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# Effect of Post-Harvest Chemical Treatments on Biochemical Properties of Kinnow fruits During Low Temperature Storage

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## Abstract

The present study was carried out in the PG Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during the years 2019 and 2020. Fresh Kinnow fruits harvested from the orchard were treated with different chemicals prior to low temperature storage. Kinnow fruits stored under low temperature conditions exhibited an increase in total soluble solids, and sugars during the course of storage. Salicylic acid (1mM) maintained the TSS and sugars in fruits upto 56 days of storage under low temperature conditions, however there was no effect of chemicals on titratable acidity.

***Key words :*** *Kinnow, chemicals, salicylic acid, sodium nitroprusside, calcium chloride, putrescine, storage.*

## Introduction

Kinnow fruits are highly perishable since they contain very high amount of water and exhibit relatively high metabolic activity (1). Post-harvest losses of fresh fruits in India are quite high, thus, reduction of these losses becomes quite necessary. Salicylic acid is a simple phenolic compound and has been used to control the post-harvest losses of perishable crops (2). Calcium is a key plant nutrient that has a significant role in cell functions, including reducing softening and senescence of fruits (3) and it is also considered the most important mineral element determining the fruit quality (4). Nitric oxide NO-donor compounds, such as diethylenetriamine / nitric oxide (DETANO) and sodium nitroprusside have been studied to maintain the quality and extend the post-harvest life of horticultural crops (5, 6). Polyamine comes under the new class of growth regulators and they regulate the various physiological processes in plants. The major forms of polyamines including diamine putrescine, triamine spermidine and tetraamine spermine are found in every plant cell. Exogenous application of polyamines influences the post-harvest life of fruits (7). According to U.S. Food and Drug Administration salicylic acid, nitric oxide and calcium chloride are Generally Recognized as Safe (GRAS) compounds. Cold storages are essential for extending the shelf life, period of marketing, avoiding glut, reducing transport bottlenecks during peak period of production and maintenance of quality of produce. Cold storage of mandarins allows for an extended market period, long-distance transport of the fruit and a more regulated supply of fruit in the market (8).

## Materials and Methods

The present investigation was carried out in the PG Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar during the years 2019 and 2020. The fresh fruits of Kinnow mandarin having uniform size were harvested with the help of secateurs at mature stage keeping small intact pedicel with each fruit from the orchards of Department of Horticulture, CCS Haryana Agricultural University, Hisar. Fruits were cleaned with muslin cloth and used for experiment. The treatments consisted of salicylic acid (1 mM), calcium chloride (1 mM), sodium nitroprusside (1 µM) and putrescine (1 mM) were applied as post-harvest dip treatment. After dip treatments, fruits were stored in cold storage at 5-7°C temperature and 85-90% RH. Total soluble solids were determined by using digital refractometer by putting a drop of juice on the prism and the values were expressed in percentage. Titratable acidity was determined in terms of citric acid as per the method suggested by (9). Method given by (10) was used for estimation of sugars.

## Results and Discussion

**Total soluble solids (%) :** The total soluble solids of Kinnow fruits coated with different chemicals represented in Table-1 exhibited statistically significant variation with respect to treatments and period of storage. Minimum TSS (10.31 and 10.23 %) was assessed in Kinnow fruits coated with salicylic acid (1mM) and maximum (10.74 and 10.63%) in untreated control fruits during 2019 and 2020, respectively.

This might be due to the effect of salicylic acid in lowering the respiration rate and ethylene production (11) or due to lower activity of cell wall degrading enzymes (12). Similar results were recorded by (13) in Kinnow, (14) in litchi, (15) ber and (16) in peach cv. Elberta. Slow increase in TSS of calcium chloride treated fruits might be

