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# Effect of natural oil coatings and antiageing compounds on shelf-life and quality of Daisy mandarin under ambient storage conditions

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**Abstract**

Coating of fruit is a trend to extend the shelf-life of fresh produce. But, every coating may not suit to different produce. An investigation was held to evaluate the impact of coating mandarins with natural oils and an antiageing compound (chitosan) on the quality of postharvest storage of 'Daisy' mandarin at a temperature of 18 ± 4°C. The mandarins were sorted and washed with water, and then the coating materials were applied to the fruit surface before being left to dry under fans. The fruits were coated with six different natural oils, including tulsi oil (100%), almond oil (100%), coconut oil (100%), olive oil (100%), mustard oil (100%), chitosan (1.5%) and compared with control. The study was designed using a complete randomized design (CRD) with three replications, and the fruits were analyzed for various physical and chemical parameters at 10th, 20th, and 30th days after coating. Results showed that coconut oil coating had resulted minimum reduction in physiological weight loss, acidity, juice content, and minimum upsurge in total sugar and reducing sugars content during storage. As a result, this study concluded that the application of a coconut natural oil coating (100%) is an appropriate method to prolong the quality and shelf-life of 'Daisy' mandarin under sub-tropical environments for up to 30 days.

## 1. Introduction

Introduction of hybrid mandarin 'Daisy' in country requests the proper postharvest technologies, because it is defenseless to postharvest damages due to the high rate of respiration and microbial attacks (Panghal *et al*., 2018). Daisy mandarin is cross between (Fortune mandarin × Fremont mandarin). This hybrid fruit of *Citrus reticulata*, commonly is a medium to large, mid-season mandarin type sideways with eye catching dark orange rind (Shorbagi *et al*., 2022). The Daisy mandarin titled for the lady of California citrus nursery holder who admired the taste of the fruit (Chahal and Singh, 2017).

Progress of edible coverings has been noted extraordinary development in current times. It expected to ensure an important influence on the quality of food products in the approaching centuries (Galus *et al*., 2020). Essential oils turn out to be a further widespread and effective method in current decades. It exchanges the regular outmost cuticle cover of fruits which wiped out after harvesting from tree (Saberi and Golding, 2018). Natural edible oils such as: tulsi oil, almond oil, coconut oil, olive oil, and mustard oil are ordinary, nonsynthetic, antibacterial, antifungal and antimicrobial in nature (Jianglian and Shaoying, 2013; Sharma and Chakraborty, 2019).

Edible coatings are being conventionally cast-off to expand horticultural produce. Edible coating tulsi oil ensures hindering of microbial activity in stored commodities (Rahman *et al*., 2021).

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Almond oil rich in monounsaturated fatty acids, used broadly to magnitude service life of countless horticultural crops (Maestri *et al*., 2015). Coconut oil provide fruits a glossy appearance and is fetching further well-known edible fruit layer substantial due to its antiageing belongings (Chitranshi *et al*., 2020). Olive oil is ironic in high phenolic content as well as has anticorrosion properties (Borchani *et al*., 2010). Additional application of olive oil in diverse fruits also reveal that it has antifungal properties which would help in delaying fungal attack in various horticultural crops (Sherani *et al*., 2021). Diversity and claims of natural oils are unique, such as essential oils are rich in antifungal and antioxidant properties which can be used as natural edible coating materials to horticulture produce from microbial and fungal attacks (Fahim *et al*., 2017). Likewise, mustard oil showed anti-bacterial properties in mango and in other horticultural crops, which exhibited essential oils to be a prospective foundation for fabrication of edible coating materials (Yang *et al*., 2023).

Advanced edible coating material of chitosan nano-particles produced primarily by fungi and bacteria like, *Botrytis cinerea, Rhizopus stolonifera* and *Aspergillus niger* (Salgado-Cruz *et al*., 2021; Hammia and Bouatrous, 2021).

