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Review Article

ETHYLENE *VIS-A-VIS* FRUIT RIPENING

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Abstract: Ethylene is a natural producing phytohormone regulates many developmental processes in plants by inducing metabolism of various organic molecules. The two biosynthetic enzymes 1-Amino cyclopropane-1-carboxylic acid (ACC) synthase and ACC oxidase are the key regulator of ethylene production in fruits. Fruits ripening a developmental program in which cells and tissues disintegration make the fruits consumable with attractive flavor and aroma. Fruits harvest after full maturity ripens easily in off vine due to release of biosynthetic ethylene within the fruits come under climacteric fruits. Ethylene spurt in climacteric fruits, shift the metabolic activity from green mature to ripening stage led to increase the ripening inducing factors which facilitate fast ripening with attractive appearance. Thus, ethylene regulation in climacteric fruits played major role in their ripening processes and shelf life.

Keywords: Climacteric fruit, Ethylene, Ripening, Enzymes, Inhibitors.

Introduction

Ethylene is a gaseous hormone mainly responsible for triggering of degradative processes which led to either development of new organs/tissue or senescence of whole organ/plant. It is the key inducer of development of vegetative as well as reproductive part of plant with interaction of other phytohormone (Iqbal et al., 2017). There are two categories of ethylene production have been proposed to operate in plants. System I or basal ethylene is synthesized in whole plant irrespective of their stage while in system II dramatically increase in ethylene has been seen before onset of ripening in climacteric fruit. System I production of ethylene are auto inhibitory it is detected in all tissues including those of non-climacteric fruits. System II operates after the maturity or before onset of ripening in climacteric fruit and senescence of some petals, and it is autocatalytic (Ables et al., 1992). Its spurt usually commences in one region of a fruits and spreading to neighboring regions as it diffuses freely from cell to cell and integrates the ripening process throughout the fruits (Alexander and Grierson, 2002). Ethylene showed its full biological activity at 6.53×10^{9} M (1 ml l^{-1}) at $25^{0}C$ and its concentration highest in ripening, meristematic and stressed tissues (Ables et al., 1992). Thus, being triggering of fast ripening in climacteric fruit their removal or inhibition

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of biosynthesis in the fruits determines their longevity and ripening period (Giovannoni, JJ., 2004).

Common Name	Scientific Name	Common Name	Scientific Name
Mango	Mangifera indica	Custard apple	Annona reticulata
Banana	Musa paradisicum	Guava	Psidium guajava
Papaya	Carica papaya	Jack fruits	Artocarpus integra
Apple	Pyrus malus	Pear	Pyrus sp.
Tomato	Solanum lycopersicon	Avocado	Persea americana
Peach	Prunus sp	Kiwi	Actinidia deliciosa
Persimon	Diospyros kaki	Apricot	Prunus sp.
Plum	Prunus domestica	Sapota	Manikara zapota
Fig	Ficus carica	Durian	Durio zibethinus
Cantaloupe	Cucumis melo	Mangosteen	Garcinia mangostana

Table 1. Common ethylene sensitive/climacteric fruits

Postharvest losses are common phenomena which accounts loss of 30-40% of horticultural produce. Regulating ethylene production/concentration and their effects on fruit ripening might reduce the loss of horticultural produce particularly ethylene sensitive fruits and vegetables (Kant and Arora, 2014). Some of the flowers are also sensitive to ethylene hence their vase life enhanced by down regulating the ethylene. There are two types of regulation of ethylene by using different chemicals has been proved by different laboratories. Firstly, the inhibition of biosynthetic pathway (Fig. 1) and secondly the inhibition of its signaling pathway (fig. 2) which led to inhibition of ethylene response and gene expression (Giovannoni, JJ., 2004).

The ethylene biosynthetic pathway has three main metabolic stages in which three different enzymes are involved. Among three, two enzymes (ACC Synthase and ACC oxidase) are the key regulator of ethylene biosynthetic pathway (Kant et al., 2016). It is up regulated during certain developmental stages and specific stress (Fig. 1). Regulating these two enzymes might regulate the ethylene production during ripening, senescence and stress (Giovannoni, JJ., 2004). Formation of ACC from SAM by the enzyme ACC synthase considered as rate limiting steps of ethylene biosynthesis and it is inhibited by aminoethoxy vinyl glycine (AVG) and amino oxyacetic acid (AOA) (Fig. 1) (Wang et al., 2004). The second regulatory

