International Journal of Food Science and Nutrition
ISSN: 2455-4898, Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 2; Issue 4; July 2017; Page No. 156-162

Post-harvest treatments for extension of mango fruit var. Dashehari (*Mangifera indica* L.)

[1] Jay Prakash Thakur, [2] Padam Prakash Gothwal, [3] Iboyaima Singh

[1, 2] Correspondence CSIR-Central Food Technological Research Institute, Resource Centre, Lucknow, Uttar Pradesh, India
[3] Department of Fruit and Vegetable Technology, CSIR-CFTRI Mysore, Karnataka, India

Abstract
Experiments were conducted to study the effects of post-harvest treatment of mango fruits (cv.Dashehari) on the extension of shelf life at two different storage temperatures (Cold store and ambient condition). The mango fruits were harvested at defined physiological maturity stage from a well-managed commercial mango orchard at Malihabad, Uttar Pradesh. The fruits were washed adequately and subjected to 6 treatments with different combinations of fungicide solutions with control viz.Carbendazim (500ppm) + Tween 80 (0.01%) (Treatment 1; T_1), Hexanal (250 ppm) + Tween 80 (0.01%) (Treatment 2; $T_{2)}$, Hexanal (500 ppm) + Tween 80 (0.01%) (Treatment 3; T_3), Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%) (Treatment 4; T_4), Hexanal (500 ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%) (Treatment 5; T_5) and distilled water (Treatment 6; T_6). The fruits of various treatments were loosely packed in corrugated fibreboard boxes and were kept under ambient conditions (37 ± 2°C; 55–65% RH) and cold storage conditions (12 ± 2°C; 80–85% RH) and the physiological and biochemical parameters changes during storage were measured at regular interval of days till the fruits get deteriorated. The total soluble solids, reducing sugar, total sugar and total carotenoids were found increasing trend whereas total acidity, ascorbic acid and physiological loss in weight were found linearly decreasing during the ripening. The fruits treated with Hexanal (500 ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%) (T_5) were observed superior in respect to pre-ripening quality attributes. The treatments retarded the physico-chemical changes feasible for manifestation of ripening quality features and certainly helped considerably in delaying the ripening. This has profoundly notified the extended storage life of Dashehari mango. The observations on physicochemical changes and sensorial quality parameters were used as ripening and shelf life monitoring indices. Therefore, using the application of combined treatment with Hexanal, Carbendazimand tween 80 of mango at 10°C to 12°C is a feasible technology for maintainingfruit quality and prolonged storage life in order to expand marketability and export opportunities.

Keywords: mango, dashehari, postharvest, treatment, carbendazium, hexanal

Introduction
Mango *(Mangifera indica* L.*)* fruit belongs to the family of Anacardiaceae and is known as "king of fruits" [1]. It is nutritious; having an excellent exotic flavor, attractive fragrance, and delicious taste [2].In India, mango is a very important cultural and religious symbol [3]. The area under mango cultivation and production have both increased manifold in the past three decades, but expected productivity is very low when compared to other Countries. However, trade of mango has been limited by the perishable nature of this fruit which is susceptible to extremes of temperature and physical injury and due to postharvest losses of mango fruits accounting to 25–40% annually worldwide [4]. Uttar Pradesh ranked second in case of area coverage of mangoes, but stood first in production and productivity, having production and productivity 3823.22 thousand tones and 15.56 tonnes per hectares, respectively during 2013-14 [5]. Dashehari is one of the choicest commercial cultivars of mango grown in Northern India with an annual production of 0.68 million tonnes, which has good flavour and excellent processing qualities [6]. Mango fruits suffer from having a brief shelf-life and post-harvest deterioration problems as a result of post-harvest disease, insect infestation, and over-rapid ripening [7]. Although mango fruit are susceptible to chilling injury (CI), refrigerated storage of mango is needed to slow deterioration [8]. Refrigeration has also been shown to be an effective method to prolong the shelf life of mango fruit, without causing CI, at temperatures above 13ºC [7,9]. In addition, refrigeration combined with the post-harvest application of chemicals such as pesticides or fungicides [10], polyamines [11], or a combination of 2% (w/v) CaCl2 + 6% (w/v) waxol + 0.1% BavistinTM, a fungicide [12], can extend the shelf-life and reduce deterioration by delaying the ripening and/or successfully controlling post-harvest diseases in mango fruit. Hexanal, an inhibitor of phospholipase D, has been successfully applied for the pre- and postharvest treatment of fruits, vegetables and flowers [13]. The antimicrobial activity against decomposing microbial species of hexanal was already tested in model as well as in real systems [14]. The efficacy of hexanal as a metabolizable organic fungicide and the improvement of the aroma production by the inter conversion to other aroma volatiles in minimally processed apples [15]. Indeed, it positively overwhelmed the shelf life by reducing the growth of natural occurring pathogen population during storage at 4°C and 15°C [16]. In addition, hexanal is commercially approved safer food additive as stated by the U.S. food and drug administration [17]. Susceptibility of mango fruit to postharvest diseases increases after harvest and prolonged storage as a result of physiological changes in the fruit, favouring pathogen development [18]. Major postharvest fruit quality threats include anthracnose, stem end rot and soft nose [19, 20]. Postharvest management of mango fruits is one of the major challenges faced by mango industry [21].Carbendazim (methyl-2-benzimidazole carbamate), a systemic fungicide, is commonly used to control post harvest diseases like

