene or polypropylene film which has property that under tension it stretches and when tension is released it comes back to its original forms. This property can help in packaging a few (4 to 6) fruits on a tray. The whole operation can be carried out without the application of heat.
- This type of packaging can be carried out easily without using any instrument or equipment.
- Any locally available material can be used for holding the fruits and then wrapping with stretch / cling film.
- This can be a popular and safe retail packaging.
- Modified atmosphere inside the package develops due to controlled respiration of fruit.
- Inside the package O<sub>2</sub> decreases and CO<sub>2</sub> increases, as a result it has enhanced shelf life.



*Cling Film wrapping*

### Shrink-wrap:

- In this method apples are wrapped in heat shrinkable plastic film.
- The whole operation is carried out in a shrink-wrapping machine.
- The main advantages of shrink film and stretch / cling film wrapping of fruits are :
  - i. reduced weight loss and extended shelf life;
  - ii. minimized fruit deformation
  - iii. prevention of injury and
  - iv. reduced decay by prevention of secondary infection of fruit packed in the same box.



*Shrink wrapping*

### Palletisation:

- By using pallets, post harvest loss of fruits in CFB boxes can be considerably reduced.
- All the subsequent operations become very easy once the boxes are placed on the pallets.

### Containerization:

- Though containers have been introduced in India, these are not at present used for carrying fresh fruits.
- In the advanced countries, refrigerated containers are used for shipment of fruits.
- One of the greatest advantages of the container is that it can be placed on truck or rail.
- Palletisation and containerization will go a long way in establishing both internal and international trade of fruits on a firm footing.

### IMPORTANCE OF PRE-COOLING AND METHODS INCLUDING ON-FARM PRE-COOLING.

- Prompt pre cooling and temperature management is critical in lowering the rate of physiological activity of apple.
- The fruits remain alive even after harvest and carry out transpiration, respiration and other life processes (ripening-ethylene, injuries etc).
- The energy that is needed for life process comes from the food reserves that accumulated when the fruits were still attached to the tree.



*Source : UC Davis*

### Transpiration:

- Fresh commodities constantly lose water to the surrounding environment.
- After harvest this lost water cannot be replaced and weight loss of apple will occur.
- Maintenance of low temperature is essential in reducing water loss and subsequent product shriveling and wilting of fruits.

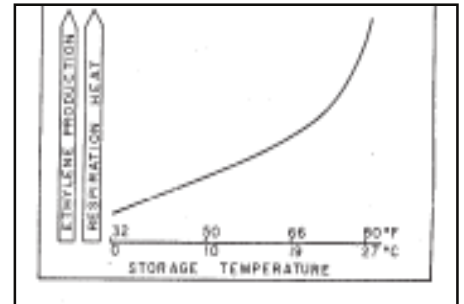


### Respiration:

- Some of the energy that is produced through respiratory activity is utilized in maintaining the life process. Excess energy is released in the form of heat called vital heat.
- The amount of vital heat varies with the type/variety of apple cooling, maturity or stage of ripening, injuries, temperature and other stress related factors. Cooling removes field heat and reduces respiratory heat, slows ethylene production and overall rate of deterioration

### Ethylene:

- It is a naturally produced gas in all plant tissues and generally recognized as a ripening hormone.
- It can have important beneficial or detrimental effects on fresh commodities, depending on management needs.
- Rates of both production and action of ethylene are temperature dependent, rapid cooling and good temperature management is vital if fruit ripening and other deterioration process are to be delayed.



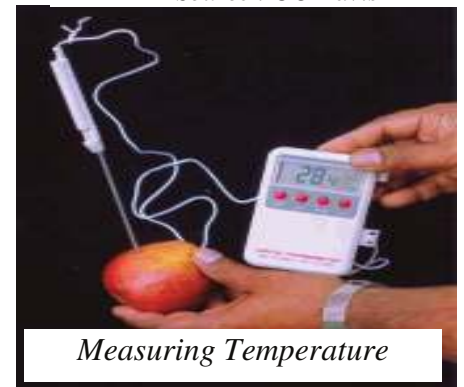
Source : UC Davis

### Injuries:

- Physical injuries can result from abuses to fresh commodities at any temperature, but temperature affects the severity of the product response to those injuries.
- Bruises and other wounds cause increased ethylene production, which may accelerate respiration, cause deterioration and initiate fruit ripening.
- Prompt cooling and maintenance of low temperature reduces the results of injuries of affecting all of these processes and the growth of decay organisms. Therefore we have to understand the importance of pre-cooling.
- The quality of a fresh apple, depends on initial quality at harvest, care exercised in physical handling, length of time since harvest and storage environment.
- Prompt, thorough cooling to a fruit's lowest safe temperature is imperative. The fruit temperature is determined by inserting the probe in the apple and the temperature is recorded from digital display.

