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# Effect of Calcium Chloride Dipping and Beeswax Coating on the Shelf Life and Quality of Nectarine (*Prunus persica (L.) Batsch var. nucipersica*) Fruits

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## Abstract

This research was conducted to evaluate the effect of $CaCl_2$ dipping and beeswax (BW) coating on the shelf life and quality of nectarine fruits. The experiment was conducted under Holeta condition during the off-season of 2018. Fruits of '89-16N' nectarine variety were harvested from HARC orchard. The treatment consisted of a combination of four levels of $CaCl_2$ (0%, 1.5%, 3.0% and 4.5%) and three levels of BW application (0%, 3% and 6%). The experiment was arranged in completely randomized design with factorial arrangement in three replications. Nectarine fruits were stored at ambient condition after being treated with the different treatment combinations of BW and $CaCl_2$. Various physico-chemical parameters were assessed. The result revealed that the PLW of nectarine fruits was significantly reduced. The TSS and pH values as well as TA and AA contents were better maintained in $CaCl_2$ dipping with BW coatings compared with the control. The highest percentage of marketable fruits with the lowest decay percentage were also retained by $CaCl_2$ dipping and BW coatings. Overall, the best result was consistently obtained at 3.0% BW with 4.5% $CaCl_2$ treated fruits for most of the parameters assessed. Hence, $CaCl_2$ dipping and BW coatings, particularly 3% BW with 4.5% $CaCl_2$ treatment, could be considered for extending the shelf life and better quality of nectarine fruits.

**Keywords:** Ambient condition, Beeswax coating, Calcium chloride, Nectarine, Physico-chemical, Quality, Shelf life.

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**Ethical:** This study follows all ethical practices during writing.

## Contents




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**Contribution of this paper to the literature**
This study contributes to existing literature by evaluating the effect of $CaCl_2$ dipping and beeswax (BW) coating on the shelf life and quality of nectarine fruits.

## 1. Introduction

Postharvest losses in fresh fruits and vegetables are estimated in the range of 20 to 50% in developing countries [1] which are also estimated as high as 50% for perishable crops in Ethiopia [2]. Minimizing postharvest food losses can help to conserve resources and improve human well-being by contributing to food and nutrition security.

Main factors responsible for the postharvest losses of most fruits are mechanical damage, microbial spoilage and physiological deterioration [1, 3]. Moisture loss is one of the main post-harvest problems that affect the quality of nectarines during long-term storage. To ensure optimum post-harvest quality, stone fruits like nectarines should be protected from excessive post-harvest moisture loss [4]. Decay and the incidence of internal defects such as woolliness, pulpiness and over-ripeness are other problems that are associated with long periods of storage [5].

Edible coatings with different composition have been tested and used to prolong storage life of fruits. Lipids including beeswaxes are among the protective coatings used to prolong storage life of fruits [6, 7]. Edible coatings or edible films contribute to enhancing the shelf life of fruits by reduction of moisture loss, solute migration and gas exchange as well as by reducing the physiological disorders. Edible coatings have high potential to control browning, off flavor, microbial activity of fruits and thus extending shelf life of treated fresh commodities [8].

Postharvest $CaCl_2$ application is also receiving considerable attention in recent times due to its positive effects on shelf life whilst maintaining quality of many fruits and vegetables. Calcium chloride delays ripening and senescence, reduces respiration, extends shelf life, maintains firmness, and reduces physiological disorders of many fruits and vegetables [9, 10]. Calcium chloride has also been reported to affect the marketing and storage of fruits through inhibition of ethylene synthesis, protein breakdown, weight loss and rotting [11]. However, there is no information on the combined effect of calcium chloride dipping and beeswax coating on the quality and shelf life of nectarines. Therefore, the present study was initiated to evaluate the effect of calcium chloride dipping and beeswax coating on the shelf life and quality of nectarine fruits.

## 2. Materials and Methods

### 2.1. Experimental Site

The experiment was conducted at Holeta Agricultural Research Center, which is situated at 9°00` N latitude and 38°29` E longitude at an altitude of 2400 m.a.s.l., 40 km west of Addis Ababa along the Ambo road. The area receives a mean annual rainfall of 1100 mm and has a relative humidity of 60.6%. The main rainy season is from June to September, which accounts for 70% of the rainfall while the remaining 30% is from February to April. The average annual maximum and minimum temperatures are 22.1 °C and 6.2 °C respectively. The soil type in the area is predominantly *Nitosol*, which is characterized by an average organic matter content of 1.8%, Nitrogen 0.17%, Phosphorous 4.55 ppm and Potassium 1.12 meq/100 g of soil and pH of 5.24 [12].

### 2.2. Treatments and Experimental Design

The treatments consisted of 4 x 3 factorial combinations of four levels of $CaCl_2$ (0%, 1.5%, 3.0% and 4.5%) and three levels of beeswax coatings (0%, 3% and 6%). There were 12 treatment combinations assigned in a completely randomized design with three replications.

### 2.3. Experimental Procedures

Nectarine fruits of variety *'89-16N'* were collected at uniform firm ripe stage from 12 years old full bearing orchard of Holeta Agricultural Research Center, temperate fruits research program experimental site**.** Hand harvesting was done and fruits were taken to the laboratory immediately after harvest. Fruits were sorted for equal size, uniform color and free of disease and blemishes. The fruits were then washed with tap water to cool the field heat down, to avoid soil particles and to reduce microbial load on the fruits and then dried with muslin cloth. Nectarine fruits were once dipped with 1.5%, 3.0% and 4.5% calcium chloride solutions for 15 minutes leaving the control. On the other hand, beeswax emulsions at the rates of 3% and 6% were prepared by dissolving with 90 °C heated 1000 ml water then 20 ml Oleic acid was added to the molten beeswax and slowly cooled with gentle stirring [13]. For fruits that received a combination of both treatments, they were first dipped in calcium chloride solution and drained for 10 minutes before coating with beeswax. All the fruits were then stored under ambient environmental condition. One hundred sixty five fruits were allotted to each treatment. Data were collected at every 5 days interval. Five fruits were taken and marked from each treatment for non-destructive measurements and five fruits were taken from each treatment randomly for destructive measurements.

