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# EFFECT OF DE-ASTRINGENCY METHOD AND MATURITY STAGES ON FRUIT QUALITY OF "COSTATA" PERSIMMON (*Diospyros kaki* L.) DURING SHELF LIFE

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## ABSTRACT

*Astringency removal is one of the most important factors that influence ripening; improve quality and shelf life of persimmon fruits. So, this study was carried out to evaluate the efficiency of some chemical treatments like ethephon, ethanol, calcium carbide and saturated lime on removal astringency of fruits harvested at two dates and its influence on fruit quality parameters during shelf life at room temperature. Fruit harvested at two dates (50 and 75% color) were dipped in tap water for 5 days as control, saturated lime ($Ca(OH)_2$) for 5 days, ethephon at 500 or 750 ppm for 5 min, ethanol at 25 or 30 % for 5 min and fruits exposed to gases resulted from mixing calcium carbide ($CaC_2$) at 10 or 20g + 40ml water in closed chamber for 24 h and then stored at room temperature 23±1 °C and 60 ± 5 % RH for 15 days.*

***The obtained results showed that** ethephon at 750 ppm for 5 min and calcium carbide at 20g +40 water had superior effect in reducing fruit weight loss %, decay %, total tannins and maintains firmness with increasing soluble solid content (SSC %) and enhancing ripening process than other treatments in both harvesting stages used. Since, these treatments were more effective to remove fruit astringency through reducing tannin content. In general, ethephon at 750ppm and calcium carbide at 20g treatments were effective in maintaining firmness, titratable acidity, ascorbic acid and soluble solids content in "Costata" persimmon fruits for 15 days of shelf life and removes the astringency. Moreover, the second picking date (75% color) was more suitable for maintaining the above mentioned quality characters.*

***Conclusively,** it could be recommended to harvest Costata persimmon fruits at 75 % coloration and use one of the above mentioned treatments for removing the astringency with maintains the quality during shelf life.*

**Key words:** Ethephon, Ethanol, Calcium, Kaki, Fruit firmness, Astringency, Decay, ripening

## INTRODUCTION

Japanese persimmon (*Diospyros kaki*, L.) is one of the most promising deciduous fruit species in Egypt, due to its low chilling requirements, adapts to the warm climate and increasing demands of local consumption (Ennab *et al.*, 2018). Moreover, persimmon fruit is a good source of some bioactive compounds like ascorbic acid, tocopherol, carotenoids, polyphenols, dietary fibre, tannins and pectin, in addition to protein, lipids, carbohydrate, vitamins and minerals such as potassium, magnesium, zinc, iron, copper and manganese (Yaqub *et al.*, 2016 and Gautam *et al.*, 2020).

So, orchards of persimmon increased rapidly and cultivation spreads in many areas in Egypt. Such extension in cultivated area encourages establishing more studies to finding out a good and suitable solutions to the problems of persimmon farmers. Persimmon varieties categorized into two different groups: astringent and non-astringent varieties. The astringent varieties consist of high levels of soluble tannins while the non-astringent varieties contain small amount of tannins (Sato and Yamada 2016, Das and Eun 2020 and Vilhena *et al.*, 2020).

Costata is the most widely grown astringent cultivar in Egypt. Therefore, the main problem facing persimmon growers are that fruit does not leave to ripe on the tree, but it needs to artificial ripening for commercial production and marketing. Some chemical substances like ethephon, ethanol, calcium carbide and carbon dioxide has been used to remove astringency content of fruits and improving fruit quality, besides maintaining fruit firmness and prolonging shelf life of persimmon fruits (Taira *et al.*, 1999, Ahmed and Sobieh 2007, El-Badawy 2007 and Tessmer *et al.*, 2016). In this respect, Abd El-Wahab *et al.*, (2017) reported that, $CO_2$ at 80% treatment was more effective and faster than Ethrel or Calcium carbide treatments in attaining a high taste score as a response to its pronouncing effect in removing astringency from Costata persimmon fruits than other treatments, also the lowest value of fruits firmness was associated with Ethrel and Calcium Carbide treatment. Moreover, El-Kady *et al.*, (2008) indicated that, Ethephon at 750 ppm was superior effect for reducing fruit firmness and total tannins with increasing total soluble solids than dipping fruits in 500 or 1000 ppm, in addition, ethanol application at 25 % was suitable to accelerate fruit ripening with increasing soluble solids than dipping fruits in 50 % concentration. Also, El-Badawy (2007) concluded that ethephon and calcium carbide were more effective to remove fruit astringency through reducing tannin content and maintain fruit quality of Costata persimmon.

Therefore, this study aimed to evaluate the influence of maturity stage of "Costata" persimmon fruit and some chemical substances on efficiency of the astringency removal process and its influence on maintenance of fruit quality during shelf life period.

## MATERIALS AND METHODS

The present study was carried out during 2019 and 2020 seasons on fruits harvested from 11 years old "Costata" persimmon trees (*Diospyros kaki*, L.) budded on (*Diospyros lotus*) rootstock, planted at 4 × 4 meter apart in a private orchard at Al-Gharbia governorate, Egypt. The fruits were harvested at two maturity stage, the first one ($P_1$) was done when the fruit peel reached 50% of color, after 157 and 155 days from full bloom in both seasons, respectively and the second one ($P_2$) when peel reached 75% of color, after 164 and 162 days from full bloom in both seasons, respectively, fruit color at picking dates were determining according to Japanese color chart (Ebert and Gross, 1985). Fruit samples in each picking date were selected for uniform size, color and free from physical injuries, insect attack and damages. Fruit samples were directly translocate to the laboratory of Sakha Horticulture Research Station, Kafr El-Sheikh governorate, cleaned, and washed with tap water, dipped in 2% boric acid for 2 minutes (surface-sterilized) and air dried with an electrical fan. Six fruits were taken to determine picking date quality parameters at each maturity stage. Thereafter, 192 fruits in each picking stage were divided into eight groups to receive one of the following artificial ripening treatments: control (dipping in tap water), saturated lime (dipping in Ca $(OH)_2$ solution), ethephon at 500 and 750 ppm (dipping in ethephon at 500 or 750 ppm for 5min), ethanol at 25 and 30 % (dipping in ethanol solution at 25 or 30 % for 5min), calcium carbide 10 and 20 (fruits exposed to the gases resulted from the interaction between calcium carbide ($CaC_2$) at 10 or 20 g + 40ml water in a closed chamber for 24 hour). The treatments were done as combinations between each maturity stage and chemical substance. The experimental design was complete randomized design, in three replicates was carried out to evaluate the effect of chemical treatments combined with maturity stage on efficiency of the astringency removal process and its influence on maintenance of fruit quality after 3, 5, 10 and 15 days of shelf life at room temperature.

### *Preparation the artificial ripening treatments*

#### *Saturated lime*

Persimmon fruits were soaked in a solution of calcium hydroxide (Ca $(OH)_2$) and water at 1:10 w/v, respectively for 5 days as recommended by Ryerson (1927).

