Original Research Article

Impact of certain fungicides and calcium nitrate on quality and shelf life of kinnow mandarin

ABSTRACT

An experimentwas carried out at Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2019-20 to study the effect of different fungicides and calcium nitrate on quality and shelf life of Kinnow mandarin". Spray of carbendazim, copper oxychloride, mancozeb, propiconazole, nimbecidine, calcium nitrate and their combinations were done ten days prior to harvesting on ten years old Kinnow plants.When compared to fruits from untreated plants, the fruits from plants treated with fungicides, nimbecidine, calcium nitrate, and their mixtures showed much less rotting. The most successful treatment for preventing fruit rot after harvest was carbendazim 0.05% + calcium nitrate 1%, followed by propiconazole 0.05% + calcium nitrate 1%. With various pre-harvest treatments, it was discovered that the TSS, acidity, TSS/acid ratio, reducing sugar, non-reducing sugar, and total sugar of Kinnow fruits were not significantly affected.Among all the treatments, the maximum ascorbic acid content (24.10 mg/100 ml of juice) was reported in mancozeb 0.2% + calcium nitrate 1% andpropiconazole 0.05% + calcium nitrate 1% during storage in Kinnow fruits. The most prominent pathogens associated with decay loss were identified as *Colletotrichum gloeosporioides*, *Diplodianatalensis* and *Penicillium sp.* during storage period.

Key words: Kinnow, decay, shelf life, fungicides and Calcium nitrate

Introduction

Kinnow mandarin (*Citrus nobilis* L. x *Citrus deliciosa* L.) is a leading citrus fruit grown in India. Citrus group belongs to the family Rutaceae. It consists of sweet orange, lime, lemon, mandarin and grapefruit. Dr. H. B. Frost created Kinnow in 1935 as a hybrid of King and Willow leaf mandarins in California. J.C. Bakhshi brought this cultivar to India in 1958 at the Punjab Agricultural University's Regional Fruit Research Station in Abohar. Because of its exceptional fruit quality, outstanding tree vigour, higher potential for cropping, and superior performance to other citrus fruits, Kinnow has become extremely well-liked among producers and consumers. Due to its nutritional benefits, delicious flavour, and refreshing taste, consumers loved Kinnow mandarin fruit. Ascorbic acid, total carotenoids, hesperidins, naringin, hydrocinnamic acid, ferulic acid, and cyaniding glucoside are among the naturally occurring bioactive components found in kinnow fruit (Sogi and Singh, 2001).Citrus fruits are non-climacteric, have a low respiratory rate, and have a lower post-harvest quality of life than climacteric fruits. To prevent a glut on the market following harvest season, it is crucial to keep Kinnow fruits for a long time.Storage has a great influence on fruit texture, colour, aroma and other various physical and biochemical parameters. Various factors have been reported to be associated with post-harvest losses of Kinnow mandarin. There are 20–30% post-harvest losses in Kinnow mandarins that occur during storage as a result of bacterial and fungal contamination on the fruit, improper disease management, poor fruit quality, unfavourable weather, a delay in harvesting, inadequate roads and cold storage facilities, and an abundance of supply in the market (Singh *et al*., 2004). Fruits in orchards may be contaminated from the time they are planted to the time they are harvested, resulting in early fruit loss. An early pre-harvest infection also contributes to post-harvest fruit rotting during storage and transportation under ideal conditions of moisture and temperature (Naqvi, 1993). The most commercially relevant post-harvest diseases of Kinnow mandarin are green mould rot, blue mould rot, stem end rot, and core rot. These diseases all induce post-harvest impairment.Various physiological activities like respiration, ethylene liberation and enzyme were also responsible for limiting the shelf life of fruits (Singh and Mandal, 2006). Fungicides are biological or chemical biocides that are used to eradicate parasitic fungi or their spores. Pre-harvest field application of fungicides is the greatest way to prevent post-harvest fruit rotting since a fungistatic slows their growth (Sharma, 1990). Fungicides applied prior to harvest have been used to lessen the amount of pre-harvest inoculum and consequent post-harvest degradation in a variety of fruits (Blackarski*et al*.,2001).The present study will contribute to understanding the biochemical status of Kinnow mandarin fruits at harvest as influenced by pre-harvest spray of fungicides and calcium nitrates, which may help in increasing the shelf life and quality of Kinnow mandarin.