### 2.4. Methodology

#### 2.4.1. Physiological Loss in Weight

Fruits samples tagged for non-destructive parameter measurements were pre-weighed by using physical balance. The physiological loss in weight were measured after each storage intervals and expressed in percentage by the following formula [14].

$$\text{PLW (\%)} = \frac{\text{Weight loss (g)}}{\text{weight of the fruits at the beginning of storage (g)}} \text{ x } 100$$



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### 2.4.2. Total Soluble Solids

The total soluble solid contents of fruits were determined by hand refractometer (0-32 °Brix). The refractometer was calibrated with distilled water before use and then a drop of fruit juice from each sample were placed on the prism and readings were recorded. The total soluble solids were expressed in degree Brix (°Brix) [15].

### 2.4.3. Titratable Acidity

The titratable acidity of nectarine fruits was determined according to Garner, et al. [16]. In a 100 ml beaker, 6 g of fruit juice with 50 ml distilled water were added and titrated against 0.1N sodium hydroxide solution to an end point of 8.2, measured with the pH meter. The milliliters (ml) of NaOH used were recorded. Then, the titratable acidity was calculated in terms of malic acid and was expressed as percent on pulp;

$$\text{Acid (\%)} = \frac{[\text{mls NaOH used}] \times [0.1\ \text{N NaOH}] \times [\text{milliequivalent factor}]}{\text{grams of sample}} \times 100$$

### 2.4.4. Ascorbic Acid

Ascorbic acid content of nectarine fruits was determined by titrimetric method using 0.5% Oxalic acid, 2, 6-Dichlorophenol-Indophenol (DCPIP) solutions and ascorbic acid standard solution. The ascorbic acid content of nectarine fruit juice was computed by the following formula and the result was expressed as mg per 100 g of sample [17];

$$\text{Ascorbic acid} = \frac{\text{DCPIP (ml)used to titrate the juice}}{\text{DCPIP (ml) used to titrate the standard ascorbic acid}} \times 1\ \text{mg/ml}$$

### 2.4.5. Decay

The percentage of disordered fruits including all of the spoiled fruits that resulted from fungus, bacterial and pathogens rots were assessed with visual observation. Decay loss was calculated from observation made on number of fruits infected on each day to the numbers of fruits initially stored and then percentage of decay loss was worked out by the following formula [18];

$$\text{Decay (\%)} = \frac{\text{No\_of fruits infected}}{\text{No\_ of sample fruits initially stored}} \times 100$$

### 2.4.6. Percentage of Marketable Fruits

The percentage of marketable fruits was subjectively assessed according to the procedure of Mohammed, et al. [19]. The descriptive quality attributes were determined by observing the level of decay, color, surface defects and shriveling. A 1–9 rating scales of which; 1= unsalable, 3 =unmarketable, 5 = fair, 7 = good and 9 = excellent were used to evaluate the marketable fruits. Fruits receiving a rating of five and above were considered marketable, while those rated less than five were considered unmarketable. The number of marketable fruits was used as a measure to calculate the percentage of marketable fruits during storage and converted by the following formula;

$$\text{Percentage of marketable fruits} = \frac{\text{Number of marketable fruits}}{\text{Total number of fruits}} \times 100$$

### 2.5. Data Analysis

The data were subjected to analysis of variance (ANOVA) in CRD with factorial arrangement to determine differences between the treatments [20]. The results were analyzed using Statistical Analysis System (SAS) version 9.0. Comparisons of the treatment means was done by the least significant difference (LSD) test at 5% significance level.

## 3. Results and Discussion

### 3.1. Physiological Loss in Weight

Highly significant ($P \leq 0.001$) difference in the physiological loss in weight (PLW) of nectarine fruits was observed due to the interaction effect of $CaCl_2$ dipping and beeswax (BW) coatings Table 1. The highest rates of PLW, 5.38% and 11.79%, were observed in control fruit samples while the lowest values of 2.44% and 5.47% were recorded in 6% BW with 0% $CaCl_2$ treatment after $5^{th}$ and $10^{th}$ days of storage, respectively. While fruits not treated with beeswax and $CaCl_2$ were discarded after 15 days of storage, the highest PLW (19.30%) was recorded from 0% BW with 1.5% $CaCl_2$ among the remaining treatments, whereas treatment of 6% BW with 0% $CaCl_2$ had the lowest loss in Weight. However, 6% wax combined with 3.0 and 4.5% $CaCl_2$ equally reduced the PLW of fruits, which were in the range of 10.26 to 10.3%. At day 20, the PLW for 3% BW with 4.5% $CaCl_2$ treated fruits was reduced nearly by half as compared to the highest PLW of 27.55% for 0% BW with 3.0% $CaCl_2$ treatment. Fruits not treated with beeswax as well as those treated with 3% beeswax combined with no and 1.5% $CaCl_2$ were all discarded on day 25. Among the remaining treatments, the highest loss (23.36%) was observed from 6% BW with 1.5% $CaCl_2$ while the lowest PLW (19.30%) was recorded in 3% BW with 4.5% $CaCl_2$ treatment.

There was a general increase of PLW as the storage period advanced for all of the treatments. Treating nectarine fruits with 3% BW with 4.5% $CaCl_2$ kept the PLW low up to the end of shelf life though 6% BW combined with 0% $CaCl_2$ treatment better reduced PLW up to day 15 Table 1. This result is in agreement with reports of El-Badawy [21] who observed reduced weight loss in 'Florida prince' peach treated by the combination of $CaCl_2$ and chitosan coating. Weight loss of fresh fruits is mainly due to water loss because of evaporation and transpiration while dry matter is lost by respiration. Hence, the lowest PLW of the fruits could be related to modified atmosphere created by BW coatings and effect of $CaCl_2$ dipping on respiration, which probably lowered the rate of transpiration, water loss and oxidation reactions when the treatments are combined. However, waxed barrier must not be so complete as to block essential movement of $O_2$ gas in to the fruit or $CO_2$ out of it Kader [22].



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### 3.2. Total Soluble Solids

The interaction effect of $CaCl_2$ dipping and beeswax (BW) coatings had highly significant ($P \leq 0.001$) influence on the TSS content of nectarine fruits Table 2. The control fruit samples had the highest TSS of 10.73 °Brix, whereas fruits treated with 6% BW with 4.5% $CaCl_2$ had the lowest TSS of 8.4 °Brix on day 5. Similarly, the highest TSS value was recorded in the control fruit samples while the lowest was observed in 6% BW with 0% $CaCl_2$ treatment on day 10. On day 15, TSS value of 13.80 °Brix was recorded in 0% BW with 3.0% $CaCl_2$ treatments while fruits treated with 6% BW combined with 0% $CaCl_2$ had 2.6 °Brix less TSS value. On day 25, fruits dipped in 6% BW in combination with 0% $CaCl_2$ recorded the highest TSS value (13.27 °Brix), which did not vary statistically with those treated with 6% BW combined with 1.5 and 4.5% $CaCl_2$. Whereas, the lowest TSS value (12.33 °Brix) was observed both in 3% BW with 4.5% $CaCl_2$ and 6% BW with 3.0% $CaCl_2$ treated fruits.

