BRJ BASIC RESEARCH JOURNALS

Basic Research Journal of Agricultural Science and Review ISSN 2315-6880 Vol. 6(5) pp. 34-38 August 2018
Available online http//www.basicresearchjournals.org

Case Study

Review on the effects of ethylene (C_2H_4) on quality of fresh fruit and vegetable. The case of banana and tomato

Muluneh Bekele Etana

Samara University, College of Dry-land Agriculture, Department of Horticulture P.O. Box 132, Ethiopia

Author's email: muluneh.b2002@yahoo.com

Acceptance 23 July 2018

ABSTRACT

The plant hormone ethylene has become the focus of plant biology over the last 100 years. It is a gaseous plant hormone that is responsible for fruit ripening, growth inhibition, leaf abscission, aging and a wide range of other plant processes. It is color less gas that is naturally produced by plant and function as a plant growth regulator. In this way ethylene behaves in the same way as hormones in mammals. It triggers specific during plants natural growth and development such as ripening. Though this action it induces changes in certain plant organs such as Texture change, color change and tissue degradation some of this change may be desirable qualities associated with ripening; in other cases it can bring damage or premature decay. Harvesting of Fruits and Vegetables (i.e. Banana and Tomato) may be intentionally or unintentionally exposed to biological active levels of ethylene and both endogenous and exogenous source of ethylene contribute to its biological activity. Ethylene is also at the centre of postharvest technology acting as a key in the extension of shelf life and fruit quality during storage. Ethylene synthesis and sensitivity are enhanced during certain stage of plant development, as well as by a number of biotic and a biotic stresses. Therefore, the main objective of this paper is to review the effects of ethylene on quality of fresh fruit and vegetable.

Keywords: Banana, Ethylene, Fruit, Quality, Tomato, Vegetable

INTRODUCTION

The plant hormone ethylene has become the focus of plant biology over the last 100 years. It is a gaseous plant hormone that is responsible for fruit ripening, growth inhibition, leaf abscission, aging and a wide range of other plant processes. It is color less gas that is naturally produced by plant and function as a plant growth regulator. This gaseous plant hormone plays role in the regulation of harvested horticultural crops at very low concentration. The response of harvested Fruits, Vegetables and Ornamental to endogenously applied Ethylene are numerous and varied they can be beneficial or detrimental depending each case (Marchal *et.al.,* 1998).

Ethylene production is stimulated by various type of stress, including mechanical wounding and cutting. Consequently, ethylene production is increased when fruits and vegetables are sliced or cut for preparation as fresh products. Bananas, plantains and cooking bananas are crops of vital importance to the food security of hundreds of millions of people in developing countries.

Nearly all inhabitants in the tropics of all continents benefits directly or indirectly from Musa crops as a source of food or cash export (Hailu *et al.,* 2013).

The quality of fresh fruits and vegetables offered to consumers is constrained by the level of quality achieved at harvest and generally, cannot be improved by postharvest handling rather can be maintained. Genetic and environmental factors affect the growth, development and final quality of fresh fruits and vegetables (Shewfelt and Prussia, 1993). The quality of the fresh and processed fruit depends on the post-harvest handling during harvesting, transportation, storage and should be monitored effectively to keep the best quality of fruit at harvest. However, lack of storage facilities, limited access to transportation and risk of high losses, growers are often forced to dispose off their produce over a short period of time (Hailu *et al*., 2013).

According to Stover and Simmonds (1987), destructive ripening is caused by too high or too low temperature. High temperature disorders (cooked fruit) are indicated by soft, ripe pulp with a greenish-yellow skin colour, weak neck, split peel and brown flecks on a greenish yellow peel. Uneven ripening can be caused by low temperature and insufficient ethylene. The ripening process involves the production of ethylene which in turn controls several physiological events such as loss of firmness, peel discoloration, sugar biosynthesis (Thompson and Seymour, 1982).

Climacteric and non-climacteric fruits may be further differentiated by their response to applied ethylene and their pattern of production during ripening. It has been clearly established that all fruits produce minute quantity of ethylene during development. However, coincident with ripening, climactic fruits produce much larger amounts of ethylene than non-climacteric fruits. The rise in respiration in response to ethylene may occur more than once in non climacteric fruits in contrast to the single respiration increase in climacteric fruits. All horticultural crops produce ethylene. Whereas, the rate of production varies from one produce to another: Banana 0.05-2.1 µL L^{-1}, avocado 28.9-74.21 µL L^{-1} and tomato 3.6-29.81 µL L^{-1} (Wills *et al*., 1998). Ethylene production of banana is lesser compared to other climacteric fruits. Poor flavor development and uneven ripening are very common in fruit ripened by local methods like Ethiopian case which simply done by sorting bunches in open air as whole (Stover and Simmonds, 1987).

