Agriculture for Sustainable Development 5(1):6-10, 2017/Article ISSN 2347-5358 (Print)/ 2349-2228 (Online)

Agriculture for Sustainable Development

http://www.sustainableagriculture.in

ETHYLENE SYNTHESIS INHIBITORS AS TECHNIQUE FOR INCREASING SHELF LIFE AND QUALITY OF FRUITS AND VEGETABLES

PALLAVI NEHA[1*], K. PRASAD[2] AND UADAL SINGH [3]

[1] Division of Post Harvest Technology, ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka-560089

[2]Division of Postharvest Technology, ICAR-Indian Agricultural Research Institute, New Delhi-110012

[3]PSS Central Institute of Vocational Education, NCERT, Bhopal, Madhya Pradesh -426013

Received: 03.02.2017 **Revised accepted: 11.03.2017**

ABSTRACT

Ethylene synthesis inhibitors are present in plants itself but in very small amounts and their levels decrease with maturation and ripening. These inhibitors can also be synthesized artificially and applied externally to bring the desirable changes in ripening behaviour of fruits (McKeon and Yang, 1987; Reid, 1987). Ethylene is an important plant growth regulator that affects diverse developmental processes including fruit ripening, senescence and stress responses. Chemical inhibitors of ethylene synthesis block ripening and senescence in many plant species. Their role in regulating climacteric fruit ripening is particularly well established. Ethylene is synthesized from S-adenosylmethionine (SAM) by way of the intermediate 1- aminocyclopropane-1- carboxylic acid (ACC) (McKeon and Yang, 1987). Ethylene synthesis inhibitors like Aminooxyacetic acid (AOA), Aminoethoxyvinylglycine (AVG), Salicylic acid (SA), Brassinosteroid inhibitor brassinazole (BRZ), Nitric oxide (NO) affect the synthesis of 1- aminocyclopropane-1- carboxylic acid synthase (ACS), 1- aminocyclopropane-1-carboxylic acid oxidase (ACO) or process of ACC production. Hence, there is an opportunity for modulating ethylene evolution thereby ripening process and shelf life with exogenous application of these inhibitors. This will not only delay ripening process but also alleviate the chilling injury, reduce the disease incidence and maintain the fruit quality.

Keywords:

Introduction- Ethylene and its effect on ripening:

Ripening is nowadays not only a physiological process but it is becoming a tool for farmer to manage and sell their produce at a proper stage and quality of the fruit. Physiologically it is defined as the process by which fruits attain their desirable flavour, colour, palatable nature and other textural properties which ultimately make it more attractive and edible. Ripening is not only associated with the change in internal composition i.e. sugar, TSS, acids, but also external appearance like colour, flavour, texture. Thus, ripening is the process which affect horticulture commodity from the point of view of farmer, wholesaler, trader and consumer. As we know that

Corresponding author Email: pallavinehasingh@gmail.com;

horticulture produce is exported to the extent of 1 436487.85 lakhs rupees worth (A.P.E.D.A. Database 15) and 3694860.51 metric ton in quantity annually (N.H.B. Database 2015), it becomes more important to know the phenomenon like ripening, whose management can even increase it to further extent**.** It is obvious that one should know which fruit crop is to be ripened on tree, ripened under storage, and ripened under transit, this will be more clear by knowing the ripening behavior of fruit crops which were classified in two groups i.e. climacteric and non- climacteric fruits.

Climacteric fruits: These fruits emit ethylene along with increased rate of respiration on the onset of ripening on and off tree. In general these fruits become soft and delicate and care should be taken during their transit and handling. These fruits are generally harvested at green stage and can be ripened by the use of small dose of ethylene under controlled conditions which can be maintained during storage or transit.

Examples of Climacteric fruits are: Apple, Apricot, Banana, Fig, Guava, Kiwi, Mango, Passion fruit, Papaya, Pear, Plum, Sapota, etc.

Non-Climacteric fruits: Non-climacteric fruits are very peculiar in nature as if they once harvested unripe will not ripen further. They produce very small amount of ethylene and also don't respond well or significantly to ethylene treatment. There is no significant increase in Carambola, Cashew, Cherry, Grapefruit, Grapes, Kinnow, Litchi, Mousambi, Orange, Pomegranate, Rambutan, Raspberry, Strawberry, Watermelon, etc.