Chitosan coating comprised of hydroxyl and amino group, which make transformation of chitosan into film material or coating layer at ease (Lustriane *et al*., 2018). Aim of natural oil coatings and nano-particles are not just to amplify the mean life of fruits but the various challenges during storage like, spoilage, microbial and bacterial attack can be hinder by its application (Esyanti *et al*., 2019). Advance application of chitosan edible coatings is wide in protecting fresh cut horticultural crops from microbial contamination in present day (Pilon *et al*., 2015). Edible coatings obtained from natural oils are gaining attentiveness of researchers worldwide due to positive impacts of these natural oil coatings in maintaining shelf-life and quality of various horticultural crops (Kurkcuoglu *et al*., 2021).

## 2. Materials and Methods

To study impact of natural oil coating and antiageing compound on shelf-life and quality of Daisy' mandarin' was carried out in School of Agriculture at Lovely Professional University, India from 18th November to 28th December 2022. Authentic mandarin var. 'Daisy' fruits were bought from citrus farm of Punjab Agriculture University (P.A.U.), Ludhiana, India. The fruits were washed with cold water, followed by cleaning with muslin cloths. The seven treatments were used, *i.e*., tulsi oil (100%), almond oil (100%), coconut oil (100%), olive oil (100%), mustard oil (100%), and chitosan (1.5%). All coating materials were applied on fruits surfaces on next day after harvest. Dipping method was used for application of coatings on fruits. Fruits coated with edible coatings were allowed to dry up below fans for 1-2 h to remove stains of edible coatings. All fruits were stored at ambient storage conditions (18 ± 4$^0$C). Twenty fruits in each replication of each treatment were used in the experiment which were kept for observation at ambient storage. The storage temperature and relative humidity were noted on regular basis until the last day of storage. The research was designed in completely randomized design (CRD) with 3 replications. The observations were taken on 10 days after coating (DAC), 20 DAC, and 30 DAC. Statistical packages for agricultural research data analysis, SPAR 2.0 was used for analyzing of data. Duncan's multiple-range test ($p$< 0.05) for comparisons of means was performed. All values were calculated at $p$>0.05 and values are the mean ± standard error.

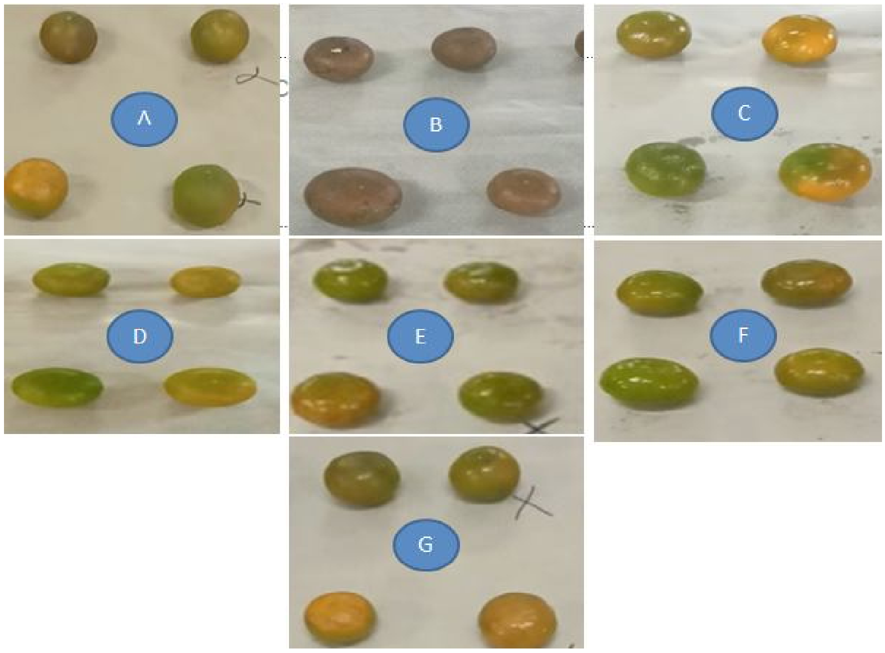


**Figure 1: Pictures representing various coatings on 'Daisy' mandarin fruit under ambient storage; where, A) Control; B) tulsi oil 100%; C) almond oil 100%; D) coconut oil 100%; E) olive oil 100%; F) mustard oil 100%, and G) chitosan 1.5%.**