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**Table-1 : Effect of different chemicals on TSS (%) of Kinnow fruits stored at low temperature conditions.**

| Treatments | Storage period (Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | | | | | 2020 | | | | | |
| | 0 | 14 | 28 | 42 | 56 | Mean | 0 | 14 | 28 | 42 | 56 | Mean |
| SA (1 mM) | 9.80 | 9.90 | 10.20 | 10.67 | 11.00 | 10.31 | 9.60 | 9.87 | 10.17 | 10.57 | 10.97 | 10.23 |
| $CaCl_2$ (1 mM) | 9.80 | 10.20 | 10.47 | 10.93 | 11.33 | 10.55 | 9.60 | 10.17 | 10.43 | 10.90 | 11.27 | 10.47 |
| SNP (1 µM) | 9.80 | 10.13 | 10.50 | 10.83 | 11.27 | 10.51 | 9.60 | 10.17 | 10.57 | 10.90 | 11.33 | 10.51 |
| Putrescine (1 mM) | 9.80 | 10.17 | 10.63 | 10.97 | 11.37 | 10.59 | 9.60 | 10.10 | 10.57 | 10.93 | 11.30 | 10.50 |
| Control (Untreated) | 9.80 | 10.27 | 10.80 | 11.17 | 11.67 | 10.74 | 9.60 | 10.20 | 10.70 | 11.10 | 11.57 | 10.63 |
| Mean | 9.80 | 10.13 | 10.52 | 10.91 | 11.33 | | 9.60 | 10.10 | 10.49 | 10.88 | 11.29 | |
| C.D. | T= 0.06, D= 0.06, T X D= 0.13 | | | | | | T= 0.05, D= 0.05, T X D= 0.12 | | | | | |

**Table-2 : Effect of different chemicals on titratable acidity (%) of Kinnow fruits stored at low temperature conditions**.

| Treatments | Storage period (Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | | | | | 2020 | | | | | |
| | 0 | 14 | 28 | 42 | 56 | Mean | 0 | 14 | 28 | 42 | 56 | Mean |
| SA (1 mM) | 0.87 | 0.83 | 0.81 | 0.79 | 0.72 | 0.81 | 0.86 | 0.83 | 0.81 | 0.78 | 0.73 | 0.80 |
| $CaCl_2$ (1 mM) | 0.87 | 0.82 | 0.80 | 0.77 | 0.72 | 0.80 | 0.86 | 0.82 | 0.79 | 0.77 | 0.70 | 0.79 |
| SNP (1 µM) | 0.87 | 0.81 | 0.79 | 0.76 | 0.69 | 0.78 | 0.86 | 0.81 | 0.79 | 0.76 | 0.69 | 0.78 |
| Putrescine (1 mM) | 0.87 | 0.82 | 0.79 | 0.76 | 0.71 | 0.79 | 0.86 | 0.82 | 0.79 | 0.75 | 0.70 | 0.79 |
| Control (Untreated) | 0.87 | 0.80 | 0.77 | 0.74 | 0.67 | 0.77 | 0.86 | 0.81 | 0.77 | 0.73 | 0.66 | 0.77 |
| Mean | 0.87 | 0.82 | 0.79 | 0.76 | 0.70 | | 0.86 | 0.82 | 0.79 | 0.76 | 0.70 | |
| C.D. | T= NS, D= NS, T X D= NS | | | | | | T= NS, D= NS, T X D= NS | | | | | |

**Table-3 : Effect of different chemicals on total sugars (%) of Kinnow fruits stored at low temperature conditions.**

| Treatments | Storage period (Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | | | | | 2020 | | | | | |
| | 0 | 14 | 28 | 42 | 56 | Mean | 0 | 14 | 28 | 42 | 56 | Mean |
| SA (1 mM) | 7.86 | 8.58 | 9.04 | 9.26 | 9.58 | 8.86 | 7.98 | 8.66 | 9.13 | 9.31 | 9.62 | 8.94 |
| $CaCl_2$ (1 mM) | 7.86 | 8.80 | 9.26 | 9.39 | 9.78 | 9.02 | 7.98 | 8.84 | 9.31 | 9.44 | 9.82 | 9.08 |
| SNP (1 µM) | 7.86 | 8.88 | 9.38 | 9.52 | 9.91 | 9.11 | 7.98 | 8.92 | 9.42 | 9.55 | 9.95 | 9.16 |
| Putrescine (1 mM) | 7.86 | 8.89 | 9.32 | 9.45 | 9.84 | 9.07 | 7.98 | 8.95 | 9.39 | 9.48 | 9.88 | 9.14 |
| Control (Untreated) | 7.86 | 9.03 | 9.45 | 9.67 | 9.96 | 9.20 | 7.98 | 9.09 | 9.50 | 9.52 | 10.03 | 9.23 |
| Mean | 7.86 | 8.84 | 9.29 | 9.46 | 9.82 | | 7.98 | 8.89 | 9.35 | 9.46 | 9.86 | |
| C.D. | T= 0.02, D= 0.02, T X D= 0.06 | | | | | | T= 0.06, D= 0.06, T X D= 0.12 | | | | | |

