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Pre-harvest treatments for shelf-life extension of *Khasi* mandarin under different storage conditions

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ABSTRACT

Mishandling and decay due to mold growth cause significant post harvest losses of *khasi* mandarin in India. The types of decay and severity are, however, dependent on the climate, varieties, agricultural practices, pre and post-harvest handling practices etc. An experiment was conducted with pre harvest sprays of carbendazim 0.1 per cent and a mixture of *Pseudomonas fluorescens* and *Bacillus subtilis* (10% v/v) to the immature fruits of *Khasi* mandarin twice during August and September at an interval of 30 days. Uniformly matured fruits from the treated plants were harvested during last week of December and stored in three different storage conditions, *viz*. ambient condition, evaporative cool chamber and cold storage. The pre-harvest treated fruits stored in cold storage showed no decay loss till 30 days of storage as against 9.57 per cent decay loss in the fruits without pre-harvest treatment under the same condition. Likewise, decay loss in pre-harvest treated fruits stored in evaporative cool storage was also much lower than the fruits stored at ambient condition on 30th day of storage. The shelf-life of 30 days was recorded in the fruits treated with carbendazim 0.1 per cent at ambient conditions as against 20 days without treatment in the same storage condition.

Key words: *Khasi* mandarin, pre-harvest sprays, shelf-life, quality.

INTRODUCTION

Among various citrus fruits grown in India, Mandarin occupies a prominent position and accounts for over 50 percent of the citrus area. *Khasi* mandarin, the delicious among all the citrus fruits is principally grown in North-eastern region of India. The total citrus production in NE region (2009-10) is 4.03 lakh tonnes from an area of 0.87 lakh ha. with a productivity of 4.63 t/ha against the national productivity of 9.84 t/ha. Due to the adoption of faulty post harvest management system a bulk quantity of the fruits gets damaged during the process of handling, transportation and marketing. A recent study conducted by Assam Agricultural University, Jorhat reveals that the post harvest loss of mandarin in Assam is about 13.95 per cent (Deka *et al*., 4). This loss is due to improper harvesting, rough handling, shriveling, weight loss, absence of packaging systems and inadequate storage facilities. Moreover, the fruits are harvested either in immature or in improper stage which further reduces the shelf life of the mandarin besides its edible quality. The fruits also loose their fresh appearance and market value due to decay at different stages of marketing. The loss in marketable quality of mandarin due to post harvest decay is a major factor for the economic losses faced by traders and consumers.

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Post harvest decay due to green and blue mold caused by *Penicillium digitatum* (Pers.) Sacc. and *P. italicum* Wehmer, respectively, cause significant loss of *Khasi* mandarin. The types of decay and severity are, however, dependent on the climate, varieties, agricultural practices, pre and post-harvest handling practices etc. Kinay *et al.* (10) reported that green and blue mold incidence of *satsuma* mandarin after harvest during storage was inhibited by pre-harvest treatments containing benomyl. Pre-harvest foliar application of organic sprays reduced the rotting significantly in potato during storage (Ravichandran *et al*., 13). Pre-harvest spraying of carbendazim at 0.1% or benomyl at 0.1% or thiophanate methyl [methyl-thiophanate] at 0.1% or captan at 0.2%, ten days before the harvest of *ber* fruits effectively reduced post-harvest rotting (Mani *et al*., 11). Keeping these facts in view, the present study was conducted to study the effect of pre-harvest treatments on post-harvest decay and shelf-life of *Khasi* mandarin in different storage environments.

MATERIALS AND METHODS

Fifteen years old *Khasi* mandarin orchard managed by Citrus Research Station, Assam Agricultural University, Tinsukia was selected for the study. Carbendazim 0.1 per cent and a mixture of *Pseudomonas fluorescens* and *Bacillus subtilis* (10% v/v) were sprayed to the immature fruits twice during August and September at an interval of 30

days. The uniformly matured fruits were harvested in the first week of December from the previously treated fruits and were graded in the laboratory by removing undersized, oversized, insect damaged and deformed ones with physical injuries.

