

Unit



# Harvest and Post-harvest Management in Solanaceous Crops

## INTRODUCTION

Solanaceous vegetables are delicate and perishable. In order to prevent deterioration and maintain quality, utmost care is essential right from the time of harvesting till it reaches the consumer. The post-harvest life of vegetables depends upon the judgements of maturity, the right stage of harvesting and careful handling of the produce. Harvesting of immature or over mature vegetables leads to deterioration of quality and early decay. If harvested at improper stages, the vegetables may not grow into attractive sizes, colours, and flavours and could be rejected by the consumers. Hence, the correct maturity indices have to be observed along with the right stage of harvesting with a proper method. Post-harvest handling is equally important to maintain the quality of produce and to enhance the storage life. Post-harvest technology works on the principle 'to save means to produce'. Proper management of harvested produce reduces losses after harvest, and makes the harvested produce more nutritive and acceptable. Besides eliminating spoilage and other food problems, it also boosts the country's economy by creating rural industries. Different factors like pre-cooling,



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washing, treatments, packaging, storage and careful transportation are important in the maintenance of harvested produce. These post-harvest factors influence the shelf life and price of the vegetables in the markets. It is essential for a cultivator, seeking maximum returns from their produce, to have knowledge of harvesting, and post-harvest handling of solanaceous vegetables.

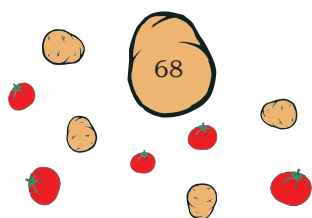
### SESSION 1: MATURITY STANDARDS AND HARVEST OF SOLANACEOUS CROPS

#### Maturity of Solanaceous Vegetables

Maturity is the attainment of the final stage of biological development of a plant, fruits or other plant parts. It is also called physiological maturity. Maturity stage differs from crop to crop and also depends on the purpose for which the produce is harvested. The stage of maturity at which the produce is in the most desirable form and is harvested as per the consumers' preference, is called horticultural maturity. In most of the vegetable crops, horticultural maturity comes prior to physiological maturity. Brinjals and chilies are harvested at horticultural maturity when the crop is still tender and under development stage. Solanaceous vegetables are non-climacteric and ripen on the plant itself. In most cases, physiological maturity overlaps the ripening process therefore the produce is harvested after ripening. Tomatoes, potatoes and dry chilies are harvested at physiological mature stage when the crop is fully mature. Solanaceous vegetables are mostly harvested depending on the distance to the markets and the choice of the consumers.

#### Role of respiration in shelf life

Vegetables are classified in two groups—climacteric and non-climacteric, based on their respiration rate. In climacteric vegetables, ripening is associated with a rapid increase in respiration. This sudden rise in respiration is called 'climacteric rise'. On ripening, the climacteric vegetables produce more ethylene than non-climacteric vegetables. The ripening process in climacteric vegetables will continue while attached



to the plant or even after harvest. Non-climacteric vegetables ripen on the plant itself and must be harvested at the appropriate maturity stage. Tomato and musk melon are climacteric vegetables, whereas, cucumber, brinjal, pepper, summer squash, etc., are non-climacteric vegetables.

### Maturity Indices

Maturity indices indicate the stage of maturity of vegetables to be harvested for fresh consumption, storage or marketing to distant places. In vegetables, it is very difficult to standardise the appropriate stage of maturity. Growing experience (harvesting and marketing) of a particular vegetable with important parameters is the most excellent method to measure optimum maturity.

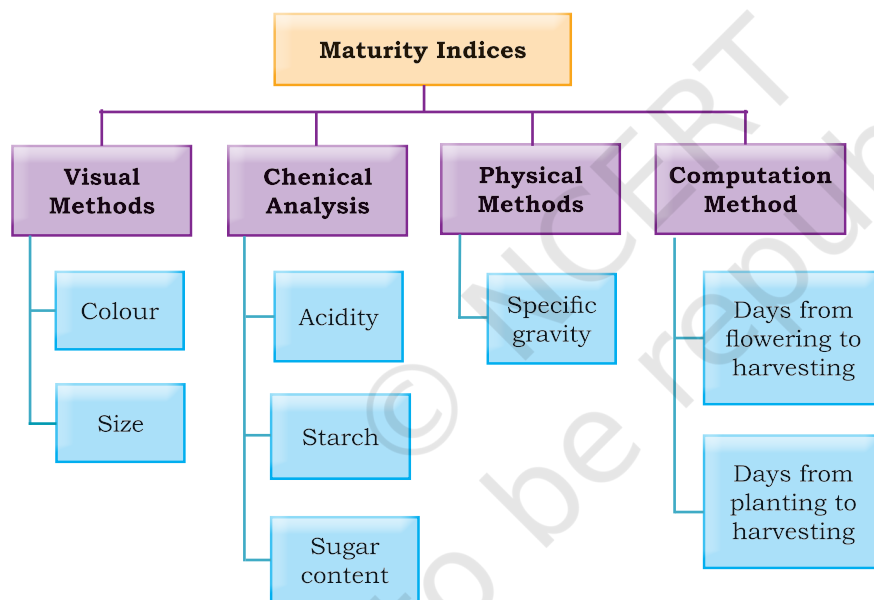
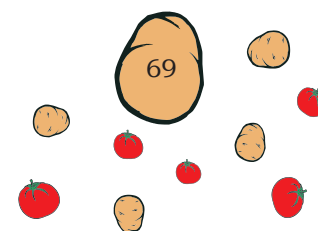


Fig. 4.1: Maturity indices of solanaceous vegetable crops

### Importance of maturity indices

1. To ensure the sensory (flavour, colour, aroma, texture) and nutritional quality.
2. To ensure a sufficient post-harvest shelf life
3. To facilitate scheduling of harvest and packing operations.
4. To ensure market price.