Banana and tomato fruits ripening were characterized a number of biochemical and physiological changes including fruit softening, changes color and an increase in respiratory activity. Although ethylene is produced by the fruit, ripening can also be stimulated by the application of ethylene. The physiological changes that occur during ripening are not altered considerably by the application of ethylene. In general ethylene can influences the quality of both climacteric and non-climacteric fruits by inducing the developments of physiological disorders. Therefore, the main objective of this paper is to review the effects of ethylene on quality of fresh fruits and vegetables.

Effects of ethylene in fruit and vegetable production

Effects of ethylene on quality of banana and tomato fruits

Ethylene production is promoted by stresses such as chilling and wounding (Abeles *et.al*, 1992) and this stress-induced ethylene can enhance fruits ripening. Hertog *et.al,* (1992) reported that phenylopanoid metabolism is enhanced by ethylene and certain phenolic compounds that have been associated with reduction of certain diseases and the responses to endogenously produce and exogenously applied ethylene are numerous and valid in hastening of fruit repining i.e. tomato (*Lycopersicon Esculentum*).

Identifying, characterizing and isolating inducers for these genes should allow the genetic engineering of transgenic plants with anti-sense constructs to nullify specific developmental change. This technology has been used to produce tomato lines with fruit that have reduced rates of ethylene synthesis during repining reduce ability to perceive and react to ethylene (Williams, 2002).

Beneficial effects of ethylene in fruits and vegetables

The beneficial effect of ethylene is related by its application to grow plants in the field and orchard, to plants in the green house and to harvested commodities. Ethylene gases may have accounted for the ability of taste panel to distinguish between tomato fruit. The flavor of tomato was different; the taste panel did not express a preference of one treatment over other (Robinson, 1996).

Abeles *et.al*., (1992) also reported that ethylene may used in liquid form and has effect in seed germination, bulb sprouting, to reduce apical dominance, to initiate root initiation, to stimulate latex and other secretions, to enhance color development and to assist cultural control of insect pest.

Effects of ethylene on fruits and vegetables appearance

Consumer equates the visual appearance of fresh banana and tomato fruits with their quality. Treatment of banana fruits with ethylene accelerates chlorophyll degradation and leads to the appearance of yellow or orange color. A similar process occurs in tomato where C_2H_4 stimulates chlorophyll loss and the appearance of

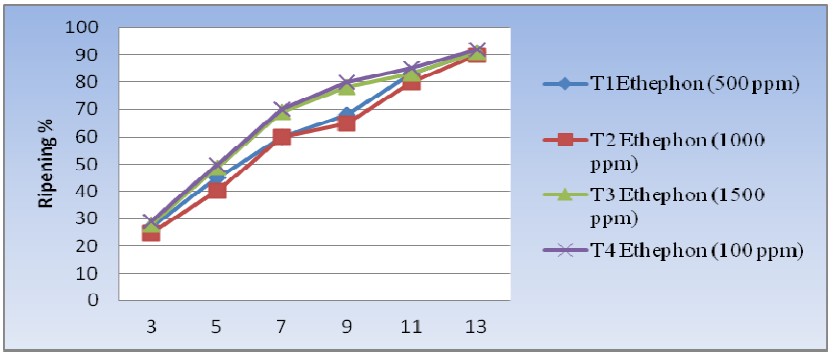

Figure 1. Effects of Ethephons and ethylene gases on physiological loss in weight (%), fruit firmness, ripening (%), rotating of tomato and 90-95% RH

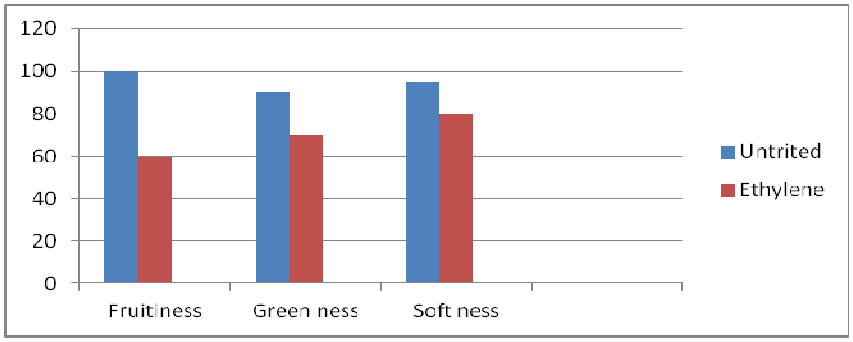

Figure 2. Effect of ethylene treatment on the subjective quality of banana fruit harvested mature green and left unrelated.

red color (Williams, 2002).