Uniform size fruits were washed with tap water and air dried. The fruits were then grouped into three lots *i.e*. i) Pre-harvest spraying with 0.1% Bavistin, ii) Pre-harvest spraying with the mixture of *Pseudomonas fluorescens* and *Bacillus subtilis* (10% v/v), and iii) No spray or control. From each of the above treatments the fruits were further sub divided into three lots each. One lot of the fruits from each of the above treatments was stored in ambient conditions (17.4-20.88°C), another lot was stored in Evaporative Cool Chamber (14.86-17.1°C) and the third lot was stored in cold storage (7 ± 1°C). The evaporative cool storage structure was a semi-underground chamber designed and developed at Assam Agricultural University, Jorhat (Goswami *et al.*, 7).

Shelf-life of *khasi* mandarin was determined based on the visual and textural qualities of the produces by a panel comprising of five members, using the methodology of Bhowmik and Pan (2). The fruits were considered unmarketable when the score for visual quality was found less than 5. Physiological weight loss (PWL) was determined by weighing them every other day and expressed as percent of initial. The decay loss was recorded at a periodical interval and the cumulative decay loss was found out. The rate of respiration of the fruits was measured by using portable oxygen analyzer (Model No. 101, Nucon Engineers). The depleted oxygen concentration was recorded after two hours of incubation and the respiration rate was calculated and expressed as mg/kg/h.

For TSS and titratable acidity, the fruit segments were crushed after removing the seeds and the pulp was homogenized in a blender at 2000 rpm for 1 min. and then filtered. The TSS was determined by placing 2-3 drops on a temperature-compensated refractometer. The titratable acidity was measured in aliquots of 10 ml of juice by titration with 0.1 N NaOH using phenolphthalein as an indicator (Ranganna, 12). Sugars were estimated by following the method of Lane and Eynon as described by Ranganna (12). Ascorbic acid was determined by 2,6-dichlorophenol indo-phenol visual titration method. The experimental design was completely randomized. The data were analysed by ANOVA and the significance among treatment mean values was determined by least significant difference (LSD) at the P = 0.05 or 0.01 levels.

RESULTS AND DISCUSSION

A significant difference was recorded in the physiological loss in weight (PLW) of fruits under pre-harvest treatments and storage conditions (Table 1). PLW was lowest in the fruits with pre-harvest spray of 0.1 per cent carbendazim followed by those treated with biological agent and with no treatment. Data presented in the Table 1 also revealed that the PLW was only 1.10 per cent in cold room as against 10.8 and 8.22 per cent in ambient conditions and evaporative cool storage, respectively on 30th day of storage under the pre-harvest treatment of carbendazim 0.1 per cent.

Lower PLW in cold storage and in evaporative cool chamber might be due to lesser water vapour deficit compared to ambient condition (Hardenburg *et al.*, 8), thereby causing minimum loss of moisture. Modified atmosphere produced inside the sealed wrap slowed down the physiological metabolism; especially respiration that reduced the weight loss.

An impressive result was observed in regards to decay loss (Table 1). The fruits sprayed with 0.1 per cent carbendazim showed a significant reduction in decay loss during storage as compared to the fruits without pre-harvest treatments. The decay loss was also significantly affected by storage environment. The pre-harvest treated mandarin fruits stored in cold storage showed no decay loss till 30 days of storage as against 9.57 per cent decay loss in the fruits without pre-harvest treatment under the same condition. Likewise, decay loss in pre-harvest treated fruits stored in evaporative cool storage was also much lower than the fruits stored at ambient condition on 30th day of storage.

Higher decay loss with no pre-harvest treatment at ambient condition might be due to the continuous transpiration and respiration which made the produces prone to microbial spoilage caused by fungi, bacteria, yeasts and moulds (Desai *et al*., 5). Shelf-life of *Khasi* mandarin fruits stored at different storage conditions was determined based on visual and textural qualities of the fruits (Figs. 1&2). The fruits with no pre-harvest treatment reached the level that limited the marketability on 20th day of storage at ambient condition as against 30th day of storage with 0.1 per cent carbendazim under same storage condition. The fruits with pre-harvest application of 0.1 per cent carbendazim remained fresh with maximum score for both visual and textural quality till 30th day of storage in cold storage. The shelf-life of fruits was also much higher in evaporative cool storage.

The longer shelf-life of the produces stored in evaporative cool storage was attributed to the lower temperature coupled with higher relative humidity

Table 1. Physiological loss in weight (%), decay loss (%) and change of respiration rate (mg/kg/h) of *Khasi* mandarin during storage.

