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Review Article

METABOLISM DURING FRUIT RIPENING

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Abstract: The various anabolic and catabolic processes during fruits ripening make them attractive, consumable and marketable. The metabolic shift in physiological and biochemical characteristics after pre-harvest and post-harvest provide a different texture, taste, aroma and constituent to the fruits. These metabolic changes regulated by the number of external and internal factors that make fruit healthy, nutritious, colourful, attractive and pleasant odour. Ethylene and climacteric respiration are the main physiological factors which regulate ripening behaviour of climacteric fruits. The biochemical factors include soluble solids, acids, flavour, texture, aroma etc. which facilitate the enhancement of organoleptic characteristics, sensory quality and quantity of the fruits.
Keywords: Fruits, respiration, aroma, flavour, texture, soluble solids.

Introduction

Fruits are one of the major sources of minerals, vitamins, energy, freshness, pleasure, sweetness etc. and are readily available in Nature. They may consume as fresh just after harvest or store for ripening after harvest. There are pre-harvest and post-harvest phenomena occurring in fruits which make them suitable for consumption and marketable. The fruit ripening is a complex metabolic process occurs in physio-biochemically and genetically programmed manner. The ripening behaviour of a different fruits varies according to their nature, temperature and climatic condition. On the basis of ethylene spurt and dramatic rise in respiration before onset of ripening, fruits are divided into two groups: climacteric and non-climacteric. The peculiar behaviors of climacteric fruits are characterized by sudden increase of ethylene followed by respiration before the onset of ripening and its concentration decline after triggering the ripening factors. After attainment of full maturation climacteric fruits might be ripened in off vine due to the burst of ethylene production in the fruits. These ripening phenomena do not occur in non-climacteric fruits because there is no spurt of ethylene after maturity in the fruits (Kant, 2018). The different climacteric and non-climacteric fruits are enlisted in **table 1.**

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Maturity is one of the stages of fruits that determine the harvesting time of fruit. Harvesting at this stage keeping the fruits away from microbial and physiological spoilage. Their handling, storage and transportation become easy and their storage life extended. Firmness, juiciness and appearance of colour led to attractiveness and market value of the fruits. The anatomy of the tissue, cell size, shape, cell wall thickness and strength, extent of cell-to-cell adhesion, and turgor status determined these traits the fruits (Cappai et al., 2018).

Table 1.

Climacteric fruits		**Non-Climacteric fruits**	
Scientific Name	Common Name	Scientific Name	Common Name
Actinidia deliciosa	Kiwi	*Vitis* sp.	Grapes
Annona cherimola	Cherimoya	*Averrhoa carambola*	Carambola
Mangiferaindica	Mango	*Ananas comosus*	Pine apple
Prunus persica	Peach	*Borojo apatinoi*	Borojo
Prunus armeniaca	Apricot	*Bunchosia armeniaca*	Peanut
Prunus domestica,	Plum	*Citrullus lanatus*	Watermelon
Prunus spp.,	Cherry	*Citrus aurantiifolia*	Lime, Kinnow
Psidium guajava	Guava	*Citrus grandis*	Pummelo
Pyrus spp.,	Pear	*Citrus limetta*	Sweet Lime
Artocarpus heterophyllus	Jack fruit	*Citrus reticulata*	Mandarin
Asimina triloba	Pawpaw	*Citrus sinensis*	Orange
Carica papaya	Papaya	*Cucumis melo*	Cantaloupe
Persea americana	Avocado	*Dimocarpus longan*	Longan
Diospyros virginiana	Persimmon	*Fragaria sp.*	Strawberry
Manikarazapota	Sapota	*Eriobotrya japonica*	Loquat
Duriozibethinus	Durian	*Litchi chinensis*	Lychee, Litchi
Manilkarazapota	Sapodilla	*Rubus sp.*	Raspberry
Ficuscarica	Fig	*Eugenia uniflora*	Surinam Cherry
Prunus persica	Peach	*Punica granatum*	Pomegranate
Passiflora sp.	Passion Fruit	*Rubus fruticosus*	Blackberry
Ziziphusmauritiana	Indian Jujube	*Syzygium samarangense*	Wax Jambu
Solanum lycopersicum	Tomato	*Syzygium malaccense*	Malay Apple
Malus domestica	Apple	*Rubusidaeus*	Red Raspberry