## Determination of Maturity in Solanaceous Vegetables

### Visual method

The colour of the produce changes with maturity. Colour is an important index that indicates the stage of maturity. Most tender vegetables are green in colour, which turn paler as they mature. Tender fruits are glossy. Tomato and chili are harvested after ripening on the plant so they are red in colour.

As for size, some vegetables reach a certain size. This can be used as an index to determine the time of harvest.



Fig. 4.2: A view of maturity stages in tomato

### Chemical analysis

Starch, acidity and sugar content are measured in chemical analysis. More sugar content in the samples indicates maturity. Acidity decreases with maturity. Thus, low acid content indicates maturity of the produce.

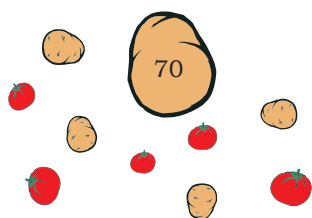
### Physical method

A pressure tester is used to measure the softness of a fruit.

A fruit's specific gravity increases, as it matures. During harvesting, specific gravity to determine the right time of harvesting is rarely used. It can be calculated by dividing the weight of the produce in air by the weight in water.

### Computation method

This method involves calculating the days from flowering to harvesting and from planting to harvesting.



## Harvesting of Solanaceous Vegetables

### Tomato

**(a) Maturity indices:** the harvesting stage in tomato depends upon the purpose for which the tomatoes are being used. Generally, there are four types of maturity stages found in tomatoes for harvesting.

- (i) Green stage fruits are green in colour but are fully mature. They are harvested to be sent to distant markets.
- (ii) Pink stage tomatoes are picked for the local market. At this stage, the colour turns to pink or red at the end of the blossom.
- (iii) Ripe stage fruits are red colour on the surface and soft.
- (iv) Fully ripe tomato fruits are soft in texture and have reached their maximum colour development. Starch is converted into sugar. These fruits are either consumed or used for canning and/or processing purpose.

Depending on its use and the distance to the market, the tomato fruits are harvested manually by plucking the fruits at different maturity stages.

In indeterminate cultivars, tomatoes can normally be harvested at 80-100 days after planting and 70 days after planting in determinate cultivars. Harvesting of the fruit should be done at the right stage depending on the consumption purpose of the fruit.

**(a) Dark green colour**— when the dark green colour fades, a reddish pink shade can be seen on the fruit. Harvesting at this stage is suitable for fruits to be shipped to long distance market. These fruits are then sprayed with ethereal or ethephon 48 hours before shipping or transportation. Slicing a tomato with a sharp knife is the easiest way to determine the maturity of the fruit. If the seeds cut easily, the fruit is too immature for harvest and will not ripen properly.

**(b) Pink or the Breaker stage**— the fruits are harvested at breakage stage to ensure the best quality. In this

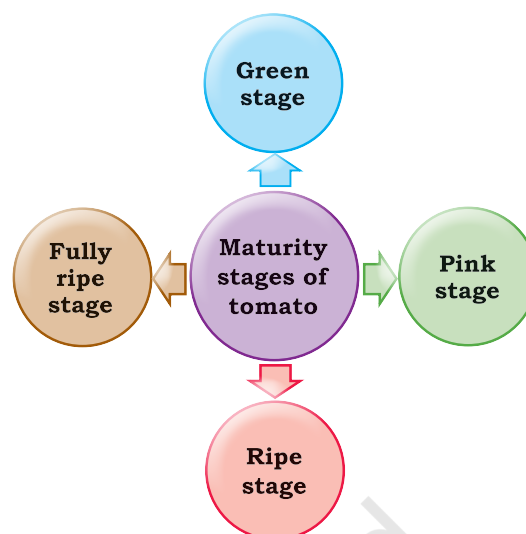
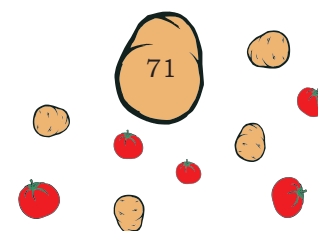


Fig. 4.3: Maturity stages of tomato



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stage, a light pink colour can be seen on 1/4th of the fruit. These fruits injure less during shipping and often bring in a higher economic return than less mature tomatoes.

**(c) Ripe or the Turning stage**— at this stage, 3/4th of the fruit is pink in colour. At the reddish pink stage the fruits are still firm. Harvesting is done at this stage to sell the fruits in the local markets.