**Table 1: Various coatings applied on fruit surface with name of treatments, concentration and notations**

| Name of treatment | Concentration | Notation |
|---|---|---|
| Control | Water wash | $T_0$ |
| Tulsi oil (TO) | 100% | $T_1$ |
| Almond oil (AO) | 100% | $T_2$ |
| Coconut oil (CO) | 100% | $T_3$ |
| Olive oil (OO) | 100% | $T_4$ |
| Mustard oil (MO) | 100% | $T_5$ |
| Chitosan | 1.5% | $T_6$ |

### 2.1 Physiological weight loss

Prior to the application of natural oils, all the mandarins were weighed, and weights were again recorded at 10th, 20th and 30th days interval after treatments. The weight reduction was calculated using the equation below:

Physiological loss in weight (%)

$$= \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

### 2.2 Juice content (%)

After peeling the juice was collected by straining the extracted juice form pulp in the container. Furthermore, weight of juice is obtained from digital weighing device. Final juice per cent of mandarin fruits was collected by dividing the juice weight by the total fruit weight:

$$\text{Juice content (\%)} = \frac{\text{Fruit juice weight}}{\text{Fruit weight}} \times 100$$

### 2.3 Acidity (% citric acid)

Fruits acidity was measured by adding 100 ml of distilled water to 10 ml of juice to make the preferred volume. 10 ml aliquot of this was taken, and one drop of phenolphthalein indicator was added in it. Thereafter, it was titrated by 0.1N NaOH. The titre value was noted after receiving pink colour and the formula below was used to calculate the percent titratable acidity in fruits:

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{Volume} \times \text{Normality of alkali} \times \text{Equivalent weight of acid}}{\text{Weight of sample} \times \text{Aliquot used}} \times 100$$

### 2.4 Total, reducing and non-reducing sugars (%)

The total, reducing, and non-reducing sugars were estimated using the Lane and Eynon chemical approach, which involves first converting starch into reducing sugars. This approach is based on the idea that sugar reduction may be used to reduce Fehling's solution. Copper sulphate and alkaline rochelle salt (sodium potassium tartrate) are both components of Fehling's solution. The term "total sugars" states to reducing sugars as well as non-reducing di- and oligosaccharides, such as sucrose, which under moderate acid hydrolysis are transformed into reducing sugars. Strong acids hydrolyze starch to produce glucose:

Total sugars (%)

$$= \frac{\text{Fehling's solution factor} \times \text{Dilution made}}{\text{Titre volume} \times \text{Weight of sample taken} \times 50} \times 100$$

Reducing sugars (%)

$$= \frac{\text{Invert sugars (mg)} \times \text{Dilution}}{\text{Value per sample} \times \text{Weight per volume} \times 1000} \times 100$$

## 3. Results

### 3.1 Physiological loss in weight (%)

It was noted that in comparison to control, all coated fruits exhibited the minor physiological loss in weight (PLW). Coconut oil had the least (9.18%) PLW at 30 DAC, followed by tulsi oil (12.16%), chitosan (12.34%), almond oil (12.74%), olive oil (13.38%), and mustard oil (13.87%) as compare to control (15.34%). It was observed that there was a minor upturn in PLW till 10 DAC in all treatments, but after 20 days, a rise on PLW was witnessed in all treatments. The rate in PLW was minimum (100%) in coconut oil coated fruits (9.18%) till 30 days of storage at ambient room temperature.