***Calcium carbide ($CaC_2$)***

Persimmon fruits were exposed to the gases that resulted from calcium carbide ($CaC_2$) mixed with water in a closed chamber (8 $m^3$) for 24 hour at 20-25°C as described by El zayat *et al* (2004). This treatment was done at two concentrations of $CaC_2$ (10 g + 40 ml of water) and (20 g + 40 ml of water).

***Ethephon method***

Persimmon fruits were dipped in ethephon solution (2- chloroethyl phosphonic acid) at concentration of 500 and 750 ppm for 5 min.

***The treatments were arranged as follow:***

$T_1$: Fruits of $P_1$ dipped in tap water for 5 days (control).
$T_2$: Fruits of $P_2$ dipped in tap water for 5 days (control).
$T_3$: Fruits of $P_1$ dipped in saturated lime for 5 days.
$T_4$: Fruits of $P_2$ dipped in saturated lime for 5 days.
$T_5$: Fruits of $P_1$ soaked in ethephon at 500 ppm for 5 min.
$T_6$: Fruits of $P_2$ soaked in ethephon at 500 ppm for 5 min.
$T_7$: Fruits of $P_1$ soaked in ethephon at 750 ppm for 5 min.
$T_8$: Fruits of $P_2$ soaked in ethephon at 750 ppm for 5 min.
$T_9$: Fruits of $P_1$ soaked in ethanol at 25% solution for 5 min.
$T_{10}$: Fruits of $P_2$ soaked in ethanol at 25% solution for 5 min.
$T_{11}$: Fruits of $P_1$soaked in ethanol at 30% solution for 5 min.
$T_{12}$: Fruits of $P_2$soaked in ethanol at 30% solution for 5 min.
$T_{13}$: Fruits of $P_1$exposed to calcium carbide ($CaC_2$) at 10g + 40ml water for 24 h.
$T_{14}$: Fruits of $P_2$exposed to calcium carbide ($CaC_2$) at 10g + 40ml water for 24 h.
$T_{15}$: Fruits of $P_1$exposed to calcium carbide (CaC2) at 20g + 40ml water for 24 h.
$T_{16}$: Fruits of $P_2$exposed to calcium carbide (CaC2) at 20g + 40ml water for 24 h

Samples from fruits exposed to above treatments (six fruits per treatment) were taken to determine fruit quality parameters after 3 days from treatments date. The remaining fruits were packed in ventilated plastic bags and hold in carton boxes (40 x25 x15 cm dimensions). Each treatment was represented by three carton boxes for each date. Each carton box contains six of "Costata" persimmon fruits. All boxes were stored at room temperature 23±1 °C and 60 ± 5 % RH for 15 days. During shelf life period, the fruit quality variables were measured at five day intervals as follow:

***1. Weight loss (%):***

"Costata" persimmon fruits were weighed at zero time (before storage) and reweighted again at 5 day intervals during shelf life period. Weight loss was calculated according to the following equation:

Fruit weight loss %= $(W_0 – W_S) / W_0 \times 100$
Where, $W_0$ = Fruit weight before treatment. Ws = Fruit weight after each shelf life periods.

***2. Fruit decay (%):***

Fruit decay % was determined by calculating the number of decayed fruits in the sampling date and expressed as a percentage of fruit decay according to the following equation:

Fruit decay % = {NO. of decayed fruits ÷ Initial NO. of stored fruits} × 100

***3. Fruit firmness (Ib/inch$^2$):***

Fruit firmness was examined in two sides of the fruit using Effigi pressure tester (mod. Ft327).

***4. Total tannins content (mg/100ml):***

Total tannins was determined in fruit juice by titrating 5 ml of juice against 0.1 N of potassium permanganate ($KMnO_4$) using indigo-carmine as indicator according to A.O.A.C., (1990). The results were calculated as mg per 100 ml juice.

***5. Fruit carotenoids content (mg/100ml):***

Carotenoids content was determined using colorimetric method described by Holm (1954) and Wettstein (1957).

***6. Soluble solids content (%):***

Soluble solid content (SSC %) of persimmon fruits was recorded with the help of hand refractometer.

***7. Titratable acidity (%):***

The acidity % of the fruit juice was estimated by titrating against standard alkali solution (0.1N NaOH) with phenolphthalein indicator and expressed as percentage of malic acid/100 ml of juice according to A.O.A.C., (1990),

**8. SSC/acid ratio:** SSC/acid ratio was calculated.

**9. Ascorbic acid mg/100 ml juice**:

Ascorbic acid was determined by using 2, 6 dichlorophenol indophenol pigment according to Rangana, (1977).

***Statistical analysis****:*

The experiment treatments were arranged as complete randomized design. The data was analyzed using analysis of variance by MSTATC software program according to Snedecor and Cochran (1990) and treatment means were compared by using Duncan multiple range tests at 5% level according to Duncan (1955).

## RESULTS AND DISCUSSION

***Weight loss (%):***

Data in Table 1 shows the changes in weight loss % of "Costata" persimmon fruits harvested at different maturity stages and exposed to some chemical treatments for removal astringency substances during 2019 and 2020 seasons. The results revealed that as the shelf life period progressed the percentage of weight loss was increased from 4.49 to9.17 and 4.78 to 9.40 % after 15 days of shelf life in both seasons, respectively. Also, all chemical treatments showed a significant increase in fruit weight loss percentage compared to untreated fruits (control). Similar results were obtained by Rouhani *et al.*, (1975) and Ramin and Tabatabaie (2003) they reported that weight loss of persimmon fruit was significantly affected by the stage of maturity under short term storage.

The highest percentage weight loss was observed in fruits of second maturity stage that exposed to calcium carbide 20g treatment followed by ethephon at 750 ppm and ethephon at 500 ppm treatment in the first seasons. By the second one the highest weight loss % was associated with fruits of both maturity stages that treated with ethephon at 500 and 750 ppm and calcium carbide at 10 and 20 g after 15 days in shelf life. On the other hand, the lowest percentage of weight loss was observed in untreated fruits of first maturity stage (control) in both seasons. Generally, the results indicated that exposure to some chemical treatments for removal astringency substances were significantly effective in weight loss percentages of "Costata" persimmon fruits in both maturity stages. In this respect, fruit harvested at 50% colored or at 75% and dipped in tap water for five days gave the lowest fruit weight loss percentage, followed by those dipped in saturated lime for five days. Similar results were obtained by Kou *et al.*, (2020) on some persimmon cultivars. In this respect, Kamal and Rabeh (1989) revealed that "Costata" persimmon fruits soaked in ethephon solutions at concentrations of 500, 1000 and 2000 ppm exhibited higher weight loss than those soaked in tap water (control). The loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and weight loss. In this line, El-Badawy (2007) showed the role of chemical substances (ethephon and calcium carbide) in increasing weight loss of persimmon fruits may be due to increasing respiration rate and accelerating fruit ripening which known as ripe fruits lose their moisture content more quickly than unripe ones.