Ethylene biosynthesis inhibition for enhancing shelf life -

Ethylene is colourless gas, naturally occurring organic compound. It is readily diffuses within the tissue and from tissue. It reacts on very less concentration, it active at ≤ 0.1 ppm (even 0.005ppm). It is explosive in nature. Explosive at concentrations 3.1% - 3.2%. Acetylene, propylene, CO, 1-butene are analogues to ethylene. Ethylene plays important role from pollination to ripening and senescence. It acts as evil after maturity of fruit so after harvest control of ethylene production is big challenge in front of us. There are methods by which growers and researchers can manage the ethylene production of fruit and vegetables for their successful storage. The various methods are described in the flow diagram below:

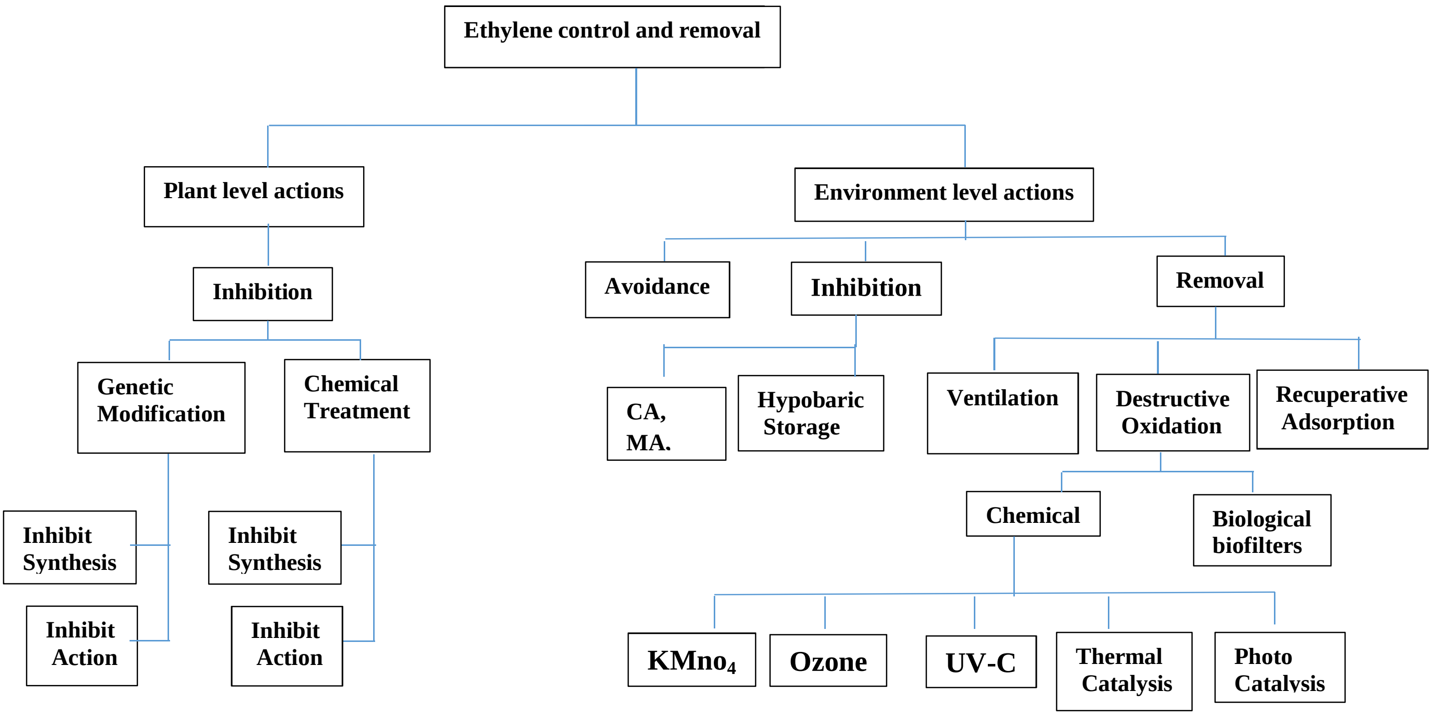

Fig.1 ethylene synthesis inhibitors in ethylene pathway

Approaches of ethylene management for successful storage of fruit and vegetables

1. Ethylene inhibitors: These are those biological or chemical compounds which reduces the production as well as action of ethylene. eg. AOA, AVG, MCP *etc*.

2. Ethylene synthesis inhibitors: These are those entity which reduces the production of ethylene by disturbing the ethylene synthesis pathway. eg.

