

## Need for Biotechnology in Fruits and Vegetables production

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### **Abstract: -**

*The biotechnological approaches to improve fruits and vegetables are necessary. Developed biotechnological approaches have the potential to enhance the yield, quality, nutritional quality, and shelf life of fruits and vegetables to meet the demands of the 21<sup>st</sup> century and make important contributions to sustainable vegetable and fruit production by overcoming limiting factors, which are not easily addressed through conventional vegetable breeding alone. However, the biotechnological approaches for fruits and vegetables were more of academic jargon than a commercial reality. A barrier to the successful use of transgenic techniques might be the acceptance or lack thereof transgenic fruit and vegetable crops by the public. To make sure that the current debates and complexities surrounding the registration and the commercialization of genetically modified fruits and vegetables are adequately addressed. Various stakeholders in the industry, policy makers, private sectors, agriculturalists, biotechnologists, scientists, extension agents, farmers, and the general public must be engaged in policy formulations, seed embodiments and products development. The full benefit of the knowledge can be reaped if there are total commitments by all stakeholders regarding increased and sustained funding, increased agricultural research and development, and less cost and time for registration and commercialization of new traits.*

**Keywords:** *Biotechnology, fruits, vegetables, transgenic etc.*

### **Introduction**

The ever-increasing identification of the molecular factors recruited by ethylene during postharvest ripening and senescence has provided a number of possible targets for

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biotechnological interventions to enhance the shelf-life of fruits and vegetables. Historically, biotechnological approaches have followed the progressive discovery of the main players of the “ethylene scene.” The first attempts to hasten shelf-life were mostly aimed at controlling specific ethylene-dependent responses, among which enhancing firmness maintenance in fruits through the manipulation of genes encoding cell wall enzymes clearly appeared as one of the most important targets to improve postharvest storage life. The biotechnological downregulation of expression of cell wall encoding genes either by RNA antisense technology and more recently by RNA interference (RNAi), proved to be at least in part successful in conferring better maintenance of fruit firmness for a certain number of enzymes, among which PGs, PLs, and PME should be listed, while it did not do so for other enzymes in such manner. This approach leads to an intrinsic inability of the plant to respond to endogenous ethylene but also to exogenously applied ethylene. A consequence of such a constitutive ethylene insensitivity is definitely a rather significant increase in shelf-life and much slower decay. However, this also implies the unfeasibility of restoring a normal ripening process by providing exogenous ethylene and therefore obtaining fruits of acceptable quality for the market (Yahia, 2018).

## **THE NEED FOR BIOTECHNOLOGY IN FRUITS AND VEGETABLE PRODUCTION**

Genetic engineering has the potential to address some of these most challenging constraints faced by vegetables and fruit growers, which are not easily addressed through conventional plant breeding alone. Many vegetables exhibit a very short life span after harvesting and require very elaborate measures to expand their life. Reducing the rate of senescence in these crops is not an easy task either by conventional or biotechnological methods. The main obstacle to devising new technologies is the complexity of the problem and lack of basic knowledge about the biochemical and cellular processes accompanying postharvest-induced senescence. This is accentuated by the extraordinary variety of tissue types that are commercialized. Early attempts to use genetic manipulation to alter senescence have been based on hormone physiology, either enhancing cytokinin production or blocking ethylene production or perception. In order to extend the postharvest life of leafy vegetables we first need to focus on the events that occur in regular leaves during senescence. Most fruits ripen, deteriorate in appearance and eating quality, and succumb to postharvest diseases very rapidly after harvest. Poor postharvest characteristics, such as deficient

flavor development, very short shelf life, quick softening, easy spoilage, sensitivity to low temperatures (chilling injury), and easy pathogen attack (fungi, etc.), are major constraints to profitability for the domestic market, and to the expansion of existing and new export markets. Among all fruits, tropical fruits are notorious for their poorer-than-average postharvest qualities.

