Indian Journal of Agricultural Sciences **81** (11): 1082–6, November 2011

Response of Royal Delicious to the post-harvest treatment of Smart fresh (1-MCP) under ambient storage*

SANDEEP K CHAUHAN

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230

Received: 13 October 2010; Revised accepted: 23 May 2011

Key words: Ambient storage, Post-harvest treatment, Royal delicious, Smart fresh (I-MCP)

In India apple (*Malus domestica* Borkh.) is the most important fruit of Himalayan region comprising Himachal Pradesh, Jammu and Kashmir and Uttrakhand. Despite spectacular progress made in the area and production, it is estimated that 20–30% of the total production is lost during the post-harvest handling period due to lack of proper handling and storage facilities. With the ever-increasing demand for good quality fruits, which are free from fungicides and pesticides residues, the growers are forced to produce quality fruit, especially after the removal of restrictions on international trade. In the absence of highly capital-intensive handling infrastructure like pre-cooling, refrigerated transport and controlled atmospheric storage, growers will have to depend upon on alternative, simple and low-cost technique till such facilities are created. Harvested apples are highly perishable as a result of which there is rapid deterioration in fruit quality, making them unmarketable within a short span of time.

These fruits fetch lower prices in the markets which has a direct influence on the growers income. Harvested apples are living structures and continue to respire and carry out most of the metabolic processes that were predominant before harvest. Once the fruit is detached from its source of metabolites, nutrients and water, losses in these constituents that occur during respiration and transpiration are not made up and senescence is initiated. Therefore, it is essential to reduce these losses by adopting suitable handling procedures at post-harvest level. In order to overcome these postharvest losses, many storage methods have been developed and used successfully for different commodities including apples. However, some of these methods are highly capital-intensive and beyond the reach of a majority of the growers, whereas some other methods require certain facilities which are not available in or near orchard. An alternative method to reduce spoilage and enhance storage quality during storage includes application of fumes of the 1-MCP (Mir *et al* 2001) in a closed air sealed chamber before storage at ambient or low temperature (0 ± 1^oC). Apple is a climacteric fruit shows considerable variation in physico-chemical changes as a result of which the fruit that reaches the consumer is usually in an over-ripe stage. Such fruits also show marked losses in quality during storage. In order to overcome this severe problem of immediate ripening after ripening due to autocatalytic production of ethylene Samrt fresh is believed to act on the same site of ethylene receptor and binds the ethylene at molecular lavel, therefore inhibiting ethylene dependent ripening in apple.

Treating fruits with 1-MCP holds promise as it can be done immediately after harvest of fruits without the use of sophisticated equipments. This method is a low cost technique and the orchardist can adopt it with very little investment. This approach is commercially adopted in USA, Australia, Israel and most of the European countries and needs to be popularized in India as well.

The present study was undertaken in the Department of Postharvest Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2006–07 and 2007–08. To conduct the experiment apple fruits were procured from commercial orchards situated in apple growing areas of Shimla and Kinnaur districts of the state. Freshly harvested fruits were transported from the above locations to the Department of Post-harvest Technology for the application of Smart fresh (1-MCP) treatments and evaluating its response during refrigerated storage. During 2006–07–08 fruits were procured from four sites (Jubbal, Kinnaur–2006–07, i e Site 1 and 2 and Jubbal, Kinnaur 2007–08, i e Site 3 and Site 4) After receiving the fruits in the laboratory, entire lot of fruits were divided into two lots having 600 fruits/lot. 1-methylcyclopropene (1-MCP) was applied as a postharvest treatment in the form of vapours by dissolving the requisite quantity of Smart fresh powder in water in a glass jar and immediately placing it inside an

*Short note

Scientist (e mail: sandeep.chauhan@ rediffmail.com), BGIR, MoEF Noida

airtight polyethylene chamber containing fruit samples in plastic crates.Fruits were taken out of the treatment chamber 24 hr after the start of the treatment and packed in corrugated fibre board (CFB) cartons with paper moulded trays as a cushioning material and stored under ambient conditions. Fruit quality was evaluated after 14, 21and 28 days of storage under ambient conditions.