**Table 1:** Effect of removal astringency method and maturity stage on weight loss (%) of "Costata" persimmon fruits during shelf life periods in 2019 and 2020 seasons

| Treatments | | Weight loss (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | *Mean* | 3 days | 5 days | 10 days | 15 days | *Mean* |
| Control | $P_1$ | - | 2.31f | 4.24f | 6.35lg | **3.23L** | - | 2.55d | 5.23e | 7.36c | **3.79H** |
| | $P_2$ | - | 3.34d | 6.21de | 8.19e | **4.44I** | - | 3.28cd | 5.64e | 7.23c | **4.04G** |
| Saturated lime | $P_1$ | - | 2.97e | 5.21ef | 7.35f | **3.88K** | - | 3.42cd | 6.38d | 8.11bc | **4.48F** |
| | $P_2$ | - | 3.94cd | 6.87d | 8.79d | **4.90H** | - | 3.85c | 6.13d | 8.16bc | **4.54F** |
| Ethephon 500 ppm | $P_1$ | - | 4.88c | 7.42cd | 9.62c | **5.48F** | - | 4.85bc | 9.25ab | 9.85ab | **5.99C** |
| | $P_2$ | - | 5.81b | 9.33b | 10.41b | **6.39B** | - | 6.22a | 8.87b | 10.15ab | **6.31B** |
| Ethephon 750 ppm | $P_1$ | - | 5.15bc | 7.95 c | 9.99bc | **5.75E** | - | 5.27b | 9.98a | 10.34a | **6.40B** |
| | $P_2$ | - | 6.12ab | 9.52b | 10.26b | **6.48B** | - | 6.85a | 9.33ab | 10.62a | **6.70A** |
| ethanol 25 % | $P_1$ | - | 3.15d | 5.85e | 7.82f | **4.21J** | - | 3.96i | 7.43c | 8.77b | **5.04E** |
| | $P_2$ | - | 4.11cd | 7.42cd | 9.32cd | **5.21G** | - | 4.22c | 7.32c | 9.12b | **5.17E** |
| ethanol 30 % | $P_1$ | - | 3.75cd | 6.32ed | 8.16e | **4.56I** | - | 4.45c | 8.28bc | 9.76ab | **5.62D** |
| | $P_2$ | - | 4.77c | 8.15c | 9.91bc | **5.71E** | - | 5.02bc | 7.93f | 9.87ab | **5.71D** |
| CaC2 at 10 g | $P_1$ | - | 4.11cd | 6.93d | 8.91d | **4.99H** | - | 4.67bc | 8.43b | 9.84ab | **5.74D** |
| | $P_2$ | - | 5.50b | 8.85bc | 10.38b | **6.18C** | - | 5.80b | 8.62b | 9.92ab | **6.09C** |
| CaC2 at 20 g | $P_1$ | - | 5.21bc | 8.61bc | 10.14b | **5.99D** | - | 5.32b | 9.86a | 10.45a | **6.41B** |
| | $P_2$ | - | 6.66a | 10.26a | 11.13a | **7.01A** | - | 6.74a | 9.84a | 10.78a | **6.84A** |
| ***Mean*** | | **-** | **4.49C** | **7.45B** | **9.17A** | | **-** | **4.78C** | **8.03B** | **9.40A** | |
| Initial value $P_1$ | | 0.00 | | | | | 0.00 | | | | |
| Initial value $P_2$ | | 0.00 | | | | | 0.00 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, P ≤ 0.05.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

### *Fruit decay (%):*

Data presented in Table 2 show the effect of maturity stages and exposure to some chemical treatments on fruit decay percentage of "Costata" persimmon during shelf life period in 2019 and 2020 seasons. The results showed that fruit decay percentage was gradually increased with increasing shelf life since; it rose from 0.00 to 4.75 and 0.00 to 4.78 % after 15 days of shelf life in both seasons, respectively. Also, results showed that advanced maturity of fruit promotes decay during shelf life.

Also, data in the same Table (2) reveal that, a significantly higher fruit decay % was recorded in fruits that harvested in second date ($P_2$) and treated by ethanol 25 % after 10 and 15 days of shelf life. These results were true in both seasons. Anyhow, ethanol at 25% treatment produced the highest fruit decay percentage as compared with the other treatments especially in second maturity

**Table 2:** Effect of removal astringency method and maturity stage on fruit decay (%) of "Costata" persimmon fruits during shelf life period in 2019 and 2020 seasons

| Treatments | | Fruit decay (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | *Mean* | 3 days | 5 days | 10 days | 15 days | *Mean* |
| Control | $P_1$ | 0.00a | 0.00a | 0.00e | 4.37c | **1.09H** | 0.00a | 0.00a | 0.00g | 2.72f | **0.68L** |
| | $P_2$ | 0.00a | 0.00a | 0.00e | 5.24b | **1.31G** | 0.00a | 0.00a | 0.00g | 4.05d | **1.01I** |
| Saturated lime | $P_1$ | 0.00a | 0.00a | 0.00e | 3.22d | **0.81I** | 0.00a | 0.00a | 0.00g | 3.42e | **0.86K** |
| | $P_2$ | 0.00a | 0.00a | 0.00e | 4.56c | **1.14H** | 0.00a | 0.00a | 0.00g | 4.83cd | **1.21H** |
| Ethephon 500ppm | $P_1$ | 0.00a | 0.00a | 0.00e | 3.15d | **0.79I** | 0.00a | 0.00a | 0.00g | 5.18c | **1.30G** |
| | $P_2$ | 0.00a | 0.00a | 1.55d | 5.62b | **1.79E** | 0.00a | 0.00a | 4.85b | 5.82bc | **2.67C** |
| Ethephon 750ppm | $P_1$ | 0.00a | 0.00a | 1.66d | 4.36c | **1.51F** | 0.00a | 0.00a | 0.00g | 2.34f | **0.59M** |
| | $P_2$ | 0.00a | 0.00a | 3.66b | 5.33b | **2.25B** | 0.00a | 0.00a | 3.46d | 6.14b | **2.40D** |
| Ethanol 25 % | $P_1$ | 0.00a | 0.00a | 2.33c | 5.73b | **2.02CD** | 0.00a | 0.00a | 1.33f | 6.34ab | **1.92F** |
| | $P_2$ | 0.00a | 0.00a | 4.42a | 6.63a | **2.76A** | 0.00a | 0.00a | 5.22a | 6.78a | **3.00A** |
| Ethanol 30 % | $P_1$ | 0.00a | 0.00a | 3.38b | 4.56c | **1.99CD** | 0.00a | 0.00a | 2.11e | 3.26e | **1.34G** |
| | $P_2$ | 0.00a | 0.00a | 3.15b | 5.72b | **2.22B** | 0.00a | 0.00a | 4.11c | 5.39c | **2.38D** |
| CaC2 at 10 g | $P_1$ | 0.00a | 0.00a | 1.66d | 4.55c | **1.55F** | 0.00a | 0.00a | 0.00g | 4.23cd | **1.06I** |
| | $P_2$ | 0.00a | 0.00a | 2.33c | 3.15d | **1.37G** | 0.00a | 0.00a | 3.24d | 5.78bc | **2.26E** |
| CaC2 at 20 g | $P_1$ | 0.00a | 0.00a | 2.33c | 5.25b | **1.90DE** | 0.00a | 0.00a | 0.00g | 3.75d | **0.94J** |
| | $P_2$ | 0.00a | 0.00a | 3.52b | 4.62c | **2.04C** | 0.00a | 0.00a | 4.72b | 6.43ab | 2.79B |
| ***Main*** | | **0.00C** | **0.00C** | **1.87B** | **4.75A** | | **0.00C** | **0.00C** | **1.82B** | **4.78A** | |
| Initial value $P_1$ | | 0.00 | | | | | 0.00 | | | | |
| Initial value $P_2$ | | 0.00 | | | | | 0.00 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control =**Fruits dipped in water for 5 days, **Saturated lime =**Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm =**Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30% =**Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g =**Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

stage in both seasons.