In general, there was a gradual increase in TSS value of nectarine fruits for most of the treatments over time. However, $CaCl_2$ dipping and BW coatings had significantly maintained the TSS of nectarine fruits higher towards the end of storage period. The increase in TSS was probably due to the hydrolysis of polysaccharides and concentrated juice content because of dehydration with the passage of storage time [9, 23]. The higher TSS content in control fruits might be due to faster changes of ripening resulting in breakdown of complex carbohydrates into simple sugars at a faster rate. This might also be due to high weight loss, which is mainly due to the water loss that leads to higher concentration of sugars in fruits during the storage [24, 25]. The lower respiration rate for $CaCl_2$ dipping and BW coatings might, therefore, reduce the use of metabolites resulting in slow conversion of carbohydrates to sugars.

**Table-1.** Effect of calcium chloride dipping and beeswax coating on the physiological loss in weight (%) of nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| BW (%) | $CaCl_2$ (%) | 5 | 10 | 15 | 20 | 25 |
| 0 | 0 | $5.38^{a} \pm 0.07$ | $11.79^{a} \pm 0.39$ | - | - | - |
| 0 | 1.5 | $5.18^{a} \pm 0.25$ | $11.05^{b} \pm 0.10$ | $19.30^{a} \pm 0.29$ | - | - |
| 0 | 3.0 | $4.57^{b} \pm 0.09$ | $10.28^{c} \pm 0.07$ | $17.76^{b} \pm 0.18$ | $27.55^{a} \pm 0.21$ | - |
| 0 | 4.5 | $4.78^{b} \pm 0.16$ | $9.74^{d} \pm 0.05$ | $17.46^{b} \pm 0.29$ | $25.47^{b} \pm 0.56$ | - |
| 3 | 0 | $3.06^{cd} \pm 0.10$ | $7.49^{f} \pm 0.26$ | $12.35^{c} \pm 0.32$ | $18.60^{c} \pm 0.45$ | - |
| 3 | 1.5 | $3.32^{c} \pm 0.38$ | $7.98^{e} \pm 0.16$ | $12.65^{c} \pm 0.80$ | $18.39^{c} \pm 1.04$ | - |
| 3 | 3.0 | $2.92^{de} \pm 0.39$ | $6.47^{h} \pm 0.18$ | $10.74^{de} \pm 0.66$ | $16.08^{de} \pm 0.65$ | $22.18^{b} \pm 0.26$ |
| 3 | 4.5 | $2.58^{ef} \pm 0.15$ | $5.76^{ij} \pm 0.10$ | $9.35^{fg} \pm 0.93$ | $14.08^{g} \pm 0.26$ | $19.30^{e} \pm 0.73$ |
| 6 | 0 | $2.44^{f} \pm 0.34$ | $5.47^{j} \pm 0.23$ | $9.11^{g} \pm 0.62$ | $14.51^{fg} \pm 0.50$ | $20.00^{de} \pm 0.95$ |
| 6 | 1.5 | $3.07^{cd} \pm 0.12$ | $7.01^{g} \pm 0.28$ | $11.68^{cd} \pm 0.51$ | $17.07^{d} \pm 0.90$ | $23.36^{a} \pm 0.32$ |
| 6 | 3.0 | $2.76^{def} \pm 0.08$ | $5.96^{i} \pm 0.28$ | $10.30^{ef} \pm 0.66$ | $15.81^{e} \pm 0.28$ | $21.93^{bc} \pm 0.78$ |
| 6 | 4.5 | $2.60^{ef} \pm 0.13$ | $5.98^{i} \pm 0.21$ | $10.26^{ef} \pm 0.44$ | $15.35^{ef} \pm 0.59$ | $21.02^{cd} \pm 0.11$ |
| Significance | | | | | | |
| BW (A) | | *** | *** | *** | *** | ns |
| $CaCl_2$ (B) | | *** | *** | *** | *** | *** |
| A * B | | *** | *** | *** | *** | *** |

**BW:** beeswax; data after ± are standard deviations (n=3); means with the same letter (s) in a column are not significantly different at $P \leq 0.05$ (LSD test); ns: non-significant; ***: $P \leq 0.001$.

**Table-2.** Effect of calcium chloride dipping and beeswax coating on the total soluble solids content (°Brix) of nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| BW (%) | $CaCl_2$ (%) | 5 | 10 | 15 | 20 | 25 |
| 0 | 0 | $10.73^{a} \pm 0.12$ | $13.57^{a} \pm 0.15$ | - | - | - |
| 0 | 1.5 | $10.50^{ab} \pm 0.10$ | $12.67^{b} \pm 0.23$ | $11.80^{e} \pm 0.20$ | - | - |
| 0 | 3.0 | $10.47^{b} \pm 0.12$ | $12.73^{b} \pm 0.12$ | $13.80^{a} \pm 0.20$ | $13.53^{ab} \pm 0.12$ | - |
| 0 | 4.5 | $9.63^{de} \pm 0.21$ | $11.93^{c} \pm 0.12$ | $12.47^{b} \pm 0.23$ | $13.80^{a} \pm 0.20$ | - |
| 3 | 0 | $9.47^{e} \pm 0.12$ | $11.40^{d} \pm 0.20$ | $11.73^{e} \pm 0.12$ | $13.47^{b} \pm 0.12$ | - |
| 3 | 1.5 | $9.20^{f} \pm 0.20$ | $10.87^{e} \pm 0.12$ | $12.40^{bc} \pm 0.20$ | $12.93^{de} \pm 0.12$ | - |
| 3 | 3.0 | $9.80^{cd} \pm 0.17$ | $10.80^{e} \pm 0.20$ | $11.80^{e} \pm 0.20$ | $12.73^{e} \pm 0.12$ | $12.80^{b} \pm 0.35$ |
| 3 | 4.5 | $8.70^{g} \pm 0.10$ | $10.37^{f} \pm 0.15$ | $11.87^{de} \pm 0.23$ | $12.20^{g} \pm 0.20$ | $12.33^{c} \pm 0.12$ |
| 6 | 0 | $9.40^{ef} \pm 0.00$ | $9.50^{g} \pm 0.10$ | $11.20^{f} \pm 0.20$ | $13.27^{bc} \pm 0.12$ | $13.27^{a} \pm 0.23$ |
| 6 | 1.5 | $9.47^{e} \pm 0.12$ | $10.93^{e} \pm 0.12$ | $11.93^{de} \pm 0.12$ | $12.67^{ef} \pm 0.31$ | $13.07^{ab} \pm 0.12$ |
| 6 | 3.0 | $10.00^{c} \pm 0.20$ | $11.03^{e} \pm 0.15$ | $12.13^{cd} \pm 0.23$ | $12.40^{gf} \pm 0.20$ | $12.33^{c} \pm 0.12$ |
| 6 | 4.5 | $8.40^{h} \pm 0.20$ | $10.33^{f} \pm 0.23$ | $11.93^{de} \pm 0.12$ | $13.07^{cd} \pm 0.12$ | $13.00^{ab} \pm 0.00$ |
| Significance | | | | | | |
| BW (A) | | *** | *** | *** | *** | ns |
| $CaCl_2$ (B) | | *** | *** | *** | *** | *** |
| A * B | | *** | *** | *** | *** | *** |

