



## Effect of ethrel spray on the ripening behaviour of mango (*Mangifera indica* L.) variety 'Dashehari'

P. S. Gurjar\*, A.K. Verma, Abhay Dikshit and D. K. Shukla

Division of Post Harvest Management, ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101 (U.P.), INDIA

\*Corresponding author. E-mail: pawan09996@gmail.com

Received: November 5, 2016; Revised received: February 27, 2017; Accepted: August 8, 2017

**Abstract:** An experiment was carried out to investigate the effect of post harvest spray of different concentrations (100, 200, 400, 600 and 800 ppm) of ethrel (2-chloroethyl phosphonic acid) on ripening and colour development in 'Dashehari' mango fruits harvested in second week of June, 2015. The treated fruits were assessed for physico-chemical parameters such as physiological loss in weight (%), firmness (Kg/cm<sup>2</sup>), TSS (°Brix), titrable acidity (%), total carotenoids (mg/100g) and peel chlorophyll (mg/100g) and observations were recorded at 2 days interval during 8 days storage at ambient temperature. Changes in total soluble solids (8.5 to 23.23° Brix), total carotenoids (0.807 to 7.12 mg/100g) and PLW (14.58%) showed increasing trends up to 8 days during storage whereas fruit firmness (8.5 to 0.68 Kg/cm<sup>2</sup>), titrable acidity (1.26 to 0.08%) and total peel chlorophyll (5.2 to 0.14 mg/100g) showed decreasing trends. At the end of the storage period for 8 days, Ethrel spray at 600 ppm induced uniform ripening with attractive yellow colour within 4 days while untreated control fruits failed to ripen uniformly and remain light green even after 8 days of storage. Ripening advances by 4 days in fruits sprayed with 600 ppm ethrel compared to unsprayed control fruits.

**Keywords:** 'Dashehari' mango, Ethrel Spray, Ripening, Uniform colour

### INTRODUCTION

Mango is one of the choicest fruit of India popularly known as 'king of fruits' continues to dominate the Indian fruit basket contributing 36 per cent to total fruit area and 20.3 per cent to total fruit production. It is grown over an area of 2.5 million ha with an annual production of 18.45 million tonnes in the country (Anonymous, 2014). Dashehari is one of the important variety of mango, largely being grown in northern states of India. It is known for its excellent flavor, fragrance and taste but suffers from poor colour development and uneven ripening causes economic losses to growers and traders. Being a climacteric fruit, uniform ripening and colour development can be induced by artificial means in mango. Now a day's calcium carbide (CaC<sub>2</sub>) popularly known as 'masala' is being indiscriminately used for artificial ripening of mango. However, it possesses impurities of arsenic and phosphorus hydride which are extremely harmful for human health (Hossain *et al.*, 2015). Further, calcium carbide is banned under Prevention of Food Adulteration (PFA) rules, 1955 and also under Food Safety and Standards (Prohibition and Restrictions on sales) regulations, 2011, its use is still unabated. Therefore, the need for alternative safe methods of artificial ripening is of the utmost importance for providing good quality and safe fruits for consumers.

The Food Safety and Standards (Prohibition and Restriction on Sales) Regulations, 2011, permitted use of Ethrel/Ethylene gas for the artificial ripening of fruits. Early and uniform ripening and colour development can be achieved by dipping of fruits in diluted ethrel (2 - Chloroethyl phosphonic acid) solution which is recommended for a number of climacteric fruits including mango (Venkatesan and Tamilmani, 2013, Gupta *et al.*, 2015), banana (Kulkarni *et al.*, 2011), Tomato (Dhall and Singh, 2013), papaya (Singh *et al.*, 2012) and guava (Mahajan *et al.*, 2008). Dipping of fruits in ethrel solution is cumbersome process and required more time and labour. Another method of ripening of mango is through exposure of fruits to ethylene gas in modern ripening chambers which requires huge investment and is not economical for farmers or small traders. Therefore, an alternative simple method of post harvest application of ethrel on fruits through hand spray is standardized for induction of uniform ripening and colour development in 'Dashehari' mango.