Material and Methods

The present investigation was conducted during the year 2019-20 in the experimental orchard, Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The objective wasdetermining suitable treatments for better shelf life and quality of Kinnow mandarin. The experiment was laid out in 6×6 Randomized block design comprising 12 treatments *i.e*. Carbendazim 0.05% + calcium nitrate 1% (T1), Carbendazim 0.1% (T2), Copper oxy chloride 0.2% + calcium nitrate 1% (T3), Copper oxy chloride 0.3% (T4), Mancozeb 0.2% + calcium nitrate 1% (T5), Mancozeb 0.3% (T6), Propiconazole 0.05% + calcium nitrate 1% (T7), Propiconazole 0.1% (T8): Nimbecidine 0.0009% + calcium nitrate 1% (T9), Nimbecidine 0.0015% (T10), Calcium nitrate 1% (T11), Control (T12) with three replication. These fungicide combinationswere used because of better results in reviewed articles. Application of the above treatments was done on 5th December 2019 and fruits were harvested on 16th December 2019 with the help of secateurs. Harvested fruits were stored in Corrugated FiberBoxes at room temperature. At room temperature, total soluble solids were measured using a hand refractometer with a range of 0 to 30 °Brix. The assessment of titratable acidity and Ascorbic acid was conducted using the technique recommended by A.O.A.C. (2000).Sugars were estimated by the method suggested by Hulme and Narain (1931).Fruits showing rotting due to over ripening and pathogenic infection were considered as decayed over and weighed on the date of each observation. Fruit decay loss was calculated by dividing the starting fruit weight by the weight of the decayed fruits, and then converting the result to a percentage.Pathogens associated with decay loss will be identified and isolation of organism was made on the Potato Dextrose Agar by infected tissue transplant method according to Richer and Richer (1936).

Results and Discussion

Total Soluble Solids (^{o}Brix)

According to the current study, total soluble solids in Kinnow fruits grew as storage time progressed, but pre-harvest interventions had no discernible impact on total soluble solids. The total soluble solids in Table (1) increased dramatically after storage, which may have been caused by fruit surface moisture loss, the breakdown of complex organic compounds into simpler molecules, or the hydrolysis of starch into sugars(Wills *et al.*, 1980). Secondly increased loss in weight resulted in an increase in concentration of juice. The current study's findings are consistent with those of Kaur and Kumar (2014), who claimed that different treatments had no discernible impact on the total soluble solids content of Kinnow fruits. But as the storage duration extended, the total soluble solids concentration increased.Similar results were obtained by Beniwal*et al.* (2018) in Kinnow, Prakash *et al.* (2014) in pomegranate and Panwar *et al.* (2017) in litchi.

Titratable acidity %

In this experiment,juice acidity of Kinnow fruit decreased with advancement of storage period, whereas various pre-harvest treatments had non-significant effect on acidity during storage period. The maximum acidity (0.82%) was observed on initialday of storage, while the minimum (0.59%) was observed on 49th day of storage (Table 2). The oxidation of organic acid and subsequent use of this acid in metabolic processes may be the cause of the fruit's decreasing acidity trend as storage time increases (Obenland*et al.*, 2011). The results of this study support those of Kaur and Kumar (2014) and Beniwal *et al.* (2018), who found that the acidity of Kinnow fruit juice reduced with increasing storage time and that the effects of the various treatments on the acidity of fruits were non-significant. The results are also in line with the findings of Shiri *et al.*(2011) who observeddecreased acidity with advancement of storage period in grapes.

Total Soluble Solids/acid ratio

The results of this experiment, which are shown in Table (3), show that the TSS/acid ratio of Kinnow fruit with various pre-harvest treatments increased as the storage duration lengthened. The increased TSS/acid ratio over time may be the result of the juice's increased TSS and decreased acidity during storage. These results are in close conformity with the earlier findings of Dhakad*et al.* (2020) in acid lime and Panwar *et al*. (2017) in litchi who showed that TSS/acid ratio increased during storage period.