anthracnose and stem end rot of mango through either pre harvest spray [22] or post harvest spray and dip in hot fungicidal solution [23,24]. However, most of the works reported on post-harvesttreatment for extension of shelf life of mangoes are mainly on the popular and commercial varieties viz. alphanso, totapuri, banganapalli, etc. Similar studies for northern Indian mango like Dashehari are scanty in the literature. With this background the present study was therefore taken up with the objective to observe the behavioural pattern of physicochemical properties of postharvest mango fruits cv. Dashehariatdifferent storage conditions. We investigated to find out anefficient technology for reduction of postharvest losses and thereby extension of shelf life of Dashehari mangoes by optimizing the different physical-chemical treatments at different storage temperatures.

Materials and methods

Harvesting and pre-treatments of Mangoes:

Fruits at 80% maturity along with the stalk (1cm length) were harvested from the trees, brought to the laboratory and de-sapped. Only healthy firm fruits were selected. Fruits, which showed partial yellowing, and softness (suspected of fruit fly infestation) were discarded. The fruits were graded, washed thoroughly in running cold water containing 0.01% detergent, drained and then they were subjected to the following six post-harvest treatments. There were 18 fruits of uniform size in each lot for treatments.

1. T1 = Carbendezim (500ppm) + Tween 80 (0.01%)
2. T2 = Hexanal (250 ppm) + Tween 80 (0.01%)
3. T3 = Hexanal (500 ppm) + Tween 80 (0.01%)
4. T4 = Hexanal (250 ppm) + Carbendezim (500ppm) + Tween 80 (0.01%)
5. 5. T5 = Hexanal (500 ppm) + Carbendezim (500 ppm) + Tween 80 (0.01%)
6. T6 = Distilled water (T6).

The treated fruits were packed in export quality CFB box. Two lots of such packed materials were prepared and kept in perforated plastic crates. One lot of these was stored at room temperature (37.15-39.25°C and 55.50-65.00% RH) and the other lot stored in a cold room at 12°C with 80.0-85.0% RH. The above treatments were replicated three times and each replication consisted of 50 numbers of fruits. The periodical observations on various physicochemical parameters like firmness, colour, loss in weight etc. were made and all the observations of the fruits under cold storage were determined at 10 days interval starting from the date of harvesting till the end of storage. Observation of mango fruits which were kept at room temperature was taken at 5 days interval starting from the date of harvesting. Fruits were weighed on the first day of treatment and their weights were recorded.

Physico-chemical parameters

Physiological loss in weight

To estimate thephysiologicalloss in weight (PLW), initial weight of fruits under each treatment was measured replication wise at the time of storage and final weight was also measured at the end of storage and expressed the loss in percentage of initial

Weight basis

Changes in physical and sensory characteristics of mango during storage were assessed with respect to appearance, colour, texture (hand feel), taste, flavour and overall quality by a panel of judges as per the methods given by [25].

Total Soluble Solids

The total soluble solids (TSS) of fruits were recorded with the help of Erma hand refractometer.

Acidity

Total titratable acidity, ascorbic acid, total sugars and reducing sugars were analyzed as per methods stated by [26].

Carotenoids

Total carotenoids in pulp was extracted (by repeated extraction) with acetone (3:2, v/v) and petroleum ether (60-80°C) according to the method of Roy [27]. Each of the estimations was done in triplicate.

Result and discussion

Changes in Firmness

Change in firmness or softness is the indication of fruit ripening. Delaying in softening of fruit is the one of the objectives to extend the shelf life of fresh produces. As the days of storage are increased the firmness of the fruits decreased as shown in Table 1. The fruits could be stored upto 25-27 days without getting over soft at cold storage as compared to 15 days at ambient temperature.