### MATERIALS AND METHODS

Mango (*Mangifera indica* L. 'Dashehari') fruit were obtained from the experimental orchard of the ICAR-Central Institute for Subtropical Horticulture, Lucknow India. Mature green mango fruit with light-cream coloured pulp and total soluble solids of 8° - 9° Brix, titrable acidity 1.20-1.40%, were harvested in morning

hours. Immediately after harvesting, all fruit were brought to the handling and storage laboratory of IC-AR-CISH. Healthy fruits ( $n = 720$ ) of a uniform size, without any defect and free from visual blemishes, cuts, pests, or diseases were washed in water and spread on the floor. The experiments involved six treatments, each with three replications. The 720 fruits were divided into six lots of 120 fruits for each treatment. The five lots of fruits were sprayed with aqueous solutions of ethrel (100, 200, 400, 600 and 800 ppm) as a donor of ethylene gas with the help of hand sprayer, remaining one lot sprayed with water (the control). Following each treatment, the fruits were air-dried at room temperature, packed in corrugated fiberboard (CFB) boxes and stored under ambient conditions (RH: 70-80%, Temperature:  $32^{\circ} \pm 2^{\circ}\text{C}$ ) for 8 days. After 2, 4, 6, and 8 days fruits ( $n = 30$ ) from each treatment were sampled at random and used for ripening related observations. Post-treatment physiological loss in weight (PLW) in both ethrel treated and control fruits were recorded at each sampling interval up to 8 days. PLW was calculated as the difference between the initial weight of fruit (on day-0) and the weight of fruits at the time of sampling, expressed in terms of percentage. Firmness in treated and untreated fruits was measured at three points per fruit (without peel) using a 'McCormick fruit tester FT 327' penetrometer with head diameter of 11 mm. Fruit firmness was expressed in  $\text{Kg}/\text{cm}^2$ . Total Soluble Solids (TSS) were measured by using hand refractometer (Erma, Japan), while titratable acidity by titrimetric methods using 0.1N NaOH (Ranganna, 2000). Peel chlorophyll was extracted in 80% acetone and estimated in spectrophotometer as method described by Pandey *et al.* (2015) with minor modifications. Total carotenoids of fruit pulp was extracted (by repeated extraction) with petroleum ether and acetone (3:2 v/v ratio, 60–80 °C) according to the method of Roy (1973). The ripening percentage of the fruits was estimated by counting the total number of ripened fruits on the basis of their appearance and desirable colour. The data obtained were subjected to statistical analysis by using 'Statistical Software Package for Agricultural Research Workers' (Sheron *et al.*, 1998) software at 5% significance level.

## RESULTS AND DISCUSSION

### Effect of ethrel spray on peel chlorophyll degradation:

Total chlorophyll content in peel of 600

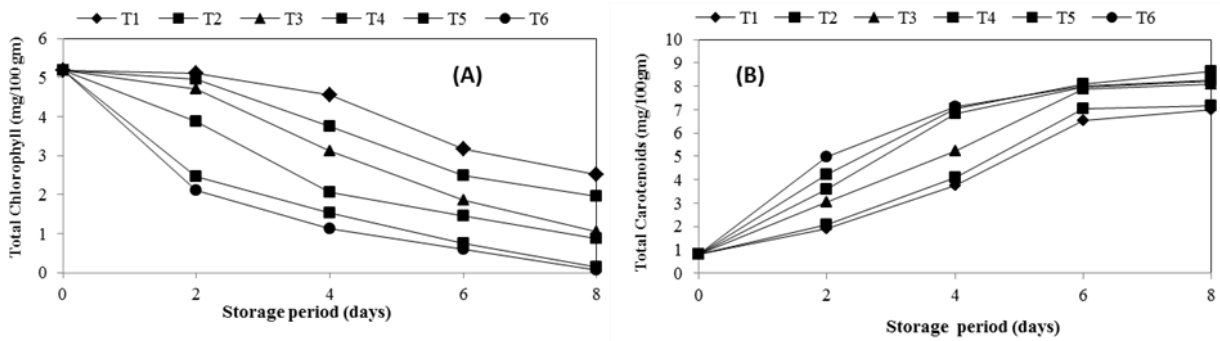
and 800 ppm ethrel treated fruits decreased from 5.2 to 0.14 and to 0.058 mg/ 100 g, respectively after 8 days of storage. Whereas in control fruits, the total chlorophyll content decreased from 5.2 to 2.51 mg/100 g after 8 days of storage. Fruits sprayed with 600 and 800 ppm ethrel reached the full yellow stage 4 days earlier than the untreated fruits. The results indicated that the degradation of chlorophyll pigments in fruit peel in ethrel treated fruits was more rapid than in untreated fruits (Fig 1). This could be due to accelerated rate of diffusion of exogenous ethylene into peel of ethrel treated fruits which triggered the degradation of chlorophyll pigments (Terai *et al.* 1973). Ethrel was reported to accelerate chlorophyll destruction in many fruits including mango (Mohamed and Goukh, 2003, Siddqui and Dhua, 2009, Gupta *et al.*, 2015), Banana (Kulkarni *et al.*, 2011) and papaya (Singh *et al.*, 2012).