Ascorbic acid content (mg/100 ml juice)

In the present study (Table 4), the maximum ascorbic acid content of Kinnow fruit (24.1%) was observed in mancozeb 0.2% + calcium nitrate 1% and propiconazole 0.05% + calcium nitrate 1% treatment during the storage period, while the minimum ascorbic acid content (22.8%) was found in control. With increased storage time, the ascorbic acid level of Kinnow fruits reduced.The higher retention of ascorbic acid was found in pre-harvest treatments of fungicides with combinations of calcium nitrate. This may be because calcium nitrate slowed down the oxidation process, which in turn slowed down the rate at which L-ascorbic acid was transformed into de-hydro ascorbic acid. Fruits treated with 1% calcium nitrate may have decreased oxidising enzyme activity, resulting in fruit storage with higher ascorbic acid content. These outcomes corroborated Singh *et al.* (2008)'s findings in ber fruits. Kaur and Kumar (2014) found similar findings, stating that ascorbic acid content declined with increasing storage time and that $CaCl_2$@2% under ambient storage produced the highest ascorbic acid content.

Reducing sugars (%)

A reducing sugar is any sugar that is capable of acting as a reducing agent. In an alkaline solution, a reducing sugar forms some aldehyde or ketone, which allows it to act as a reducing agent.The data presented in Table (5)clear that reducing sugars in fruits were increased with the advancement of storage period irrespective of pre-harvest treatments. Kinnow is a non-climacteric fruit, so no fresh synthesis of reducing sugars takes place. The increase in reducing sugars content during storage might be due to water loss from fruits. These findings closely match those of Beniwal*et al.* (2018), who found that reducing sugars increased with storage time and stated that different pre-harvest fungicide applications had no discernible impact on reducing sugar in Kinnow fruits. Gangle*et al.* (2019) found similar results in guava fruits.

Non-reducing sugars (%)

A non-reducing sugar is a carbohydrate that is not oxidized by a weak oxidizing agent in basic aqueous solution.The data presented in Table (6)show that non-reducing sugars of Kinnowincreased with the advancement of storage period up to 42 days of storage and then decreased because the increase in total sugars content was less as compared to increase in reducing sugars during storage period. As a result of which non-reducing sugars decreased during storage after 42 days of storage. It might be due to utilization of already existing non-reducing sugars in the process of respiration and there was no fresh synthesis of non-reducing sugars. This resulted in a decrease in total non-reducing sugars content.The increase in non-reducing sugars up to 42 days of storage might be due to transformation of polysaccharides into soluble sugars and conversion of certain cell wall compounds like hemicelluloses and pectin into non-reducing sugars. These findings closely align with earlier research by Gangle*et al.* (2019), which found that non-reducing sugars in guava fruits rose as storage time increased.Similar results were obtained by Meena *et al*. (2016) in Nagpur mandarin.

Total sugars (%)

The present study points that the amount of total sugars increased with increase in storage period, whereas the effect of various treatments was found non-significant on total sugarsTable (7). This might be due to increase in loss of moisture and physiological loss in weight which resulted in concentrated soluble sugars. The increase in sugar during storage was probably due to water loss from Kinnow fruits (Ahmed *et al*., 1980). Another reason for increase in the total sugars content might be the transformation of polysaccharides into soluble sugars by increasing enzymatic activity (especially due to the activity of cell wall degrading enzymes) slowly during the entire storage period. These findings closely match those of Beniwal*et al.* (2018), who found that total sugars increased with extending storage time and that different pre-harvest fungicide sprays had no statistically significant impact on total sugars in Kinnow fruits. Similar results were obtained by Gangle*et al*. (2019) in guava, Ganga *et al*. (2019) in acid lime and Sinha *et al*. (2019) in plum fruits.

Decay loss (%)

The data presented in Table (8) clearly indicates that the decay loss was increased with the passage of storage period. Under ambient room conditions, no decay loss was recorded up to seven days of storage. Theminimum decay loss (1.45%)was recorded on 14 days of storage, whereas maximum decay loss (17.13%) was observed on 49 days of storage. The extent of decay was reduced to a great extent by use of fungicides, nimbecidine, calcium nitrate and their combinations. The highest reduction in decay loss was recorded with carbendazim 0.05% + calcium nitrate 1% followed by propiconazole 0.05% + calcium nitrate 1%. Both the treatments were statistically at par with respect to reduction of decay loss.The maximum decay loss was reported in control fruits.The incidence of fruit rot increased during storage because fungicides degraded the fruit'sdefenses against microbial attack were weakened by decreasing the pectin compounds and already present pathogens grew during storage.These results are in close conformity with the earlier findings of Charpe*et al*. (2019) who observed that application of propiconazole @0.1% + citrashine wax @6% was most effective for control of *Colletotrichum* rot of Nagpur mandarin. Similar findings were obtained by Baria*et al*. (2016) in citrus, Ingole*et al*. (2018) in Nagpur mandarin, Beniwal*et al*. (2018) in Kinnow and Rajput *et al*. (2008) in guava fruits.