Treatment	Ambient condition					Evaporative cool chamber					Cold room				
	7th day	11th day	20th day	30th day	mean	7th day	11th day	20th day	30th day	mean	7th day	11th day	20th day	30th day	mean
PLW (%)															
Carbendazim (0.1%)	6.81	8.01	9.10	10.8	8.68	1.51	4.38	7.70	8.22	5.45	0	0	0.74	1.10	0.92
Biological agent	5.15	9.12	9.80	16.8	10.22	1.78	5.90	8.62	10.02	6.58	0	0	1.20	1.80	1.50
Control	7.66	11.22	15.06	25.37	14.83	3.86	7.32	11.12	16.38	9.67	0	0	2.80	3.44	3.12
CD at 5%	Day	Storage		Treatment		Day × storage		Day × treatment			Storage × treatment		Day × storage × treatment		
	0.01934	0.015		0.0145		0.034		0.034			0.26		0.058135		
Decay loss (%)															
Carbendazim (0.1%)	0.00	0.00	6.30	24.00	12.46	0.00	0.00	2.71	11.42	6.87	0.00	0.00	0.00	0.00	0.00
Biological agent	0.00	3.40	11.20	40.00	19.26	0.00	1.34	8.46	30.00	15.36	0.00	0.00	0.00	2.85	1.14
Control	8.33	33.13	48.00	62.11	44.31	1.45	21.12	41.00	45.18	33.79	0.00	0.00	0.00	9.57	4.12
CD at 5%	Day	Storage		Treatment		Day × storage		Day × treatment			Storage × treatment		Day × storage × treatment		
	0.088	0.069		0.069		0.153		0.153			0.119		0.266		
Change of respiration rate (mg/kg/h)															
Carbendazim (0.1%)	2.88	3.16	5.15	7.12	4.20	2.88	3.10	6.04	6.50	5.07	1.15	1.44	2.20	2.28	0.00
Biological agent	5.32	6.01	7.80	8.22	7.13	4.30	5.74	6.50	7.00	6.15	1.15	1.85	2.22	3.22	2.41
Control	5.86	6.34	6.90	8.84	7.92	5.12	5.80	6.40	7.70	6.76	1.42	2.25	3.81	3.86	3.32
CD at 5%	Day	Storage		Treatment		Day × storage		Day × treatment			Storage × treatment		Day × storage × treatment		
	0.022	0.017		0.017		0.0389		0.0389			0.030		0.067		

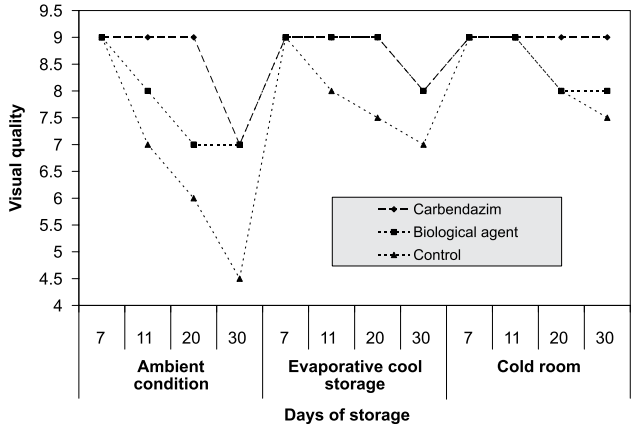

Fig. 1. Visual quality of *Khasi* mandarin under different storage environments.

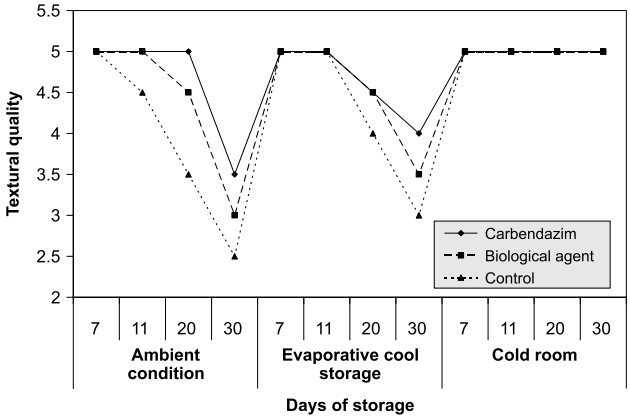

Fig. 2. Textural quality of *Khasi* mandarin under different storage environments.

recorded in the structure, which reduced the rate of different metabolic activities of the produces. Similar results were also observed by Goswami *et al*. (7) in different fruits and vegetables, Baviskar *et al.* (1) in *ber*, and Wasker and Gaikwad (15) in pomegranate.