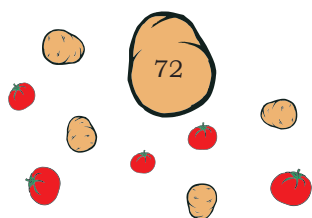
**(d) Fully ripe or the Red ripe**— the red ripe stage means the tomato fruits are fully ripe and soft. These fruits are used for canning and processing. Such fruits must be harvested either in the early morning or late evening. A twisting motion of the hand separates the fruit from the plant. The harvested fruit should be placed in suitable containers in the shade. All the fruits do not mature at the same time as they are harvested at 4–5 days interval. During the crop's life span, tomatoes can be harvested 7–11 times.

### Chili and capsicum

Chili is harvested manually by hand picking, either as a green fruit or red ripe fruit. The green fruit picking continues for about two months at an interval of 10–12 days. There are five to six pickings for green chilies and three to four for red ripe fruits. The red ripe chili fruits should be dried for 5–7 days in bright sunlight before being sent to the market or stored. When there is a good demand for green chilies, one or two pickings of the green fruit can be done even if the crop grown is for red chilies. For vegetable purposes, the chili crop should be harvested at fully grown green stage and for drying purposes it must be harvested at the red ripe stage. For pickle making, the chilies can be picked at either the green or red ripe stage. The number of harvesting depends on cultivar, season and cultural practices. It can continue for three months with proper cultural practices.

### Brinjal

Brinjal fruits are harvested when they have developed a marketable size, have a good colour, are immature and



have an attractive bright glossy appearance with soft seeds. The fruits are harvested with a stack at the joint where they are attached to the branch. The frequency of harvest depends upon the size of the fruit. Small size fruits are harvested more frequently than the bigger fruits. Fruits should be harvested in the morning to avoid sun scalding.

## Potato

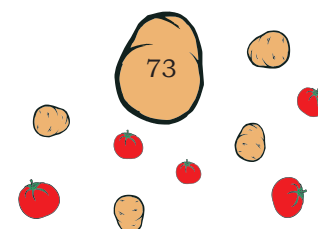
Big size tubers are harvested at full physiological maturity stage. The crop falls off when it is fully matured. This is the sign of maturity of the tuber inside the soil.

**Table 4.1: Maturity indices of solanaceous vegetables**

S.No.	Crop	Crop Maturity Indices
1.	Tomato	<b>Mature green</b> : fruit firm and mature, colour changes from green to light green <b>Pink</b> : pink colour on the blossom end. At room temperature, fruits will ripen in about three days. <b>Ripe</b> : when the fruit is completely red but still firm, it should be used immediately
2.	Potato	Collapse of the crop, size of the tuber, development of periderm, starch content and specific gravity
3.	Brinjal	Glossy skin, desirable size, tender and soft seed
4.	Chili	Fully mature, green, before they change from green to red
5.	Bell pepper	Well developed, firm, shining and bright coloured (red, yellow, orange, green, etc.)

## Harvesting

The assembling of plants or its parts at a certain stage for economic purposes is called harvesting. After attaining proper maturity, the produce is harvested for marketing. It involves detachment or separation of the produce from the main plant at the right stage of maturity, depending on the purpose for which it is grown. Vegetables are delicate, hence, avoid mechanical injuries. Bruises, splits, cuts, breakage and wounds during harvest could become the path for pathogens to enter and accumulation of dust, which affects the appearance and leads to early decay. The persons involved in harvesting must be efficiently trained and skillful in handling the fresh produce.



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### Harvesting management

Harvesting should be done

- during the cool hours of the day as low temperature reduces physiological activities in plants.
- at the proper stage of maturity, otherwise it affects acceptability and shelf life.
- by using proper methods to reduce losses and damage to the produce as well as the plant.
- by an experienced, skilled person who can harvest selectively (only the mature produce).
- by maintaining proper hygiene standards (clean tools, baskets or containers).

### Harvesting arrangement

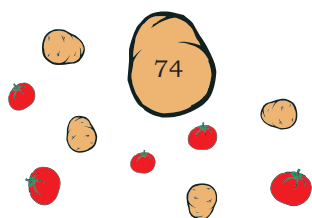
- Inspect the field to identify the correct stage of the crop.
- Remove obstructions in the field, if any, to facilitate harvesting and avoid damages to the produce.
- Erect a temporary shade to stack the harvested produce and to prevent it from scorching in the sun.
- Wash and clean the harvesting tools, collecting baskets, etc.
- Use proper harvesting methods like fruit plucking (brinjal, tomato, chili) or digging (potato).
- Harvesting containers should be used to collect and transfer the produce into the shade directly.

### Methods of harvesting

Harvesting can be done either manually or mechanically. Careful harvesting and transporting practices are essential to ensure that wound and bruise free good quality produce reaches the market.

#### **Manual harvesting**

It is one of the most accepted and suitable methods of vegetable harvesting. Selective harvesting by well-trained and experienced people ensures that harvesting is done at the right stage of maturity. Tomatoes, brinjals and chilies must be picked with a gentle twisting motion of the hand to separate the



fruit from the plant. Manual harvesting includes hand picking, clipping, cutting with knives and digging.

### ***Mechanical harvesting***

It results in a significant reduction in management and labour costs and can result in savings as high as 30–45%. The mechanical method involves the use of machinery and specialised equipment made especially for harvesting purpose. It is common in large scale harvesting. It is a fast method and requires less labour. Nowadays, in many countries automatic robotic systems are used for harvesting high value crops like tomatoes and capsicum in poly houses. This method is not economical in small scale production.