Pathogens associated with decay loss

The decay percent increases with the advancement of storage period. During storage it was observed that many pathogens were responsible for the decaying of Kinnow fruits. After isolation and identification, it was noticed that *Colletotrichum gloeosporioides, Diplodianatalensis*and *Penicillium* *sp.*were the most prominent fungi on the rotted fruits. These results are in close conformity with the earlier findings of Fatima and Iram, 2019 (*Citrus reticulate* Blanco.) and Parida*et al.*(2020) in orange and wood apple fruits.

Conclusion

The most successful treatment for preventing fruit rot after harvest was carbendazim 0.05% + calcium nitrate 1%, followed by propiconazole 0.05% + calcium nitrate 1%. With various pre-harvest treatments, it was discovered that the TSS, acidity, TSS/acid ratio, reducing sugar, non-reducing sugar, and total sugar of Kinnow fruits were not significantly affected. The two treatments with the highest ascorbic acid content (24.10 mg/100 ml of juice) during storage in Kinnow fruits were mancozeb 0.2% + calcium nitrate 1% and propiconazole 0.05% + calcium nitrate 1%. During the storage period, *Penicillium sp.*, *Diplodianatalensis*, and *Colletotrichum gloeosporioides* were shown to be the most prevalent pathogens linked to decay loss.

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Table 1 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on TSS (^{o}brix) in Kinnow mandarin during storage at room temperature.

Treatment	Days during storage								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	9.45	9.75	10.10	10.70	11.50	12.30	12.70	12.80	11.16
Carbendazim 0.05% + calcium nitrate 1%	9.55	9.85	10.25	10.75	11.55	12.35	12.72	13.10	11.27
Carbendazim 0.1%	9.50	9.80	10.20	10.70	11.45	12.20	12.70	12.90	11.18
Copper oxychloride 0.2% + calcium nitrate 1%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20
Copper oxychloride 0.3%	9.50	9.80	10.10	10.65	11.50	12.30	12.70	12.90	11.18
Mancozeb 0.2% + calcium nitrate 1%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20
Mancozeb 0.3%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20

Propiconazole 0.05% + calcium nitrate 1%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20
Propiconazole 0.1%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20
Nimbecidine 0.0009% + calcium nitrate 1%	9.45	9.75	10.20	10.70	11.45	12.20	12.60	12.85	11.15
Nimbecidine 0.0015%	9.40	9.75	10.10	10.65	11.45	12.20	12.60	12.80	11.12
Calcium nitrate 1%	9.50	9.80	10.20	10.70	11.50	12.30	12.70	12.90	11.20
Mean	9.49	9.79	10.18	10.70	11.49	12.28	12.68	12.90	
C.D. at 5%	Treatment(T)=NS, Storage(S)=0.14, T×S=NS								

Table 2 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on titratable acidity (%) inKinnow mandarin during storage at room temperature.

Treatment	**Days during storage**								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	0.82	0.77	0.74	0.72	0.65	0.63	0.61	0.59	0.69
Carbendazim 0.05% + calcium nitrate 1%	0.83	0.83	0.78	0.74	0.69	0.67	0.60	0.62	0.72
Carbendazim 0.1%	0.79	0.75	0.72	0.70	0.63	0.62	0.58	0.57	0.67
Copper oxychloride 0.2% + calcium nitrate 1%	0.83	0.79	0.78	0.74	0.68	0.65	0.65	0.60	0.72
Copper oxychloride 0.3%	0.79	0.76	0.72	0.70	0.63	0.62	0.62	0.57	0.68
Mancozeb 0.2% + calcium nitrate 1%	0.82	0.80	0.76	0.73	0.68	0.66	0.61	0.58	0.70
Mancozeb 0.3%	0.81	0.78	0.72	0.69	0.63	0.61	0.58	0.57	0.67
Propiconazole 0.05% + calcium nitrate 1%	0.83	0.79	0.78	0.74	0.69	0.68	0.63	0.61	0.72
Propiconazole 0.1%	0.82	0.74	0.73	0.71	0.64	0.62	0.60	0.56	0.68
Nimbecidine 0.0009% + calcium nitrate 1%	0.83	0.81	0.79	0.74	0.67	0.65	0.65	0.62	0.72
Nimbecidine 0.0015%	0.82	0.76	0.73	0.70	0.65	0.62	0.60	0.56	0.68
Calcium nitrate 1%	0.82	0.80	0.76	0.72	0.68	0.65	0.64	0.60	0.71
Mean	0.82	0.78	0.75	0.72	0.66	0.64	0.62	0.59	
C.D. at 5%	Treatments(T)=NS, Storage(S)=0.04, T×S=NS								