On the other hand, fruits of both picking date and treated as control and soaked in saturated lime treatments didn't showed any fruit decay percentages after 5 and 10 days in shelf life in the first season. Moreover, fruits that picked in the first date (P1) and treated by ethephon at 750ppm, CaC2 at 10 g, and CaC2 at 20 g didn't showed any fruit decay percentages after 5 and 10 days in shelf life in second season. This means that, fruits harvested at an early stage of maturity (first harvest date) suffered less. Similar results were obtained by Ramin and Tabatabaie (2003) they reported that, persimmon fruits were harvested at four stages of maturity to evaluate the practical maximum postharvest storage, the results showed fruit decay percentage was significantly increased with increasing maturity stage (harvest date) during storage. In this

respect, Nawito (2008) concluded that, shelf life of "Hachiya" persimmon fruits greatly affected by fruit maturity where early harvest (150 days after full bloom) produced fruits with less shelf life. Late harvest (210 days after full bloom) greatly decreased fruit shelf-life as the fruits become more ripen with increased respiration rate than optimum harvested fruits (180 days after full bloom). These results are agree with the obtained of Testoni *et al.,* (2002) and El-Badawy (2007). In this respect, decay is very important parameter due to it has a great affects the appearance and marketability of persimmons, therefore must be considered in evaluating the storage potential of persimmon fruits.

***Fruit firmness (Ib/inch$^2$)***

Data in Table 3 clear that, maturity stage and exposure to some chemical treatments were significantly affected fruit firmness of "Costata" persimmon fruits in both seasons. Fruit firmness of both maturity stages was declined after soaking in some chemical treatments as compared with control treatment where it decreased from 16.3 to 8.5 and from 16.2 to 8.3 Ib/inch$^2$ after 15 days of shelf life in both seasons, respectively. "Costata" persimmon fruit of second maturity stage ($P_2$) that soaked in ethephon at 750 ppm showed the lowest values of fruit firmness until 15 days of shelf life during both seasons. On contrary, the highest values of fruit firmness were recorded in fruits harvested at early maturity stage (P1) that treated with tap water (control) followed by those in saturated lime with significant differences between them in both seasons. These results are in accordance with those of El-Badawy (2007) and Abd El-Wahab *et al.,* (2017) on "Costata" persimmon. They indicated that using ethephon, calcium carbide and ethereal for ripening persimmon fruits affected fruit firmness, in general causes a decrease in fruit firmness. Moreover, fruit firmness was higher when "Costata" persimmon fruits were harvested at the first maturity stage (50% coloration) than that in the second one (75% coloration) in both seasons. Similar results were obtained by Ramin and Tabatabaie (2003), Abd El-Hafeez (2005) and Zanamwe (2014) they reported that harvesting persimmon fruit at early stage of maturity was better firmness and good shelf life than late harvest dates. Similar results were reported by Homnava *et al.,* (1991), Edagi *et al.,* (2009) and Kou *et al.,* (2020). The highest fruit firmness at the end of shelf life period was recorded with control treatment followed by saturated lime; however the lowest values were noticed in ethephon at 750 ppm treatment during the two seasons. The other treatments gave intermediate values of fruit firmness. These findings are in harmony with that of El-Zayat *et al.,* (2004) on six varieties of persimmon, Ahmed and Sobieh (2007) and El-Badawy (2007) on "Costata" persimmon fruits.

**Table 3:** Effect of removal astringency method and maturity stage on fruit firmness Ib/inch$^2$ of "Costata" persimmon fruits during shelf life periods in 2019 and 2020 seasons

| Treatments | | Firmness (Ib/inch$^2$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | Mean | 3 days | 5 days | 10 days | 15 days | Mean |
| Control | $P_1$ | 21.7a | 19.9a | 17.2a | 16.4a | **18.8A** | 19.3a | 18.8a | 17.7a | 17.1a | **18.2A** |
| | $P_2$ | 18.3c | 16.2bc | 14.3b | 12.2b | **15.3B** | 17.0c | 15.4c | 13.9c | 12.5b | **14.7B** |
| Saturated lime | $P_1$ | 19.3b | 17.2b | 14.5b | 12.5b | **15.9B** | 18.1b | 16.5b | 14.6b | 10.4c | **14.9B** |
| | $P_2$ | 17.0d | 15.9bc | 12.8cd | 8.9c | **13.6C** | 15.4d | 13.5e | 10.6e | 8.6e | **12.0D** |
| Ethephon 500ppm | $P_1$ | 17.2d | 14.6 c | 10.2fg | 7.6de | **12.4D** | 17.2c | 15.0cd | 12.6d | 9.5d | **13.6C** |
| | $P_2$ | 16.4de | 13.3cd | 10.7ef | 5.1fg | **11.4DE** | 13.4e | 10.4g | 10.7e | 6.5g | **10.3E** |
| Ethephon 750ppm | $P_1$ | 14.2ef | 12.4 de | 9.3g | 6.4e | **10.6E** | 16.6cd | 13.3e | 11.2de | 6.9fg | **12.0D** |
| | $P_2$ | 13.6f | 11.3 e | 9.2g | 4.7g | **9.7F** | 14.1de | 8.5i | 5.4h | 3.5i | **7.9H** |
| Ethanol 25 % | $P_1$ | 17.5d | 15.2bc | 13.4bc | 8.5cd | **13.7C** | 17.5c | 16.5b | 13.5c | 8.5e | **14.0C** |
| | $P_2$ | 14.6ef | 12.4de | 10.4fg | 8.5cd | **11.5DE** | 15.0d | 10.5g | 8.7f | 7.5f | **10.4E** |
| Ethanol 30 % | $P_1$ | 15.7de | 13.5cd | 11.9de | 7.2de | **12.1DE** | 17.4c | 15.7c | 13.7c | 9.4d | **14.0C** |
| | $P_2$ | 15.9de | 12.6de | 10.5fg | 7.2de | **11.6DE** | 14.9d | 9.2h | 7.6j | 5.8h | **9.4F** |
| CaC2 at 10 g | $P_1$ | 16.4de | 14.2c | 13.5bc | 7.5de | **12.9D** | 17.0c | 14.8cd | 12.9d | 9.3d | **13.5C** |
| | $P_2$ | 15.2de | 13.2cd | 10.9ef | 8.9c | **12.0DE** | 15.2d | 12.5f | 7.3j | 6.8fg | **10.5E** |
| CaC2 at 20 g | $P_1$ | 14.3ef | 12.5de | 9.5lfg | 6.3ef | **10.6E** | 16.3cd | 14.3d | 11.3de | 7.0fg | **12.3D** |
| | $P_2$ | 14.0ef | 12.8 de | 10.2fg | 8.1cd | **11.3DE** | 14.2d | 10.7g | 5.7h | 3.3i | **8.5G** |
| ***Mean*** | | **16.3A** | **14.2B** | **11.8C** | **8.5D** | | **16.2A** | **13.5B** | **11.1C** | **8.3D** | |
| Initial value $P_1$ | | 21.4 | | | | | 19.5 | | | | |
| Initial value $P_2$ | | 18.2 | | | | | 17.2 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