Two major obvious targets to improve the postharvest characteristics of fruits are:

- (1) extension of shelf life and
- (2) resistance to pathogen attack

The ripening process involves a large number of biochemical pathways in the fruit that will result in marked changes in texture, taste and color. At the molecular level there are a large number of genes involved and they are tightly regulated in order to induce the right changes at the right time in a highly coordinated process. In general, fruits are classified as climacteric or non-climacteric depending on their patterns of respiration and ethylene synthesis during ripening. Climacteric fruits are characterized by an increased respiration rate at an early stage in the ripening process accompanied by autocatalytic ethylene production whereas non-climacteric fruits show a different respiration pattern and display a lack of autocatalytic ethylene synthesis. Many of the economically important fruit crops are climacteric; therefore, a large amount

of research has been devoted to studying the biochemical and molecular pathways operating during the climacteric ripening of fruits. Most of the genetic engineering approaches attempted in order to improve the shelf life and general appearance of fruits have centered on the set of genes controlling fruit firmness (membrane and cell wall properties) and the ripening rate (ethylene production or perception). These approaches have targeted endogenous genes with vital functions in the ripening process aiming to downregulate their activity by gene silencing. Postharvest decay of fruits and vegetables are a major challenge throughout the world.

In the industrialized countries, it is estimated that about 20%-25% of the harvested fruits and vegetables are decayed by pathogens during postharvest handling (Barkai-Golan, 2001 and Sharma *et al.*, 2009).

The use of synthetic fungicides, such as benomyl and iprodione to control postharvest diseases of fruits and vegetables is well known in scientific literature (Singh and Sharma, 2007 and Zhang *et al.*, 2007). The health and environmental concerns associated with the continuous use of synthetic fungicides have alarmed legal enforcers and consumers to demand greener technology and quality products from the food industry as well as the scientific community. Further after harvesting of fruits like king chilli, to increase the shelf-

life of green king chilli is very challenging due to its perishability; it is subject to quick worsening the shelf life during storage, transportation and marketing, so there is need of biotechnology improvement on king chilli fruits (Angousana *et al.*, 2026).

In the past 20 years, microbial antagonists like yeasts, fungi, and bacteria have been used with limited successes to reduce postharvest decays in fruits and vegetables (Barkai-Golan, 2001; Sharma *et al.*, 2009; Singh and Sharma, 2007; Zhang *et al.*, 2005, 2007). For instance, fungal diseases like gray mold, powdery mildew, and downy mildew in grapes do notably only cause losses in yield but also reduce wine quality (Compass, 2009). However, the advances in biotechnology can be employed to develop fruits and vegetables with improved quality and shelf life. The ability to maintain the quality of stored fruits and vegetables during postharvest storage is highly related to the physiological, biochemical, and molecular traits of the plant from which they derive (Lers, 2012). These traits are genetically determined and can be manipulated using genetic breeding and/or biotechnology. Published research results have revealed potential genes, which when manipulated can be used to improve shelf life and nutritional qualities of fruits and vegetables. Moreover, the nutritional value of fruits and vegetables

depends on their composition, which shows a wide range of variation depending on the species, cultivar, and maturity stage. The composition of fruits and vegetables includes a great number of metabolites. It could be predicted that no single commodity might be rich in all these constituents, which might be one of the reasons that consumption fruit and vegetable is still below the dietary guideline goal. However, the biotechnological approaches have the potential to overcome these limitations, which is not possible by conventional breeding and the knowledge of these biotechnological approaches have not only led to major improvements in the extended shelf life of fruits and vegetables but improved nutritional quality as well.

### **TOMATO AS AN IMPORTANT MODEL SYSTEM FOR FLESHY FRUIT RIPENING**

Tomato is the center piece system for genetic and molecular research in the family Solanaceae has emerged as a model for fleshy fruit ripening. It is due to its facilitating attributes including simple genetics, numerous characterized mutants, cross fertile wild germplasm to promote genetic studies and routine transformation technology. Recently it has been taken for genome sequencing by an international consortium currently funded and supported by 10 contributing countries. From the perspective of genetic and molecular

research, tomato has advantages, such as ease of seed and clonal propagation, short generation time (approximately 45-100 days), efficient cross and self-pollination ability, and year-round growth potential in the greenhouse has made tomato a plant of choice for fruit-ripening studies as well.

## TOMATO RIPENING STAGES

Once the tomato fruit completes its development and attains final size then it is in mature green (MG) stage. The fruit then stops growing and starts ripening by sequential stage transition. Ripening process in tomato sequentially passes through six stages, based on the percentage of the external color: MG (no external red coloration), breaker (<10% red color at blossom end), turning (10%-30% of fruit surface having red color), pink (30%-60% of fruit surface having red shade), light red or orange (60%-90% of fruit surface having red color), and red (at least 90%-95% of fruit surface having red color). The key regulator for all the changes during ripening is the climacteric rise of ethylene observed in breaker stage.