**BW:** beeswax; *data after ± are standard deviations (n=3)*; means with the same letter (s) in a column are not significantly different at $P \leq 0.05$ (LSD test); ns: non-significant; ***: $P \leq 0.001$.

### 3.3. Titratable Acidity

Nectarine fruits showed highly significant ($P \leq 0.001$) difference in titratable acidity (TA) due to the interaction effect of $CaCl_2$ dipping and beeswax (BW) coatings up to 20 days of storage Table 3. The highest TA values (1.55% and 1.42% malic acid) were recorded in 6% BW with 0% $CaCl_2$ treated fruits while the lowest TA values (1.16% and 0.68% malic acid) were observed in control fruit samples on day 5 and 10, respectively. However, at day 15 and 20, the highest TA values were maintained at 3% BW with 4.5% $CaCl_2$ treated fruits whereas fruits treated at 0% BW combined with 1.5% and 3.0% $CaCl_2$ on day 15 and 20, respectively, recorded the least (0.78%) TA value.



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Generally, the TA of nectarine fruits declined as storage period prolonged for all of the treatments. While TA value of non-treated fruits were low at all storage periods, treatments that involved $CaCl_2$ dipping and beeswax coatings, particularly 3% BW with 4.5% $CaCl_2$, maintained relatively higher TA levels. This result agreed with reports of Sahar [26] who detected a decrease in acidity of nectarine fruits during 28 days of storage. During fruit ripening in storage, fruit utilizes carbohydrates and acids for energy requirement of cells and synthesis of other compounds such as flavor compounds [25, 27]. Titratable acidity (TA) is often related to maturity [28]. Titratable acidity of fruits is an indicator of potential storage quality, which declines gradually over the storage period [29]. The faster decrease in acidity gives rise to a faster senescence [30]. The highest reduction and lowest value of titratable acidity could, therefore, be due to higher respiration rate and related metabolic activity, which enhances the consumption of organic acids.

**Table-3.** Effect of calcium chloride dipping and beeswax coating on the titratable acidity (%) of nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| **BW (%)** | **$CaCl_2$ (%)** | **5** | **10** | **15** | **20** | **25** |
| 0 | 0 | $1.16^{h}\pm0.08$ | $0.68^{h}\pm0.02$ | - | - | - |
| 0 | 1.5 | $1.29^{g}\pm0.02$ | $1.17^{g}\pm0.08$ | $0.78^{d}\pm0.07$ | - | - |
| 0 | 3.0 | $1.43^{cde}\pm0.03$ | $1.23^{cdef}\pm0.02$ | $1.12^{c}\pm0.00$ | $0.78^{f}\pm0.02$ | - |
| 0 | 4.5 | $1.49^{ab}\pm0.02$ | $1.28^{c}\pm0.02$ | $1.23^{b}\pm0.09$ | $0.91^{e}\pm0.04$ | - |
| 3 | 0 | $1.36^{f}\pm0.07$ | $1.19^{efg}\pm0.03$ | $1.12^{c}\pm0.00$ | $0.92^{de}\pm0.00$ | - |
| 3 | 1.5 | $1.29^{g}\pm0.02$ | $1.20^{defg}\pm0.02$ | $1.15^{bc}\pm0.07$ | $0.92^{de}\pm0.05$ | - |
| 3 | 3.0 | $1.38^{ef}\pm0.03$ | $1.25^{cd}\pm0.04$ | $1.19^{bc}\pm0.06$ | $0.94^{cde}\pm0.05$ | $0.72\pm0.02$ |
| 3 | 4.5 | $1.44^{bcd}\pm0.01$ | $1.36^{b}\pm0.00$ | $1.33^{a}\pm0.03$ | $1.12^{a}\pm0.00$ | $0.75\pm0.03$ |
| 6 | 0 | $1.55^{a}\pm0.02$ | $1.42^{a}\pm0.02$ | $1.24^{b}\pm0.03$ | $1.01^{b}\pm0.00$ | $0.72\pm0.06$ |
| 6 | 1.5 | $1.42^{def}\pm0.03$ | $1.19^{fg}\pm0.06$ | $1.18^{bc}\pm0.03$ | $0.98^{bcd}\pm0.03$ | $0.69\pm0.03$ |
| 6 | 3.0 | $1.48^{bc}\pm0.02$ | $1.24^{cdef}\pm0.03$ | $1.19^{bc}\pm0.03$ | $0.95^{bc}\pm0.03$ | $0.69\pm0.02$ |
| 6 | 4.5 | $1.47^{bcd}\pm0.00$ | $1.25^{cde}\pm0.02$ | $1.22^{b}\pm0.09$ | $0.98^{bc}\pm0.02$ | $0.75\pm0.03$ |
| Significance | | | | | | |
| BW (A) | | *** | *** | *** | *** | ns |
| $CaCl_2$ (B) | | *** | *** | *** | *** | ns |
| A * B | | *** | *** | *** | *** | ns |

**BW:** beeswax; data after ± are standard deviations (n=3); means with the same letter (s) in a column are not significantly different at $P \leq 0.05$ (LSD test); ns: non-significant; ***: $P \leq 0.001$.