### Harvesting of solanaceous crops

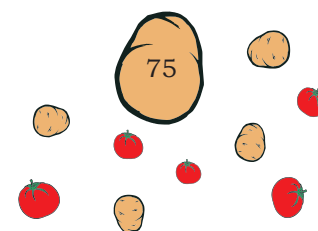
Solanaceous vegetables can be efficiently harvested by plucking with hand (except potato) and no specialised tool is required. With maturity, a natural abscission layer is formed, which enables easy plucking. The presence of abscission zones between the stem and the stalk of the fruit, such as tomato, brinjal and chili has been observed to become prominent at maturity. That is why the matured tomato fruits can be easily detached from the plant with just a slight pressure.

A crop like potato is dug out with the help of a potato digger or wooden plough. In large scale production, the mechanised method can be followed. Tubers that are dug out are collected and brought to the shade house.

### Harvesting containers

The harvesting containers should be easy to handle for workers to harvest the vegetables. Containers made of material, such as paper, polyethylene film are relatively cheap but they give little protection to the produce against handling and transport damage. The fruits with firm skins, like brinjal and chili are harvested and collected in harvesting bags, which are later emptied from the bottom into a field container instead of tipping the bag. Plastic crates are most suitable for harvesting tomatoes. For harvesting fresh fruits and vegetables,

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bulk bins of 200–500 kg capacity are used. Such bins are more useful than the field boxes, in terms of fruit carried per unit volume and the protection of the product in transit to the packing house. Pallet boxes have a standard size of  $1.2 \times 1$  metre with varying height. These are generally used to carry harvested produce from the field to the packing house or for handling produce in the packing house.

Sacks or gunny bags are still commonly used for crops, such as potatoes, onions, pumpkins, etc. Other types of field harvest containers, such as plastic baskets, buckets, picking baskets and plastic crates are used for tomatoes, brinjal and chilies. For high-risk produce, like sweet pepper, woven baskets and sacks are not recommended because of the risk of contamination. Vegetables should be harvested in plastic crates and further handled in cardboard boxes or cartons in transit to maintain better quality. These containers should be smooth so that they do not damage the produce or harm any person.

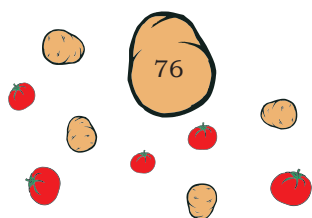


Fig.4.4: Harvesting container (Plastic crates)

### Precaution during harvesting of solanaceous vegetables

In all solanaceous vegetables, care should be taken to prevent any injury because of faulty operations during harvesting and handling. The hands of the harvesters are the most important points of contact as they touch the product. The injuries occurred during harvesting can be reduced if

- the field containers do not possess any protruding nails or staples or have rough edges.
- the worker wears cotton gloves, trims the fingernails, does not wear jewellery, such as rings and bracelets during harvest.



- care is taken while transferring products from one container to another.
- all impact areas are padded, wherever possible.
- clean equipment and containers are used and sand and all debris are removed from the containers.
- overfilling of containers is avoided.

### Practical Exercise

Identify the different maturity stages of tomato fruits.

**Material required**

Different samples of tomato fruit, plastic baskets, blade or knife and writing material.

**Procedure**

1. Tomato fruits in different maturity stages procured from a farmer’s field or the local market.
2. Compare the fruit samples with the colour chart and fruit maturity stages given in images.
3. Visualise the fruit maturity stage.
4. Note down the following observations.

Sample number (S)/ sample code	Maturity stages/indices of fruit (Mention with colour grading from chart)	Expected days of maturity

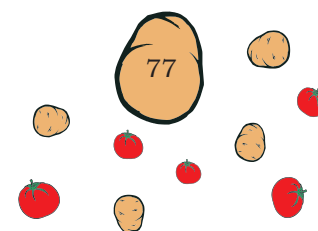
### Check Your Progress

**A. Fill in the blanks**

1. The attainment of the final stage of biological development of a plant or plant part is known as \_\_\_\_\_.
2. The examples of climacteric vegetables are \_\_\_\_\_.
3. Vegetables that ripen on the plant itself and must be harvested at the appropriate maturity stage are known as \_\_\_\_\_ vegetables.
4. Vegetables should be harvested either in the \_\_\_\_\_ or \_\_\_\_\_ hours.

**B. Multiple choice questions**

1. The stage of maturity at which the produce is in the most desirable form and is harvested as per the consumer’s preference is called \_\_\_\_\_.
  - (a) physiological maturity
  - (b) horticultural maturity
  - (c) ripening
  - (d) none of the above



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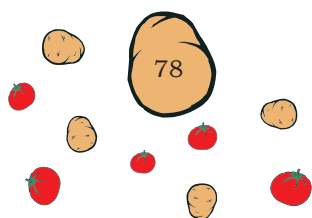
- Horticultural maturity in most of the vegetable crops occurs \_\_\_\_\_.
  - prior to the physiological maturity
  - after the physiological maturity
  - with physiological maturity
  - both a and b
- Tomato fruits for distant markets may be harvested at \_\_\_\_\_.
  - green stage
  - red stage
  - ripe stage
  - over ripe stage
- Ripening is associated with a rapid increase in \_\_\_\_\_.
  - transpiration
  - respiration
  - evaporation
  - pollination
- The specific gravity of a fruit or vegetable is \_\_\_\_\_.
  - its weight in air divided by the weight in water.
  - its weight in water divided by the weight in air.
  - its weight in air multiplied by the weight in water.
  - its weight in air plus weight in water.