**Table 2: Impact of different natural oil coatings and antiageing compound on PLW (%) under ambient storage**

| Treatments | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|
| Control ($T_0$) | 11.10 ± 0.26[a] | 17.63 ± 0.13[a] | 15.34 ± 0.55[a] |
| Tulsi oil 100% ($T_1$) | 7.83 ± 0.45[bc] | 12.14 ± 0.09[c] | 12.16 ± 0.79[b] |
| Almond oil 100% ($T_2$) | 7.03 ± 0.18[cd] | 14.25 ± 0.36[b] | 12.74 ± 0.13[b] |
| Coconut oil 100% ($T_3$) | 3.57 ± 0.33[e] | 10.03 ± 0.43[d] | 9.18 ± 0.42[c] |
| Olive oil 100% ($T_4$) | 6.38 ± 0.27[d] | 14.73 ± 0.61[b] | 13.38 ± 0.49[b] |
| Mustard oil 100% ($T_5$) | 6.90 ± 0.21[d] | 15.27 ± 0.34[b] | 13.87 ± 0.69[ab] |
| Chitosan 1.5% ($T_6$) | 8.47 ± 0.24[b] | 14.47 ± 0.29[b] | 12.34 ± 0.66[b] |

* All values are calculated at $p > 0.05$ and values are mean ± standard error.

### 3.2 Acidity (%)

Acidity in all treatments decreased continuously till 30 DAC. All initial values were recorded on 0 DAC in all treatments. The acidy lessened from its initial value (1.43%) to (0.63%) till 30 DAC. Fruits without coating recorded the faster reduction in acidity (0.63%) as compare to initial value. Whereas, minimum (1.01%) reduction in acidity was noted in coconut oil coated fruits, followed by, olive oil (0.97%), mustard oil (0.94%), chitosan (0.91%), almond oil (0.87%), and tulsi oil (0.74%) from initial value till 30 DAC. Among all the coatings, coconut oil found lowest drop in acidity of 'Daisy' mandarin fruits at ambient storage conditions up to 30 DAC.

**Table 3: Impact of different natural oil coatings and antiageing compound on acidity under ambient storage**

| Treatments | 0 DAC | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|---|
| Control ($T_0$) | 1.43 | 1.14 ±0.07$^b$ | 0.74 ± 0.07$^f$ | 0.63 ± 0.07$^g$ |
| Tulsi oil 100% ($T_1$) | 1.43 | 1.24 ± 0.07$^b$ | 0.84 ± 0.07$^e$ | 0.74 ± 0.07$^f$ |
| Almond oil 100% ($T_2$) | 1.43 | 1.24 ± 0.03$^b$ | 0.87 ± 0.03$^d$ | 0.87 ± 0.07$^e$ |
| Coconut oil 100% ($T_3$) | 1.43 | 1.27±0.07$^a$ | 1.10 ± 0.07$^a$ | 1.01 ± 0.07$^a$ |
| Olive oil 100% ($T_4$) | 1.43 | 1.21 ± 0.06$^c$ | 1.07 ± 0.07$^b$ | 0.97 ± 0.03$^b$ |
| Mustard oil 100% ($T_5$) | 1.43 | 1.23 ± 0.07$^{bc}$ | 1.04 ± 0.00$^c$ | 0.94 ± 0.07$^c$ |
| Chitosan 1.5% ($T_6$) | 1.43 | 1.22 ± 0.07$^{bc}$ | 1.04 ± 0.07$^c$ | 0.91 ± 0.07$^d$ |

* All values are calculated at $p>0.05$ and values are mean ± standard error.

### 3.3 Juice content (%)

In all treatments, great reductions were noted in juice content with increase in storage duration. Fruit coated with coconut oil showed minimum reduction in juice content (27.49%) till 30 DAC as compared to initial value (39.69%). Nontreated fruits showed highest reduction in juice content (19.18%) till 30 days compare to its initial value (39.48%). The juice quantity in fruits decreased from 39.77 to 19.88% from 0 to 30 days in control. Whereas, fruits coated with coconut oil showed minimum reduction in juice content ranged from 39.69 to 27.49% from 0 to 30 DAC followed by olive oil (26.58%), mustard oil (24.49%), chitosan (23.60%), almond oil (22.58%), and tulsi oil (21.48%) till 30 days of storage at 18 ± 4°C.