### *3.4. Ascorbic Acid*

Highly significant ($P\leq0.001$) variation in the ascorbic acid (AA) content of nectarine fruits was recorded due to the interaction effect of $CaCl_2$ dipping and beeswax (BW) coatings except for day 25 Table 4. The lowest AA value of 8.44 mg/100 g was recorded in control fruit samples while the highest of 12 mg/100 g was observed in 6% BW + 4.5% $CaCl_2$ and 6% BW + 0% $CaCl_2$ treated fruits on day 5. However, non-significant difference between 0% BW with 1.5% $CaCl_2$ and 0% BW with 1.5% $CaCl_2$ as well as between 0% BW with 4.5% $CaCl_2$, 3% BW with 0% $CaCl_2$, 3% BW with 4.5% $CaCl_2$ and 3% BW with 4.5% $CaCl_2$ was observed on the same day. On day 10, fruits treated at 6% BW with 0% $CaCl_2$ had the highest AA value (9.78 mg/100 g) while it dropped to 4.44 mg/100 g in control fruits. Whereas, fruits treated with 0% BW with 4.5% $CaCl_2$ and 6% BW with 1.5% $CaCl_2$ showed non-significant variation.

**Table-4.** Effect of calcium chloride dipping and beeswax coating on the ascorbic acid contents (mg/100 g) of nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| **BW (%)** | **$CaCl_2$ (%)** | **5** | **10** | **15** | **20** | **25** |
| 0 | 0 | $8.44^{d}\pm0.77$ | $4.44^{d}\pm0.77$ | - | - | - |
| 0 | 1.5 | $9.33^{bcd}\pm0.00$ | $7.33^{c}\pm0.67$ | $4.89^{e}\pm0.77$ | - | - |
| 0 | 3.0 | $9.33^{bcd}\pm0.00$ | $7.56^{c}\pm0.77$ | $5.78^{cde}\pm0.77$ | $4.00^{d}\pm0.00$ | - |
| 0 | 4.5 | $10.67^{ab}\pm0.00$ | $8.89^{ab}\pm0.77$ | $7.00^{ab}\pm0.00$ | $4.00^{d}\pm0.00$ | - |
| 3 | 0 | $10.67^{ab}\pm1.34$ | $8.00^{bc}\pm0.67$ | $5.78^{cde}\pm0.77$ | $4.00^{d}\pm0.00$ | - |
| 3 | 1.5 | $8.89^{cd}\pm0.77$ | $7.78^{c}\pm0.39$ | $5.33^{de}\pm0.00$ | $4.00^{d}\pm0.00$ | - |
| 3 | 3.0 | $10.22^{bc}\pm1.54$ | $8.00^{bc}\pm0.00$ | $6.22^{bcd}\pm0.77$ | $4.00^{d}\pm0.00$ | $4.00\pm0.00$ |
| 3 | 4.5 | $10.67^{ab}\pm0.00$ | $9.55^{a}\pm0.39$ | $8.00^{a}\pm0.00$ | $5.78^{a}\pm0.77$ | $4.44\pm0.77$ |
| 6 | 0 | $12.00^{a}\pm0.00$ | $9.78^{a}\pm0.77$ | $7.11^{ab}\pm1.54$ | $5.33^{ab}\pm0.00$ | $4.44\pm0.77$ |
| 6 | 1.5 | $9.78^{bcd}\pm0.77$ | $8.00^{bc}\pm0.00$ | $6.78^{bc}\pm0.19$ | $4.44^{cd}\pm0.77$ | $4.00\pm0.00$ |
| 6 | 3.0 | $10.67^{ab}\pm1.34$ | $8.22^{bc}\pm0.39$ | $6.89^{abc}\pm0.19$ | $4.89^{bc}\pm0.77$ | $4.00\pm0.00$ |
| 6 | 4.5 | $12.00^{a}\pm0.00$ | $8.89^{ab}\pm0.38$ | $6.22^{bcd}\pm0.77$ | $4.22^{cd}\pm0.39$ | $4.00\pm0.00$ |
| Significance | | | | | | |
| BW (A) | | *** | *** | * | ** | ns |
| $CaCl_2$ (B) | | *** | *** | ** | ns | ns |
| A * B | | *** | *** | *** | *** | ns |

**BW:** beeswax; data after ± are standard deviations (n=3); means with the same letter (s) in a column are not significantly different at $P \leq 0.05$ (LSD test); ns: non-significant; *: $P \leq 0.05$; **: $P \leq 0.01$; ***: $P \leq 0.001$.

The AA content of nectarine fruits in general had substantially decreased as storage period advanced irrespective of the treatments. However, relatively higher AA content of nectarine fruits was maintained with $CaCl_2$ dipping and beeswax coating, particularly 3% BW + 4.5% $CaCl_2$ treated fruits, compared with the control Table 4. Sahar [26] reported similar result on nectarine fruits using essential oils and Davarynejad, et al. [31] on



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apricot fruits. The lower level of AA in control might be due to increased respiration, which accelerates the deteriorative oxidation reaction and loss of ascorbic acid [32, 33]. Ascorbic acid is an important nutrient and is very sensitive to degradation due to its oxidation compared to other nutrients during food processing and storage [34].

### *3.5. Decay*

Highly significant (P≤0.001) difference on the occurrence of nectarine fruit decay was observed due to the interaction effect of $CaCl_2$ dipping and beeswax (BW) coatings Table 5. There was a highest and massive decay of fruits in control fruit samples. At day 5, only control fruit samples had decayed fruits (40%), which increased to 73.33%, followed by fruits treated with 1.5% $CaCl_2$ with no beeswax coating on day 10. All fruits that received 6% BW, irrespective of $CaCl_2$ treatments, as well as fruits treated by 3% BW with 3.0 and 4.5% $CaCl_2$ and 0% BW with 4.5% $CaCl_2$ did not show sign of decay till day 15. While, it reached 66.67% in fruits treated with 1.5% $CaCl_2$ alone and discarded in the control treatment (Table 5). However, a relatively reduced fruit decay amounting to 20% to 60% was observed in fruits receiving 6 and 3% BW combined with higher concentrations of $CaCl_2$ during the subsequent storage periods. At day 25, the highest decay (60%) was observed from 6% BW with 0% $CaCl_2$ and 6% BW with 1.5% $CaCl_2$ treated fruits whereas the lowest (20%) was from 3% BW with 3.0% $CaCl_2$ and 3% BW with 4.5% $CaCl_2$ treated fruits Table 5.