Data on total soluble solid (TSS) content of apple as affected by post-harvest treatment of 1-MCP are presented in Table 1 (Site 1 and 2). A perusal of data reveals that TSS contents of fruits irrespective of sites in general, increased as the storage periods progressed up to 21 days and there after followed a declining trend during subsequent storage at ambient condition. After analyzing fruits of site 1, highest mean TSS (13.06ºB) was recorded in response to 1-MCP (280mg) whereas, the lowest mean TSS (12.59ºB) was recorded in response to untreated fruits. On the other hand in Site 2 (Table 1) fruits highest mean TSS (13.47ºB) was recorded in response to 1-MCP(280mg) whereas, the lowest mean TSS (13.17ºB) was recorded in response to control fruits. Similarly, in Site 3(Table 2) fruits a perusal of data reveals that TSS contents, in general, increased as the storage periods progressed up to 28 days and there after followed a declining trend during subsequent storage at ambient condition. Highest mean TSS (14.04ºB) was recorded in response to 1-MCP (560 mg), whereas, the lowest mean TSS (12.78ºB) was recorded in response to control fruits. Whereas the TSS contents of fruits harvested from Site 4 (Table 2) recorded highest mean TSS (13.87ºB) in response to 1-MCP (560 mg) whereas, the lowest mean TSS (12.77ºB) was recorded in response to content fruits.

Table 1 Effect of post harvest treatment of Smart fresh (I-MCP) on the TSS(Degree Brix), fruit firmness(lbs/inch), acidity(%) and starch iodine rating of Starking Delicious apples stored at ambient storage and harvested from Site 1 and 2

	Site 1 Mean Value for 21 days storage at ambient storage			
Treatment	TSS(B)	Fruit firmness	Acidity (%)	Starch iodine rating
Control	12.59	10.81	0.62	7.92
1-MCP	13.06	13.88	1.04	6.39
Initial value	12.01	15.01	1.24	3.25
CD (*P*=0.05)				
T	0.01	0.03	0.01	0.02
I	0.03	0.04	0.02	0.03
TXI	0.06	0.17	0.03	0.07

	Site 1 Mean Value for 21 days storage at ambient storage			
Treatment	TSS	Fruit firmness	Acidity	Starch iodine rating
Control	13.17	13.31	0.52	6.86
1-MCP	13.47	13.35	0.74	5.50
Initial value	12.40	15.11	1.10	3.75
CD (*P*=0.05)				
T	0.02	0.01	0.04	0.11
I	0.03	0.02	0.06	0.12
TXI	0.09	0.03	0.27	0.45

Table 2 Effect of post-harvest treatment of Smart fresh (I-MCP) on the TSS (Degree Brix), fruit firmness (lbs/inch), acidity(%) starch iodine ratting and juice yield (%) of Starking Delicious apples stored at ambient storage and harvested from Site 3 and 4

	Site 3 Mean Value for 21 days storage at ambient storage				
Treatment	TSS	Fruit firmness	Acidity	Starch iodine rating	Juice yield
Control	12.78	10.65	0.25	6.36	58.11
1-MCP (280g)	13.98	14.71	0.36	5.11	63.39
1-MCP (560g)	14.04	14.73	0.41	4.91	63.91
Initial value	12.50	16.96	1.10	4.91	62.44
CD (*P*=0.05)					
T	0.02	0.01	0.04	3.25	62.11
I	0.03	0.02	0.05	0.08	0.02
TXI	0.06	0.03	0.27	0.57	0.04

	Site 4 Mean Value for 21 days storage at ambient storage				
Treatment	TSS	Fruit firmness	Acidity	Starch iodine rating	Juice yield
Control	12.77	11.54	0.27	6.93	52.10
1-MCP (280g)	13.40	14.51	0.36	5.17	61.74
1-MCP (560g)	13.87	14.84	0.40	4.97	62.79
Initial value	12.57	18.07	0.76	3.25	58.44
CD (*P*=0.05)					
T	0.02	0.01	0.04	0.05	0.04
I	0.03	0.02	0.06	0.08	0.05
TXI	0.07	0.04	0.28	0.54	0.27

Physiological changes are expected to be slower with treated fruits since 1-MCP is directly involved in lower downing ripening processes (Fan *et al.* 1999). Increase in the TSS content in apple fruit during storage has previously been reported to be due to hydrolysis of polysaccharides and dehydration of fruit (Fidler *et al.* 1973, Jawanda *et al.* 1978, Gross and Sams, 1984, Miszeak 1995, Suni *et al.* 2000). On complete hydrolysis of starch, no further increase occurs and subsequently a decline in these parameter is predictable as sugars along with organic acid (malic acid) act as primary substrates for respiration (Otles 1993). Higher value for TSS under these treatments could be due to maintenance of cell wall integrity for longer duration thereby retarding ripening and senescence related process (Singh *et al.* 2000).