Fruits treated with pre-harvest spraying of 0.1 per cent carbendazim recorded the lowest rate of respiration as compared to the fruits with no treatments. The rate of respiration was slower in the fruits kept in cold room as compared to evaporative cool storage and ambient condition irrespective of post harvest treatments (Table 1).

The reduced rate of respiration might be due to lower infection of fruits by the moulds. Gane (6) also reported that respiration rate increased with increase in temperature. However, the *Khasi* mandarin stored in evaporative cool storage recorded lower rate of respiration compared to the ambient condition. The results are in corroboration with the findings of Waskar (14) in banana fruits. This was due to the fact that in evaporative cool storage, the plastic crates containing *Khasi* mandarin fruits were covered with a polythene sheet which might had trapped the CO_2 evolved during storage, thereby creating a modified atmosphere.

Data presented in the Table 2 revealed that the different treatments had significant effect on the TSS and sugar content of the fruits. An increasing trend in TSS and sugar content (both reducing and total) was observed with the increase in storage period irrespective of treatments. However, pre-harvest treated fruits with 0.1 per cent carbendazim resulted in lower and slower accumulation of TSS and sugar (both reducing and total) during storage as compared to the fruits with no treatment and biological agent.

The slower accumulation of TSS and sugar during storage might be due to slower degradation of metabolites. The present findings were in conformity with that of Tarkase and Desai (13) in orange cv. Mosambi and Waskar *et al.* (16) in pomegranate. The rate of change of TSS and sugars of fruits stored in cold storage and evaporative cool storage was lower than the fruits stored at ambient conditions. Low temperature storage is considered to be the most effective method for maintaining the quality of most fruits and vegetables because it retards respiration, ethylene production, ripening, senescence and undesirable metabolic changes and decay (Hardenburg *et al.*, 8).

It was clear from the results (Table 2) that the acidity of mandarin fruits decreased continuously with the progress in storage period regardless of pre-harvest treatments, but the rate of decrease was slower in the fruits with 0.1 per cent carbandezim treatment as compared to control. The retention of ascorbic acid during storage was significantly higher in the fruits with pre-harvest treatment than control. This might be due to the higher rate of respiration since acid is utilized to form the necessary respiratory substrate for catabolic process in fruits. Similar observations were noticed by Bhullar *et al.* (3) in Kinnow mandarin and Waskar *et al*. (16) in pomegranate. Similar trend was also observed in ascorbic acid content. The retention of ascorbic acid during storage was significantly higher in the fruits with pre-harvest treatment than control. This might be due to oxidation of vitamin C in the presence of molecular oxygen by ascorbic acid oxidase.

REFERENCES

1. Baviskar, M.R., Waskar, D.P. and Kaulgud, S.N. 1995. Effect of various post-harvest treatments on shelf life and quality of *ber* fruit. *Indian J. Hort.* **52**: 37-45.

Table 2. Chemical changes of *Khasi* mandarin during storage.

Treatment	Initial	Ambient		Evaporative cool chamber		Cold room	
		20th day	40th day	20th day	40th day	20th day	40th day
TSS (°Brix)							
Carbendazim (0.1%)	10	10.67	11.12	10.12	11.22	10.00	11.10
Biological agent		11.5	11.2	10.88	11.44	10.75	11.70
Control		11.6	10.5	11.12	11.22	11.00	11.75
CD at 5%	Days (D)	Storage (S)	Treat (T)	D × S	D × T	S × T	D × S × T
	0.024	0.029	0.029	0.041	0.041	0.051	0.071
Reducing sugar (%)							
Carbendazim (0.1%)	1.96	3.90	3.92	3.28	3.30	3.11	3.20
Biological agent		3.94	3.98	3.32	3.34	3.10	3.18
Control		3.96	3.96	3.10	3.18	3.00	3.10
CD at 5%	Days (D)	Storage (S)	Treat (T)	D × S	D × T	S × T	D × S × T
	0.008	0.10	0.010	0.014	0.014	0.017	0.024
Total sugars (%)							
Carbendazim (0.1%)	7.12	8.36	8.40	8.20	8.40	7.56	8.40
Biological agent		8.44	8.48	8.36	8.44	7.66	8.40
Control		8.58	8.62	8.68	8.32	7.90	8.60
CD at 5%	Days (D)	Storage (S)	Treat (T)	D × S	D × T	S × T	D × S × T
	0.007	0.009	0.009	0.012	0.012	0.015	0.021
Acidity (%)							
Carbendazim (0.1%)	0.62	0.52	0.58	0.58	0.56	0.62	0.59
Biological agent		0.50	0.56	0.56	0.54	0.60	0.59
Control		0.48	0.54	0.54	0.54	0.60	0.58
CD at 5%	Days (D)	Storage (S)	Treat (T)	D × S	D × T	S × T	D × S × T
	0.004	0.005	0.005	0.007	0.007	0.008	0.0114
Ascorbic acid (mg/ 100 g)							
Carbendazim (0.1%)	26.24	26.12	25.80	26.44	26.00	26.56	26.50
Biological agent		26.00	25.10	26.40	25.56	26.54	26.48
Control		25.56	24.54	25.94	25.00	26.50	26.32
CD at 5%	Days (D)	Storage (S)	Treat (T)	D × S	D × T	S × T	D × S × T
	0.018	0.022	0.022	0.031	0.031	0.037	0.053

