

MATURITY TRAITS, QUALITY STANDARDS OF FRESH VEGETABLES AND THEIR POST-HARVEST HANDLING

OBJECTIVES

After studying this unit, you will be able to understand:

- Growth and developmental stages of fruits and vegetables
- Different maturity indices used for harvesting of fruits at right maturity
- Post harvest handling techniques of fruits and vegetables
- Important storage methods of storing harvested horticultural produce

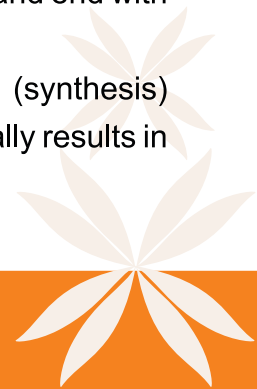
INTRODUCTION

We consume different kinds of vegetables. Majority of the vegetables are eaten when they are mature. Have you ever tried to know how they grow and attain ready-to-eat condition? At what stage of maturity, a particular vegetable should be harvested and why? What will happen if they are not harvested at appropriate maturity stage? How should these harvested fruits be handled to keep them in fresh and eatable condition for longer time? Many questions of this kind must be arising in your mind. There are several processes involved in the growth and development of a vegetable, which are harvested after attaining a proper maturity. For harvesting of vegetables at right time of maturity, several maturity indices have been standardized.

PHYSIOLOGICAL DEVELOPMENT STAGES IN VEGETABLES

Physiological development of vegetables can be divided into three stages as under:

1. **Growth:** Growth refers to cell division, enlargement and differentiation which ultimately result in a particular size, shape and weight of the product.
2. **Maturation:** This stage takes place before the termination of growth and end with the onset of senescence.
3. **Senescence:** The stage that leads to the termination of anabolic (synthesis) processes and initiation of catabolic (degradation) processes and finally results in ageing and death of plant tissues.



Chemical changes in vegetables: The vegetables are classified into following main groups:

1. Fruits
2. Pods and seeds
3. Edible stems, leaves, buds and flowers
4. Underground parts such as bulbs, roots, tubers *etc.*

1. **Fruits:** Fruits are consumed as a vegetable either ripe (tomato, bell pepper) or immature (okra and different cucurbits like cucumber, squashes and gourd *etc.*).
2. **Pods and seeds:** Fully mature harvested pods and seeds have low metabolic rates because of their low water content like pea and beans. In contrary, seeds of garden pea and sweet corn which are consumed as fresh vegetables have high metabolic activity because they are harvested at an immature stage. Flavour and texture determines the eating quality. Generally, immature seeds of peas are more sweet and tender but as the maturity advances, the sugars are converted into starch and as a result there is reduction in sweetness. In French bean, there is decrease in water content and increase in fibre contents. Seeds for fresh consumption are harvested when the water content is about 70 per cent.
3. **Edible stems, leaves, buds and flowers:** The rate of deterioration of different plant parts is different due to the differences in metabolic activity of the respective plant parts. Stems and leaves often rapidly lose their attractiveness and nutritive value. In general, green coloured plant parts turn yellow. This stage determines the harvest date and quality as delayed harvesting results in loss of texture and turgidity of the produce due to loss of water. The natural flavour is often less important than texture. Growth processes such as cell division and expansion, and protein and carbohydrate synthesis usually stop after harvesting and the metabolism goes into a catabolic or degradation mode.
4. **Underground parts like bulbs, roots and tubers:** Bulbs, roots and tubers are storage organs that contain the food reserve. These products upon harvesting have low metabolic rate and dormancy of these economic products can be prolonged by providing better storage conditions.

Role of respiration in vegetables: Based on respiration rate, vegetables can be classified as climacteric and non-climacteric. In climacteric vegetables, ripening is associated with a rapid increase in respiration. This sudden rise in respiration is called as 'climacteric rise' and the product is conventionally called as 'climacteric vegetable'.

At ripening, the climacteric vegetables produce large amount of ethylene than non-climacteric fruits. The ripening process in climacteric vegetables may continue whether attached to or detached from the plant. On the other hand, the non-climacteric vegetables produce very less amount of ethylene than climacteric vegetables. Non-climacteric vegetables ripe on the plant itself and must be harvested at appropriate maturity stage.