Data pertaining to the effect of post-harvest treatment of

1-MCP on fruit firmness at various storage intervals is depicted in Table 1 (Site 1). The data reveals gradual decrease in fruit firmness under all treatments with a progressive increase in storage durations up to 28 days at ambient storage conditions. It is evident from the data that the fruits treated with 1 MCP exhibited the lowest decline in fruit firmness, thereby retaining highest mean fruit firmness (13.88 lbs/inch^2). However the lowest mean value of 10.81 (lbs/inch^2) was recorded in response to control fruits. Whereas fruits from Site 2 depicted same trend thereby retaining highest mean fruit firmness (13.35 lbs/inch^2). However the lowest mean value of 13.31 (lbs/inch^2) was recorded in response to control fruits. Similarly TSS in fruits from Site 3 (Table 2) also showed same trend and the data reveals gradual decrease in fruit firmness under are treatments with a progressive increase in storage durations up to 28 days at ambient storage conditions. It is evident from the data that 1 MCP (560 mg) exhibited the lowest decline in fruit firmness, thereby retaining highest mean fruit firmness (14.73 lbs/inch^2). However, the lowest mean value of 10.65 (lbs/inch^2) was recorded in response to control fruits. Whereas, TSS in fruits from Site 4 (Table 2) reveals that 1 MCP (560 mg) exhibited the lowest decline in fruit firmness, thereby retaining highest mean fruit firmness (14.84 lbs/inch^2). However, the lowest mean value of 11.54 (lbs/inch^2) was recorded in response to control fruits. Retention of relatively high firmness under these treatments, especially under treated fruits could be due to slower metabolic activities because of creation of modified atmosphere and efficacy of 1-MCP in blockening the the cell wall degradation due to pectin (Watkins *et al.* 1999). The present findings are in conformity with the findings of Ben-Arie *et al.* (1979), Wills *et al.* (1980), Ozdemir (1996), Lim *et al.* (1998) and Hwang *et al.* (1998)

Data pertaining to the effect of post-harvest treatment of 1-MCP on titratable acidity (TA) (Site 1 and 2) at different storage interval are presented in Table 1. A perusal of the data reveals that titratable acidity (TA) content, in general, followed a decline trend under treated and untreated fruits, however, fruits treated with 1-MCP showed a slower decline and therefore, retained higher TA. Same trend was observed in fruits from both the sites. In site 1, highest T.A content was (1.04) levels as compare to control fruits where significantly lowest mean TA content (0.62) was recorded and in Site 2 fruits treated with 1-MCP showed a slower decline and therefore, retained higher TA (0.74) levels as compare to control fruits where significantly lowest mean TA content (0.52) was recorded. Whereas among fruits from Site 3 fruits treated with 1-MCP (560 mg) showed a slower decline and therefore, retained higher TA (0.41) levels as compare to control fruits where significantly lowest mean TA content (0.25) was recorded, whereas among fruits from Site 4, 1-MCP (560 mg) showed a slower decline and therefore, retained higher TA (0.40%) levels as compare to control fruits where significantly lowest mean TA content (0.27%) was recorded.A gradual decline in titratable acidity contents observed with the advancement of storage periods under both all treatments. These changes were, however, slower under treated fruits The faster rate of decline in acidity in control fruits could be due to the faster rates of metabolism leading to earlier ripening and senescence changes and such changes have been reported by (Stein 1986). Among these metabolic reactions, respiration is an important process, which may utilize organic acids as a substrate for the production of energy resulting in decrease in the acidity levels during prolonged storage (Sonkar and Ladaniya 1999). Similar decrease in titratable acidity contents during storage of apple fruits at different temperature have also been reported by earlier workers (Ulrich 1974). The reported higher acidity during storage in fruits treated with 1-MCP is the direct consequence of the lower degradation of malic acid in treated fruits and minor weight loss in treated fruits is associated with lower metabolism linked to lower respiration (Fan *et al.* 1999).