**Table-5.** Effect of calcium chloride dipping and beeswax coating on the percentage decay of nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| BW (%) | $CaCl_2$ (%) | 5 | 10 | 15 | 20 | 25 |
| 0 | 0 | 40.00±0.00 | 73.33ᵃ±7.31 | - | - | - |
| 0 | 1.5 | 0.00±0.00 | 20.00ᵇ±0.00 | 66.67ᵃ±7.31 | - | - |
| 0 | 3.0 | 0.00±0.00 | 0.00ᶜ±0.00 | 20.00ᵇ±0.00 | 40.00ᵇ±0.00 | - |
| 0 | 4.5 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 20.00ᶜ±0.00 | - |
| 3 | 0 | 0.00±0.00 | 0.00ᶜ±0.00 | 20.00ᵇ±0.00 | 53.33ᵃ±6.66 | - |
| 3 | 1.5 | 0.00±0.00 | 0.00ᶜ±0.00 | 20.00ᵇ±0.00 | 40.00ᵇ±0.00 | - |
| 3 | 3.0 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 20.00ᶜ±0.00 | 20.00ᶜ±0.00 |
| 3 | 4.5 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 20.00ᶜ±0.00 | 20.00ᶜ±0.00 |
| 6 | 0 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 33.33ᵇ±7.32 | 60.00ᵃ±0.00 |
| 6 | 1.5 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 40.00ᵇ±0.00 | 60.00ᵃ±0.00 |
| 6 | 3.0 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 20.00ᶜ±0.00 | 40.00ᵇ±0.00 |
| 6 | 4.5 | 0.00±0.00 | 0.00ᶜ±0.00 | 0.00ᶜ±0.00 | 20.00ᶜ±0.00 | 33.33ᵇ±7.32 |
| Significance | | | | | | |
| BW (A) | | | ns | *** | *** | *** |
| $CaCl_2$ (B) | | | *** | *** | *** | *** |
| A * B | | | *** | *** | *** | *** |

**BW:** beeswax; data after ± are standard deviations (n=3); means with the same letter (s) in a column are not significantly different at P ≤ 0.05 (LSD test)**;** ns: non-significant; ***: P ≤ 0.001.

The percentage of decayed fruits gradually increased as storage period advanced for all of the treatments. However, $CaCl_2$ and beeswax coating significantly reduced fruit decay loss for relatively longer period. Fruits treated either at 3% BW + 3.0% $CaCl_2$ or 3% BW + 4.5% $CaCl_2$ better reduced the decay occurrence up to shelf life termination. Gayed, et al. [35] reported similar finding where $CaCl_2$ and chitosan application reduced decay percentage of 'Early Swelling' peach fruit. It has been observed that coating has the ability to prevent the growth of fungi in wide horticultural produces [36]. The use of edible coating combined with natural antimicrobials is a good strategy to increase shelf life of fruits [37]. The reduction of decay in $CaCl_2$ dipping and BW coatings could be due to the coatings film property which acted as a barrier for the growth of microbes. The difference in decay percentage might also be due to the modified atmospheric difference created by different levels of BW coatings. Fruit decay might also be reduced due to the combined role of $CaCl_2$, which act as a reducer of fruit softening by strengthening of the cell walls, and beeswax by covering cuticle and lenticels of the fruits. Hence, reduction of respiration rate and ripening process by the treatments probably minimized the occurrence of fruit decay.

### *3.6. Percentage of Marketable Fruits*

The percentage of marketable nectarine fruits was highly significantly (P≤0.001) influenced due to the interaction effect of $CaCl_2$ dipping and BW coatings (Table 6). Beeswax (3 and 6%) with all levels of $CaCl_2$, and 3 and 4.5% $CaCl_2$ alone kept fruits 100% marketable up to 10 days of storage while it dropped to 26.7 and 80% in the control and 1.5 % $CaCl_2$ treated fruits alone, respectively. Treatment combinations of 3% BW + 4.5% $CaCl_2$ and 6% BW + 0% $CaCl_2$ maintained fruits marketability to 100% till day 15 while it dropped to nil in the control to 33.33% in 0% BW + 1.5% $CaCl_2$ treated fruits. At day 20, fruits in the 0% BW + 1.5% $CaCl_2$ treatment were discarded, while the highest percentage of marketable fruits (80%) was recoded for 3% BW with 4.5% $CaCl_2$ treated fruits and the lowest (33.33%) was from 0% BW with 3% $CaCl_2$ treated fruits. Similarly, at day 25, all treatment combinations consisting of 0% BW with all levels of $CaCl_2$ and 3% BW with 0 and 1.5% $CaCl_2$ were discarded. Among the remaining treatments, the highest percentage of marketable fruits (53.33%) was observed from 3% BW + 4.5% $CaCl_2$ and 6% BW + 3.0% $CaCl_2$ treated fruits while the lowest (20%) was recorded for 6% BW + 1.5% $CaCl_2$ treated fruits Table 6.

In general, the marketability of nectarine fruits gradually declined over storage time. Decay and over ripening were the reason of shelf life termination for control fruits, while shriveling as well as little decays were the cause of shelf life termination and un-marketability for treated fruits. However, $CaCl_2$ dipping and beeswax coatings had significantly maintained the marketability of fruits. Particularly, treatment with 3% BW + 4.5% $CaCl_2$ had consistently kept the highest percentage of marketable fruits up to the last date of storage. This result was comparable with reports of Eryani-Raqeeb, et al. [38] who noticed that 2.5% calcium combined with chitosan



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coating extended the storage life of papaya fruits. Similarly, extended shelf life period was observed in plum fruits [39] and strawberries treated with edible coatings [40]. The lowest firmness loss, shriveling, decay occurrence and better appearance due to delayed metabolic rates might be the reason for the highest percentage of marketable fruits of $CaCl_2$ + BW coating treatments. However, the causes of shelf life termination for $CaCl_2$ dipping and BW coating treated fruits were fruit shriveling, decay and over ripening while decay was the main cause of shelf life termination for control fruits.