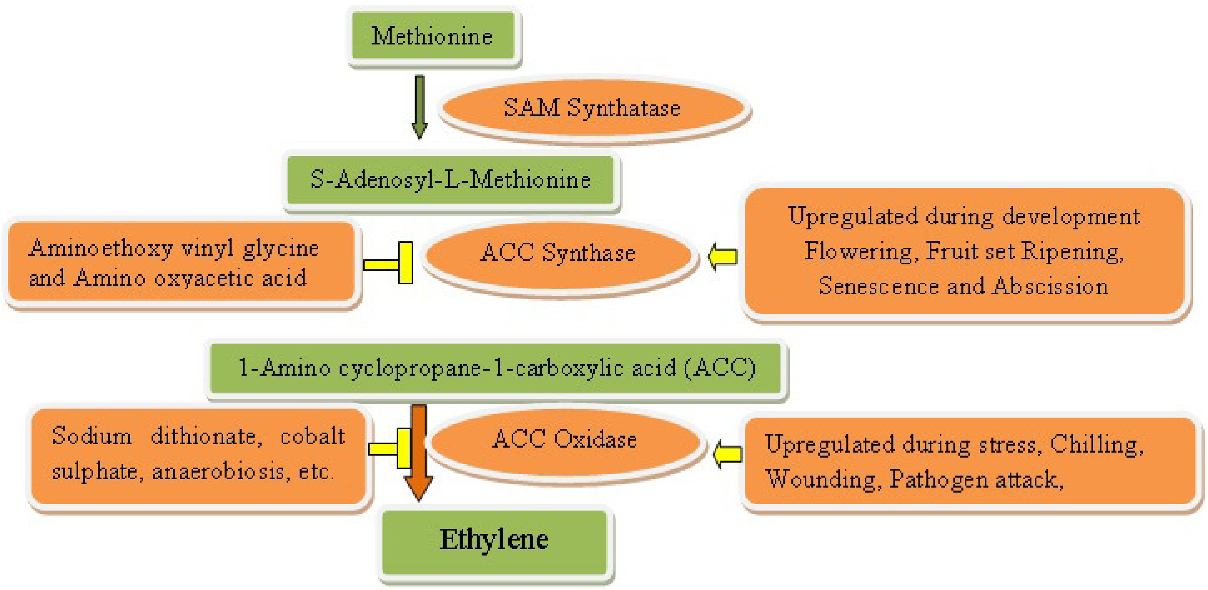

Fig. 1. Biosynthetic Pathway of ethylene

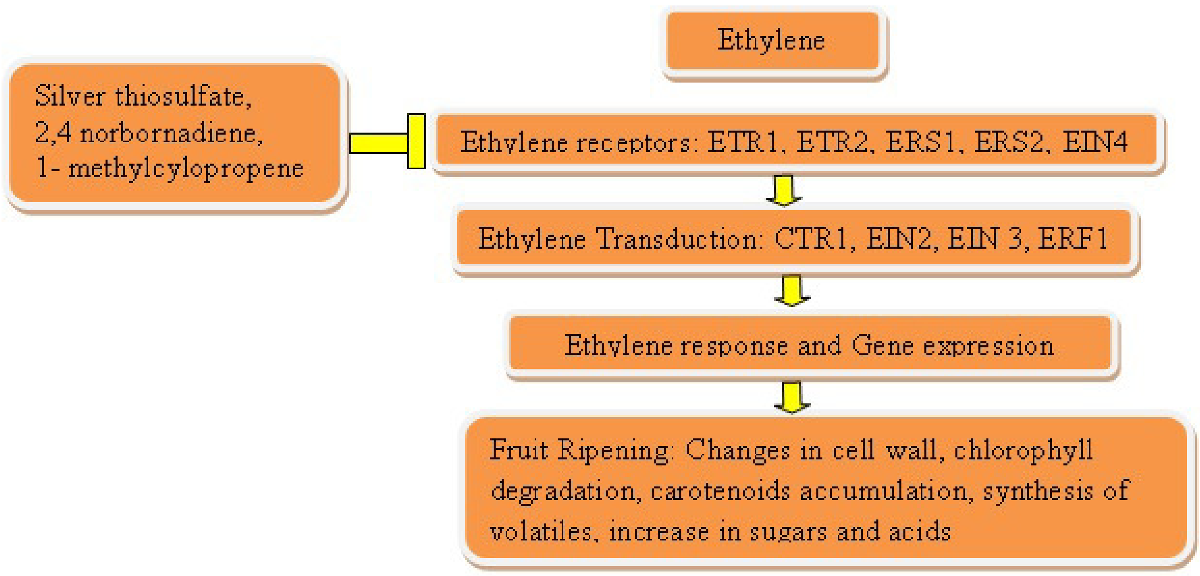

Fig. 2. Ethylene signaling   Wilkinson et al., 1995

enzyme ACC oxidase, which acts in the formation of ethylene from ACC inhibited by n-propyl gallate, sodium dithionate, cobalt sulphate and sodium metabisulphite, high temperature (>35^{0}C) as well as anaerobiosis (Kende, 1993) (Fig. 1). The signaling pathway is blocked/ inhibited by Silver thiosulfate, 2,4 norbornadiene, 3,3 dimethylcyclopropene and 1- methylcylopropene (Macnish, 2000) (Fig. 2). The ethylene can also be suppressed and delayed by diazocyclopentadiene (Blankenship and Sisler, 1992), salicylic acid (Kant et al., 2016), Vitamin K, maleic acid, auxin as well as gibberellins (Golden et al., 2014). However, for extending storage life of climacteric fruits utilization of these chemicals limited commercially, due to their cost and health implications (Table.1). The way to reduce ethylene and its effects are refrigeration and modified/controlled atmosphere which might be beneficial for extending the storage life of fruits. The modified/controlled atmosphere generally requires oxygen below 8% and carbon dioxide above 1% and temperature depend upon the sample/commodities. Ethylene can also be minimized by ventilation and application of ethylene absorber (potassium permanganate) (Chamara et al., 2000). It has been reported that silicone membrane, modify atmosphere of the chamber by reducing ethylene and extends the storage life of fruits with excellent quality (Stewart et al. 2005). Thus, using these technologies ethylene production/concentration minimized and storage life of fruits might be extended with keeping in view of quality and safety.

Conclusion

The phytohormone ethylene is safe for utilization in even and fast ripening of climacteric fruits. However, due to their perishable in nature fruits are no longer available for consumption. Hence, it might be useful strategy to regulate the ethylene production/concentration to enhance the shelf life of fruits.

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