Table 3 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on TSS/acid ratio in Kinnow mandarin during storage at room temperature.

Treatment	**Days during storage**								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	11.65	12.41	13.65	14.86	17.85	19.52	20.82	21.69	16.56
Carbendazim 0.05% + calcium nitrate 1%	11.33	11.71	13.01	14.32	16.74	18.21	20.00	20.32	15.70
Carbendazim 0.1%	11.85	13.13	14.31	15.36	18.41	20.00	21.50	22.98	17.19
Copper oxychloride 0.2% + calcium nitrate 1%	11.33	11.91	13.14	14.32	16.91	18.77	19.23	21.17	15.85
Copper oxychloride 0.3%	11.79	12.96	14.31	15.29	18.49	19.92	20.48	22.54	16.97
Mancozeb 0.2% + calcium nitrate 1%	11.39	12.06	13.25	14.52	17.06	18.48	19.84	21.25	15.98
Mancozeb 0.3%	11.65	12.56	14.31	15.65	18.49	20.41	21.17	22.63	17.11

Propiconazole 0.05% + calcium nitrate 1%	11.39	11.85	13.08	14.32	16.88	17.94	19.92	20.08	15.68
Propiconazole 0.1%	11.71	13.07	14.18	15.21	18.13	19.92	21.42	23.07	17.09
Nimbecidine 0.0009% + calcium nitrate 1%	11.39	11.98	12.72	14.39	17.24	18.77	19.23	20.48	15.77
Nimbecidine 0.0015%	11.65	12.79	14.11	15.29	17.85	19.92	20.83	22.54	16.87
Calcium nitrate 1%	11.59	12.13	13.22	14.72	16.91	18.92	19.69	21.08	16.03
Mean	11.54	12.37	13.59	14.86	17.55	19.23	20.20	21.65	

Table 4 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on Ascorbic acid content (mg/100 ml juice) in Kinnow mandarin during storage at room temperature.

Treatment	**Days during storage**								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	27.01	24.80	23.90	23.04	21.80	21.10	20.70	19.75	22.76
Carbendazim 0.05% + calcium nitrate 1%	27.70	25.60	25.01	24.01	22.90	22.60	22.02	21.65	23.94
Carbendazim 0.1%	27.18	25.16	24.70	23.84	22.75	22.10	21.70	20.14	23.45
Copper oxychloride 0.2% + calcium nitrate 1%	27.25	25.22	24.92	23.87	22.82	22.18	22.00	21.50	23.72
Copper oxychloride 0.3%	27.21	25.19	24.90	23.85	22.80	22.18	21.90	20.48	23.56
Mancozeb 0.2% + calcium nitrate 1%	27.90	25.85	25.10	24.10	23.15	22.95	22.20	21.95	24.15
Mancozeb 0.3%	27.09	25.07	24.20	23.70	22.65	22.80	21.85	21.24	23.58
Propiconazole 0.05% + calcium nitrate 1%	27.85	25.85	25.05	24.15	23.04	22.90	22.20	21.90	24.12
Propiconazole 0.1%	27.18	25.16	24.70	23.88	22.80	22.20	21.95	20.60	23.56
Nimbecidine 0.0009% + calcium nitrate 1%	27.25	25.13	24.62	23.90	22.70	22.10	21.95	20.60	23.53
Nimbecidine 0.0015%	27.09	25.07	24.20	23.70	22.65	22.80	21.80	20.40	23.46
Calcium nitrate 1%	27.09	25.07	24.20	23.72	22.65	22.10	21.90	20.40	23.39
Mean	27.32	25.26	24.63	23.81	22.73	22.33	21.85	20.88	
C.D. at 5%	Treatments(T)=0.32, Storage(S)=0.26, T×S=NS								

Table 5 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on reducing sugars (%) in Kinnow mandarin during storage at room temperature.