**Total carotenoids content:** The total carotenoid content in ethrel treated fruits increased from 0.807 to 7.12 and 7.14 mg/100 g in 600 and 800 ppm of ethrel treated fruits, respectively after 4 days of treatment, whereas in untreated fruits pulp developed 7.05 mg/100 g even after 8 days of storage (Fig. 1). The improper development of total carotenoid pigments in pulp of control samples could be due to delayed ethylene biogenesis. Higher carotenoid content in ethrel treated fruits could be due to enhancement in activity of carotenoid  $\beta$ -hydroxylase enzyme responsible for carotene synthesis (Yah *et al.*, 1998). These results were in agreement with the findings of Siddqui and Dhua (2009) in 'Himsagar' mango dipped in 700 ppm ethrel and Singh *et al.* (2012) in papaya treated with 1000 ppm ethrel.

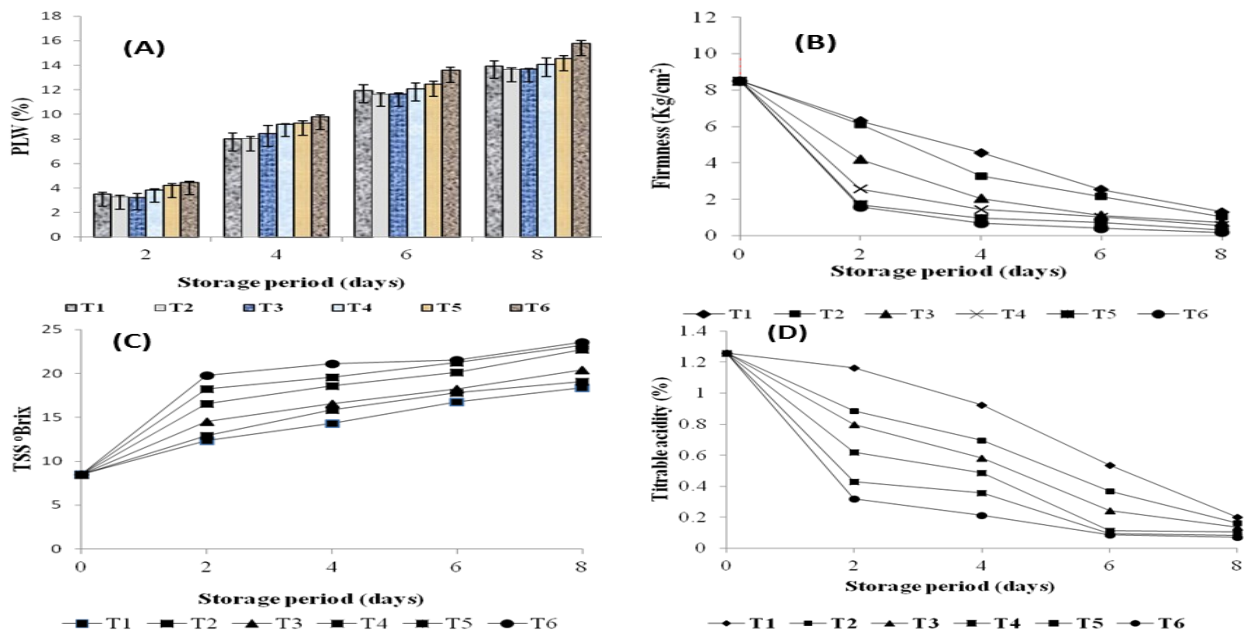
**Physiological loss in weight (PLW):** Data on the cumulative loss in weight due to transpiration and respiration processes indicated that fruits kept without ethrel spray lost weight up to 13.92% on 8th day of storage (Fig 2A). The highest PLW was observed with 800 ppm (15.78%) ethrel spray during ripening period of 8 days, resulted in shriveling, softening and over-ripening of fruits and hence found unsuitable. Ethrel spray of 600 ppm recorded 14.58% weight loss during ripening period of 8 days leading to uniform ripening and colour development and softening of fruits. Results showed that increase in PLW was directly proportional to increase in ethrel concentration. This increase in PLW of ethrel treated fruits during ripening could be due to upsurge in respiration rate leading to faster