**Table-6.** Effect of calcium chloride dipping and beeswax coating on the percentage of marketable nectarine fruits under Holeta condition, 2018.

| Treatment | | Storage period (days) | | | | |
|---|---|---|---|---|---|---|
| **BW (%)** | **$CaCl_2$ (%)** | **5** | **10** | **15** | **20** | **25** |
| 0 | 0 | $60.00^{c}\pm0.00$ | $26.67^{c}\pm11.55$ | - | - | - |
| 0 | 1.5 | $93.33^{b}\pm11.55$ | $80.00^{b}\pm0.00$ | $33.33^{e}\pm11.55$ | - | - |
| 0 | 3.0 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $60.00^{d}\pm0.00$ | $33.33^{e}\pm11.55$ | - |
| 0 | 4.5 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $80.00^{c}\pm0.00$ | $40.00^{de}\pm0.00$ | - |
| 3 | 0 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $80.00^{c}\pm0.00$ | $46.67^{cd}\pm11.55$ | - |
| 3 | 1.5 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $66.67^{d}\pm11.55$ | $40.00^{de}\pm0.00$ | - |
| 3 | 3.0 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $93.33^{ab}\pm11.55$ | $53.33^{bc}\pm11.55$ | $40.00^{b}\pm0.00$ |
| 3 | 4.5 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $80.00^{a}\pm0.00$ | $53.33^{a}\pm11.55$ |
| 6 | 0 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $73.33^{a}\pm11.55$ | $40.00^{b}\pm0.00$ |
| 6 | 1.5 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $86.67^{bc}\pm11.55$ | $40.00^{de}\pm0.00$ | $20.00^{c}\pm0.00$ |
| 6 | 3.0 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $80.00^{c}\pm0.00$ | $60.00^{b}\pm0.00$ | $53.33^{a}\pm11.55$ |
| 6 | 4.5 | $100.00^{a}\pm0.00$ | $100.00^{a}\pm0.00$ | $86.67^{bc}\pm11.55$ | $60.00^{b}\pm0.00$ | $40.00^{b}\pm0.00$ |
| Significance | | | | | | |
| BW (A) | | ns | ns | *** | *** | ns |
| $CaCl_2$ (B) | | *** | *** | *** | *** | *** |
| A * B | | *** | *** | *** | *** | *** |

**BW:** beeswax; data after ± are standard deviations (n=3); means with the same letter (s) in a column are not significantly different at $P \leq 0.05$ (LSD test); ns: non-significant; ***: $P \leq 0.001$.

## 4. Conclusion

Calcium chloride dipping and BW coatings had substantially reduced the PLW and significantly maintained the TSS, TA and AA of nectarine fruits. It also significantly minimized nectarine fruit decay and maintained marketability as well. Hence, calcium chloride dipping and beeswax coatings, particularly treatment with 3% BW + 4.5% $CaCl_2$, could be considered as an alternative technology for shelf life extension and better quality.

## References

[1] A. A. Kader, *Fruits in the global market. In: Knee, M. (Ed.), Fruit quality and its biological basis*: Sheffield Academic Press Limited, 2002.

[2] FAO (Food and Agricultural Organization), *The state of the food insecurity in the world.* Rome, Italy, 2004.

[3] M. L. Choudhury, "Recent developments in reducing postharvest losses in the Asia-Pacific region. In: Rolle, R. S. (ed.)," in *Reports of the APO Seminar on Reduction of Postharvest Losses of Fruit and Vegetables. Tokyo, Japan*, 2006, pp. 15-22.

[4] C. H. Crisosto and K. R. Day, *Stone fruit. In: Crop post-harvest: Science and technology.* United States of America: Blackwell Publishers, 2012.

[5] K. Kaur, W. Dhillon, and B. Mahajan, "Effect of different packaging materials and storage intervals on physical and biochemical characteristics of pear," *Journal of Food Science and Technology*, vol. 50, pp. 147-152, 2013. Available at: https://doi.org/10.1007/s13197-011-0317-0.

[6] E. A. Baldwin, M. O. Nisperos-Carriedo, and R. A. Baker, "Use of edible coatings to preserve quality of lightly (and slightly) processed products," *Critical Reviews in Food Science & Nutrition*, vol. 35, pp. 509-524, 1995. Available at: https://doi.org/10.1080/10408399509527713.

[7] M. Vargas, C. Pastor, A. Chiralt, D. J. McClements, and C. Gonzalez-Martinez, "Recent advances in edible coatings for fresh and minimally processed fruits," *Critical Reviews in Food Science and Nutrition*, vol. 48, pp. 496-511, 2008. Available at: https://doi.org/10.1080/10408390701537344.

[8] R. Dhall, "Advances in edible coatings for fresh fruits and vegetables: A review," *Critical Reviews in Food Science and Nutrition*, vol. 53, pp. 435-450, 2013. Available at: https://doi.org/10.1080/10408398.2010.541568.

[9] A. Akhtar, N. A. Abbasi, and A. Hussain, "Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage," *Pakistan Journal of Botany*, vol. 42, pp. 181-188, 2010.

[10] P. Senevirathna and W. Daundasekera, "Effect of postharvest calcium chloride vacuum infiltration on the shelf life and quality of tomato (cv.'Thilina')," *Ceylon Journal of Science*, vol. 39, pp. 35-44, 2010. Available at: https://doi.org/10.4038/cjsbs.v39i1.2351.

[11] M. Faust and C. P. Shear, "The effect of calcium on respiration of apples," *Journal of the American Society for Horticultural Science*, vol. 97, pp. 437-439, 1972.

[12] HARC (Holetta Agricultural Research Centre), "Annual review report," HARC, Holeta, Ehiopia2004.

[13] Z. Hassan, S. Lesmayati, R. Qomariah, and A. Hasbianto, "Effects of wax coating applications and storage temperatures on the quality of tangerine citrus (Citrus reticulata) var. Siam Banjar," *International Food Research Journal*, vol. 21, pp. 641-648, 2014.

[14] AOAC (Association of Official Analytical Chemists), *Official methods of analysis*, 14th ed. Washington, DC, USA: AOAC, 1984.

[15] S. Ranganna, *Hand book of analysis and quality control for fruit and vegetable products.* New Delhi, India: Tata McGraw-Hill Publishing Co. Ltd, 1986.

[16] D. Garner, C. H. Crisosto, P. Wiley, and G. M. Crisosto, *Measurement of pH and titratable acidity. In: Crisosto, C. H. (ed.)* vol. 2: Central Valley Postharvest Newsletter, 2008.

[17] O. A. Bessey and C. King, "The distribution of vitamin C in plant and animal tissues, and its determination," *Journal of Biological Chemistry*, vol. 103, pp. 687-698, 1933.

[18] A. El-Anany, G. Hassan, and F. R. Ali, "Anna apple (Malus domestica Borkh) during cold storage," *Journal of Food Technology*, vol. 7, pp. 5-11, 2009.