### C. Subjective questions

- Write short notes on
  - Maturity indices
  - Physiological maturity
  - Horticultural maturity
  - Climacteric and non-climacteric vegetables
- Explain the different methods of determination of maturity in solanaceous vegetables.
- Describe the harvesting process of solanaceous vegetable crops.

### D. Match the columns

A	B
1. Maturity indices	(a) Assembling of plants or parts at a certain stage
2. Colour of the produce	(b) Indicate the stage of maturity
3. Abscission layer	(c) Important visual maturity index
4. Acid content	(d) Eases plucking of fruits
5. Harvesting	(e) Falls with maturity



## SESSION 2: POST-HARVEST HANDLING OF SOLANACEOUS CROPS

### NOTES

### Post-harvest Handling

Post-harvest handling involves careful movement of harvested commodities from the time of harvest to just before meal preparation. Its objective is to reduce losses at the least possible cost. It includes precautions, care and treatment of harvested produce to reduce damage loss and to enhance its appearance, quality and storability. This includes pre-cooling, cleaning, treating, sorting, grading, packing, transport, etc.

### Causes of post-harvest losses

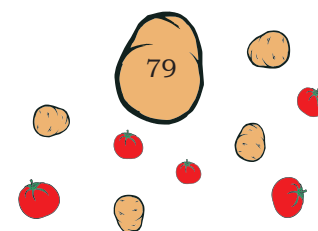
- Improper method of harvesting and carelessness
- Mechanical injuries to the produce
- Presence of infected and decayed produce in the lot
- Improper curing (roots, tubers and bulbs)
- Improper packing
- Improper storage conditions
- Sprouting in potatoes
- Bruising in transit

### Objectives of post-harvest technology

- To keep the produce in more acceptable conditions.
- To maintain the appearance and flavour of the harvested produce.
- To protect food safety and nutritive value.
- To reduce losses after harvesting up to consumption.
- To make them available in off season.

### Post-harvest process

- Collection of harvested produce
- Pre-cooling
- Sorting
- Cleaning and disinfection
- Drying
- Grading



- Other treatments
- Packing
- Storage
- Transport

Since vegetables are perishable, careful and proper handling of the produce during all the above processes is important.

### Collection of harvested produce

Horticultural produce is delicate as the water content is more in them. A slight bruising or pressure to it post-harvest may show up as blemishes, patches or injuries. Care should be taken during the collection of the harvested produce.

#### **Pre-sorting**

It is the process in which injured, wanted, diseased, bird pecked, decayed, misshapen produce is separated. This minimises further handling expenses as the lot becomes free of undesirable produce.

#### **Pre-cooling**

It is a treatment given to the harvested produce to remove the field heat. It reduces respiration rate, enzymatic activity, ethylene production rate, water loss and microbial spoilage.

#### *Methods of pre-cooling*

*Hydro cooling* is when the harvested produce is either showered or submerged in running cold water. It is mostly practised on leafy vegetables. During hydro cooling, water temperature should be maintained at 12–15°C.

*Room cooling* is when in an insulated and refrigerated room, cool air is circulated by a convection.

*Forced air cooling* is when the produce is kept in a refrigerated room and cold air is circulated with the help of powerful fans.

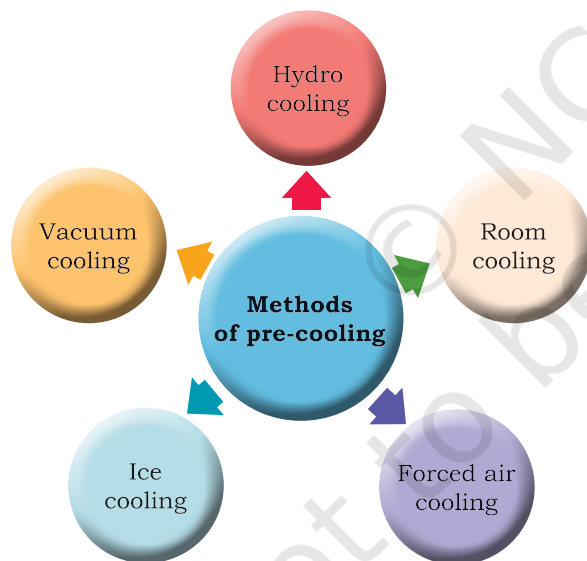
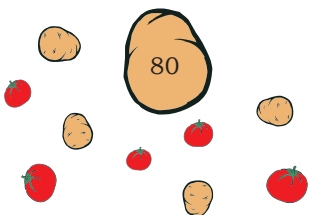


Fig. 4.5: Methods of pre-cooling



*Ice cooling* is when harvested produce is pre-cooled with crushed ice. Waterproof packages are used to wrap the produce.