Table 1. Effect of post harvest ethrel spray on ripening of mango fruits.

Number of Days	Percentage of ripened fruits					
	Concentration of Ethrel (ppm)					
	Control	100	200	400	600	800
0	0	0	0	0	0	0
2	0	0	0	0	20	40
4	20	25	35	50	100	100
6	50	75	75	100	100	100
8	100	100	100	100	100	100



**Fig. 1.** Effect of post harvest ethrel spray on change in peel chlorophyll content and total carotenoids content in pulp during ripening of mango fruits.



**Fig. 2.** (A) Effect of post harvest ethrel spray on physiological loss in weight, (B) change in firmness, (C) TSS and (D) titrable acidity during ripening of mango fruits.

and uniform ripening compared to untreated fruits. Similar results were reported by Singh and Janes (2001) in mango and Mahajan *et al.* (2008) in winter guava fruits during ripening process caused by ethylene application.

**Fruit firmness:** Fruit firmness is one of the most widely used indicators of fruit quality. It influences appearance, texture and consumer acceptability of fresh fruits. Various industries use firmness tests as part of their quality control procedure (Jackson and Harker, 1997). The rapid decline in fruit firmness (shear force) values were recorded from 8.5 Kg/cm<sup>2</sup> at 0 day to 0.68 and 0.96 Kg/cm<sup>2</sup> in 800 and 600 ppm ethrel treated fruits, respectively at full ripe stage of 4 days (Fig 2B). Acceptable quality characteristics of Dashehari mango were considered as pulp firmness of 0.96 to 0.31 Kg/cm<sup>2</sup>. Firmness value of less than 0.31 Kg/cm<sup>2</sup> were indicative of over ripe fruits (Fig. 1B). Firmness of fruits decreased at faster rate in treated

fruits with increase in ethrel concentration could be due to enhance activity of polygalactouronase and pectin lyase enzymes result into breakdown of insoluble protopectin into soluble pectin or by cellular disintegration leading to membrane permeability (Brinston *et al.* 1988; Ali *et al.*, 1995; Yashoda *et al.*, 2006). In control fruits, firmness of fruits decreased slowly from 8.5 Kg/cm<sup>2</sup> at 0 day to 4.56 Kg/cm<sup>2</sup> at 4<sup>th</sup> day of storage. Similar results were obtained by Mohamed and Goukh (2003) in mango, Kulkarni *et al.*, (2011) in banana.