[19] M. Mohammed, L. A. Wilson, and P. L. Gomes, "Postharvest sensory and physiochemical attributes of processing and non-processing tomato cultivar," *Journal of Food Quality*, vol. 22, pp. 167-182, 1999. Available at: https://doi.org/10.1111/j.1745-4557.1999.tb00549.x.

[20] K. A. Gomez and A. A. Gomez, *Statistical procedures for agricultural research.* New York, United States of America: John Willey and Sons, 1984.

[21] H. El-Badawy, "Effect of chitosan and calcium chloride spraying on fruits quality of Florida Prince peach under cold storage," *Research Journal of Agriculture and Biological Sciences*, vol. 8, pp. 272-281, 2012.



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[22] A. A. Kader, *Postharvest technology of horticultural crops*: Agriculture and Natural Resources, University of California, Publication 3311, 1992.

[23] N. G. Tao, T. T. Ao, Y. J. Liu, and S. R. Huang, "Effect of sucrose-based polymers on quality of Satsuma mandarin fruit (Citrus unshiu Marc. cv. Miyagawa Wase)," *International Journal of Food Science & Technology*, vol. 47, pp. 997-1003, 2012. Available at: https://doi.org/10.1111/j.1365-2621.2011.02933.x.

[24] M. Suni, M. Nyman, N. A. Eriksson, L. Björk, and I. Björck, "Carbohydrate composition and content of organic acids in fresh and stored apples," *Journal of the Science of Food and Agriculture*, vol. 80, pp. 1538-1544, 2000. Available at: https://doi.org/10.1002/1097-0010(200008)80:10<1538::aid-jsfa678>3.0.co;2-a.

[25] D. R. Bhattarai and D. M. Gautam, "Effect of harvesting method and calcium on post harvest physiology of tomato," *Nepal Agriculture Research Journal*, vol. 7, pp. 37-41, 2006. Available at: https://doi.org/10.3126/narj.v7i0.1864.

[26] M. A. Sahar, "Maintain postharvest quality of nectarine fruits by using some essential oils," *Middle East Journal of Applied Science*, vol. 5, pp. 855-868, 2015.

[27] P. E. Zerbini, "The quality of pear fruit," *Acta Horticulture*, vol. 596, pp. 805-813, 2002.

[28] G. Bhattacharya, "Served fresh spotlight," *Times Food Processing Journal*, pp. 39-44, 2004.

[29] R. C. Soliva-Fortuny and O. Martín-Belloso, "Microbiological and biochemical changes in minimally processed fresh-cut Conference pears," *European Food Research and Technology*, vol. 217, pp. 4-9, 2003. Available at: https://doi.org/10.1007/s00217-003-0701-8.

[30] A. Ali, M. T. M. Muhammad, K. Sijam, and Y. Siddiqui, "Effect of chitosan coatings on the physicochemical characteristics of Eksotika II papaya (Carica papaya L.) fruit during cold storage," *Food Chemistry*, vol. 124, pp. 620-626, 2011. Available at: https://doi.org/10.1016/j.foodchem.2010.06.085.

[31] G. Davarynejad, M. Zarei, E. Ardakani, and M. E. NASRABADI, "Influence of putrescine application on storability, postharvest quality and antioxidant activity of two Iranian apricot (Prunus armeniaca L.) cultivars," *Notulae Scientia Biologicae*, vol. 5, pp. 212-219, 2013. Available at: https://doi.org/10.15835/nsb529041.

[32] R. B. Wills, W. B. McGlasson, D. Graham, T. H. Lee, and E. G. Hall, *Postharvest: An Introduction to the physiology and handling of fruit and vegetables*. Kensington, England: New South Wales University Press Limited, 1981.

[33] M. W. Davey, M. v. Montagu, D. Inze, M. Sanmartin, A. Kanellis, N. Smirnoff, I. J. J. Benzie, J. J. Strain, D. Favell, and J. Fletcher, "Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing," *Journal of the Science of Food and Agriculture*, vol. 80, pp. 825-860, 2000. Available at: https://doi.org/10.1002/(sici)1097-0010(20000515)80:7<825::aid-jsfa598>3.3.co;2-y.

[34] R. Veltman, R. Kho, A. Van Schaik, M. Sanders, and J. Oosterhaven, "Ascorbic acid and tissue browning in pears (Pyrus communis L. cvs Rocha and Conference) under controlled atmosphere conditions," *Postharvest Biology and Technology*, vol. 19, pp. 129-137, 2000. Available at: https://doi.org/10.1016/s0925-5214(00)00095-8.

[35] A. A. N. A. Gayed, S. A. M. A. Shaarawi, M. A. Elkhishen, and N. R. M. Elsherbini, "Pre-harvest application of calcium chloride and chitosan on fruit quality and storability of 'early swelling'peach during cold storage," *Science and Agrotechnology*, vol. 41, pp. 220-231, 2017. Available at: https://doi.org/10.1590/1413-70542017412005917.

[36] P. Tripathi and N. Dubey, "Exploitation of natural products as an alternative strategy to control postharvest fungal rotting of fruit and vegetables," *Postharvest Biology and Technology*, vol. 32, pp. 235-245, 2004. Available at: https://doi.org/10.1016/s0925-5214(03)00235-7.

[37] N. d. F. F. Soares, D. F. P. Silva, G. P. Camilloto, C. P. Oliveira, N. M. Pinheiro, and E. A. A. Medeiros, "Antimicrobial edible coating in post-harvest conservation of Guava," *Brazilian Journal of Fruticulture*, vol. 33, pp. 281-289, 2011.

[38] A. Eryani-Raqeeb, T. Mahmud, S. S. Omar, A. M. Zaki, and A. Al Eryani, "Effects of calcium and chitosan treatments on controlling anthracnose and postharvest quality of papaya (Carica papaya L.)," *International Journal of Agricultural Research*, vol. 4, pp. 53-68, 2009. Available at: https://doi.org/10.3923/ijar.2009.53.68.

[39] H. L. Eum, D. K. Hwang, M. Linke, S. K. Lee, and M. Zude, "Influence of edible coating on quality of plum (Prunus salicina Lindl. cv.'Sapphire')," *European Food Research and Technology*, vol. 229, pp. 427-434, 2009. Available at: https://doi.org/10.1007/s00217-009-1054-8.

[40] N. B. Gol, P. R. Patel, and T. R. Rao, "Improvement of quality and shelf-life of strawberries with edible coatings enriched with chitosan," *Postharvest Biology and Technology*, vol. 85, pp. 185-195, 2013. Available at: https://doi.org/10.1016/j.postharvbio.2013.06.008.


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