Tomato and musk melon are climacteric vegetables whereas, cucumber, brinjal, pepper, summer squash etc. are non-climacteric

During respiration, a number of enzymatic reactions take place inside the produce and rate of these reactions depend upon temperature. In non-climacteric vegetables, reduction in temperature lowers the rate of deterioration whereas in climacteric ones, low temperature can delay the ripening process. However, the vegetables which are sensitive to *chilling temperature*, on exposure to a temperature below 10°C for long durations may damage the produce. There is an opposite relationship between storage life and respiration rate. Higher respiration rate results in reduced storage life and *vice versa*. However, there is a direct relationship between temperature and respiration rates *i.e.*, higher the temperature, higher will be the respiration rate and lesser will be the storage life. Therefore, it is recommended that the harvesting of vegetables should be carried out in the cooler hours of early morning or late evening for better shelf- life of the produce. The respiration rate is governed by the concentration of oxygen in the atmosphere surrounding the produce. Respiration involves the breakdown of sugar into carbon dioxide and water in the presence of oxygen. Further, ethylene is produced during the ripening of fruit vegetables like tomato and musk melon. Ethylene is released into the packages during transit and it initiates unwanted ripening of unripe fruits. Therefore, ethylene concentration affects respiration of climacteric vegetables in a big way.

Classification of vegetables on the basis of ethylene production rates

Category	Crops
Very Low	Cabbage, cauliflower, asparagus leafy vegetables, root vegetables etc.
Low	Cucumber, brinjal, okra, bell pepper, pumpkin, watermelon etc.
Moderate	Tomato
High	Must melon



Maturity of vegetables

Maturity is the state of development when the desirable part of crop reaches physiological or horticultural maturity. Proper maturity at harvest is one of the keys to high quality and better post-harvest life. Fruits harvested too early may lack flavour and may not ripen properly, they lose moisture quickly, and deteriorate at a faster pace while produce harvested late (may be over ripe) has very short postharvest life. For example, tomato fruits for local market can be harvested red ripe, while for distant markets should be harvested at mature green or pink stage as they attain red ripe stage in transit.

Types of maturity:

a) Physiological maturity: It is the state when fruit is capable of further development or ripening after being harvested.

b) Horticultural maturity: It is the state of development when plant and plant part possesses the pre-requisites for the use by consumers for particular purpose. For example, horticultural maturity stage of tomato for long distance transportation would be the mature green or turning stage whereas the optimum stage of harvesting for local markets would be hard ripe stage.

Maturity traits and their importance

Maturity traits (indices) indicates the stage of maturity of vegetable to be harvested for fresh consumption, storage or marketing. Immature harvested vegetable may not develop attractive size, colour, and flavor and thus they fetch very low price in the market. Hence, a commodity should be harvested at an appropriate stage of maturity. In vegetables, it is very difficult to standardize the appropriate stage of maturity. Experience of growing, harvesting and marketing a particular vegetable along with critical observations would be the best for determination of the optimum maturity.

Importance of maturity traits

- 1) Assist us to ensure the quality of product (sensor and nutritional)
- 2) Ensures an adequate postharvest shelf life
- 3) Facilitate scheduling of harvest and packaging operation
- 4) Facilitates marketing

Important indices for judging maturity of some common vegetables

Crop	Maturity indices
Potato, onion and garlic	Tops begin to dry out and topple down
Tomato	Development of jelly in the locules and atleast attain mature green stage
Bell pepper Brinjal, cucumber, bitter gourd	Well developed shining and green fruits Tender with desirable size having soft seeds (overmature if dull in colour and seedy)
Green onion	Leaves at their longest and broadest 2 to 5 cm diameter
Garden pea	Well filled, green, tender pods that open easily
French bean, cow pea and other beans Okra	Tender pods, desirable size, stringless (without fibre formation), seeds soft and snap easily Desirable fruit size (5-10 cm long) and tender. Tips of fruits can easily be snapped.
Snake gourd and bottle gourd	Desirable size and thumbnail can penetrate flesh readily (over mature if thumbnail cannot penetrate flesh easily)
Cauliflower	Curd compact, well developed and atleast 15 cm in diameter
Cabbage Broccoli	Compact, well developed atleast 750-1000 g Bud cluster compact, adequate diameter, all florets should be closed
Brussels' sprout	Bud should be 2.5 to 5 cm in diameter
Radish, turnip and carrot	Large enough and crispy but should not be over mature (pithy)
Lettuce(head) (leaf)	Compact head, not too firm Adequate leaf size