Fruit ripening is a developmental process that is exclusive to plants whereby mature seed-bearing organs undergo physiological and metabolic changes that promote seed dispersal (Seymour, 1993). Anatomically, fruits are swollen ovaries that may also contain associated flower parts. Their

development follows fertilization, and occurs simultaneously with seed maturation. Initially, fruits enlarge through cell division and then by increasing cell volume. The embryo matures and the seed accumulates storage products, acquires desiccation tolerance, and loses water. The fruit then ripens. Fruit ripening is a highly coordinated, genetically programmed, and an irreversible phenomenon involving a series of physiological, biochemical, and organoleptic changes that finally lead to the development of a soft edible ripe fruit with desirable quality attributes (Seymour *et al.*, 2002). During maturation stage several structural and biochemical changes occur in fruit, which confers on them specific organoleptic qualities, such as modifications in the external aspect, texture, and flavor of the fruit. Although the specific biochemical programs resulting in ripening phenomena vary among species, changes typically include:

- (1) Modification of color through the alteration of chlorophyll, carotenoid, and/or flavonoid accumulation
- (2) Textural modification via alteration of cell turgor and cell wall structure and/or metabolism
- (3) Modification of sugars, acids, and volatile profiles that affect nutritional quality, flavor and aroma
- (4) Generally enhanced susceptibility to opportunistic pathogens (likely

associated with the loss of cell wall integrity)

The series of cell divisions followed by a phase of cell expansion stops after reaching maturity. The tomato maturation process is accompanied with alterations in the texture of the fruit, more specifically the loss of firmness, due to structural changes in the principle cell wall components (cellulose, hemicellulose and pectin). The change in the color of tomato fruit results from transformation of chloroplasts into chromoplasts and from the degradation of chlorophyll, as well from the accumulation of pigments, such as carotenes and lycopene, which are responsible for the orange and red color of the fruit (Gray *et al.*, 1994). Finally, the accumulation of sugars, such as glucose and fructose and organic acids in vacuoles and the production of complex volatile compounds are responsible for the aroma and flavor of the fruit (Seymour, 1993).

### **CHALLENGES ASSOCIATED WITH GENETICALLY MODIFIED FRUITS AND VEGETABLES**

It is revealed that although biotechnological approaches are seen by the scientific community as a panacea to solve recent increased demands for fruits and vegetables, still the technology is more of a scientific jargon than a commercially viable entity. This is because of the dilemma and uncertainties that remain up to today regarding

the consumption of biotechnological fruits and vegetables. Although the first biotech crop to be commercialized was a genetically modified tomato for processing as a consumer tomato paste, since then there have been comparatively few introductions of biotech fruits and vegetables (Anthony and Ferroni, 2011). Reported cases with potential benefits for farmers in developing countries include virus-resistant papaya in China, now commercially grown, and, more recently, the high-profile case of Bt eggplant, or brinjal, in India (Choudhary and Gaur, 2009). Due to the susceptibility of brinjal to the fruit and shoot borer insect, multiple insecticide applications are required to prevent uneconomic losses of yield in this crop. In India, the Indian Genetic Engineering Appraisal Committee recommended the commercial release of Bt brinjal (Event EE1) in 2010, but no authorization was given by the Ministry of Environment and Forestry (Jayaraman, 2010). A wide array of vegetables, such as tomato, broccoli, cabbage, and okra are also under development in India (James, 2010). In a study involving 77 fruits and vegetables and other specialty crops, Miller and Bradford (2010) attempted to understand the factors driving the lack of traits for commercialization. They reported that during 2003-08 more than 300 research papers were published describing more than 250 unique transgenic events for

these kinds of crops of which some 20% of the papers were from China and India. The various researches addressed not just input traits, such as herbicide tolerance and insect resistance but also output traits, such as yield, postharvest quality, and modifications to compositions of oil, starch, protein, and nutrients. The primary conclusion was that the traits did not reach the market not because of poor performance or lack of grower interest but because of regulatory approval uncertainty and prohibitively high and uneconomic development.

### Conclusion

Biotechnology has emerged as an effective method for increasing the shelf life, nutritional value, and disease resistance of fruits and vegetables. Genetic engineering efforts aimed at ethylene production, ripening control, and cell wall metabolism have had significant success, notably in climacteric fruits such as tomatoes. Despite scientific improvements, the commercialisation of genetically modified fruits and vegetables is still limited because to regulatory, economic, and public acceptability issues. Continued research and enhanced biosafety regimes are required to realise the full promise of biotechnology in sustainable horticulture and postharvest management.

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