**Factors responsible for deterioration of harvested fruits and vegetables**

**Four factors:** 1.Respiration, 2.Transpiration, 3.Ethylene, 4.Mechanical damage to the harvested produce.

1. **RESPIRATION:**

A continuous supply of energy is essential for each and every living organism. The energy is required to perform various necessary biochemical functions like maintenance of cellular organization, membrane permeability, transportation of metabolites etc. Respiration is defined as the process by which cells release energy from organic compounds to generate ATP through a series of chemical reactions involving the transfer of electrons and these ATP molecules act as energy resource for cell.

 A reduction in respiration cause decreased ATP production and consequently lesser energy is available for carrying biochemical processes associated with ripening, resulting in quality changes. Respiration is considered as a programmed continuation of both catabolic and anabolic processes.

 There are mainly two types of respiration: aerobic respiration and anaerobic respiration, depending upon availability of oxygen.

It is the most deteriorating biological process of the harvested fruits and vegetables which leads to oxidative breakdown of complex material (CHO/acids) into simpler molecules (CO2, H2O) with production of energy. Despite having been detached from the plant, fruits and vegetables remain as living organs after harvest. Like all living tissues, harvested produce continues to respire throughout its postharvest life. During the process of respiration, carbohydrates are broken down to their constituent parts to produce energy to run cellular processes, thus keeping the cells and organism alive. The carbohydrates stored in the harvested plant portion are continuously “burned” as energy to keep the vegetable alive; as respiration continues, compounds that affect plant flavor, sweetness, weight, turgor (water content), and nutritional value are lost. Thus, reducing the rate of respiration is an important consideration in extending the postharvest life of a fruit or vegetable and optimizing postharvest quality. Harvested fruits and vegetables of different plants have different rates of respiration; some respire at a faster rate (and thus are more perishable vegetables), while some respire at a relatively slow rate (less perishable vegetables). In addition, storage conditions affect respiration, with higher temperatures leading to a faster rate of respiration; for every 10°C (18°F) rise in temperature, the respiration rate will double or even triple. Because of the significant effect of temperature on respiration, the amount of time a harvested product is exposed to heat should be minimized; the fruit or vegetable should be quickly brought to its optimal storage temperature.

C6H12O6 +6 O2= 6CO2 + 6 H2O + 36 ATP (686 kcal energy)

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| **Classification of Sample Horticultural Commodities According to Respiration Rates (Wilson, 1999).** |
| **Respiration Rates** | **Types of Fruits and Vegetables** |
| Very Low | Dried fruit and nuts |
| Low | Apples, garlic, grapes, onions, potatoes (mature), sweet potatoes |
| Moderate | Apricots, cabbages, carrots, figs (fresh), lettuce, nectarines, peaches, pears, peppers, plums, potatoes (immature), tomatoes |
| High | Artichokes, Brussels sprouts, cut flowers, green onions, snap beans |
| Extremely High | Asparagus, broccoli, mushrooms, peas, sweet corn |

The rate of respiration is again influenced by number of factors during storage. These factors are divided into two groups. (A) Plant factors (B) Environmental factors.

**Plant Factors:**

**Stage of Development:** At maturation stage degree of respiration rate decreases as compared to initial development stage. In Climacteric fruit the rate of respiration is minimum at maturity stage but when ripening is about to start after harvest the respiration rate will increase to climacteric peak. Young tissues have more respiration rate.

**Soluble Sugars:** Soluble sugars particularly glucose are chief sugars used in respiration. Hence, the greater the conc. of soluble sugars within the living tissues, the greater is the rate of respiration.

**Proportion of living cells:** Living cells require constant supply of energy. So the rate of respiration will be directly proportional to the number of living cells.

**Water content of the product:** The rate of respiration varies directly with water content of the product. Generally succulent products respire more rapidly than non-succulent products. Thus lettuce heads respire (deteriorate) more rapidly than potatoes or sweet potatoes or even peppers.

**Environmental factors:**

**Availability of O2:** If Oxygen is supplied more to produce like carrots, the respiration rate is increased to certain level.

**CO2:** Proper CO2 concentration prolongs the storage life by less respiration.

**Temperature:** Higher the temperature greater will be the respiration rate. At 0 to 350 C temperature respirations rate is increased at rate of 2 to 2.5 for every 20C temperature raising. The biological and chemical processes are affected. When level of CO2 is more under this condition, respiration rate is low even at higher temperature.

**Coating on Surface of Fruits:** More thickness of coating less the respiration rate.

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

**Growth Regulator Application:** Malic hydrazide (MH) application inhibits or accelerates the respiration rate act to purpose of application.

**Fruit Injury:** This mechanical injury is also responsible for stimulating respiration rate.

**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 many 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.

**Transpiration**

During postharvest handling and storage, fresh fruits and vegetables lose moisture through their skins via the transpiration process. Commodity deterioration, such as shriveling or impaired flavor, may result if moisture loss is high. In order to minimize losses due to transpiration, and thereby increase both market quality and shelf life, commodities must be stored in a low temperature, high humidity environment. In addition to proper storage conditions, various skin coatings and moisture-proof films can be used during commodity packaging to significantly reduce transpiration and extend storage life (Ben-Yehoshua, 1969).