Treatment	**Days using storage**								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	2.90	3.32	3.62	3.90	4.15	4.43	4.73	5.06	4.02
carbendazim 0.05% + calcium nitrate 1%	3.01	3.44	3.76	3.96	4.21	4.51	4.80	5.16	4.11
Carbendazim 0.1%	3.00	3.34	3.67	3.94	4.17	4.50	4.76	5.10	4.06
Copper oxychloride 0.2% + calcium nitrate 1%	2.98	3.34	3.71	3.99	4.17	4.51	4.76	5.10	4.07
Copper oxychloride 0.3%	2.98	3.36	3.77	3.96	4.12	4.48	4.76	5.10	4.07
Mancozeb 0.2% + calcium nitrate 1%	3.03	3.44	3.71	3.92	4.13	4.48	4.74	5.10	4.07
Mancozeb 0.3%	2.98	3.36	3.67	3.93	4.12	4.49	4.77	5.11	4.05
Propiconazole 0.05% + calcium nitrate 1%	2.96	3.34	3.65	3.93	4.12	4.48	4.73	5.10	4.04
Propiconazole 0.1%	2.92	3.34	3.67	3.92	4.12	4.47	4.73	5.06	4.03

Nimbecidine 0.0009% + calcium nitrate 1%	2.98	3.39	3.67	3.97	4.19	4.53	4.77	5.10	4.07
Nimbecidine 0.0015%	2.91	3.34	3.71	3.97	4.12	4.48	4.75	5.10	4.05
Calcium nitrate 1%	2.92	3.34	3.65	3.89	4.13	4.44	4.73	5.08	4.02
Mean	2.96	3.36	3.69	3.94	4.15	4.48	4.75	5.10	
C.D. at 5%	Treatments(T)=NS, Storage(S)=0.05 T×S=NS								

Table 6 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on Non-reducing sugars (%) in Kinnow mandarin during storage at room temperature.

Treatment	Days using storage								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	2.98	3.95	4.72	5.21	5.90	6.66	6.87	6.83	5.39
Carbendazim 0.05% + calcium nitrate 1%	2.95	3.88	4.63	5.24	5.90	6.67	6.86	6.80	5.37
Carbendazim 0.1%	2.96	3.95	4.70	5.18	5.95	6.63	6.87	6.80	5.38
Copper oxychloride0.2% + calcium nitrate 1%	2.92	3.99	4.68	5.16	5.92	6.62	6.89	6.82	5.38
Copper oxychloride 0.3%	2.94	3.93	4.58	5.17	5.96	6.66	6.88	6.82	5.37
Mancozeb 0.2% + calcium nitrate 1%	2.90	3.87	4.68	5.22	5.98	6.66	6.89	6.81	5.38
Mancozeb 0.3%	2.96	3.92	4.69	5.18	5.99	6.63	6.85	6.80	5.38
Propiconazole 0.05% + calcium nitrate 1%	2.95	3.98	4.74	5.24	5.96	6.68	6.92	6.82	5.41
Propiconazole 0.1%	3.00	3.97	4.71	5.25	5.96	6.65	6.89	6.86	5.41
Nimbecidine 0.0009% + calcium nitrate 1%	2.95	3.92	4.71	5.18	5.92	6.61	6.85	6.84	5.37
Nimbecidine 0.0015%	3.01	3.98	4.64	5.17	5.95	6.67	6.88	6.81	5.39
Calcium nitrate 1%	2.99	3.95	4.72	5.24	5.95	6.68	6.89	6.85	5.41
Mean	2.96	3.94	4.68	5.20	5.95	6.65	6.88	6.82	

Table 7 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on Total sugars (%) in Kinnow mandarin during storage at room temperature.