(B)Biochemical changes

Flavour is one of the components of fruits which attribute sweet, sour, salty and bitter to the fruits and vegetable. It is the trait which attribute aroma (odor) and taste to the fruits. Sugar, organic acid and volatile compounds are the main determinants of flavour and aroma in the fruits (Defilippi et al., 2009). Besides these two criteria, taste is important trait which contribute specific flavour to the particular fruits. Sweet, sour, salty, bitter and umami are the five types of taste considered to be the important flavour of the fruits. The umami taste of the fruits is due to the presence of salt of amino acids and nucleotides. The odour generally

classified as flowery, fruity, resinous or balsamic, burnt, foul and spicy which emanating from the particular fruits (Barrett et al., 2010). Taste primarily depends on the sugar: acid ratio of particular fruits. The total water soluble portion of the fruit dry matter is about half is in the form of the reducing sugars fructose (25%) and glucose (22%) and further quarter of the dry matter consists of citric (9%), malic (4%) and dicarboxylic amino acids (2%), lipids (2%), and minerals (8%). Hence, 75% contribution is made by sugar and acids (Young et al., 1993). The breakdown of polymer into monomer during progression of ripening increases the ratio of sugar and acid in the ripening fruits. Citric acid and malic acid are the two main acids in the fruits, in which their higher and lower content determine the sourness and sweetness of the fruits (Toivonen PMA, Brummel DA, 2008). Moreover, Tartaric acid and succinic acid are present mostly in apple, grapes, peach, pear, plum, etc. Higher acidity (pH <4.4) makes fruits resistant against pathogens specifically less susceptible to thermophylic organisms (Kim et al., 2018).

Texture is the properties of a fruits which are sensed by touch and their deformation and disintegration. The trait which affect texture of fruits mainly are cell wall composition and cell wall strength, intercellular adhesion, cell size, starch/sugar conversion and water loss. These provide special textural properties to particular/specific variety of fruits. Pectin rich component of cell wall, mainly responsible for firmness or softness of the fruits which contain1 to 25% of air depending upon the fruit crops. Hence, enzymatic breakdown of pectin rich middle lamella determine the firmness/softness of the fruits. Calcium ions associated with pectins make them strong and rigid hence removal of calcium led to softness and crispy of fruits (Crouzet et al., 1990).After de-esterification by Pectin methyl esterase there are chances of binding of Ca again to form Ca-pectate, so removal of Ca led to fruit softening whereas binding or adding of Ca facilitate firmness and longevity of the fruits. Softening enzymes mainly act during progression of fruit ripening are polygalacturonase (PG), pectin methyl esterase (PME) and cellulase. The PG and PME act on pectin which is considered as hard component of cell wall and degrade it into its monomer component. The hydrolytic cleavage of the methyl ester groups of pectin by PME resulting in the de-esterifcation of pectin. Thereafter the chains of polygalacturonic acid linked through α-1-4 linkage cleaved by PG, those which are de-esterified by PME. Hence, PME action on pectin facilitates further action of PG on pectic substrates because this enzyme has greater catalytic activities against demethylated substrates. The cellulase act on β-1-4 linkage of cellulose present in component of cell wall and fecilitate softening of the fruits (Luis FG and Cristina MO, 2008).

Conclusion

Fruits ripening are the pre and post harvest phenomena after maturation in or off vine. Regulation of their physio-biochemical phenomena during ripening make them more nutritious, delicious and marketable for longer time period.

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