**Factors:**

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

It is the main cause of deterioration because it results in not only direct quantitative losses (loss of salable weight) but also in loss in appearance (wilting and shriveling), textural quality loss (softening loss of crispness) and loss in nutritional quality. Transpiration is also influenced by both plant factors as well as environmental factors.

1. Plant factors

Differentiation of tissues: Plant products differ in the degree of differentiation of their tissues and hence they differ in the rate of transpiration under the same conditions. In general, non-differentiated very succulent tissues contain more water than highly differentiated, non-succulent tissues. Under the same conditions tissues with high water content lose water more rapidly than tissues with low water content. Ex: Highly succulent –Asparagus spears, spinach leaves. Highly differentiated products– mature cabbage heads, onions, celery etc.

1. Outer cover: Two kinds of tissues constitute the outer cover of plant products. These are epidermis and periderm. The epidermis consists of a single layer of living cells, on the outer walls a layer of wax on epidermis retards transpiration, plant products with cutinized (covered or impregnated with cutin) epidermis will shrink less rapidly in storage than those with non-cutinized epidermis.

The plant products with a well developed and non-injured periderm lose water less rapidly and keep longer in storage than those products with a poorly developed (or) badly injured or bruised periderm. Plant products which possess a periderm as the outer cover are apples, pears, citrus fruits, root crop vegetables, potatoes and sweet potatoes.



 B) Environmental factors:

1) Temperature: High storage temperature induces a greater rate of transpiration and greater shrinkage than comparatively low temperature.

 2) Relative humidity: The rate of transpiration is inversely proportional to the relative humidity. In other words low relative humidity induces a high rate of transpiration and high RH induces low rate of transpiration.

**ETHYLENE:**

Where does ethylene come from?

 Ripening fruits

 Smoke

 Vehicle exhausts

 Ripening rooms

 Ripening fruit

All the living cells are capable of producing ethylene. Moreover, ripening fruits are rich source of ethylene production. The cuticle on fruit surface acts as a resistant barrier through which it is dissipated. This is one of the reasons, due to which internal concentration of ethylene within the fruit is greater than the external concentration in atmosphere.

Ethylene is a colorless gas that is naturally produced by plants and functions as a plant growth regulator. In this way, ethylene behaves in the same way as hormones in mammals. It triggers specific events during a plant’s natural course of growth and development, such as ripening. Through this action, it induces changes in certain plant organs such as textural changes, color changes and tissue degradation. Some of these changes may be desirable qualities associated with ripening; in other cases, it can bring damage or premature decay.

Ethylene causes degreening in oranges and banana, it bleaches green colour of leafy vegetables, celery, cabbage, broccoli etc. In the post harvest physiology of most horticultural crops, ethylene plays an important role, sometime beneficial (improving quality of the produce by faster and more uniform ripening prior to retail distribution) and often deleterious (increasing the rate of senescence and reducing shelf-life).

Fruits and vegetables may be classified depending on their response to ethylene. Climacteric species produce ethylene as they ripen, and the harvested produce is capable of ripening during the postharvest period. These commodities, such as bananas, apples, and peaches, tend to get sweeter and softer after harvest. Non-climacteric plants, such as leafy vegetables, do not continue to ripen after harvest; they will soften and rot, but this is due to moisture loss, decay and tissue deterioration.

In addition to being naturally produced by plants, ethylene is produced by a variety of other sources. These include internal combustion engines, cigarette smoke and natural gas leaks. Even low concentrations of ethylene throughout the postharvest life of a commodity can affect quality, so care must be taken to minimize exposure from both natural sources (i.e. climacteric fruit or veggies being stored with non-climacteric ones) or to artificial sources (engine exhaust, heaters, etc). All ethylene-producing sources should be considered when optimizing postharvest storage conditions as inadvertent exposure to ethylene can contribute to loss of quality in some fruits and vegetables.

Impacts of ethylene on post harvest quality of fruits and vegetables (Suslow, 2000)

* Russet spotting of lettuce (dark brown spotting on the mid-ribs of lettuce leaves)
* Yellowing or loss of green color (for example, in cucumber, broccoli, kale, spinach)
* Increased toughness in turnips and asparagus spears
* Increase or decrease sprouting in potatoes
* Yellowing and abscission (dropping) of leaves in Brassicas
* Softening, pitting, and development of off-flavor in peppers, summer squash, and watermelons
* Browning and discoloration in eggplant pulp and seed
* Discoloration and off-flavor in sweet potatoes
* Increased ripening and softening of mature green tomatoes
* Development of bitter taste in carrots and parsnips

Steps to reduce ethylene exposure during storage (Jobling, 2000)

* Do not store or transport green leafy vegetables in containers holding ripening fruit (apples, pears, mangoes, tomatoes, bananas).
* If possible, use electric powered equipment in storage areas versus gas powered.
* Remove overripe or rotting fruit from storage loads (these produce higher amounts of ethylene).
* Avoid storing ethylene sensitive products with products that produce high levels of ethylene.
* Increase the ventilation rate of the storage area, assuming that the outside air is ethylene free.
* Use ethylene scrubbers in storage areas to remove ethylene in the air.