### *Total tannins content:*

The results in Table 4 indicated that, postharvest dipping of persimmon fruits in some ripening chemical treatments were effective in reducing total tannins content during shelf life period compared to control treatment in both seasons. Total tannins were gradually decreased with increasing ripening duration from 1.07 to 0.53 and from 1.04 to 0.56 mg/100ml of fruit juice after 15 days of shelf life in both seasons, respectively. Moreover, combination (control+ $P_1$) treatment recoded the highest significant value of total tannins as compared with the other treatments in both seasons. On the other hand, the lowest value of total tannins was associated with fruits that harvested in second picking date ($P_2$) and soaked in ethephon at 750 ppm, CaC2 at 20 g after 5 and 10 days of shelf life in first seasons, however in the second season it was associated with ethephon at 500 and 750 ppm as well as CaC2 at 10and 20 g,

**Table 4:** Effect of removal astringency method and maturity stage on total tannins content of "Costata" persimmon fruits during shelf life in 2019 and 2020 seasons

| Treatments | | Tannins (mg/100ml) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | Mean | 3 days | 5 days | 10 days | 15 days | Mean |
| Control | $P_1$ | 1.48a | 1.36a | 1.21a | 1.07a | 1.28A | 1.41a | 1.32a | 1.16a | 0.97a | 1.22A |
| | $P_2$ | 1.17b | 0.95bc | 0.88ab | 0.81ab | 0.95AB | 1.10ab | 0.98ab | 0.86b | 0.73a | 0.92AB |
| Saturated lime | $P_1$ | 1.15b | 1.03b | 0.85ab | 0.64b | 0.92AB | 1.27ab | 1.09ab | 0.94b | 0.76a | 1.02A |
| | $P_2$ | 1.09b | 0.97bc | 0.73b | 0.68b | 0.87AB | 1.05ab | 0.92ab | 0.78bc | 0.68ab | 0.86AB |
| Ethephon 500 ppm | $P_1$ | 1.06b | 0.97bc | 0.73b | 0.48bc | 0.81AB | 1.15ab | 0.86ab | 0.42d | 0.31c | 0.69AB |
| | $P_2$ | 0.98c | 0.75c | 0.71b | 0.43bc | 0.72AB | 0.96b | 0.84ab | 0.43d | 0.32c | 0.64B |
| Ethephon 750 ppm | $P_1$ | 0.92c | 0.86bc | 0.65bc | 0.32bc | 0.69B | 0.92b | 0.64c | 0.43d | 0.34c | 0.58B |
| | $P_2$ | 0.86c | 0.53d | 0.42c | 0.37bc | 0.55B | 0.81b | 0.70bc | 0.41d | 0.34c | 0.57B |
| Ethanol 25 % | $P_1$ | 1.23ab | 0.98bc | 0.82ab | 0.55b | 0.90AB | 1.14ab | 0.93ab | 0.76bc | 0.62ab | 0.86AB |
| | $P_2$ | 0.92c | 0.85bc | 0.71b | 0.67b | 0.79AB | 0.98b | 0.86ab | 0.72bc | 0.64ab | 0.80AB |
| Ethanol 30 % | $P_1$ | 1.33a | 1.10b | 0.98ab | 0.52b | 0.98AB | 1.16ab | 0.86ab | 0.68c | 0.51b | 0.80AB |
| | $P_2$ | 0.95c | 0.76bc | 0.69b | 0.59b | 0.75AB | 0.95b | 0.81ab | 0.70bc | 0.63ab | 0.77AB |
| CaC2 at 10 g | $P_1$ | 1.25ab | 0.97bc | 0.83ab | 0.38bc | 0.86AB | 1.12ab | 0.82ab | 0.62cd | 0.53b | 0.77AB |
| | $P_2$ | 0.92c | 0.70c | 0.41c | 0.32bc | 0.59B | 0.94b | 0.86ab | 0.75bc | 0.61ab | 0.79AB |
| CaC2 at 20 g | $P_1$ | 0.96c | 0.84bc | 0.62bc | 0.34bc | 0.69B | 0.93b | 0.70bc | 0.49d | 0.36c | 0.62B |
| | $P_2$ | 0.81c | 0.52d | 0.48c | 0.37bc | 0.55B | 0.80b | 0.74bc | 0.48d | 0.54b | 0.64B |
| ***Main*** | | 1.07A | 0.88B | 0.73B | 0.53C | | 1.04A | 0.87B | 0.66BC | 0.56C | |
| Initial value $P_1$ | | 1.52 | | | | | 1.46 | | | | |
| Initial value $P_2$ | | 1.21 | | | | | 1.14 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

regardless picking dates. These results are in agreement with El-Badawy (2007) and Abd El-Wahab *et al.,* (2017) on "Costata" persimmon fruits.

Moreover, Kim *et al.,* (2004) and Borras (2015) they reported that, ethephon treatment greatly accelerated the coagulation and disappearance of astringency from persimmon fruits. Also, Del Bubba *et al.,* (2009) showed that treatments of ethylene and $CO_2$ had a significant influence on soluble tannin concentrations and the corresponding antiradical activity. Based on the usually accepted threshold level for human de-astringency detection, the 3-day treatment with ethylene was not sufficient for making the persimmons edible, while the application of $CO_2$ for 24 h reduced the soluble tannins to well below the above-mentioned level. In this respect, ethylene treatment from different sources *i.e*. Ethephon, ethanol, ethylene generating kits at different concentrations (100-5000 ppm) for different periods on the relationship between the decrease in tannin concentration and loss of astringency of persimmon fruits (Rouhani *et al.,* 1975, Kamal and Rabeh 1989 and Zanamwe, 2014).