Table 1. Compounds reported to be ethylene synthesis inhibitors

Ethylene synthesis inhibitors	Abbreviation	References
Aminooxyacitic acid	AOA	Wills *et al*., 1998
Aminoethoxyvinylglycine	AVG	Fadhil and Al-Bamarny, 2010
Rhizobitoxine	RT	Wills *et al*., 1998
Salicylic acid	SA	Barman *et al*. 2014
Brassinazole	BRZ	Zhu *et al*., 2015
Nitric oxide	NO	Singh *et al*., 2015
Microorganisms	-----	Klee *et al*., 1991

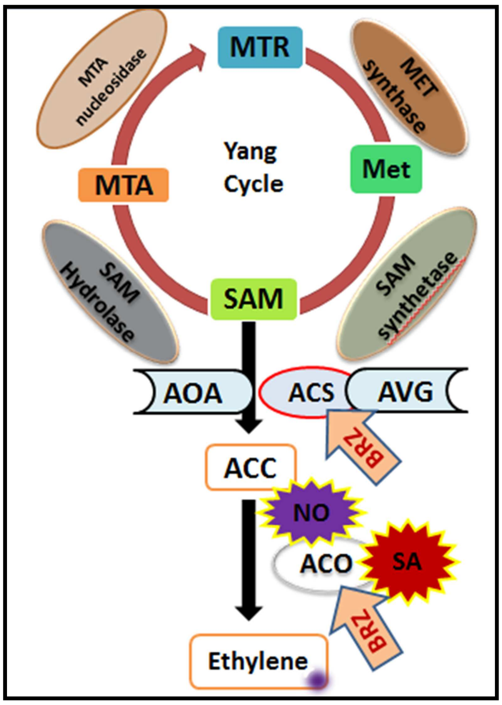

Fig.2. Approach of ethylene management by its inhibition

Abbreviations

MTR : 5' methyl thio ribose-1- P

Met : L- methionine

SAM : S- Adenosyl Methionine

MTA : Methyl thioadenosine

ACC : 1-Aminocyclopropane-1-carboxylic Acid

ACS : ACC synthase

ACO: ACC oxidase

Working mechanism of ethylene biosynthesis inhibitors-

Salicylic acid (SA) is an endogenous plant growth regulator, has been found to generate a wide range of metabolic and physiological responses in plants thereby affecting their growth and development. Salicylic acid as a natural and safe phenolic compound that exhibits high potential in controlling post-harvest losses in horticultural crops. Barman and Asrey (2014) reported that SA not only delays the ripening in mango but also alleviate the chilling injury as well as control the methylesterase and polygalacturonase activity.

Nitric oxide (NO) is recognized as a biological messenger in plants. Optimum NO levels could delay the climacteric phase of many tropical fruits and prolong the post-harvest shelf life of a wide range of horticultural crops by preventing ripening and senescence (Singh *et al*., 2013). Nitric oxide fumigated fruits reduced ethylene production due to binding of NO with ACC and ACC oxidase to form a stable ternary complex, thus limiting ethylene production (Tierney *et al*., 2005). Tran *et al.* (2015) reported that SNP (Sodium nitroprusside, a NO donor) treatment at 1 mM for 10 min can be used to maintain quality and extend shelf life of 'Nam Dok Mai Si Thong' mango fruit.

Brassinosteroids (BRs) are plant steroid hormones known mainly for their effects on cell expansion and a wide range of developmental and physiological processes that occur ubiquitously in plants (Guo *et al*., 2013). Zhu *et al*. (2015) enzymatic activity of ACC synthase and ACC oxidase by this way it reduces the production of ethylene.

AVG reduces the activity of ACC synthase, decreased significantly preharvest drop ratio and ethylene production relative to control. AVG delayed fruit ripening and slowed loss of flesh firmness and degradation of starch.

studied the effect of BRs on tomato and found that BRs involved in the development of fruit quality attributes and brassinazole delayed fruit ripening in tomato. Brassinozole reduces the

AOA reduces the production of ACC from the SAM, because of less or slow production of ACC (which is immediate precursor of ethylene) it inhibits the ethylene production. Many research work has been done on these inhibitor and there effect on different horticulture commodity. Few of them are mentioned below in the table.