Harvesting and handling

Harvesting is the gathering of plant parts that are of commercial interest. After attaining the proper maturity stage, the produce is harvested for various markets. Harvest marks the end of the growing period and the commencement of market preparation or conditioning of fresh products. During harvesting, care must be taken as all the vegetables are very delicate and mishandling at harvesting may lead to mechanical injuries thereby reducing the quality and shelf-life of the produce.

The quality and condition of produce sent to market and its subsequent selling price are directly affected by the care taken during harvesting and field handling.

Goals of harvesting: After successful cultivation of a quality crop, fresh produce must be harvested and prepared for market. The goals of harvesting a commodity are:

Harvesting means removal of the produce from the point of its growth or origin. This point of origin may be an above ground plant part or an underground plant part.



- 1) To collect the produce from the field at proper stage of maturity depending upon the purpose
- 2) Minimum amount of damage and losses
- 3) Minimum time of harvesting to make it cost effective

Methods of harvesting: Harvesting can be performed by hand or with machine (mechanically). Harvesting by hand is, in general, being followed in all the vegetable crops since time immemorial. In India, hand harvesting is still the most common method due to inadequate mechanization, small land holding and diversity of crops being grown by a small farmer. Some harvesting aids can be used for increasing the efficiency of labour. In some vegetables like onion, garlic, potatoes *etc.* both manual and mechanized methods can be used. Vegetables for the fresh market are hand harvested while for processing or on large scale, mechanical methods can be used.

a) Hand harvesting: It is particularly suitable for crops with an extended harvest period. The main benefit of hand harvesting over mechanized harvesting is that the growers can select the produce at its correct stage of ripening and then handle it carefully. This ensures high quality of the product with minimum damage. Most staple roots and tubers that grow beneath the soil are likely to suffer from mechanical injury at harvest from digging tools. The major disadvantages of hand harvesting are time and labour which add to the cost of cultivation of a crop to the growers.

b) Mechanized harvesting: It is used in those crops that require single harvest, but there should be synchronous maturity in crop and all the cultural operations should be designed in such a way that it facilitates mechanical harvesting. But this method is quite expensive as initial cost of equipment as well as its maintenance cost is high. The main advantage of mechanized harvesting is speed and reduced cost of harvesting but skilled manpower is required for operating machine(s).

Precautions to be taken during harvesting

- Harvesting should be done at optimum stage
- Minimum damage to the commodity should be there

Time of harvesting: Harvesting of vegetables can be done at any time of the day but these should be harvested either in the early morning or late in the evening hours. Harvesting during noon hours or warmer time of the day may result in rapid loss of freshness in tender vegetables because of high rate of respiration and transpiration.

In addition, such vegetables require much more précised handling than those harvested in the morning or evening hours.

Field harvesting means selection, sorting, trimming and packing the produce in the field at the time of harvest and then the commodities are transported to central cooling facility. It reduces the cost since there is no need to build and manage a pack-house and can reduce the handling problem.

In vegetables, harvesting method vary with plant part harvested such as

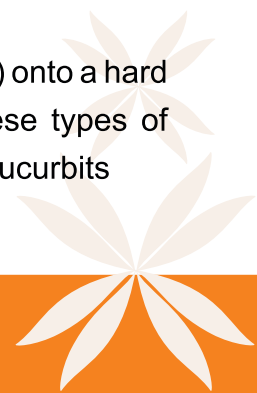
1. By hand: Leafy vegetable like spinach, palak, coriander and also lateral buds in Brussels' sprout are snapped off by hand. Immature green onions are usually pulled from the soil by hand
2. Sickle/Knife: Above ground parts of cabbage, cauliflower, lettuce is cut with sickle or knife and trimming is done in the field.
3. Digging fork: Garlic and mature onion bulbs are loosened by using a digging fork and lifted by hand. Same is the case with root crops such as radish and carrot.