Table 2: Sensory quality (texture) of Dashehari mango fruits

Treatments	Cold storage (12°C)							Ambient storage (39°C)			
	0th day	5th day	10th day	15th day	20th day	25th day	27th day	0th day	5th day	10th day	15th day
T1	H	H	F	SS	ES	OS	OS	H	H	ES	OS
T2	H	H	F	SS	ES	OS	OS	H	H	ES	OS
T3	H	H	F	SS	ES	OS	OS	H	H	ES	OS
T4	H	H	F	SS	ES	OS	OS	H	H	ES	OS
T5	H	H	F	SS	ES	OS	OS	H	H	ES	OS
T6	H	H	SS	SS	ES	OS	OS	H	H	OS	OS

H=Hard, F=Firm; SS=slightly soft, ES= Edible soft, OS= Over soft

This trend was attributed to the fact that the ripening of mango fruit is characterized by loss of firmness due to cell wall digestion by pectinesterase, olygalacturonase, and other enzymes and this process was increased by the increase in storage temperature [28].

Changes in colour

The decrease in green colour was the most obvious change in mango ripening and was attributed to an increase in carotenoids pigments during the storage (Table 2).

Table 2: Sensory quality (colour) of Dashehari mango fruits

Treatment	Cold storage (12°C)							Ambient storage (39°C)			
	0th day	5th day	10th day	15th day	20th day	25th day	27th day	0th day	5th day	10th day	15th day
T1	G	G	LY	LY	Y	DY	DY	G	G	Y	DY
T2	G	G	LY	LY	Y	DY	DY	G	G	Y	DY
T3	G	G	LY	LY	Y	DY	DY	G	G	Y	DY
T4	G	G	LY	LY	Y	DY	DY	G	G	Y	DY
T5	G	G	LY	LY	Y	DY	DY	G	G	Y	DY
T6	G	G	LY	LY	Y	DY	DY	G	G	DY	DY

G; Green, LY; Light yellow; Y; Yellow, DL; Dull yellow

The principal agent responsible for colour variations may be the oxidative system, pH change and enzymes like chlorophyllases [29, 30]. The colour changes were lowest at cool store and highest at room temperature.

Changes in weight

Physiological loss in weight (PLW) is one of the prime parameters indicating the ability of the fruits to retain its freshness during storage. Our data clearly demonstrated that that there was a sharp increase in physiological loss in weight of fruits stored at room temperature whereas, the increase in PLW was found to be very slow in fruits stored in Cold Store (Fig. 1). The low temperature and high humidity prevalent in cool storage might have brought about the reduction in PLW by reducing the moisture loss through decrease in respiration rate and transpiration as well delaying in ripening due to restricted ethylene accumulation in the treated fruits. These results are in line with the observations as reported by [29, 30] in mature green Alphanso. Patel [31] reported that the physiological loss in weight in mango could be decreased by pre-cooling treatment. It is quite interesting to note that hexanal formulation is more beneficial to retain the fresh-ness of fruits especially under ambient storage conditions. Our data are in agreement with Yaptenco *et al.* [32] reported PLW of vegetables are low when they are transported under refrigerated conditions. The data also closely coincided with the reported literature on temperate fruits where they elucidated the physiological mechanismssuch as inhibition of phosphor-lipase-D and slowing down ethyleneevolution that may have contributed for the shelf-life extension of tropical fruits like mango [33]. The exogenous application of hexanal slows down the lipogenases in the skin of the fruits which would have assisted in delayed ripening processes and lower PLW.

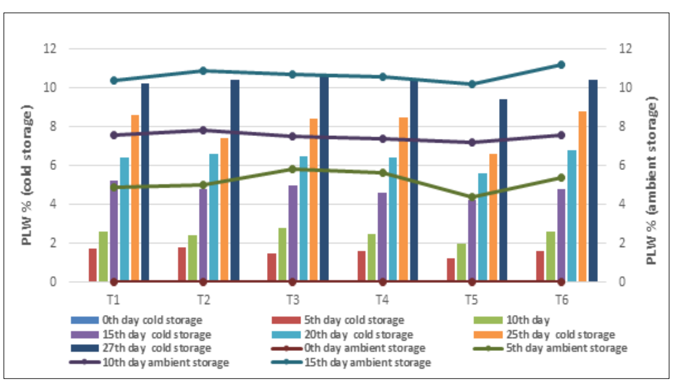

Fig 1: Mean physiological loss in weight (%; PLW) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

The lower PLW values recorded in treated fruits closely coincided with the retentionof firmness which is likely to be a physiological effect rather than physical alteration caused by turgor changes. Consequently, the observed changes may be due to increased fruit cell wall biosynthesis and membrane preservation [33]. Our data are in agreement with the observations of Barman and Asrey [34] that have attributed higher firmness with lower activities of pectinmethyl esterase and polygalacturonase due to suppressed ethylene production in cold storage along with salicylic acid treatments.