*Vacuum cooling* is when heat from the harvested produce is removed at low atmospheric pressure in a chamber.

### Trimming, washing and cleaning

The harvest must be washed to remove the soil and dust from the produce. Decayed or damaged portions should be trimmed off. A solution of chlorine @ 100-150ppm can be used for washing the harvested produce. Washing removes inoculums from the surface of the produce, gives a fresh appearance and cleans any foreign smell or taste from the surface.

### Drying

This step is important after washing or pre-cooling the produce to bring the moisture to a desirable level in the produce. Drying should be done in partial shade.

Waxing is done on the surface of the harvested produce to

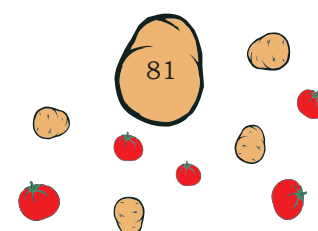
- prevent water loss during handling and marketing,
- protect against bruising and scars,
- seal openings against any unwanted entry, and
- extend shelf life and maintain quality.

### Sorting

It is the process of separating the damaged, diseased and insect pest affected vegetables that are not suitable for either the market or storage. It is done by hand after the vegetable produce is harvested.

### Grading

It is the categorisation of the produce according to size, shape and colour into different uniform lots. It can be done manually or by grading lines. Grading according to size of round produce can be done by sizing rings. Better grade produce fetches a better price in the market.



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Tomato fruits are graded into four groups based on its size that is, Super A, Super, Fancy and Commercial. Similarly, large, medium and small tubers are graded as per their size. Low grade produce can be utilised for making value added products like pickle, ketchup, sauce, etc.

### Packaging

It is the process of preparing commodities for transportation, distribution, storage, retailing and presenting to the consumer in the most attractive form. Packaging ensures delivery of the produce to the end user in good condition at the minimum cost.

Packaging must be appropriate to protect the produce during handling and transport. The selection of right packing material is important. It should be selected according to the produce, means of transport, distance to the market or period of storage. Bamboo baskets and jute sacks are commonly used for transporting to local markets.

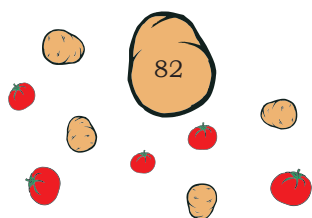
Packages can be classified as follows:

- *Flexible sacks and bags* that are made of plastic, jute, canvas, wire and net are used for potatoes, chilies and brinjals.
- *Wooden crates* are generally used for tomatoes and pepper.
- *CFB boxes* (cardboard) are used for tomatoes.
- *Plastic crates* are used for tomatoes, chilies, brinjals, potatoes, etc.
- *Different types of baskets* made of bamboo, plastic and even leaves woven together can be used.
- *Pallet boxes and shipping containers* are used for exporting the produce.

### Transportation

Transporting the produce to the market is the next step to packaging. At present, vegetables are transported in bulk in rickshaws, carts, jeeps, rail and trucks. This results in severe loss and damage during transportation. However, now producers are paying attention to this and even refrigerated vans are

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being used for transporting fresh vegetable produce. Transportation during cool hours, use of refrigerated vans or cool-chain vehicles for long distance, a well-ventilated vehicle for nearby markets, proper stacking of baskets or racks are certain factors that can minimise transit damage. The government is providing support to establish a cool chain facility for the horticultural produce.

### **Causes of Impairing Quality of Produce in Transit**

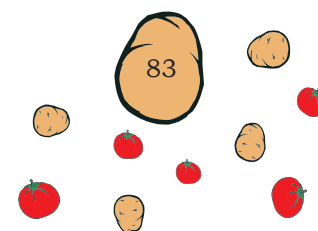
- Bruising, vibration caused by loose packing of vegetables.
- Careless loading and unloading of produce.
- High transit temperatures (if not cooled immediately).
- Poor or no packaging.

### **Storage**

This is a step that comes after harvesting. It is necessary to store the produce till it reaches the market. Hence, it is an important activity that helps to prevent the produce from spoiling and enhances its shelf life. Temperature and relative humidity of the storage house are the main factors that affect respiration and transpiration of the stored produce. If temperature and relative humidity are not maintained, it can cause spoilage of the produce. Innovative technologies that can make it possible to achieve optimal environment in the insulated storage areas are now available.

### **Objectives of storage**

1. To meet the demand of fresh vegetables throughout the year.
2. To avoid glut season and maintain the price during the peak season.
3. To provide planting material when needed.
4. To slow the biological activity of the produce by maintaining a low temperature.
5. To protect moisture content of the produce.
6. To protect the produce from micro-organisms.



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### Storage methods

There are two kinds of storage methods.