According to Stover and Simmonds (1987), the destructive ripening is caused by too high or too low temperature. High temperature disorders (cooked fruit) are indicated by soft, ripe pulp with a greenish-yellow skin colour, weak neck, split peel and brown flecks on a greenish yellow peel. Uneven ripening can be caused by low temperature and insufficient ethylene. The ripening process involves the production of ethylene which in turn controls several physiological events such as loss of firmness, peel discoloration and sugar biosynthesis (Thompson and Seymour, 1982).

In climacteric fruits, ethylene production begins at the onset of the climacteric period (increase in respiration rate and metabolic activities) and thereafter, increases and decreases parallel with changes in respiratory climacteric towards the full ripe stage. The onset of ripening is marked by a number of critical metabolic and physical changes including acceleration in metabolic activity, rapid transformation of starch to sugars, increase in acids, decrease in tannins and hemicelluloses and softening of the skin and pulp tissues (Liu *et al*., 1999). Treatment with different concentration of Ethephon (500,100 and 1500ppm) during complete ripening period tomato fruit showed decreased firmness of fruits with increased concentration of Ethephon (500-1500ppm) during the ripening period (Figure 1).

Effects of ethylene on fruits and vegetables texture

Apart from its beneficial effects on promoting tissue softening, ethylene determinately affects the texture by unwanted softening. The firmness of tomato and banana are decreases with ethylene treatment mostly used in tomato (Williams, 2002).

Removal of C_2H_4 from storage rooms, even for controlled atmosphere storage can improve quality. Melons (Cucumis melo) stored in controlled atmospheres of 10% CO_2 plus 10% O_2 where firmer and exhibit less decay when a C_2H_4 absorbent was included in the storage room (Aharoni *et.al*., 1993).

Effects of ethylene on fruit and vegetables ripening and flavor

Ethylene enhances taste and flavor of fruit by stimulating repining. The sensory qualities of fruit nesses, green nesses and soft nesses of banana where evaluated by a trained analytical sensory panel (Figure 2).

Ethylene Production from Banana and Tomato Fruits

Ethylene oxide has been shown to be most effective in delaying banana ripening at low concentrations. At a concentration of 50-100ppm the banana fruit was storable for 6 weeks and was of excellent quality. However, when the fruit was treated with 400ppm of ethylene oxide it caused burning of the peel; however the damage did not extend to the pulp. Storage using sulphur dioxide was effective in maintaining banana quality and prevented fungal infection in treated fruit. By comparison, control fruit stored at regular atmosphere suffered fungal infection (Williams, 2002).

Ethylene is formed from the precursor 1-aminocyclopropance-1- carboxylic acid by the activity of ACC oxidase also referred to as the ethylene forming enzyme in banana ethylene production in low or under testable during fruit development and was only observed during fruit repining. After harvest of the fruit ACC and ethylene production are low in banana fruit during the pre- climatic phase. Plants produce C_2H_4, but only ripening climacteric fruit and diseased or wounded tissue produce it in sufficient amounts to affect adjacent tissue. In all but ripening climacteric fruit tissue, C_2H_4 suppresses its own synthesis. As climacteric fruit start to ripen, this negative feedback inhibition of C_2H_4 on C_2H_4 synthesis changes into a positive feedback promotion in which C_2H_4 stimulates its own synthesis (i.e. autocatalytic C_2H_4 production) and copious amounts of C_2H_4 are produced (Williams, 2002).

Once the ripening of climacteric fruit has started, the internal C_2H_4 concentration quickly increases to saturation levels and exogenous application of C_2H_4 has no further promotive effect on ripening. Reducing the external concentration of C_2H_4 around bulky fruit like apples (*Malus domestica*), bananas (*Musa* spp.), melons and tomatoes) has almost no effect on reducing the internal concentration in these ripening climacteric fruit because of the large diffusion resistance of their skin and flesh. In these fruit, the rate of production far outstrips the rate of diffusive losses until a fairly high level is reach. Internal C_2H_4 concentration can exceed 100 ml l-1, even when the external concentration is zero. Therefore, reducing the external C_2H_4 concentration by ventilation or with C_2H_4 scrubbers generally has no effect on the subsequent ripening of fruit that have progressed a few days into their climacteric. However, at the initial stages of ripening when internal C_2H_4 levels are still low, enhancing the rate of diffusion with low-pressure storage/inhibiting synthesis/action of C_2H_4 significantly retard ripening. Sources of C_2H_4 not only include other plants, but also include smoke, exhaust gases, compressed C_2H_4 gas, C_2H_4 releasing chemicals, catalytic production of C_2H_4 from ethanol, and C_2H_4 analogues produced by a variety of processes. Other gaseous chemicals are analogs of C_2H_4 and can elicit the same physiological effects as C_2H_4, but often much higher concentrations are required to produce the same effect (Admas *et al*., 1979).