**TSS and total titrable acidity:** TSS increased with increase in the concentration of ethrel during ripening. The TSS of pulp during ripening increased from 8.5° B (Brix) to 22.73° B in 400 ppm, 23.23° B in 600 ppm and 23.56° B in 800 ppm ethrel treated fruits at the end of 8 days storage. In unsprayed fruits, the change in TSS content in the pulp was steady and reached to a maximum of 18.42° Brix after 8 days of storage (Fig

2C). The increase in TSS of fruit pulp could be due to the breakdown of starch into soluble sugars. The results indicated that the conversion of starch into sugars was rapid in ethrel treated fruits than in untreated fruits. This could be due to the rapid induction of pre-climacteric and climacteric phases and onset of climacteric peak in respiratory metabolic pathways in starch hydrolysis (Marriot, 1980). Total titratable acidity reduced in all fruits irrespective of treatment though reduction of acidity is more pronounced in ethrel treated fruits compared to control (Fig. 2D). The decline in acidity on ripening of fruits appears to result, at least in part, from the conversion of acids into sugars and their derivatives and their further utilization in metabolic process i.e. respiration in the fruit. These findings are in the line with the reports of Yashoda et al. (2006) in Alphonso mango, Mahajan et al., (2008) in winter guava fruits treated with 750 ppm aqueous solution of ethrel and Kulkarni et al., (2011) in banana treated with 500 ppm ethrel who reported the similar results.

**Ripening of fruits:** For initial 2 days the fruits remained hard and green in all the treatments except 600 and 800 ppm ethrel treatments where 20 and 40% fruits are ripened (Table 1). However, on fourth day there was dramatic increase in ripening of fruits and highest ripening percentage (100%) of mango fruits was observed after 4 days with ethrel 600 ppm and 800 ppm while lowest was in control fruits (20%). After 6 days, 100% ripening takes place in 400 ppm ethrel treated fruits while in control only 50% fruits were ripened. Similar results were obtained by Mahajan et al. (2010) in ethrel treated banana fruits. The improvement in ripening of ethrel treated fruits is due to multifunctional nature of ethylene which coordinates expression of genes that are responsible for a variety of processes, including a rise in respiration and activities of ACC synthase and ACC oxidase, autocatalytic

ethylene production and changes in color, texture, aroma and flavor (Kader and Mitcham 1994).

**Cost of ripening:** Ripening cost was calculated as Rs. 0.13-0.40 per kilogram fruits for the best treatment i.e. 600 ppm ethrel spray which was lowest among all ripening methods in guava.

## Conclusion

Post harvest spray of mature Dashehari mango fruits with aqueous solution of ethrel (600 ppm) followed by air drying, packing in CFB boxes and storage at room temperature ensures faster and uniform ripening in 4 days with development of uniform attractive yellow colour, desirable firmness and consumer acceptability. This method may be adapted by the growers and small traders as replacement to calcium carbide treatment for ripening.

## ACKNOWLEDGEMENTS

Authors are grateful to Director, ICAR-CISH, Lucknow for his keen interest, constant encouragement and support during the course of investigation.