***Carotenoids content:***

It is obvious from Table 5 that, removal astringency methods used were effective in enhancing fruit carotenoids content in both maturity stages of fruits. Carotenoids content of fruit was gradually increased with the incidence of maturation stage from 1.89 to 2.26 and from 1.73 to 2.26 mg/100ml after 15 days of shelf life in seasons, respectively. Moreover, the results indicated that chemical treatments caused a progressive increment in fruit carotenoids content as compared with control in both seasons. Fruits that harvested in the second maturity stage ($P_2$) and soaked in ethephon at 500 and 750 ppm, Ethanol 25 and 30%, and exposed to calcium carbide at 10 and 20g showed the highest values of fruit carotenoids content after 5, 10 and 15 days in shelf life without significant differences between them in first seasons. Whoever, the highest values of fruit carotenoids content observed by fruits of $2^{nd}$ maturity stage ($P_2$) which soaked in ethephon at 750ppm and calcium carbide at 20g in most cases during second season. On the other hand, the lowest values in this concern were recorded in fruits of $P_1$ that dipped in tap water (control) and saturated lime in both seasons. The enhancement of carotenoids development due to calcium carbide and ethephon treatments were explained by El-Badawy (2007) and Bordiga *et al.* (2019) they summarized that, fruit carotenoids content was in parallel with the ripening duration, this may be due to the fact that the synthesis of carotenoids is accompanied by changes in the ultra-structure of plastids. Moreover, the role of ethephon in enhancing fruit carotenoids may be due to the fact that ethephon accelerates the previously mentioned changes which lead to carotenoids synthesis (Kamal and Rabeh, 1989). The enhancement and positive effect of ripening treatments on persimmon fruit

**Table 5:** Effect of removal astringency method and maturity stage on carotenoids content of "Costata" persimmon fruits during shelf life period in 2019 and 2020 seasons

| Treatments | | Carotenoids (mg/100ml) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | *Mean* | 3 days | 5 days | 10 days | 15 days | *Mean* |
| Control | $P_1$ | 1.43b | 1.52d | 1.58c | 1.62c | **1.54C** | 1.15e | 1.22d | 1.38d | 1.42c | **1.29C** |
| | $P_2$ | 1.57b | 2.18bc | 2.26ab | 2.29ab | **1.65C** | 1.73cd | 2.21b | 2.34b | 2.41b | **2.17AB** |
| Saturated lime | $P_1$ | 1.85ab | 1.56d | 1.61c | 1.68c | **2.15AB** | 1.21e | 1.26d | 1.41d | 1.48c | **1.34CB** |
| | $P_2$ | 1.92ab | 2.31ab | 2.39a | 2.43a | **2.30A** | 1.82c | 2.32ab | 2.40b | 2.49ab | **2.26A** |
| Ethephon 500 ppm | $P_1$ | 1.51b | 1.75cd | 2.28ab | 2.46a | **1.59C** | 1.39de | 1.65c | 1.78c | 2.36b | **1.80B** |
| | $P_2$ | 1.62b | 2.45a | 2.53a | 2.62a | **1.70B** | 2.48a | 2.57ab | 2.65ab | 2.81a | **2.63A** |
| Ethephon 750 ppm | $P_1$ | 1.91ab | 1.84cd | 2.33a | 2.41a | **2.26A** | 1.42de | 1.58cd | 1.73cd | 2.41b | **1.79B** |
| | $P_2$ | 1.97ab | 2.50a | 2.57a | 2.63a | **2.33A** | 2.53a | 2.63a | 2.69ab | 2.84a | **2.67A** |
| Ethanol 25 % | $P_1$ | 1.69b | 1.62d | 1.68c | 1.72c | **2.05AB** | 1.28e | 1.31cd | 1.48cd | 1.52c | **1.40BC** |
| | $P_2$ | 1.65b | 2.37a | 2.42a | 2.47a | **1.77B** | 1.88bc | 2.39ab | 2.48ab | 2.53ab | **2.32A** |
| Ethanol 30 % | $P_1$ | 2.52a | 1.67d | 1.73c | 1.78c | **2.53A** | 1.32e | 1.37cd | 1.53cd | 1.63c | **1.46BC** |
| | $P_2$ | 2.07ab | 2.38a | 2.45a | 2.51a | **2.38A** | 1.94bc | 2.51ab | 2.57ab | 2.64ab | **2.42A** |
| CaC2 at 10 g | $P_1$ | 1.72b | 1.72cd | 1.81bc | 1.88bc | **2.08AB** | 1.35e | 1.42cd | 1.61cd | 1.74c | **1.53BC** |
| | $P_2$ | 1.82ab | 2.42a | 2.49a | 2.55a | **2.11AB** | 2.21ab | 2.55ab | 2.58ab | 2.67ab | **2.50A** |
| CaC2 at 20 g | $P_1$ | 2.48a | 1.87cd | 2.30a | 2.44a | **2.55A** | 1.42de | 1.67c | 1.78c | 2.34b | **1.80B** |
| | $P_2$ | 2.47a | 2.56a | 2.59a | 2.64a | **2.57A** | 2.55a | 2.62a | 2.73a | 2.79a | **2.67A** |
| ***Main*** | | **1.89B** | **2.05B** | **2.19AB** | **2.26A** | | **1.73B** | **1.96B** | **2.07AB** | **2.26A** | |
| Initial value $P_1$ | | 1.34 | | | | | 1.02 | | | | |
| Initial value $P_2$ | | 1.76 | | | | | 1.66 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

color is in agreement with Testoni (2002), Luo (2006) and El-Naggar (2018).

***Soluble solids content (SSC %):***

Data in Table 6 show the results of soluble solid content (SSC %) of Costata persimmon fruits at two maturity stages treated by some chemical applications. Soluble solid content (SSC %) increased gradually as shelf life time progressed where it increased from 13.7 to 18.5 and from 13.1 to 18.5 % after 15 days of shelf life in both seasons, respectively. The values of SSC % of control (fruit dipped in tap water) in both maturity stages were lower than those dipped in different chemical treatments in both seasons. During shelf life period, the highest SSC % was recorded in fruits of 2$^{nd}$ maturity stage ($P_2$) which soaked in ethephon at 500 and 750 ppm as well as exposed to CaC2 at 10 and 20g without significant deference among them in both seasons, while the lowest value was found in control treatments of 1$^{st}$ maturity stage ($P_1$) in

