Biochemical changes during ripening process:-

1. Change in Carbohydrate -

Carbohydrate serve as the storage material in most of the fruits. During ripening enzymatic conversion of starch to sugar makes the fruits much sweeter and therefore more acceptable.

2. Organic acids-

Generally, the acidity decreases during ripening as organic acids are utilized in respiration of fruits except in banana, lemon and pineapple where the acid content remains high even after ripening.

Formation of respective acid salts in respiring cells during ripening due to increase in membrane permeability .

The major organic acids profoundly found in fruits include citric acid (mango, guava, pineapple, citrus except sweet lime, pear, tomato), malic acid (apple, banana, cherry, watermelon), tartaric acid (grape, tamarind), quinic acid (kiwifruit, blueberry) and ellagic acid (strawberry, jamun), respectively.

3. Flavour/Aroma compounds-

Flavour is the most important factor determining if consumers will repurchase a particular fruit. Characteristic flavour of fruit depends upon the correct sugar-acid balance and formation of aroma volatile compounds.

During ripening enzymatic break down of large organic molecules into smaller one forms a mixture of volatile aroma compounds such as volatile acids, aldehydes, alcohols, esters, ketones, terpenoids and aromatics.

4. Ascorbic Acid

L-ascorbic acid (Vitamin C) is the naturally occurring ascorbic acid in fruits.

A reduced amount of ascorbic acid is noticed in pome, stone and berry fruits at the time of harvest.

The levels declined with the advancement of maturity and onset of fruit ripening in pear, sweet potatoes, potato, asparagus and okra during the course of post harvest handling.

5. Phenolics

The phenolic content of most fruits declines from high levels during early growth to low levels

when the fruit is considered to be physiologically mature and thereafter susceptible to the induction of ripening.

6. Flavonoids

Flavonoids are present in various horticultural commodities in the form of conjugates i.e. glycosylated or esterified forms. Certain characteristic flavonoid compounds present in fruits and vegetables , example

anthocyanin (apple, pomegranate, litchi, blueberries, plum, cherry, raspberries cranberries, longan berries ,strawberries, purple onion, purple brinjal),

lycopene (tomatoes, watermelon, pink grapefruits, apricot, and pink guavas),

Quercetin (apples, green and black tea, onions, red grapes, broccoli and cherries) and

beta carotene (Carrots, sweet potatoes, winter squash, pumpkin, papaya, mango, oranges, broccoli, spinach and lettuce).

7. Change in color

Pigments are responsible for colour of fruits. The chief pigments of fruits can be classified into chlorophyll (green), carotenoids (yellow or orange) and anthocyanins (red, blue and purple).

Change in colour development during fruit ripening due to both degradation of chlorophyll and synthesis of anthocyanins or carotenoids.

8. Seed maturation

The seeds mature prior to ripening.

Physical changes during ripening:-

1.Flesh softening and textural changes -

Textural change is the major event in fruit softening, and is the integral part of ripening, which is the result of enzymatic degradation of structural as well as storage polysaccharides. Cell walls of fruit undergo a natural degradation during fruit ripening, reducing cell wall firmness and intercellular adhesion. This leads firstly to the attainment of a desirable eating texture and then, as senescence begins, to a loss of this desirable texture. Enzymatic degradation of structural as well as storage polysaccharides occurs - pectin, cellulose, and hemicelluloses.

Physiological changes during ripening:-

1. Change in cell wall-

Cell walls of fruit undergo a natural degradation during fruit ripening, reducing cell wall firmness and intercellular adhesion.

In cell wall ,particularly in middle lamella the pectic polysaccharides are degraded and solubilised during ripening.The cell wall softening occurs and there are changes in the tissue permeability.

During this softening, there is a loss of neutral sugars (galactose and arabinose) and acidic pectin of cell wall.

2. Changes in respiration rate:

Usually respiration rate decreases with the advancement of ripening in non-climacteric fruits, while in climacteric fruits it rises initially and then declines.Respiration is essential for ripening as it provides the energy required to drive many of the reactions and changes. If respiration is inhibited, ripening is also inhibited.

3. Ethylene Production:

Ethylene is a gaseous plant hormone that plays an important role in inducing the ripening process for many fruits, together with other hormones and signals. An unripe fruit generally has low levels of ethylene. As the fruit matures, ethylene is produced as a signal to induce fruit ripening. Ethylene production continues to increase after harvest in climacteric fruits.

Ethylene is produced less in non-climacteric fruits when attached to the parent plant so harvested when fully riped.

4. Development of surface wax:

The delicate waxy or powdery substance develops on the surface of certain fruits like grape and berries.

5. Abscission:

Formation of abscission layer i.e. the mark from where the fruit shall detach from the parent plant. Or Endogenous concentration of abscissic acid increased during ripening of fruits such as grape, pear, peach etc.

Climacteric fruit: “Climacteric fruit can be harvested when mature but before the onset of ripening”. These fruits may undergo either natural or artificial ripening. The onset of ripening is accompanied by a rapid rise in respiration rate, generally referred to as the respiratory climacteric. After the climacteric, the respiration rate slows down as the fruit ripens and develops good eating quality. Examples of climacteric fruit include: apples, bananas, melons, papaya and tomatoes.

Non-climacteric fruit: “Non-climacteric fruit ripen only while still attached to the parent plant.” Their eating quality suffers if they are harvested before they are fully ripe because their sugar and acid contents do not increase further. Their respiration rate gradually declines during growth and after harvesting. Maturation and ripening are a gradual process. Examples of non-climacteric fruit include: cherries, cucumbers, grapes, lemons and pineapples.

S. No.	Composition	Climacteric fruits	Non-climacteric fruits
1.	Definition	Climacteric…fruits will ripen, i.e. get softer and sweeter after harvest.	Non-climacteric fruit is fruit that does not ripen after harvest.
2.	Respiration	Increased respiration at ripening	No increase in respiration
3.	Ripening	Ripen faster.	Ripen slower.
4.	Ethylene and internal level	Ethylene produce more. Higher internal level, Level increases at ripening.	Ethylene produce less. Lower internal levels, No increase at ripening
5.	Ethylene treatment	Small amount of ethylene is used to induce ripening process.	They do not respond to ethylene treatment.
6.	Examples	Mango, pear, peach, plum, persimmon, papaya, sapota, passion fruit, apple , apricot, banana, avocado, ber, fig, guava, kiwi	Carambola, cherries, Citrus, grape, litchi, loquat, pineapple, pomegranate, strawberry