Changes in Total soluble solids (TSS)

The rate of increase in TSS was found to be faster in fruits stored at room temperature as compared to cool stored fruits (Fig. 2).

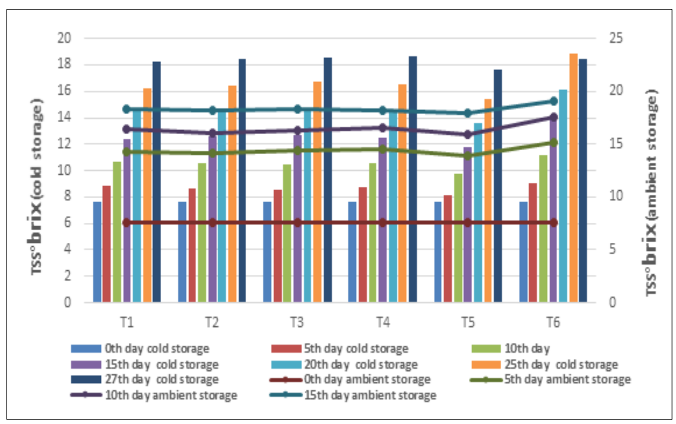

Fig 2 : Mean total soluble solids (°brix; TSS) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

The increase in TSS was the outcome of conversion of carbohydrates into simple sugars through a complex mechanism during the storage and the conversion rate was increased with the increase in temperature. This conversion is also considered to be one of the important indexes of ripening process in mango and other climacteric fruit [29, 30, 35, 36].The TSS and sugars were further utilized for respiration thus showing the lower content in fruit tissues. Prolonged storage of mango fruits at low temperature with high humidity in cool storage might be impeded the ripening process resulting in lower values of TSS. The observations are in line with the findings, reported by Joshi and Roy [37] at room temperature storage andin cool storage condition of mango fruits [38, 39, 40, 41].

Changes in Acidity

The acidity of the fruit was the highest at zero days of storage and it decreased with the advancement of storage period (Fig.3). It may be due to rapid utilization of acid of the fruit pulp in respiration process and degradation of citric acid which in turn might have influence on reduction in acidity due to their conversion into sugars and further utilization in metabolic process in the fruit [29, 42, 43].

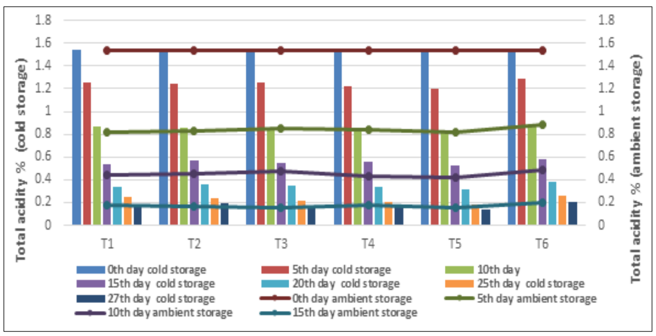

Fig 3: Mean total acidity (%) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

The rate of decrease in acidity was found to be faster in room temperature stored fruits as compared to cool stored fruits. This could be associated with the higher rates of respiration since acid forms the necessary respiratory substrate for this catabolic process in fruits. Badar [44] reported similar observations in mango under different storage conditions.

Changes in Sugar contents

Both reducing and total sugar content showed increasing trend during storage period (Fig. 4 and 5). This may be a consequence of release of sugar during starch hydrolysis and liberating reducing sugars [45]. The accumulation of reducing sugar and total sugar were slow and gradual in fruits stored in cold storage 8ºC. The higher value of total sugar and reducing sugar due to arrested respiration in ambient stored fruits. It can also be observed that reducing sugars and total sugar content were reduced in the later period of storage. This may be due to their rapid utilization in respiration. The low temperature in cool storage reduces fruit metabolism, particularly respiratory activity, delaying the ripening process and increasing fruit shelf life up to two weeks [46]. The observations are in line with the findings, reported by Joshi and Roy [37] at room temperature storage and Kapse *et al.* [47] and Krishnamurthy and Joshi [40] in cool storage condition of mango fruits.