**Table 4: Impact of different natural oil coatings and antiageing compound on juice content (%) under ambient storage conditions**

| Treatments | 0 DAC | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|---|
| Control ($T_0$) | 39.48 ± 0.00$^b$ | 29.66 ± 0.10$^f$ | 23.55 ± 0.00$^g$ | 19.88 ± 0.07$^g$ |
| Tulsi oil 100% ($T_1$) | 39.46 ± 0.09$^b$ | 30.90 ± 0.10$^e$ | 25.49 ± 0.08$^f$ | 21.48 ± 0.08$^f$ |
| Almond oil 100% ($T_2$) | 39.77 ± 0.10$^a$ | 32.47 ± 0.09$^c$ | 26.46 ± 0.07$^e$ | 22.58 ± 0.08$^e$ |
| Coconut oil 100% ($T_3$) | 39.69 ± 0.95$^a$ | 34.00 ± 0.22$^a$ | 30.58 ± 0.05$^a$ | 27.49 ± 0.08$^a$ |
| Olive oil 100% ($T_4$) | 37.59 ± 0.00$^c$ | 33.47 ± 0.08$^b$ | 29.77 ± 0.09$^b$ | 26.58 ± 0.05$^b$ |
| Mustard oil 100% ($T_5$) | 36.75 ± 0.88$^d$ | 30.75 ± 0.25$^e$ | 27.47 ± 0.05$^d$ | 24.49 ± 0.08$^c$ |
| Chitosan 1.5% ($T_6$) | 36.88 ± 0.10$^d$ | 31.54 ± 0.46$^d$ | 28.48 ± 0.07$^c$ | 23.60 ± 0.97$^d$ |

* All values are calculated at $p>0.05$ and values are mean ± standard error.

### 3.4 Total sugars (%)

Significant increases in total sugars in all the treatments were noted from initial to 30 days of storage period. Initial value recorded for all the treatments on initial DAC was 6.62%. The increase in total sugar in fruits ranged from 6.62 to 7.77% till 30 DAC. Rapid changes in values of total sugar were observed in control (7.47 to 7.77% from 20 to 30 DAC) as compared to initial value. The minimum increase in total sugar was observed in coconut oil coated fruits on 30 day (6.82%) as compared to initial value, followed by olive oil (6.94%), mustard oil (6.97%), chitosan (7.13%), almond oil (7.33%) and tulsi oil (7.52%). While uncoated fruits showed dramatically increase in total sugar from 10 to 30 day stored at 18 ± 4°C as compared to untreated fruits.

**Table 5: Impact of different natural oil coatings and antiageing compound on total sugars (%) under ambient storage**

| Treatments | 0 DAC | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|---|
| Control ($T_0$) | 6.62 | 6.88 ± 0.07$^a$ | 7.47 ± 0.07$^a$ | 7.77 ± 0.07$^a$ |
| Tulsi oil 100% ($T_1$) | 6.62 | 6.77 ± 0.07$^a$ | 7.41 ± 0.07$^b$ | 7.52 ± 0.07$^b$ |
| Almond oil 100% ($T_2$) | 6.62 | 6.76 ± 0.07$^a$ | 7.12 ± 0.07$^c$ | 7.33 ± 0.07$^c$ |
| Coconut oil 100% ($T_3$) | 6.62 | 6.74 ± 0.07$^a$ | 6.77 ± 0.07$^g$ | 6.82 ± 0.07$^g$ |
| Olive oil 100% ($T_4$) | 6.62 | 6.75 ± 0.07$^a$ | 6.85 ± 0.07$^e$ | 6.94 ± 0.07$^f$ |
| Mustard oil 100% ($T_5$) | 6.62 | 6.78 ± 0.07$^a$ | 6.82 ± 0.03$^f$ | 6.97 ± 0.07$^e$ |
| Chitosan 1.5% ($T_6$) | 6.62 | 6.83 ± 0.07$^a$ | 6.98 ± 0.07$^d$ | 7.13 ± 0.07$^d$ |

* All values are calculated at $p>0.05$ and values are mean ± standard error.

### 3.5 Reducing sugar (%)

Significant differences in reducing sugar were noted in different coated fruits from initial to 30 days of storage period at 18 ± 4$^0$C temperature. Initial value of reducing sugar recorded for treatments on initial day was 4.29%. The increase in total reducing sugar was found highest in control which ranged from 4.29 to 5.02% till 30 DAC. The minimum alteration (4.47%) in reducing sugars was observed in coconut oil, followed by mustard oil (4.53%), olive oil (4.54%), almond oil (4.66%), chitosan (4.68%), and tulsi oil (4.86%) as compared to initial value on 30 DAC.