Activity 1

Visit some fruit or vegetable garden, and harvest them at the recommended maturity index or immature, and then observe the difference at frequent intervals.

Handling during harvest: Harvesting involves a number of other activities undertaken in the field like pre-sorting, removal of foliage and other non-edible parts. There are maximum chances of getting bruises while performing harvest operations. Wounds like cuts are frequent during harvest and mainly formed by the harvesting tools which are being used for the harvesting of plants. Rotting fungi and bacteria penetrate through these wounds and many a time spoil the produce during transit. Bruises are more common than wounds and are less noticeable and symptoms appear several days later when the product is in the market. There are three main causes of bruises:

1) Impact: Injury caused either by dropping the produce (or packed produce) onto a hard surface or the impact of vegetable rubbing against other vegetable. These types of bruises are common during harvest and packing. e.g. cauliflower, cabbage, cucurbits



2) Compression: It is deformation under pressure. This often occurs during storage and bulk transportation and is caused by the weight of the mass of produce on bottom layers. e.g. Tomato.

3) Abrasion: Superficial damage to produce by any type of friction (other fruits, packaging materials, packing belts, *etc*) against thin skinned fruit such as okra.

Post harvest handling of vegetable crops

After harvesting the produce at right maturity, it should be handled carefully to ascertain maximum profit by selling good quality and fresh produce to the consumers. The following operations should be carefully undertaken:

Pre-cooling: Harvested vegetables should be pre-cooled at the field itself to reduce their field heat. Cold air or cold water (hydro-cooling), or by evaporation of water from the product under a partial vacuum (vacuum cooling) may be done for this purpose. If such facilities are not available, the produce may be kept under the shade of a tree for some time to reduce the field heat.

Sorting: The harvested vegetables may have disease or insect infection and may be overmature. This may result in spreading of the infection to healthy produce during transportation or storage, and huge postharvest losses may occur. Thus, it is essential to remove such produce from the healthy one.

Washing: Most produce carry soil or residues of various insecticides and pesticides sprays done in the field. Therefore, all traces of soils and pesticides must be removed from produce before packing. It can be done by washing the produce mechanically. This process makes the vegetables attractive.

Grading: After sorting, the healthy produce should be graded according to size, shape, colour, and firmness. Generally, produce is graded as A, B or C as per size, shape and colour. Better grade produce fetch better price in the market. Tomato fruits are graded into four groups based on its size e.g. Super A, Super, fancy and commercial. Similarly, potato tubers are graded into large, medium and small tuber sizes. Low grade produce can be utilized for making value added products like pickle or ketchup, sauce *etc*. In cauliflower, compact, medium sized and snow white curds with small stalk are the best. Grading can be done manually or by machine.

Packing: After grading, the vegetable produce is packed in containers. In India, the vegetables are packed in gunny bags or polyethylene bags which are not appropriate packing materials and result in huge losses by lowering the quality on account of bruises and non-availability of air. Other packing materials used are plastic crates, plastic field boxes, wooden field boxes, CFB boxes, bamboo baskets, and nylon nets *etc.*

Transportation: After packing, the produce has to be sent to market for sale. This is the most neglected area in our country because very less attention is paid for transporting vegetables from the production area. Vegetables are transported by loading in the rickshaws, carts, jeeps, rails and trucks. As a result, bulk of produce is lost during transportation. However, now producers are paying attention on this aspect and even refrigerated vans are used for transporting fresh vegetable produce.

Storage of vegetables

After harvesting the produce from farm, it is necessary to store the produce till it reaches the market. Hence, it is important activity to prevent produce from spoilage and enhance its shelf life. The management of temperature and relative humidity are the most important factors determining storage life of vegetable crops. The natural means like ice, cold water, night temperature have been used for long time for protecting food materials from spoilage and these are still common. However, with the development of innovative technologies, it is possible to achieve optimal environments in the insulated stores.