**Table 6:** Effect of removal astringency method and maturity stage on soluble solids content (SSC %) of "Costata" persimmon fruits during shelf life period 2019 and 2020 seasons

| Treatments | | SSC % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3days | 5 days | 10 days | 15 days | *Mean* | 3days | 5 days | 10 days | 15 days | *Mean* |
| Control | $P_1$ | 12.1d | 12.5f | 13.2e | 14.7f | 13.1D | 11.8b | 12.2f | 13.2f | 14.3f | 12.9D |
| | $P_2$ | 13.4c | 14.1c | 14.8d | 15.8e | 14.5C | 12.8ab | 13.4c | 14.5e | 16.0e | 14.2C |
| Saturated lime | $P_1$ | 12.2d | 12.9ef | 13.6de | 16.2d | 13.7CD | 12.2b | 13.0e | 14.1e | 16.4de | 13.9D |
| | $P_2$ | 13.6c | 14.4c | 16.0c | 17.7c | 15.4BC | 13.1ab | 14.0d | 15.2d | 16.9d | 14.8C |
| Ethephon 500 ppm | $P_1$ | 12.8cd | 14.2de | 17.8b | 18.9bc | 15.9B | 13.2ab | 15.7b | 17.3b | 19.2ab | 16.4B |
| | $P_2$ | 15.4a | 18.4a | 19.0a | 21.2a | 18.5A | 13.4ab | 16.1b | 18.7a | 19.4ab | 16.9A |
| Ethephon 750 ppm | $P_1$ | 13.2c | 14.6d | 18.2ab | 19.2ab | 16.3B | 14.0a | 16.8a | 18.1a | 20.1a | 17.3A |
| | $P_2$ | 15.8a | 18.7a | 19.2a | 21.5a | 18.8A | 14.2a | 17.0a | 18.5a | 20.2a | 17.5A |
| Ethanol 25 % | $P_1$ | 12.7cd | 13.2de | 14.8d | 17.5c | 14.6C | 12.1b | 13.8cd | 15.3d | 18.6bc | 15.0 C |
| | $P_2$ | 14.7ab | 16.2b | 17.4b | 18.6b | 16.7AB | 12.8ab | 14.3c | 16.7bc | 18.3c | 15.5BC |
| Ethanol 30 % | $P_1$ | 12.7cd | 13.4d | 15.3c | 17.8c | 14.8C | 12.2b | 14.2cd | 16.0c | 19.0b | 15.4BC |
| | $P_2$ | 14.1b | 16.3b | 17.7b | 19.8ab | 17.0AB | 13.2ab | 14.8c | 17.2b | 18.5bc | 15.9B |
| CaC2 at 10 g | $P_1$ | 12.8cd | 13.6d | 15.4c | 18.9bc | 15.2BC | 12.9ab | 15.5bc | 16.4bc | 20.0a | 16.2B |
| | $P_2$ | 15.4a | 18.1a | 18.8a | 19.7a | 18.0A | 14.0a | 15.1bc | 18.2a | 19.6ab | 16.7AB |
| CaC2 at 20 g | $P_1$ | 13.4c | 14.4c | 18.1ab | 19.0b | 16.2B | 14.0a | 16.4ab | 18.2a | 19.7a | 17.1A |
| | $P_2$ | 15.2a | 18.4a | 18.9a | 20.0a | 18.1A | 14.1a | 17.2a | 18.4a | 19.7a | 17.4A |
| ***Main*** | | 13.7D | 15.2C | 16.8B | 18.5A | | 13.1D | 15.0C | 16.6B | 18.5A | |
| Initial value $P_1$ | | 12.3 | | | | | 11.6 | | | | |
| Initial value $P_2$ | | 13.3 | | | | | 12.5 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

both seasons. Similar results were obtained by Rouhani *et al.* (1975) and Shiesh *et al.* (2000). In this respect, El-Badawy (2007) demonstrated that ethephon treatment had a positive effect on soluble solids content of Costata persimmon fruits. Thus, using ethephon at 750 ppm or CaC2 maintain high level of soluble solids content (SSC %) at different period of shelf life compared to control. The increase in total soluble solids of fruits resulting from treatments may be related to the hydrolytic activities in starch, the increased activity of enzymes responsible for the hydrolysis of starch to soluble sugars, and the conversion of starch to sugar, which indicates that the fruits are at the ripening process. This explanation agrees with those results obtained by Zanamwe, (2014).

***Titratable acidity***

Data presented in Table 7 show the changes in titratable acidity of "Costata" persimmon fruits harvested at two maturity stages and exposed to some chemical treatments for removal astringency substances during 2019 and 2020 seasons. All treatments recorded low levels of titratable acidity of persimmon fruits during shelf life period compared to control treatment in both seasons.

**Table 7:** Effect of removal astringency method and maturity stage on acidity % of "Costata" persimmon fruits during shelf life period in 2019 and 2020 seasons

| Treatments | | Acidity % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | **3days** | **5 days** | **10 days** | **15 days** | ***Main*** | **3days** | **5 days** | **10 days** | **15 days** | ***Main*** |
| Control | $P_1$ | 1.20a | 0.98a | 0.91a | 0.85a | **0.99A** | 1.07a | 0.96a | 0.84a | 0.77a | **0.91A** |
| | $P_2$ | 0.95ab | 0.86a | 0.75a | 0.62ab | **0.80A** | 0.87a | 0.82a | 0.75a | 0.65a | **0.77A** |
| Saturated lime | $P_1$ | 1.12a | 0.86a | 0.71a | 0.64ab | **0.83A** | 0.99a | 0.82a | 0.77a | 0.68a | **0.82A** |
| | $P_2$ | 0.92ab | 0.81a | 0.70a | 0.58ab | **0.75A** | 0.85a | 0.76ab | 0.66ab | 0.54ab | **0.70A** |
| Ethephon 500 ppm | $P_1$ | 0.75ab | 0.48c | 0.33b | 0.22c | **0.45B** | 0.83a | 0.72ab | 0.63ab | 0.37b | **0.64AB** |
| | $P_2$ | 0.51b | 0.42c | 0.32b | 0.21c | **0.37B** | 0.85a | 0.53b | 0.33b | 0.28b | **0.50B** |
| Ethephon 750 ppm | $P_1$ | 0.62b | 0.41c | 0.31b | 0.24c | **0.40B** | 0.70b | 0.51b | 0.36b | 0.31b | **0.47B** |
| | $P_2$ | 0.55b | 0.40c | 0.30b | 0.22c | **0.37B** | 0.70b | 0.41b | 0.30b | 0.21b | **0.41B** |
| Ethanol 25 % | $P_1$ | 0.85ab | 0.71ab | 0.50ab | 0.42b | **0.62AB** | 0.84a | 0.71ab | 0.64ab | 0.52ab | **0.68AB** |
| | $P_2$ | 0.81ab | 0.61b | 0.47ab | 0.36bc | **0.56AB** | 0.81a | 0.64b | 0.52ab | 0.43b | **0.60AB** |
| Ethanol 30 % | $P_1$ | 0.92ab | 0.70ab | 0.56ab | 0.50ab | **0.67AB** | 0.87a | 0.66b | 0.59ab | 0.49ab | **0.65AB** |
| | $P_2$ | 0.83ab | 0.63b | 0.54ab | 0.43b | **0.61AB** | 0.83a | 0.70ab | 0.61ab | 0.40b | **0.64AB** |
| CaC2 at 10 g | $P_1$ | 0.87ab | 0.65b | 0.51ab | 0.43b | **0.62AB** | 0.81a | 0.64b | 0.53ab | 0.47ab | **0.61AB** |
| | $P_2$ | 0.85ab | 0.70ab | 0.48ab | 0.38b | **0.60AB** | 0.86a | 0.66b | 0.32b | 0.30b | **0.54B** |
| CaC2 at 20 g | $P_1$ | 0.63b | 0.47c | 0.37b | 0.21c | **0.42B** | 0.72b | 0.48b | 0.40ab | 0.32b | **0.48B** |
| | $P_2$ | 0.56b | 0.41c | 0.34b | 0.19c | **0.38B** | 0.71b | 0.41b | 0.33b | 0.27b | **0.43B** |
| ***Main*** | | **0.81A** | **0.63AB** | **0.51AB** | **0.41B** | | **0.83A** | **0.65AB** | **0.54AB** | **0.44B** | |
| Initial value $P_1$ | | 1.22 | | | | | 1.10 | | | | |
| Initial value $P_2$ | | 0.96 | | | | | 0.91 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