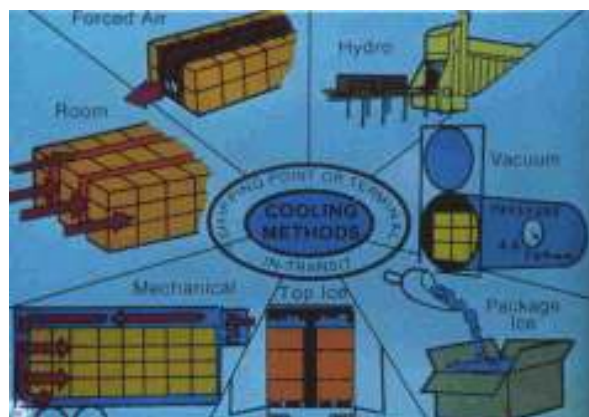


Source : UC Davis



- There are various commercial methods of pre-cooling. Out of these methods the following can be used appropriately in apple :

- Room cooling
- Forced-air cooling
- Hydrocooling
- Vacuum cooling
- Package Ice and Top Ice
- Mechanical



*Source : UC Davis*

- **On-farm pre-cooling:** Pusa zero energy cool chamber (ZECC) can be used gainfully for on-farm pre-cooling of fruits in remote areas.
- The detail of construction and operation of Pusa zero energy cool chamber is given elsewhere in this manual (Cold Chain Management).



*Pusa Zero Energy Cool Chamber*

### **STORAGE**

- The optimum storage temperature is the single most important tool responsible for maintaining quality and maximizing post-harvest life.
- The ideal storage temperature is tailor made to that particular fruit.
- The function of fruit storage is to provide an environment that minimises deterioration until finally consumed.
- Proper temperature and humidity management can be very effective tools in ensuring that produce remains in good condition throughout the storage period.
- Reducing the temperature slows down the rate of respiration, ethylene production and action, biochemical changes and biological heat production.
- It also slows down transpiration loss, thereby reducing desiccation of fruit and also checks the development of pathogens.

### **Cool Store**

- In a cool store, the temperature control is very important. The temperature is brought down by taking out the heat with the help of refrigeration .
- The ideal environment condition for fresh fruit in storage is the lowest temperature which does not cause chilling injury to the produce.
- Any variation from the desired temperature is detrimental.
- Relative humidity of the storage room also has considerable bearing on the keeping quality of fruit.

### **Controlled/ Modified Atmosphere Storage**

- Modified atmosphere (MA) essentially means any deviation from the normal atmospheric gas composition. If this deviation is strictly controlled with certain specific gaseous concentrations of  $N_2$ ,  $CO_2$  and  $O_2$  then it is termed as “Controlled Atmosphere” (CA).
- Usually modification of atmospheres during storage of fruit involves reduction in oxygen ( $O_2$ ) and or elevation of carbon dioxide ( $CO_2$ ) concentrations.
- The beneficial effects of CA/MA treatments are retardation of ripening, senescence and physiological changes. In addition it helps in reducing the physiological disorders e.g. chilling injury of various commodities.
- Modified atmosphere can have a direct or indirect effect on post harvest pathogens and consequently decay incidence and severity.
- The design and construction of Controlled Atmosphere Stores require precision control of the system. Thus the controlled atmosphere store has to be relatively gas-tight, and fitted with reliable refrigeration system with a means of measuring and controlling the concentrations of both carbon dioxide and oxygen (Kader 1985).
- The recommended % $O_2$  and % $CO_2$  in controlled / modified atmosphere storage of some important tropical and subtropical fruits.