**Table 6: Impact of different natural oil coatings and antiageing compound on total sugars (%) under ambient storage**

| Treatments | 0 DAC | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|---|
| Control ($T_0$) | 4.29 | 4.52 ± 0.07$^a$ | 4.83 ± 0.07$^a$ | 5.02 ± 0.10$^a$ |
| Tulsi oil 100% ($T_1$) | 4.29 | 4.50 ± 0.07$^a$ | 4.78 ± 0.07$^b$ | 4.86 ± 0.13$^b$ |
| Almond oil 100% ($T_2$) | 4.29 | 4.46 ± 0.00$^{bc}$ | 4.56 ± 0.07$^c$ | 4.66 ± 0.07$^c$ |
| Coconut oil 100% ($T_3$) | 4.29 | 4.33 ± 0.07$^d$ | 4.44 ± 0.07$^d$ | 4.47 ± 0.07$^e$ |
| Olive oil 100% ($T_4$) | 4.29 | 4.45 ± 0.07$^b$ | 4.48 ± 0.03$^d$ | 4.54 ± 0.07$^d$ |
| Mustard oil 100% ($T_5$) | 4.29 | 4.44 ± 0.20$^c$ | 4.48 ± 0.30$^d$ | 4.53 ± 0.20$^d$ |
| Chitosan 1.5% ($T_6$) | 4.29 | 4.52 ± 0.00$^a$ | 4.60 ± 0.13$^c$ | 4.68 ± 0.07$^c$ |

* All values are calculated at $p$>0.05 and values are mean ± standard error.

### 3.6 Non-reducing sugar (%)

Significant differences in non-reducing sugar were noted in coated fruits. Initial value of non-reducing sugar recorded in fruits was 2.14%. Non-coated fruits showed the maximum changes (2.75%) in non-reducing sugar as compared to initial value on 30 DAC. The minimum increase (2.35%) was observed in coconut oil coated fruits followed by olive oil (2.40%), chitosan (2.45%), mustard oil (2.47%), tulsi oil (2.65%), and almond oil (2.70%) as compared to initial value on 30 DAC.

**Table 7: Impact of different natural oil coatings and antiageing compound on non-reducing sugar (%) under ambient storage**

| Treatments | 0 DAC | 10 DAC | 20 DAC | 30 DAC |
|---|---|---|---|---|
| Control ($T_0$) | 2.14 | 2.34 ± 0.07$^a$ | 2.63 ± 0.13$^a$ | 2.75 ± 0.17$^a$ |
| Tulsi oil 100% ($T_1$) | 2.14 | 2.28 ± 0.07$^d$ | 2.62 ± 0.07$^a$ | 2.65 ± 0.07$^b$ |
| Almond oil 100% ($T_2$) | 2.14 | 2.28 ± 0.10$^d$ | 2.56 ± 0.07$^b$ | 2.70 ± 0.13$^b$ |
| Coconut oil 100% ($T_3$) | 2.14 | 2.29 ± 0.03$^{cd}$ | 2.32 ± 0.13$^d$ | 2.35 ± 0.13$^e$ |
| Olive oil 100% ($T_4$) | 2.14 | 2.27 ± 0.13$^d$ | 2.35 ± 0.03$^c$ | 2.40 ± 0.13$^d$ |
| Mustard oil 100% ($T_5$) | 2.14 | 2.33 ± 0.13$^{ab}$ | 2.36 ± 0.07$^c$ | 2.47 ± 0.17$^{cd}$ |
| Chitosan 1.5% ($T_6$) | 2.14 | 2.31 ± 0.03$^{bc}$ | 2.35 ± 0.07$^c$ | 2.45 ± 0.17$^c$ |

* All values are calculated at $p$>0.05 and values are mean ± standard error.