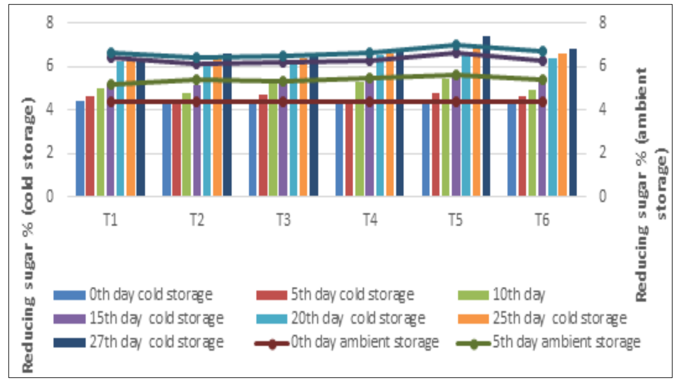

Fig 4: Mean reducing sugar(%) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

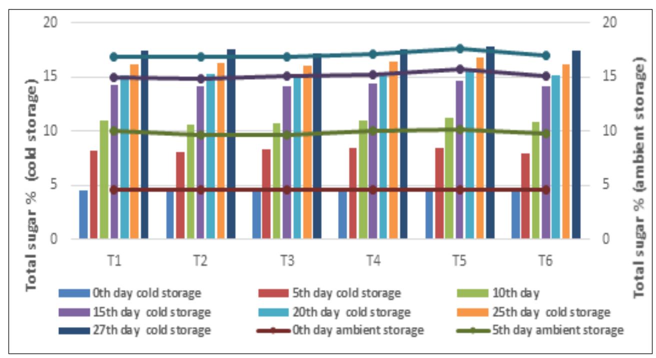

Fig 5: Mean total sugar (%) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

Changes in Ascorbic acid

A gradual decline in ascorbic acid content of the fruits was observed during storage in all the treatments (Fig. 6). This might be due to rapid loss through oxidation because of greater availability of oxygen. The loss in ascorbic acid during storage might be due to rapid conversion of L-ascorbic acid into dehydro-ascorbic acid in the presence of enzyme ascorbinase [48]. The best retention of ascorbic acid in cool storage as compared to ambient temperature storage could be attributed to prevalence of low temperature and high relative humidity. The finding is in conformity to the observations as reported by Keleny *et al.* [49] during cool chamber storage of mango fruits.Trivedi and Desai [50] reported similar observation in guava.

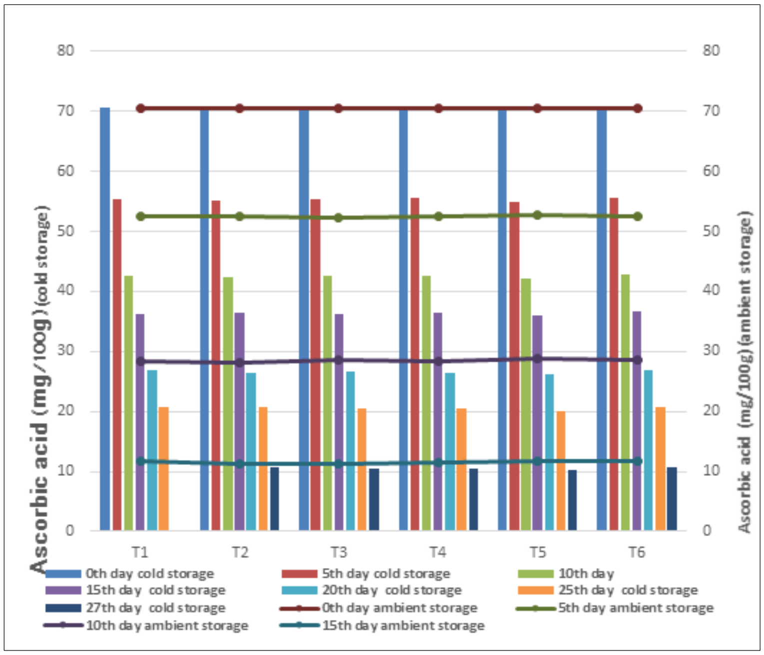

Fig 6: Mean ascorbic acid (mg/100g) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold(bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

Changes in Carotenoid contents

The analysis of the harvested fruit indicated that the total carotenoids were increased with the harvest stage or storage temperature during the ripening process (Fig. 7). During the ripening process, the transition of chlorophyll into carotenoids, biochemical conversions of starch into sugar, insoluble protopectin into pectin and loss of organic acid through oxidation are responsible for the increase in sugar and carotenoids [51, 35, 52].