Goals of storage

- a) To meet the demand of fresh vegetables throughout the year.
- b) To reduce wastage during glut season and to avoid the low price during the peak season.
- c) To extend the processing season of some commodities.
- d) To provide planting material when needed.
- e) To slow biological activity of product by maintaining low temperature.
- f) To reduce product moisture loss
- g) To slow growth and spread of micro organisms

The marketable life of most of the fresh vegetables can be extended by timely storage in congenial environment that maintains product quality. The controlled environment conditions by regulating temperature, air circulation and relative humidity can be created by rooms having low temperature or controlled atmospheric conditions.



Mature green tomato fruits can be stored for one month at 12-15°C temperature coupled with 85-90% relative humidity. Ripe fruits, on the other hand can be stored for 10 days at 4-5°C. Fresh okra fruits can be stored at 7-9°C at 70-75% relative humidity for a couple of days. Highly perishable vegetables can be stored up to 4 weeks such as beans and broccoli at 1 to 4°C for 1-4 weeks and cauliflower at 5-9°C for 2-4 weeks. Non-perishable vegetables such as carrot, onion and potato can be stored at 5-9°C upto two months.

Activity 2

Visit a vegetable field or kitchen garden in your own home. Mark some vegetables there and observe changes in their growth and development.

References

1. Chadha LK and Pareek OP. Advances in Horticulture- Fruit crops, Vol. 4. Malhotra Publishing House, Delhi.
2. Sharma SK. Postharvest management and processing of fruits and vegetables. New India Publishing Agency, New Delhi.
3. Chattopadhyay SK. Handling, transportation and storage of fruits and vegetables. Gene-Tech Books, New Delhi.
4. Sharma SK and Nautiyal MC. Postharvest technology of Horticultural crops. New India Publishing Agency, New Delhi
5. Chattopadhyay SK. Handling, transportation and storage of fruits and vegetables. Gene-Tech Books, New Delhi.

Check your progress

Fill in the blanks:

1. The stage that results in ageing and death of plant tissues is called _____.
2. Fruits of _____ are consumed as ripe vegetable and that of _____ as immature vegetable.
3. _____ and _____ parts consumed as vegetable often rapidly lose their attractiveness and nutritive value.
4. _____ vegetables ripen on the plant itself and must be harvested at appropriate maturity stage.



5. _____ at harvest is one of the keys to high quality and better post-harvest life.
6. _____ has high rate of ethylene production.
7. _____ harvesting is still the most common method in vegetables.
8. Vegetable should be harvested either in the _____ or _____ hours.
9. Above ground parts of _____ is cut with sickle or knife.
10. Three main causes of bruises in vegetables are _____, _____ and _____.
11. _____ operation is necessary in the harvested vegetables to reduce their field heat.
12. The management of _____ and _____ are the most important factors determining storage life of vegetable crops.

Write the important indices for judging maturity of following vegetables

1. Potato
2. Garden pea
3. Tomato
4. Cauliflower
5. Okra

Define the following terms

- | | | | |
|--------------------------|---------------|-------------|----------------|
| a) Growth | b) Senescence | c) Maturity | d) Harvesting |
| e) Horticulture maturity | f) Sorting | g) Impact | h) Respiration |

Short answer

1. What are different phases of growth of a fruit or vegetable?
2. List the changes that takes place in a vegetable before it is ready for consumption.
3. What changes takes place in vegetables which produce edible flowers, buds, stems and leaves?
4. Define respiration. What factors affect the respiration in vegetables?
5. Classify vegetables on the basis of respiration rate.
6. Differentiate between climacteric and non-climacteric fruits.
7. What do you understand by physiological and horticultural maturity?
8. How hand harvesting of vegetables is better than mechanical harvesting?
9. Enumerate different produce handling practices at farm level.
10. What are the goals of storage?

Long answers

1. What do you understand by maturity traits. Make a list of maturity indices of five important vegetables.
2. Describe harvesting and post harvest handling of vegetable crops.