## 4. Discussion

'Daisy' mandarin coated with natural oil and antiageing compounds recorded the minimum physiological weight loss (PLW) at ambient storage conditions (Table 3). Minimum PLW may be due to the properties of coconut oil to close the perforation of pores in fruit peel which reduced respiration rate and transpiration rate of fruit under storage conditions (Nasrin *et al.*, 2020). These results are in nearby conformity with outcomes of Bisen *et al.* (2012) who stated lowest PLW in fruit of 'Kagzi' lime coated with coconut oil. In another study, PLW value found reduced in the fruits of Kinnow stored at ambient conditions after coconut oil application (Mohan *et al.*, 2021).

Lowest juice content at 30 DAC was found in control (Table 3). Least juice content in control might be because of uncoated fruit surface facades upper rate of transpiration during the storage which results in higher juice reduction in fruits (Gao *et al.*, 2018). Coconut oil coating maintained the highest juice content. Highest juice content in coconut oil coated fruits could exist due to anti-senescence property of coconut oil coatings which rheostat the binding of the ethylene biosynthesis process (Boateng *et al.*, 2016). Similar results were found by Rashid *et al.* (2020) where coconut oil coating sustained highest juice content in 'Kinnow' mandarin.

All coated fruits showed decrease in acidity by extending the storage interval (Table 3). Noncoated fruits showed maximum reduction in acidity, because of faster respiration during the storage as well as acidity act as energy source for transformation of organic compounds to form sugar (Holcroft and Kader, 1998). Whereas, coconut oil showed minimum reduction in acidity till 30 days of storage. Least reduction in acidity of coconut coated fruits may be because of barrier in oxidation of organic acid and respiration process (Jagadeesh *et al.*, 2001). A similar effect was found by Singh *et al.* (2017) where fruit of guava coated with coconut oil exhibited least reduction in acidity.

Maximum increase in total sugar was perceived in the uncoated fruits till 30 DAC (Table 4). Higher total sugar in control may be possibly owing to nonexistence of edible coatings, which enhance the conversion of natural sugars into concentration of sucrose, fructose and glucose in fruits (Yakushiji *et al*., 1996). Coconut oil showed slightest intensification in total sugar in fruits. Slenderest escalation in total sugar in coconut coated fruits may be due to the barricade possession of coconut oil covering, decelerating the respiration percentage as well as slower conversion rate of complex carbohydrates in to simple sugars along with less hydrolysis of starch into sugars as compare to control (Hmmam *et al*., 2021). Similarly, highest increase in reducing sugar was found in control (Table 5).

Utmost upturn in reducing sugar in control fruits may be due to uncontrolled sucrose phosphate synthase leads to sucrose association which later leads to raising the soluble sugars content in fruits through the ripening and storage of fruits (Hubbard *et al*., 1991). Comparable outcomes were founded by Yadav *et al*. (2010) where reducing sugar level tends to increase by extending storage intervals. In the results, coconut oil showed minimum increase in reducing sugar. Least possible upsurge in reducing sugar in coconut oil coated fruits may be because coconut oil coating act as fence for many metabolic events inside fruits during storage. It also produces lower losses of juice *via* sealing the perforation of pores present on fruit peel, which controls the dehydration process in fruit during the storage period (Kulkarni *et al*., 2010). Comparable consequences were found by Nasrin *et al*. (2018) on mandarin kept in storage at ambient storage conditions. In case of non-reducing sugars highest escalation in reducing sugars was found in control (Table 6). Highest increase in non-reducing sugar in control can be attributable to the enzymatic transformation of the cell wall's complex polysaccharides into simpler sugars throughout the storage due to an increase in fruit respiration (Kittur *et al*., 2001). These consequences are comparable with study of Panday and Joshua (2010) who reported minimum escalation in non-reducing sugar in coconut oil coated guava fruits.

## 5. Conclusion

In comparison to the non-coated, the postharvest coating of coconut oil (100%) resulted in the least PLW, acidity, reduction in juice content, lowest deviations in total sugar, and reducing sugar, at ambient storage conditions of 18 ± 4°C, with a shelf-life of 30 days. Hence, it is recommended that 100% coconut oil is useful to extend the shelf-life of Daisy mandarin at ambient storage condition.

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## Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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