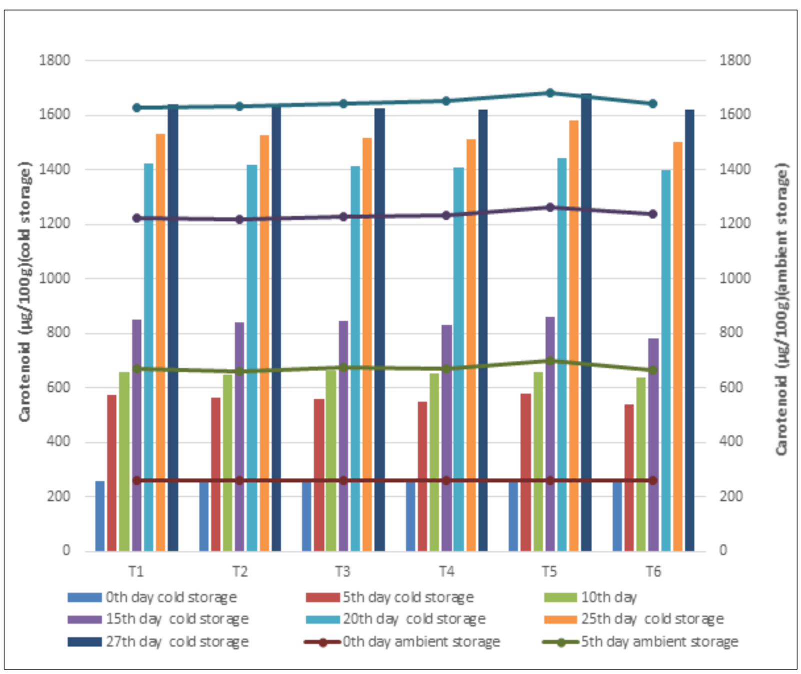

Fig 7: Mean carotenoid (µg/100g) of Dashehari mango fruits after treatment with Hexanal and Carbendazim stored under cold (bar graph; primary axis) andambient(line graph; secondary axis) storage conditions (n=3).

T1=Carbendazim (500ppm) + Tween 80 (0.01%), T2= Hexanal (250 ppm) + Tween 80 (0.01%), T3= Hexanal (500 ppm) + Tween 80 (0.01%), T4= Hexanal (250 ppm) + Carbendazim (500ppm) + Tween 80 (0.01%), T5= Hexanal (500ppm) + Carbendazim (500 ppm) + Tween 80 (0.01%), and T6= distilled water.

Conclusions

The main objective of the investigation was to determine the extension of shelf life of the Dashehari mango (*Mangifera indica* L.) which is popular in the Northern India.The overall observation indicated that all the mango fruits under investigation were found to be of good quality in terms of appearance or colour, softness and consumer acceptanceat both the storage conditions. However, the fruits stored in cold storage (12ºC) were found to be fresh, firm, glossy in appearanceand attractive as compared to those stored at ambient temperature. The results of the interaction effect of different postharvest treatments were found to be significant in terms of most of the physicochemical properties and shelf life.Thepostharvest treatment of matured mangoes with the solution of hexanal 500 ppm along with 500 ppm of carbendezimcould extendthe maximum shelf life up to 27 days after storage. Therefore, 500 PPM solution of hexanal andcarbendezim was found to be the best method for preservation and delay ripening of mango. This post-harvest treatment method could be easily adopted for extending the shelf life of Dashehari mangoes.

Acknolegement

The authors are thankful to Director CSIR-CFTRI for constant encouragement and enormous support. Research fellowship received by one of the authors (JPT) from CSIR is duly acknowledged.