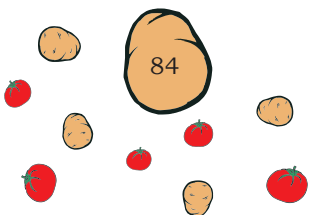
#### ***In uncontrolled condition***

- **Sand or coir** method is used to store potatoes for a long time. In this method, the produce is covered with sand and coconut fibre (coir).
- **Pits** are used to store potatoes. In this method, pits or trenches are dug at the boundaries of the field where the crop has been cultivated. Generally, pits are sited at the uppermost point of the field, particularly in areas of high rainfall. Straw or other organic material is used to line the pits or trenches, packed with the crop produce being stored, and then topped with a layer of organic material followed by a layer of soil. Straws are used to make holes on top for ventilation. Lack of ventilation could cause the crop to rot.
- **Evaporative cooling** should be ensured. The degree of cooling depends on the RH of the air and the efficiency of the evaporating surface. If the surrounding air contains low RH and is humidified to around 100% RH, then a big reduction in temperature will be achieved.
- **For night ventilation**, a fan is installed in the store room, which switches on when the external temperature at night becomes lower than the internal temperature. It switches off when the temperatures equalise. The fan is monitored by a thermostat, which continuously equalises the outside air temperature with the internal storage temperature.

#### ***In controlled condition***

*Modified atmosphere storage* is commonly used for fruits and tomatoes. These types of storages are airtight chambers with wall, roof and floor. In this method, the proportion of atmospheric gases inside the storage is altered by reducing oxygen and increasing CO<sub>2</sub> level. Depending upon the variety and kind of produce, the proportion of O<sub>2</sub>, CO<sub>2</sub> and nitrogen is maintained.

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- **In forced air ventilation**, air flowing capillaries are provided under the perforated floor of the store so that the air can be forced through the stored produce.
- **Refrigeration** can be defined as a technique of extracting heat from a substance under controlled conditions. It includes decreasing and maintaining the temperature below the ambient temperature. Such storage is provided with exhaust facilities to release the heat generated by the produce. It is essential to control the temperature and relative humidity conditions within the refrigerated storage surroundings, according to the crop or variety.
- **Cold chain or cool chain** is a temperature-controlled facility of transportation from the field to the market or storage. In this, all practices of production, storage and supply are performed under refrigerated situations. Cold chain ensures preservation and extended shelf life of the produce.

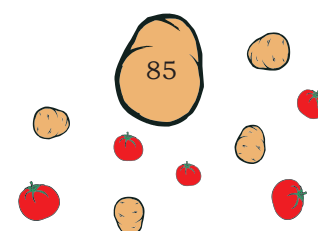
**Table 4.2: Recommended storage temperature and relative humidity for solanaceous vegetables**

Sr.No.	Crop	Temperature (°C)	Relative humidity (in %)	Storage life
1.	Tomato (Ripe)	7.0–10	85–90	4–7 days
2.	Tomato (Green)	12–20	85–90	1–3 weeks
3.	Brinjal	7–10	90	1 week
4.	Pepper	7.0–10	90–95	2–3 weeks
5.	Potato	5–10	93	2–5 months

**Source:** FAO 1989. Prevention of post-harvest food losses of fruits, vegetables and root crops training manual. Training;17(2). Rome, Italy.



*Fig.4.6: Packing in the field to transport to storage*



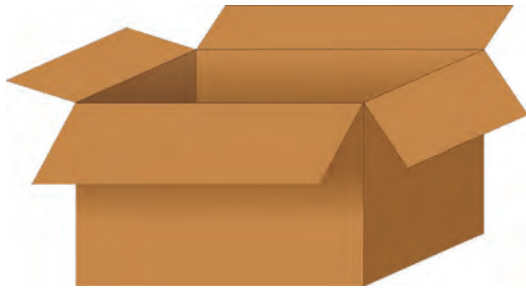


Fig.4.7: Corrugated cardboard boxes

## Post-harvest Handling of Tomato

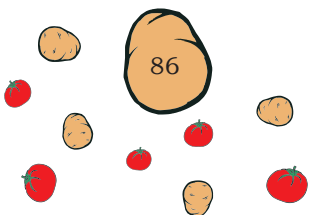
Tomato fruits should be cooled soon after harvest and stored in the appropriate temperature (7-20°C). The produce may be stored temporarily if there is a wait to transport it to the market. To maintain quality before sale and consumption, it must be stored in a cool storeroom. The life

of vegetables is greatly extended by maintaining low temperatures in the storage area. Under evaporative cool storage, tomatoes are stored at low temperature. In India, generally tomatoes are not commercially stored in cold storage. The storage life of tomatoes can be enhanced by pre-cooling the produce immediately after harvest and prior to storage and transportation. Tomato fruits in the mature green stage can be stored successfully at 12°-13°C in polythene bags of 100 gauze thickness for 4-5 weeks. The storage life of tomatoes can be increased by keeping them in evaporative cool storage (zero energy cool chambers). It is found that the shelf life of tomatoes in the breaker stage, stored in zero energy cool chambers during the summer, can be extended by 4-5 days. The cool chamber can be used effectively for longer duration storage of fruits and to reduce weight loss significantly.

Short duration storage of fruits and vegetables can be effectively done by using a zero energy cool chamber. It reduces the storage temperature and also increases the RH of the storage that is responsible for maintaining the freshness of the produce.

### Grading

Tomato is graded for specialised city markets based on the size of the fruits. This can be categorised in two groups. The first superior group comprises fully developed fruits, uniform in size and colour. The second group comprises fruits in variable size and colour. Grading is essential for higher returns but is not common in the local markets. The Bureau of Indian Standards suggested four grades for tomatoes, Super A, Super, Fancy and Commercial. The fruits are packed in plastic



crates, corrugated fibre boxes, wooden field boxes or cardboard boxes and transported to nearby markets.