Treatment	Days during storage								
	0	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**Mean**
Control	5.88	7.27	8.34	9.11	10.05	11.09	11.60	11.89	9.40
Carbendazim 0.05% + calcium nitrate 1%	5.96	7.32	8.39	9.20	10.11	11.18	11.66	11.96	9.47
Carbendazim 0.1%	5.96	7.29	8.37	9.12	10.12	11.13	11.63	11.90	9.44
Copper oxychloride0.2% + calcium nitrate 1%	5.90	7.33	8.39	9.15	10.09	11.13	11.65	11.92	9.44
Copper oxychloride 0.3%	5.92	7.29	8.35	9.13	10.08	11.14	11.64	11.92	9.43
Mancozeb 0.2% + calcium nitrate 1%	5.93	7.31	8.39	9.14	10.11	11.14	11.63	11.91	9.44
Mancozeb 0.3%	5.94	7.28	8.36	9.11	10.11	11.12	11.62	11.91	9.43
Propiconazole 0.05% + calcium nitrate 1%	5.91	7.32	8.39	9.17	10.08	11.16	11.65	11.92	9.45
Propiconazole 0.1%	5.92	7.31	8.38	9.17	10.08	11.15	11.62	11.92	9.44
Nimbecidine 0.0009% + calcium nitrate 1%	5.93	7.31	8.38	9.15	10.11	11.14	11.62	11.94	9.45
Nimbecidine 0.0015%	5.92	7.32	8.35	9.14	10.07	11.15	11.63	11.91	9.44
Calcium nitrate 1%	5.91	7.29	8.37	9.13	10.08	11.12	11.62	11.93	9.43

Mean	5.92	7.30	8.37	9.14	10.09	11.14	11.63	11.92	
C.D. at 5%	Treatments(T)= NS, Storage(S)=0.06, T×S=NS								

Table 8 Effect of pre-harvest spray using fungicides, nimbecidine, calcium nitrate, and their combinations on Decay loss (%) in Kinnow mandarin during storage at room temperature.

Treatment	Days during storage					
	14	**21**	**28**	**35**	**42**	**49**
Control	4.30 (11.96)	10.08 (18.50)	16.40 (23.88)	21.80 (27.82)	26.70 (31.10)	29.10 (32.63)
Carbendazim 0.05% + calcium nitrate 1%	0.01 (0.48)	3.05 (10.05)	5.20 (13.18)	8.15 (16.58)	9.05 (17.50)	12.10 (20.35)
Carbendazim 0.1%	0.08 (1.62)	3.60 (10.93)	5.90 (14.05)	8.85 (17.30)	9.70 (18.14)	13.10 (21.21)
Copper oxychloride 0.2% + Calcium nitrate 1%	1.10 (6.02)	5.20 (13.18)	7.35 (15.72)	11.15 (19.50)	14.10 (22.05)	16.10 (23.64)
Copper oxychloride 0.3%	1.30 (6.54)	5.40 (13.43)	7.40 (15.78)	11.30 (19.64)	14.40 (22.29)	16.20 (23.72)
Mancozeb 0.2% + Calcium nitrate 1%	1.15 (6.15)	4.10 (11.68)	6.20 (14.41)	9.10 (17.55)	11.30 (19.64)	14.00 (21.96)
Mancozeb 0.3%	1.25 (6.42)	4.30 (11.96)	6.40 (14.65)	9.30 (17.75)	11.40 (19.73)	14.20 (22.13)
Propiconazole 0.05% + Calcium nitrate 1%	0.01 (0.57)	3.15 (10.22)	5.35 (13.37)	8.25 (16.69)	9.05 (17.50)	12.25 (20.48)
Propiconazole 0.1%	0.06 (1.41)	3.40 (10.62)	5.70 (13.81)	8.75 (17.20)	9.60 (18.04)	12.90 (21.04)
Nimbecidine 0.0009% + Calcium nitrate 1%	2.20 (8.53)	6.00 (14.17)	9.45 (17.90)	13.00 (21.13)	17.00 (24.34)	19.75 (26.37)
Nimbecidine 0.0015%	2.40 (8.91)	6.20 (14.41)	9.50 (17.94)	13.10 (21.21)	17.20 (24.49)	19.90 (26.48)
Calcium nitrate 1%	3.50 (10.78)	8.40 (16.84)	14.20 (22.13)	19.70 (26.34)	23.24 (28.81)	26.00 (30.64)
Mean A	1.45 (5.78)	5.24 (13.00)	8.25 (16.40)	11.87 (19.89)	14.40 (21.97)	17.13 (24.22)
C.D. at 5%	0.12	0.28	0.40	0.37	0.50	0.63