References

1. Nunes CN, Emond JP, Bredcht JK, Dea S, Prooulx E. Quality curves for mango fruit stored at chilling and non-chilling temperatures. Journal of Food Quality. 2007; 30: 104–120.
2. Pal RK. Ripening and rheological properties of mango as influenced by ethrel and calcium carbide. Journal of Food Science and Technology Mysore. 1998; 35:358-360.
3. Litz RE. The mango botany, production and uses. 2nd ed. Wallingford CAB International. 2009; 10.1079/9781845934897.0000.
4. Pathak VN. Diseases of fruit crops. 1st Ed. New Delhi: Oxford & IBH Publishing Company. 1980.
5. National Horticulture Board, Ministry of Agriculture, Government of India, 85, Institutional Area, Sector 18, Gurgaon, 2012-2013.
6. Pruthi JS. Simple innovations in mango processing technologies. Indian Food Packer. 1992; 46(5):45-55
7. Mitra SK, Baldwin EA. Mango in Postharvest Physiology and Storage of Tropical and Subtropical Fruits.CAB International, New York, NY, USA. 1997; 85-122.
8. Ketsa S. Storage of tropical fruit in Thailand. JIRCA International Symposium Series. 1995; 3:75-79.
9. Phakawatmongkol W, Ketsa S, Doorn WG. Variation in fruit chilling injury among mango cultivars. Postharvest Biology and Technology. 2004; 32:115-118.
10. Muller AT, Burt JR. Post-harvest storage control of mango stem-end rot with fungicidal dips. Australian Journal of Experimental Agriculture. 1989; 29:125-127.
11. Malik AU, Singh Z. Pre-storage application of polyamines improves shelf-life and fruit quality of mango. Journal of Horticultural Science Biotechnology. 2005; 80:363-369.
12. Waskar DP, Gaikwad RS. Effect of various postharvest treatments on extension of shelf-life of Kesar mango fruits. Indian Journal of Agricultural Research. 2005; 39:95-102.
13. Tiwari K, Paliyath G. Microarray analysis of ripening-regulated gene expression and its modulation by 1-MCP and hexanal. Plant Physiol Bio Chem. doi:10.1016/j.plaphy.2011.01.007. 2011; 49:329-340.
14. Gardini F, Lanciotti R, Caccioni DRL, Guerzoni ME. Antifungal activity of hexanal as dependent on its vapor pressure. J Agric Food Chem.doi:10.1021/jf970347u. 1997; 45:4297-4302
15. Song J, Leepipattwit R, Deng W, Beaudry R. Hexanal vapor acts as residueless antifungal agent that enhances aroma biosynthesis in apple fruit. ActaHortic. doi:10.17660/actahortic.1998.464.31. 1998; 464:219-224.
16. Lanciotti R, Gianotti A, Patrignani F, Belletti N, Guerzoni M, Gardini F. Use of natural aroma compounds to improve shelf-life and safety of minimally processed fruits. Trends Food Sci. Techol. doi:10.1016/j.tifs.2003.10.004. 2004; 15:201-208.
17. Thavong P, Archbold DD, Pankasemsuk T, Koslanund R. Hexanalvapors suppress spore germination, mycelial growth and fungal derived cell wall degrading enzymes of postharvest pathogens of longan fruit. Chiang Mai J Sci. 2011; 38:139-150.
18. Eckert JW, Ratnayake M, Sievert JR, Strange RR. Curing citrus fruit to control postharvest diseases. In: Proceedings of VIII Congress of the International Society of Citriculture. Sun City, South Africa. 1996, 48.
19. Jeffries P, Dodd JC, Jeger MJ, Plumbley RA. The biology and control of *Colletotrichum* species on tropical fruit crops. Plant Pathol.1990; 39: 343-66.
20. Crane JH, Campbell CW. The Mango. Florida Cooperative Extension Service, Inst. Food and Agric. Sci., University of Florida. 1991.
21. Amin M, Malik AU, Mazhar MS, Din I, Khalid MS, Ahmad S. Mango fruit desapping in relation to time of harvesting. Pak. J. Bot., 2008; 40(4):1587-1593.
22. Om Prakash, Pandey BK. Control of mango anthracnose by hot water and fungicidal treatment. Indian Phytopathology. 2000; 53:92-94.
23. Sharma IM, Badiyala SD. Effect of post-harvest fungicidal sprays against stem end rot of mango fruit in storage caused by *Botrayodiplodia theobromai* pest in Himachal Pradesh. Indian Journal of Mycology and Plant Pathology. 1994; 24: 141-42.
24. Bhattacherjee AK, Pandey BK, Om Prakash. Persistence and dissipation of carbendazim residues in mango fruits after pre- and postharvest applications.Journal of Food Science and Technology. 2009; 46:347-49.
25. Amerine MA, Pangborn RM, Roessler EB. Principles of Sensory Evaluation of Food. Academic Press, New York and London. 1965.
26. Ranganna S. Hand book of analysis and quality control for fruit and vegetable products, 2nd Ed. Tata McGraw-Hill