Table 2. Effect of ethylene biosynthesis inhibitors reported in fruit crops -

Etylene synthesis inhibitor	Commodity	Effect	Authors
AVG	Apple	positive influence on the retention of fruit texture, acidity , decrease scald	Fadhil and Al-Bamarny (2010)
	Apricot	reduced the ethylene production and delayed the loss of fruit firmness	Palou and Crisosto (2003)
SA	Peach	positive effects on the firmness, total phenolic compounds and antioxidant capacity	Khademi and Ershadi (2013)
	Tomato	Expression of AOX and Cl resistant	Fung *et al*. (2006)
NO	Mango	Reduced chilling injury, pectin methylesterase and polygalacturonase activities.	Barman *et al*. (2014)
	Banana	Delay softnng, increase starch content	Cheng *et al*. (2009)
BRZ	Tomato	Delay ripening, improve quality	Zhu *et al*. (2015)

Conclusion

Recent advances in field of postharvest technology shown that there is an opportunity for modulating ethylene evolution thereby ripening process and shelf life with exogenous application of ethylene inhibitors which are mentioned in this article. This ethylene inhibitors not only delay ripening process but also alleviate the chilling injury, fruit softening, reduce the disease incidence (microbial - fungal infections) by induction of resistance and maintain the overall postharvest fruit quality.

REFERENCES

Anonymous. 2014. NHB database. National Horticulture Board, Gurgaon, Haryana, India.

Anonymous. 2015. APEDA database. Agricultural and Processed Food Products Export Development Authority, New Delhi, India.

Alexander, L. and Grierson, D. 2002. Ethylene biosynthesis and action in tomato: a model for climacteric fruit ripening. *J. Exp. Bot*. **53**: 2039–2055.

Asami, T., Mizutani, M., Fujioka, S., Goda, H., Min, Y.K., Shimada, Y. and Yoshida, S. 2001. Selective interaction of triazole derivatives with DWF4, a cytochrome P450 monooxygenase of the brassinosteroid biosynthetic pathway, correlates with brassinosteroid deficiency in planta. *J. Biol. Chem*. **276**: 25687–25691.

Barman, K. and Asrey, R. 2014. Salicylic acid pre-treatment alleviates chilling injury, preserves bioactive compound and enhance shelf life of mango fruit during cold storage. *J. Scientific and Industrial Res.***73**: 713-718.

Barry, C.S. and Giovannoni, J.J. 2007. Ethylene and fruit ripening. *J. Plant Growth Regul*. **26**: 143–159.

Fung, R. W. M., Wang, C. Y., Smith, D. L., Gross, K. C., and Tian, M. 2004. MeSA and MeJA increase steadyestate transcript levels of alternative oxidase and resistance against chilling injury in sweet peppers. *Plant Sci*, **166**: 711-719.

Guo, H., Li, L., Aluru, M., Aluru, S. and Yin, Y. 2013. Mechanisms and networks for brassinosteroid regulated gene expression. *Curr.Opin. Plant Biol*. **16**: 545–553.

Guo, H., Li, L., Aluru, M., Aluru, S. and Yin, Y. 2013. Mechanisms and networks for brassinosteroid regulated gene expression. *Curr.Opin. Plant Biol*. **16**: 545–553.

McKeon, T. and Yang, S.F. 1987. Biosynthesis and metabolism of ethylene. In: Plant Hormones and Their Role in Plant Growth and Development, P.J. Davies, *ed*. (Boston: Martinus Nijhoff), pp. 94-112.

Reid, M. 1987. Ethylene in plant growth, development and senescence. In: Plant Hormones and Their Role in Plant Growth and Development, P.J. Davies, *ed*. (Boston: Martinus Nijhoff), pp. 257-279.

Singh, Z., Khan, A. S., Zhu, S. and Payne, A. D. 2013. Nitric oxide in the regulation of fruit ripening: Challenges and thrusts. *Stewart Postharvest Rev*. **9**:1-11.

Tierney, D. L., Rocklin, A. M., Lipscomb, J. D., Que, L. and Hoffman, B. M. 2005. Studies of the ligation and structure of the non-heme iron site in ACC oxidase. *J. Amer. Chem. Soc.* **127:** 7005-7013.

Tran, T.T.L., Aiamla-or, S., Srilaong, V., Jitareerat, P., Wongs-Aree, C. and Uthairatanakija, A. 2015. Application of Nitric Oxide to Extend the Shelf Life of Mango Fruit. *Acta Hort*. **1088**: 97-102.

Zhu, T., Tan, W. R., Deng, X. G., Zheng, T., Zhang, D. W. and Lin, H. H. 2015. Effects of brassinosteroids on quality attributes and ethylene synthesis in postharvest tomato fruit. *Postharvest Biol.and Tech*. **100**: 196–204.