The influence of treatments on starch-iodine rating of fruits at various storage intervals is represented by the data presented in Table 1 (Site 1 and 2). The increase in the numerical values for starch-iodine rating with an increase in storage duration indicate that their was a gradual and continuous decline in the starch content of fruits, but the decline was slower in fruits treated with 1-MCP. On the other hand decrease was faster in untreated fruits. Fruits from site1 reveals that mean reduction (6.39) in starch content was recorded in fruits treated 1-MCP, whereas, maximum mean reduction (7.92) was recorded in response to untreated fruits. On the other hand fruits from Site 2 reveals significantly minimum mean reduction (5.50) in starch content in fruits treated 1-MCP, whereas, maximum mean reduction (6.86) was recorded in response to untreated fruits.

Whereas it was revealed form the fruits of Site 3 higher concentration of (I-MCP) retained adequate starch level (4.91) in comparison to control fruits (6.36). Similarly, starch content in fruits from Site 4 reveals that higher concentration of I-MCP retained 4.97 starch rating in comparison to untreated fruits in which loss of starch content was higher (6.93) Minimum increase in starch-iodine rating was observed in fruits from higher concentration of 1-MCP, followed by its lower concentration, indicating that these treatments resulted in minimum loss of starch. Such an affect may be attributed to slower ripening changes as the metabolism of fruits can be expected to be slower when the fruits are treated and stored in conditions which are not conducive to enhance ripening. Hardisty (1975) reported that starch-iodine test was best to indicate the quantity of starch in apple. Panovo (1975) considers the decrease in starch content to be a good indicator of the degree of maturation. The loss of starch in apple fruit during storage may be due to its hydrolysis to sugars (Wills *et al.* 1980).

Data pertaining to the juice yield (%) from fruits, as effected by post-harvest treatment of 1-MCP at various storage interval is presented in Table 2 (Site 3 and 4).From the data, it is evident that there was a slight and significant decrease in mean juice yields. The decrease in juice yield (Site 3) was more pronounced in untreated fruits, where minimum juice content (58.11%) was recorded, whereas fruit treated with 1-MCP (560 mg) resulted in retaining maximum mean juice yield (63.91%). Whereas in Site 4 the decrease in juice yield was more pronounced in untreated fruits, where minimum juice content (52.10%) was recorded, whereas fruit treated with 1-MCP (560 mg) resulted in retaining maximum mean juice yield (62.79%). Higher juice recovery under higher concentration of 1-MCP can be attributed to the lower moisture losses under ambient conditions . The juice recovery under treated fruits may be higher as transpiration losses can be expected to be lower under 1-MCP since the juiciness is positively influenced because the cells of senescent apples bind the liquids of fruits preventing the release. Smart fresh delaying the senescence of fruits keeps them more Juicy (Mir *et al.* 2001). Since then various other workers have also observed initial increase in juice content of different fruits before recording decrease during extended storage (Sullivan and Enzie 1959, Singh and Mohammed 1997).

SUMMARY

Efficacy of Smart fresh (I-MCP) were evaluated as a post-harvest treatment in order to enhance the storage quality of apple cv. Starking Delicious. Freshly harvested fruits were treated with the fumes of 1-MCP in a closed polyhouse of 4 m^3 for 24 hr. It was immediately followed by placing fruits under ambient storage condition and the fruits were analysed after 14,21 and 28 days of storage under ambient storage condition . Fruits treated with 1-MCP retained all the important constituents, viz fruit firmness, acidity, TSS, starch over the untreated fruits. Fruits from Site 1 when treated with lower concentration of Smart fresh (280mg) significantly retained almost almost all the quality attributes of apples at ambient storage in 28 days storage. Similarly, in Site 3,4 treated apple higher concentration of Smart fresh (560g) retained better quality characteristics than the lower concentration of Smart fresh and untreated fruits. In addition of this fruits harvest from Site 2 and 4 (Kinnaur) retained better storage quality characteristics in comparison to Site 1and 2.

REFERENCES

Ben-Arie R., Kislev N and Frenkel C. 1979. Ultrastructural changes in the cell wall of ripening apple and pear fruits. *Plant Physiology* **64**: 197–202.

Fidler J C , Wilkinson B G, Ednex K L and Sharples R O. 1973. Respiration rate in climacteric fruit research review. *Communication Agricultural Bulletin* **19**: 30–45. England.