## REFERENCES

- Ali, Z.M.; Armugam, S. and Lazan, H. (1995). Beta-Galactosidase and its significance in ripening mango fruit. *Phytochemistry*, 38 (5) 1109-1114
- Anonymous (2014). Indian Horticulture Database, National Horticulture Board, Ministry of Agriculture and Farmers welfare. pp. 91
- Brinston, K., Dey, P.M., John, M.A and Pridhan J.B. (1988). Post-harvest changes in *Mangifera indica* mesocarp walls and cytoplasmic polysaccharides. *Phytochemistry*, 27: 719-723
- Dhall, R.K. and Singh, P. (2013). Effect of Ethephon and Ethylene Gas on Ripening and Quality of Tomato (*Solanum lycopersicum* L.) during Cold Storage. *Journal of Nutrition and Food Science*, 3: 1-7
- Gupta, B.P., Singh, M.K., Kumar, M., Malik, S., Prakash, S., Singh K.V. and Rao, S. (2015). Ripening and post-harvest quality of Dashehari mango as influenced by different physico- chemical treatments during storage. *Hort Flora Research Spectrum*, 4(3): 192-199
- Mohamed, Haithem, E. and Abu-Goukh, A. B .A. (2003). Effect of ethrel in aqueous solution and ethylene released from ethrel on mango fruit ripening. *The Journal of Horticultural Science and Biotechnology*, 78(4): 568-573
- Hossain, M.S., Akhtar, S. and Anwar, M. (2015). Health hazards posed by the consumption of artificially ripened fruits in Bangladesh. *International Food Research Journal*, 22(5): 1755-1760
- Jackson, P.J. and Harker, F.R. (1997). Changes in firmness of the outer pericarp, inner pericarp, and core of *Actinidia* species during ripening. *New Zealand Journal of Crop and Horticultural Science* 25: 185-189
- Kader, A. and Mitcham, B. (1994). Optimum procedures for ripening mangoes. *Perishables Handlings Newsletter*, 90:16-17
- Kulkarni, G.S., Kudachikar, V. B. and Keshav Prakash, M.N. (2011). Studies on physico-chemical changes during artificial ripening of banana (*Musa* sp) variety 'Robusta'. *Journal of Food Science and Technology*, 48 (6): 730-734
- Mahajan, B.V.C., Kaur, T., Gill, M.I.S., Dhaliwal, H.S., Ghuman, B.S. and Chahil, B.S. (2010). Studies on ripening behaviour and quality of winter guava with ethylene gas ethephon treatments. *J. Food Sci. Technol.*, 45: 81-84
- Mahajan, B.V.C., Singh G. and Dhatt A.S. (2008). Studies on ripening behaviour and quality of winter guava with ethylene gas ethephon treatments. *Journal of Food Science and Technology*, 45: 81-84
- Marriot, J. (1980). Bananas—physiology and biochemistry of storage and ripening for optimum quality. *CRC Critical Review on Food Science and Nutrition*, 13: 41-88
- Pandey, V., Abhishek Chura, H.K. Pandey and M. Nasim (2015). Estimation of ascorbic acid,  $\beta$  carotene, total chlorophyll, phenolics and antioxidant activity of some European vegetables grown in mid hill conditions of

- western Himalaya. *Journal on New Biological Reports*, 4:238-242
- Ranganna, S. (2000). Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2<sup>nd</sup> edn. New Delhi, India: Tata McGraw Hill Publishing Company Ltd
- Roy, S.K. (1973). A simple and rapid method for estimation of total carotenoids pigments in mango. *Journal of Food Science Technology*, 10: 45-48
- Sheron, O.P; Tonk, D.S; Kaushik, L.S; Hasija, R.C and Panu, R.S (1998). Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics and Computer Applications by D.S. Hooda and R.C. Hasija Department of Mathematics Statistics, CCS HAU, Hisar (139-143)
- Siddque, M.W. and Dhua, R. S. (2009). Standardization of ethrel treatment for inducing ripening of mango var. 'Himsagar'. In Proceedings of International Conference on Horticulture (ICH-2009), Bangalore, 9-12 November pp. 1641-1648
- Singh, P., Sanjay Kumar and Sutanu Maji (2012). Effect of ethrel on post harvest changes in papaya (*Carica papaya* L.) fruits. *Hort Flora Research Spectrum*,1(3):225-230
- Singh, Z. and Janes, J. (2001). Effect of postharvest application of ethephon on fruit ripening, quality and shelf-life of mango under modified atmosphere packaging. *Acta Horticulturae*, 553: 599-601
- Terai, H.Y., Ueda, Y. and Ogata, K. (1973). Studies on the mechanism of ethylene action for fruit ripening. *Journal of Japan Society of Horticultural Sciences*, 42: 75-80
- Venkatesan, T. and Tamilmani, C. (2013). Effect of ethrel on the physiochemical changes of off-season fruits of mango (*Mangifera indica* L. var. Neelum) during ripening. *International Journal of Agricultural and Food Science*, 3(4): 171-175
- Yah, A.R.C., Novelo, S.A., Cortes, J.A and Sauri, E. (1998). The effect of Ethephon on the colour, composition and quality of mango (*Mangifera indica*, cv Kent). *Food Science and Technology International*, 4(3): 199-205
- Yashoda, H.M., Prabha, T.N. and Tharanathan, R.N. (2006). Mango ripening: changes in cell wall constituents in relation to textural softening. *Journal of Science, Food and Agriculture*, 86(5):713-721