SUMMARY AND CONCLUSIONS

It is obvious that ethylene plays a major role in the aging process of plants. The enhancement of the shelf-life of many fruits can be achieved by the removal of ethylene from the atmosphere surrounding the fruit. The use of postharvest technology to produce controlled or modified atmospheres is the technology that has the potential of allowing the developing countries to earn more vital foreign exchange due to the increased shelf-life of tropical fruits.

A better understanding of C_2H_4 synthesis perception and action should allow the development of post harvest storages to enhance the beneficial effects and the detrimental effects of C_2H_4 on the quality of fresh fruits and vegetables. Ethylene is produced endogenously by perhaps all plants and their organs. Bananas are climacterics fruit and ripen in response ethylene. Bananas fruit ripening is characterized by a number of biochemical and physiological change including fruit softening, changes in peel color and other respiratory activity increase. Ethylene absorbents have been successfully used to remove exogenous ethylene from the storage atmosphere. In banana, ethylene production is low or undetectable during fruit development and is only observed fruit ripening. The color and quality of ripe tomatoes are important consideration to the consumer and hence to the commercial grower. The firmness of many ripening fruit and vegetable, this was associated with ripening of tomato's and others. Another determinant of effect of C_2H_4 is on the yellowing of green stem and leafy vegetable used for acceptable appearance.

Future Prospects

The enhancement of the shelf-life of many fruits can be achieved by the removal of ethylene from the atmosphere surrounding the fruit. The use of postharvest technology to produce controlled or modified atmospheres is the technology that has the potential of allowing the developing countries to earn more vital foreign exchange due to the increased quality and shelf-life of tropical fruits. Therefore, it should be search for another control or management methods for the future which includes the use of postharvest technology to produce controlled or modified atmospheres in order to produce premium quality product and get high profit.

REFERENCES

Abeles FR (1973). "Ethylene in Plant tsiology." Academic press,New York-

Adams DO, Yong SF (1979). Ethylene biosynthesis: Identification of 1-aminocyclopropanecarboxylic acid as an intermediate in the conversion of methionine to ethylene. Proc. Natl. Acad. Sci. USA., 76: 170-174.

Aharoni R, Copel A, Fallik E (1993). Storing 'Galia' melons in a controlled atmosphere with ethylene abesobrene. Proe. Natl. Acad. Sci. USA 76,170-174

Hailu M, Workneh TS, Belew D (2013). Review on postharvest technology of banana fruit. Afr. J. Biotechnol., 12: 635-647.

Hertog MG, Hollman PCH, Katon M (1992). Content of potensially flavonoids of 28 vegitable of Fruits comenonly consumed antiearcinogenic in the Nether lands J,Agaric Food chem.40,2379-2383.

Liu X, Shiomi S, Nakatsuka A, Kubo Y, Nakamura R, Inaba A (1999). Characterization of ethylene biosynthesis associated with ripening in banana fruit. Plant Physiol., 121: 1257-1265.

Marchal J (1998). An overview of post-harvest aspects of banana. Acta Hort., 490: 501-510.

Robinson JC (1996). Banana and Plantains. CAB International, London, UK., pp: 209-215.

Seymour G, Taylor J, Tucker G (1993). Biochemistry of Fruit Ripening. Chapman and Hall, London, pp: 83-106

Shewfelt RL, Prussia SE (1993). Postharvest Handling: A Systems Approach. Academic Press, San Diego, ISBN: 9780080925769, Pages: 358.

Stover RH, Simmonds NW (1987). Banana, Tropical Agriculture Series. 3rd Edn., Longman Singapore Publisher, Singapore, pp: 373-370.

Thompson AK, Seymour GB (1982). Comparative effects of acetylene and ethylene gas on initiation of banana ripening. Ann. Applied Biol., 101: 407-410.

Williams OJ (2002). Enzyme studies and postharvest technology of tropical fruits. Ph.D. Thesis, The University of the West Indies, Mona, Jamaica.

Wills RBH, McGlasson B, Graham D, Joyce D (1998). Postharvest: An Introduction to the Physiology and Handling of Fruit Vegetables and Ornamentals. 4th Edn., CAB International, New York, USA., ISBN-13: 978-0851992648, Pages: 280.