2. Bhowmik, S.R. and Pan, J.C. 1992. Shelf-life of mature green tomatoes stored in controlled atmosphere and high humidity. *J. Fd. Sci.* **4**: 984-53.

3. Bhullar, J.S., Farmahan, H.L. and Agnihotri, R.P. 1981. Studies on storage behaviour and extending the shelf life of Kinnow mandarin. *Prog. Hort.* **13**: 115-19.

4. Deka, B.C., Sharma, S., Patgiri, P., Saikia, A. and Hazarika, C. 2004. Post harvest practices and loss assessment of some commercial horticultural crops of Assam. *Indian Fd. Packer*, **58**: 85-87.

5. Desai, U.T., Kadam, S.S. and Salunkhe, D.K. 1986. Post-harvest Handling Storage and Processing of Vegetables. **In**: *Vegetable Crops*,

T.K. Bose (Ed.). Naya Prokash, Calcutta, India, 752 p.

6. Gane, R. 1936. A study of the respiration of bananas. *New Phytl.* **35**: 382-402.

7. Goswami, S., Borah, A., Baishya, S., Saikia, A. and Deka, Bidyut C. 2008. Low cost storage structures for shelf-life extension of horticultural produces. *J. Fd. Sci. Tech.* **45**: 70-74.

8. Hardenburg, R.E., Watada, A.E. and Wang, C.Y. 1990. The commercial storage of fruits, vegetables, florists and nursery stock. *United States Department of Agriculture. Agriculture Handbook* No. 66, 130 p.

9. Kinay, P., Yildiz, F., Sen, F., Yildiz, M. and Karacali, I. 2005. Integration of pre- and postharvest treatments to minimize *Penicillium* decay of Satsuma mandarins. *Postharvest Biol. Tech.* **37**: 31-36.

10. Mani, M.T., Hepziba, S.J. and Siddeswaran, K. 2005. Management of fruit rot disease of *ber.* (*Zizypus mauritiana*) by using fungicides. *Adv. P. Sci.* **18**: 103-4.

11. Ranganna, S. 1986. *Manual of Analysis of Fruit and Vegetable Products*. Tata McGraw Hill Publishing Company Limited, New Delhi.

12. Ravichandran, G., Natarajan, N., Manorama, K. and Vanangamudi, K. 2011. Effect of organic sprays on storage behavior of seed potatoes. *Indian J. Hort.* **68**: 399-407.

13. Tarkase, B.G. and Desai, U.T. 1989. Effects of packaging and chemicals on storage of orange cv. Mosambi. *J. Maharashtra Agric. Univ.* **14**: 10-13.

14. Waskar, D.P. 1989. Studies on storage and ripening of banana (*Musa* AAA group) var. Basrai. Ph.D. thesis, PG School IARI, New Delhi.

15. Waskar, D.P. and Gaikwad, R.S. 2003. Studies on effect of post harvest treatments and storage conditions on shelf life and quality of pomegranate fruits (*Punica granatum* cv. Ganesh). *Indian Fd. Packer*, **57**: 56-61.

16. Waskar, D.P., Khedkar, R.M. and Garande, V.K. 1999. Effect of post-harvest treatments on shelf-life and quality of pomegranate in evaporative cool chamber and ambient conditions. *J. Fd. Sci. Tech.* **36**: 114-17.

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