### Post-harvest handling of chili

Immediately after harvesting green chilies and capsicum, pre-cooling is essential. Chilies are stored and transported at 7.5°C–8°C temperature with 90–95 RH. If they are properly cooled and stored, their shelf-life can be extended by 14–21 days. In case of dry chilies, pods must be dried properly after cleaning them properly of plant parts and other foreign material. Later, they can be packed in clean or dirt free, dry gunny bags and stored in cold dry places to protect them from moisture. Care should be taken to stack the bags 50–60 cm away from the wall. The stored product should preferably be exposed to sun periodically.

Dry chili can be stored better in a kraft packet 27°C and 65% relative humidity. For chili powder, a polythene bag is more effective than a glass container. The colour and pungency of chilies and colour, in the case of paprika, are maximally preserved during the storage. Preference is given to mechanically dried (dehydrated) capsicums with around 10% moisture. Overdried capsicum suffer from loss of colour and those with higher moisture level are susceptible to infection and bleaching of colours during storage.

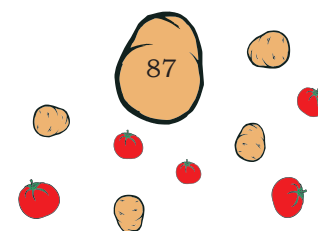
### Grading

In India, chilies are chiefly graded by farmers on the basis of colour and size, before they are sent to the market. Injured, discoloured and underdeveloped pods are removed depending on the market demand. The other factors important in grading chilies are:

- (a) Seed and fruit (pod) ratio,
- (b) Seed size and hardness,
- (c) Thickness of the pod skin, and
- (d) Pungency.

In the market, there are two types of grades: special and standard. The fruits are packed in plastic crates, corrugated fibre boxes, wooden field boxes and gunny bags and transported to nearby markets.

## NOTES



## NOTES

### Post-harvest handling of brinjal

The freshly harvested fruits, free from injury, disease and insect blemishes are cleaned properly by washing them under a sprinkler, wrapped and arranged in suitable plastic trays or cartons.

#### Grading

The fruits are graded according to their size and colour. The Bureau of Indian Standards has suggested three grades for brinjal— super, fancy and commercial.

### Practical Exercise

Demonstrate the harvesting and packaging of tomatoes

#### Material required

Tomato fruits, packaging material and writing material.

#### Procedure

1. Select a tomato crop that is at the physiological maturity stage.
2. Generally, depending on the variety, tomato fruits are ready for harvesting 60–90 days after transplanting.
3. Pick ripe fruits carefully and place them in buckets.
4. Collect the harvested fruits in the shade.
5. Clean and grade the harvested fruits.
6. Pack the harvested fruits in containers (plastic crate) for transport.

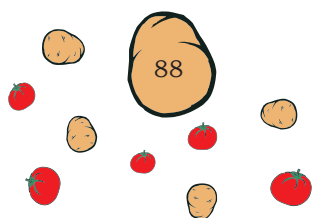
### Check Your Progress

#### A. Fill in the blanks

1. The process that removes the field heat of harvested vegetables is known as \_\_\_\_\_.
2. Chlorine solution @ \_\_\_\_\_ ppm can be used to wash harvested produce.
3. A temperature-controlled transportation facility from the field to the market is called \_\_\_\_\_.
4. The process that makes delivery of the produce to the end user in good condition at a minimum cost is known as \_\_\_\_\_.

#### B. Multiple choice questions

1. The process of categorisation of the produce according to size, shape and colour into different uniform lots is called \_\_\_\_\_.
  - (a) packing
  - (b) sorting
  - (c) grading
  - (d) None of the above



2. Storage temperature for ripe tomatoes is \_\_\_\_\_ °C.
  - (a) 3–5
  - (b) 7–10
  - (c) 12–15
  - (d) 15–20
3. Curing is an effective post-harvest operation in \_\_\_\_\_ fruit or crop.
  - (a) brinjal
  - (b) tomato
  - (c) tuber
  - (d) chili
4. The mixture of atmospheric gases inside the storage is altered in \_\_\_\_\_.
  - (a) evaporative storage
  - (b) pit storage
  - (c) modified atmospheric storage
  - (d) refrigerated storage
5. Brinjal grades suggested by the Bureau of Indian Standards is (are) \_\_\_\_\_.
  - (a) super
  - (b) fancy
  - (c) commercial
  - (d) All of the above

**C. Subjective questions**

1. List the different harvesting stages of tomato.
2. Write about grading of tomatoes and chilies.
3. Describe in detail the different causes of post-harvest losses in vegetables.
4. Write a note on modified atmospheric storage.
5. How are pit storages prepared?

**D. Match the columns**

- | A                      | B   |
|------------------------|---|
| 1. Zero energy cooling | (a) Loose packing                               |
| 2. Refrigeration       | (b) Protection of moisture content              |
| 3. Trimming            | (c) Cutting decayed part                        |
| 4. Waxing              | (d) Extracting heat under controlled condition  |
| 5. Bruising            | (e) Effectively used for short duration storage |