due to the effect of calcium in lowering of the respiration and metabolism activities or reduction in the changes from carbohydrates to sugars, resulting in lower soluble solid content (17). Similar results were obtained by (16) in peach cv. Elberta and (18) in pear. Putrescine treated fruit exhibited lower soluble solid content, delayed respiration rate than untreated fruits in Angelino plum (19). Our findings are in line with the results of (20) in mango cv. Langra, (18) in pear and (21) in strawberry, apricot and peach.

The minimum TSS (9.80 and 9.60%) was noticed on zero day of storage and maximum (11.33 and 11.29%) on 56th day of storage during 2019 and 2020, respectively. This might be due to the concentrated juice content as a result of dehydration and hydrolysis of polysaccharides (11) or due to enzymatic degradation of starch and pectins into simple sugars (22).

The interaction between chemicals and storage period significantly affected the TSS in Kinnow fruits with minimum TSS (9.80 and 9.60% during 2019 and 2020, respectively) on zero day of storage, which was at par with TSS of Kinnow fruits treated with salicylic acid (1mM) on 14th day of storage during 2019 and maximum (11.67 and 11.57%) on 56th day of storage in untreated fruits during 2019 and 2020, respectively.

The slow change in TSS content of fruits stored under lower temperature might be due to slow conversion of starch in to water soluble sugars (23). Similar results were recorded by (24) in mango and (25) in tomato.

**Titratable acidity (%) :** The analysis of variance of the titratable acidity of stored Kinnow fruits coated with different chemicals presented in Table-2 followed non-significant variation with respect to chemicals, storge

**Table-4 : Effect of different chemicals on reducing sugars (%) of Kinnow fruits stored at low temperature conditions.**

| Treatments | Storage period (Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | | | | | 2020 | | | | | |
| | 0 | 14 | 28 | 42 | 56 | Mean | 0 | 14 | 28 | 42 | 56 | Mean |
| SA (1 mM) | 3.79 | 4.19 | 4.39 | 4.52 | 4.76 | 4.33 | 3.84 | 4.22 | 4.43 | 4.56 | 4.78 | 4.37 |
| $CaCl_2$ (1 mM) | 3.79 | 4.30 | 4.50 | 4.59 | 4.86 | 4.41 | 3.84 | 4.31 | 4.52 | 4.62 | 4.88 | 4.43 |
| SNP (1 µM) | 3.79 | 4.34 | 4.56 | 4.66 | 4.93 | 4.45 | 3.84 | 4.34 | 4.56 | 4.66 | 4.94 | 4.47 |
| Putrescine (1 mM) | 3.79 | 4.35 | 4.53 | 4.62 | 4.89 | 4.44 | 3.84 | 4.37 | 4.56 | 4.64 | 4.91 | 4.46 |
| Control (Untreated) | 3.79 | 4.41 | 4.59 | 4.73 | 4.95 | 4.49 | 3.84 | 4.44 | 4.61 | 4.66 | 4.99 | 4.51 |
| Mean | 3.79 | 4.32 | 4.51 | 4.62 | 4.88 | | 3.84 | 4.34 | 4.54 | 4.63 | 4.90 | |
| C.D. | T= 0.01, D= 0.01, T X D= 0.03 | | | | | | T= 0.03, D= 0.03, T X D= 0.06 | | | | | |

**Table-5 : Effect of different chemicals on non-reducing sugars (%) of Kinnow fruits stored at low temperature conditions.**