Gross K C and Sams C E. 1984. Changes in the cell wall neutral sugar composition during fruit ripening. A special survey. *Phytochemistry* **23**: 2457–61.

Hardisty S E. 1975. How to pick apples at the right time. *Him. Hort.*, **18**(1-4): 52–5.

Hwang Y S, Kim Y A and Lee J C. 1998. Effect of postharvest application of chitosan and wax, and ethylene scrubbing on quality changes in stored 'Tsugaru' apples. *Journal of Korean Society of Horticultural Science* **38**(5): 579–82.

Jawanda J S, Singh R and Vij V K. 1978. Studies on extending postharvest life of Kinnow mandarin. *Punjab Horticulture Journal* 149–53.

Lim B S, Choi S, Lee C S, Kum Y B and Moon B W. 1998. Effect of wax-F coating on keeping quality, CO_2 and ethylene evaluation in 'Tsugaru' apple during room and low temperature storage. *Journal of Horticulture Science* **40** (1): 96–101.

Mir NA, Curell E, Khan N , Whitakar M and Beaudry RM .2001 . Harvest maturity , storage temperature and 1-MCP application frequency after firmness retention and Chlorophyll florescence of Red Chief Delicious apples . *Journal of American Society of Horticulture Science* **126** (5): 618–24

Miszeak A. 1995. Effect of pro-long treatments on quality of stored apples. *(in) Proceedings of International Symposium*. Postharvest Treatment of Horticulture Crops, 30 August-3 September. 1993, Hungary.

Otles S. 1993. The sugar composition of apples (*Malus sylvester* var. *domestica*). *Rijkusuniversitert Gentics* **57**(1): 51–4.

Ozdemir A E, Kaskan N, Ayar I T and Dumdar O. 1996. Effect of Semperfresh treatments on the post harvest physiology of cold stored apples II Golden Delicious. *Turkey Journal of Agriculture and Forestry* **19**(1): 11–5.

Panovo R. 1975. Changes in the flesh consistency and starch content in the fruit of some apple cultivar during ripening. *Gradinarska i lozerska Nauka* **12**: 32–40.

Ranganna S. 1986. *Handbook of Analysis and Quality Control of Fruit and Vegetable Products*. 2nd edn. Tata McGraw Hill Pub. Co., New Delhi.

Singh, U B and Mohammed S. 1997. Comparative efficacy of wax emulsion and rice starch on post harvest shelf life of fully ripe guava fruits. *Journal of Food Science and Technology* **34**(6): 519–22.

Singh Dinesh , Thakur R K and Singh D. 2003. Effect of pre harvest sprays of fungicides and calcium nitrate on post harvest rot in low temp. strage. *Plant Diseases Research* 9. 10

Sonkar R K and Ladaniya MS. 1999. Individual film wrapping of Nagpur mandarin with heat stretching film for refrigerated storage. *Journal of Food Science and Technology* **36**(3): 273–6.

Stein E R. 1986. Juice quality of stored polyethylene seal-packed grape fruit. *Rao Grande Valley Horticulture Society* **39**: 273–6.

Sullivan D T and Enzie J V. 1959. The expressible juice content of Richard and Jonared apples as related to respiration rate, soluble solids content and firmness. *Proceedings of American Society of Horticulture Science* **63**: 43–9.

Suni M, Nyman M., Eriksson N A., Bjork L and Bjork I. 2000. Carbohydrate composition and content of organic acids in fresh and stored apples. *Journal of Food Science and Agriculture* **80**(10): 1538–44.

Ulrich R. 1974. Organic acids. (*in*) *Biochemistry of Fruits and Their Products*, pp 89–118. Hulme A C (Ed.). Academic Press, New York.

Wills R B H., Bembridge P Aand Scott K J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apple. *Australian Journal of Experimental Agriculture and Animal Husbandry* **20**: 252–6.

Fan X Matthesi J P and Blankship S.1999. Development of apple superficial scald, soft scald, core flush, and greesiness is reduced by I-MCP. *Journal of Agriculture and Food Chemistry* **47**: 3063–8.

Watkins CB, Nock JF and Whitaker BD. 1999. Responces of early, mid and late seasons apple cultivars to postharvest applications of 1-MethylCyclopropene (1-MCP) used air and controlled atmosphere storage conditions. *Post Harvest Biology and Technology* **19**: 17–23.