Publishing Co. Ltd, New Delhi. 1986; 12-16, 83-89
27. Roy SK. A simple and rapid method for estimation of total carotenoids pigments in mango. Journal of Food Science and Technology. 1973, 10:45.
28. Narain N, Bora PS, Narian R, Shaw P, Mango. In: Shaw, P.E, Chan, H.T, Nagy, S. Eds. Tropical and Subtropical Fruits. Agr. Science, Inc., Auburndale, FL, 1998, 1-77.
29. Doreyappy-Gowda IND, Huddar AG. Studies on ripening changes in mango *Mangifera indica* L. fruits. Journal of Food Science and Technology Mysore. 2001; 38:135-137.
30. Doreyappy G, Huddar AG. Studies on ripening changes in mango fruits. J Food Sci.Tech. 2001; 38:135-137
31. Patel UA. Effect of post harvest treatments on storage behavior of hybrid mango *Mangifera indica* L Cv. Amrapali and Neelphonso. M.Sc. (Agri.) thesis, Navsari Agricultural University, Navsari, Gujarat. 2006.
32. Yaptenco KF, Agravante JU, Esguerra EB, Serrano EP. A case study on refrigerated and refrigerated transport of highland vegetables from Benguet to Manila. Quality Assurance in Marketing of Fresh Horticultural Produce, PHTRC-FRLD, PICC, Pasay City, 2001; 96(1)55-65.
33. Sharma M, Jacob JK, Subramanian J, Paliyath G. Hexanal and 1-MCP treatments for enhancing the shelf life and quality of sweet cherry Prunusavium L. Sci. Hort. 2010; 125:239-247.
34. Barman K, Asrey R. Salicylic acid pre-treatment alleviates chilling injury, preserves bioactive compounds and enhances shelf life of mango fruit during cold storage. J. Sci. Indus. Res. 2014; 73(11):713-718.
35. Kays SJ. Post harvest Phys. of Perishable Plant Products. Vas Nostr and Rein Hold Book. AVI Publishing Co. 1991; 149-316.
36. Kittur FS, Saroja N, Habibunnisa N, Tharanathan RN. Polysaccharide-based composite coating formulations for shelf-life extension of fresh banana and mango. European Food Research and Technology. 2001; 213:306-311.
37. Joshi GD, Roy SK. Effect of integrated post harvest handling on biochemical changes in Alphonso mango fruits. Progr Hort. 1985; 17:56-63
38. Kapse BM, Rane DA, Salunkhe DK, Khedkar DM. Sensory evaluation of different varieties of mango during storage.Indian Food Packer. 1985; 39:43-48
39. Gole RS. M.Sc. AgrL Thesis submitted to KKV, Dapoli M.S. 1986.
40. Krishnamurthy S, Joshi SS. Studies on low temperature storage of Alphonso mango. J Food Sci.Tech. 1989; 26:177-180
41. Patil MN. M.Sc. Agricultural Thesis submitted to KKV, Dapoli M.S. 1996.
42. Rathore HA, Masud T, Sammi S, Soomro AH. Effect of storage on physico-chemical composition and sensory properties of Mango *Mangifera indica* L. variety Dosehri. Pakistan Journal of Nutrition. 2007; 6:143-148.
43. Srinivasa P, Baskaran CR, Ramesh MN, Prashantand KVH, Tharanthan RN. Storage studies of mango packed using biodegradable Chitosan film. European Food Research and Technology. 2002; 215:504-508.
44. Badar RS. M.Sc. Agricultural Thesis submitted to KKV, Dapoli M.S. 1990
45. Kapse BM. An integrated Approach to post-harvest handling of mango. *Mangifera indica*L. Cultivar Kesar. Ph.D. thesis, G.A.U., S. K. Nagar. 1993.
46. Koksal IA. Research on the storage of pomegranate cv. Gokbahce under different conditions. Acta Hort. 1989; 258:295-302
47. Kapse BM, Rane DA, Salunkhe DK, Khedkar DM. Sensory evaluation of different varieties of mango during storage. Indian Food Packer. 1985; 39:43-48
48. Mapson LW. Vitamins in fruits, stability of l-ascorbic acid. Biochemistry of fruits and their products. 1970; 376-377.
49. Keleny AE, Sahar M, Abdel Wahab, AbdelHafeez AA, Usman. M.T. Using modified atmosphere and different storage temperature for storing Kent mango fruits. J Hort Sci Ornamen plants. 2010; 2(1):46-56
50. Trivedi YV, Desai MM. Effect of different storage techniques and conditions on quality and shelf life of guava fruits. 2006.
51. Campestre C, Marsilio V, Lanza B, Iezzi C, Bianchi G. Phenolic compounds and organic acids change in black oxidized table olives. ISHS Acta Hort. 586: IV International Symposium on Olive Growing. ISBN: 2002; 978- 90-66057-56-2.
52. Martinez BE, Guevara CG, Contreras JM, Rodriguez JR, Lavi U. Preservation of mango Azucar variety *Mangifera indica* L. at different storage stages: Proceedings of the fifth international mango symposium. 1997. Tel Aviv, Israel, 1996; 2: 747–754.