| Treatments | Storage period (Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | | | | | | 2020 | | | | | |
| | 0 | 14 | 28 | 42 | 56 | Mean | 0 | 14 | 28 | 42 | 56 | Mean |
| SA (1 mM) | 4.07 | 4.39 | 4.65 | 4.73 | 4.82 | 4.53 | 4.14 | 4.43 | 4.70 | 4.75 | 4.84 | 4.57 |
| $CaCl_2$ (1 mM) | 4.07 | 4.50 | 4.76 | 4.80 | 4.92 | 4.61 | 4.14 | 4.53 | 4.79 | 4.82 | 4.94 | 4.64 |
| SNP (1 µM) | 4.07 | 4.54 | 4.82 | 4.87 | 4.98 | 4.66 | 4.14 | 4.57 | 4.85 | 4.88 | 5.00 | 4.69 |
| Putrescine (1 mM) | 4.07 | 4.55 | 4.79 | 4.83 | 4.95 | 4.64 | 4.14 | 4.58 | 4.83 | 4.84 | 4.97 | 4.67 |
| Control (Untreated) | 4.07 | 4.62 | 4.86 | 4.94 | 5.01 | 4.70 | 4.14 | 4.65 | 4.89 | 4.86 | 5.04 | 4.72 |
| Mean | 4.07 | 4.52 | 4.78 | 4.83 | 4.94 | | 4.14 | 4.55 | 4.81 | 4.83 | 4.96 | |
| C.D. | T= 0.01, D= 0.01, T X D= 0.03 | | | | | | T= 0.03, D= 0.03, T X D= 0.06 | | | | | |

duration and interaction between chemicals and storage period under low temperature conditions.

The titratable acidity of fruits decreased with the advancement of storage period which might be due to the self utilization of acids by the fruits so that the acid in the fruits during storage decreases (26) or due to consumption of organic acids in fruits during respiration (11).

**Total sugars (%) :** The data pertaining to total sugars in stored Kinnow fruits treated with different chemicals in Table-3 revealed a significant variation with respect to chemicals and period of storage. The minimum total sugars (8.86 and 8.94%) were recorded in Kinnow fruits treated with salicylic acid (1mM) and maximum (9.20 and 9.23%) in control during 2019 and 2020, respectively. The total sugars increased with the advancement of storage period and were found minimum (7.86 and 7.98%) on zero day of storage and maximum (9.82 and 9.86%) on 56$^{th}$ day of storage during 2019 and 2020, respectively.

The total sugars were significantly affected due to interaction between treatments and storage duration. Minimum total sugars (7.86 and 7.98%) were obtained on zero day of storage and maximum (9.96 and 10.03%) on 56th day of storage in control fruits, which was statistically at par with fruits treated with 1 µM sodium nitroprusside on 28$^{th}$ day of storage during 2019 and 2020, respectively.

**Reducing sugars (%) :** The experimental results in Table-4 pertaining to reducing sugars in stored Kinnow fruits treated with different chemicals showed significant variation with respect to chemicals and storage period. The least amount of reducing sugars (4.33 and 4.37%) were recorded in fruits treated with salicylic acid (1mM) and the utmost amount of reducing sugars (4.49 and 4.51%) in control fruits during 2019 and 2020, respectively. The reducing sugars increased gradually with the advancement of storage period. The minimum reducing sugars (3.79 and 3.84%) were obtained on zero day of storage and maximum (4.88 and 4.90%) on 56th day of storage during 2019 and 2020, respectively. Similar results were obtained by (27) in ber. The interaction between chemicals and storage period had significant effect on reducing sugars in Kinnow fruits with minimum reducing sugars (3.79 and 3.84%) on zero day of storage and maximum (4.95 and 4.99%) on 56$^{th}$ day of storage in control fruits, which was at par with 1 µM sodium nitroprusside on 56th day of storage during 2019 and 2020, respectively.

**Non-reducing sugars (%) :** The analysis of variance of non-reducing sugars of stored Kinnow fruits treated with different chemicals presented in Table-5 showed significant effect of chemicals and the storage period under low temperature conditions.

Minimum non-reducing sugars (4.53 and 4.57%) were noticed in fruits treated with salicylic acid (1 mM) and maximum (4.70 and 4.72%) in control fruits during 2019 and 2020, respectively. With respect to period of storage, least amount of non-reducing sugars (4.07 and 4.14%) were recorded on zero day of storage and the highest (4.94 and 4.96%) on 56th day of storage during 2019 and 2020, respectively. Similar results were obtained by (27) in ber and (28) in guava cv. Sardar. The interaction

between chemicals and the storage period also exhibited significant effect on non- reducing sugars in Kinnow fruits. Minimum non-reducing sugars (4.07 and 4.14%) were recorded on zero day of storage and maximum (5.01 and 5.04%) in control fruits on 56th day of storage which was at par with Sodium nitroprusside treatment on 56th day of storage during 2019 and 2020, respectively.

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