In addition titratable acidity values were gradually decreased with incidence of shelf life period since; it decreased from 0.81 to 0.41 and from 0.83 to 0.44 % after 15 days of shelf life in both seasons, respectively. The higher values of titratable acidity were observed in control saturated lime treatments regardless harvesting date in most cases after 5, 10 and 15days of shelf life in both seasons. Whereas, the lowest values of titratable acidity were associated with ethephon at 500 and 750 ppm, as well as, calcium carbide at 20g in both

maturity stages used in both seasons. The differences among ethephon at 500 and 750 ppm and calcium carbide at 20g were not significant in both seasons. These results were similar with those reported by Rouhani *et al.* (1975), Kamal and Rabeh (1989) and El-Badawy (2007). In this respect, Testoni (2002) reported that persimmon fruits dipped in some growth regulators recorded low level of titratable acidity during repining and shelf life period. As the ripening of the fruits develops, a reduction in titratable acidity is observed. The decrease in acid content is caused by the use of acids in the fruit as a source of energy and the conversion of organic acids to form sugar (Borras, 2015).

***SSC/acid ratio:***

Data in Table 8 show the changes in SSC/acid ratio of "Costata" persimmon fruits harvested at two dates and exposed to some chemical treatments for removal astringency substances during 2019 and 2020 seasons.

**Table 8:** Effect of removal astringency method and maturity stage on SSC/acid ratio of "Costata" persimmon fruits during shelf life period in 2019 and 2020 seasons

| Treatments | | SSC/acid ratio | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | *Mean* | 3 days | 5 days | 10 days | 15 days | *Mean* |
| Control | $P_1$ | 10.1e | 12.8j | 14.5l | 17.3n | **13.7J** | 11.0e | 12.7li | 15.7l | 18.6m | **14.5H** |
| | $P_2$ | 14.1cd | 16.4i | 19.7k | 25.5m | **18.9HI** | 14.7bc | 16.3h | 19.3i | 24.6l | **18.8F** |
| Saturated lime | $P_1$ | 10.9e | 15.0li | 19.2k | 25.3m | **17.6I** | 12.3d | 15.9h | 18.3i | 24.1l | **17.7G** |
| | $P_2$ | 14.8cd | 17.8hi | 22.9j | 30.5l | **21.5H** | 15.4b | 18.4j | 23.0h | 31.3k | **22.0E** |
| Ethephon 500 ppm | $P_1$ | 17.1c | 29.6e | 53.9c | 85.9e | **46.6C** | 15.9b | 21.8f | 27.5g | 51.9f | **29.3D** |
| | $P_2$ | 30.2a | 43.8c | 59.4b | 101.0b | **58.6A** | 15.8b | 30.4d | 56.7b | 69.3c | **43.0C** |
| Ethephon 750 ppm | $P_1$ | 21.3b | 35.6d | 58.7b | 80.0f | **48.9B** | 20.0a | 32.9c | 50.3d | 64.8d | **42.0C** |
| | $P_2$ | 28.7ab | 46.8a | 64.0a | 97.7c | **59.3A** | 20.3a | 41.5a | 61.7a | 96.2a | **54.9A** |
| Ethanol 25 % | $P_1$ | 14.9cd | 18.6h | 29.6h | 41.7j | **26.2F** | 14.4c | 19.4j | 23.9j | 35.8j | **23.4DE** |
| | $P_2$ | 18.2c | 26.6f | 37.0f | 51.7g | **33.4D** | 15.8b | 22.3f | 32.1f | 42.6h | **28.2D** |
| Ethanol 30 % | $P_1$ | 13.8d | 19.1h | 27.3i | 35.0k | **24.0G** | 14.0c | 21.5f | 27.1g | 38.8i | **25.4DE** |
| | $P_2$ | 16.9c | 25.9f | 32.7g | 46.1h | **30.4E** | 15.9b | 21.1f | 28.2g | 46.3g | **27.9D** |
| CaC2 at 10 g | $P_1$ | 14.7cd | 20.9g | 30.2h | 44.0i | **27.5F** | 15.9b | 24.2e | 30.9f | 42.6h | **28.4D** |
| | $P_2$ | 18.1c | 25.9f | 39.2e | 51.8g | **33.8D** | 16.9b | 22.9f | 56.9b | 65.3d | **40.3CD** |
| CaC2 at 20 g | $P_1$ | 21.3b | 30.6e | 48.9d | 90.5d | **47.8B** | 19.4a | 34.2b | 45.5e | 61.6e | **40.2CD** |
| | $P_2$ | 27.1ab | 44.9b | 55.6c | 105.3a | **58.2A** | 19.9a | 42.0a | 55.8c | 73.0b | **47.6B** |
| ***Main*** | | **18.3D** | **26.9C** | **38.3B** | **58.1A** | | **16.1D** | **24.9C** | **35.8B** | **49.2A** | |
| Initial value $P_1$ | | 10.08 | | | | | 13.85 | | | | |
| Initial value $P_2$ | | 10.55 | | | | | 13.74 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control =**Fruits dipped in water for 5 days, **Saturated lime =**Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm =**Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30% =**Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g =**Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

All treatments recorded high levels of SSC/acid ratio in persimmon fruits during shelf life period compared to control treatment in both seasons. In addition SSC/acid ratio values were gradually increased with increasing shelf life period from 18.3 to 58.2 and from 16.1 to 49.2 after 15 days of shelf life in both seasons, respectively. Moreover, the higher values of SSC/acid ratio were observed in fruits of second picking date ($P_2$) which soaked in ethephon at 750 ppm after 5 and 10 days in shelf life in the first season and after 3, 5, 10 and 15 days in the second one. In contrary that, the lowest values of SSC/acid ratio were observed in fruits of 1st maturity stage that dipped in tap water (control) followed by fruits dipped in saturated lime in both seasons. These results were similar with those reported by Testoni (2002) and Borras (2015).

***Ascorbic acid:***

Data presented in Table 9 show that, ascorbic acid content in "Costata" persimmon fruits were gradually decreased as shelf life period prolonged,

**Table 9:** Effect of removal astringency method and maturity stage on ascorbic acid content of "Costata" persimmon fruits during shelf life period in 2019 and 2020 seasons

| Treatments | | Ascorbic acid (mg/100ml) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Shelf life (Days) | | | | | | | | | |
| | | First season | | | | | Second season | | | | |
| | | 3 days | 5 days | 10 days | 15 days | Mean | 3 days | 5 days | 10 days | 15 days | Mean |
| Control | $P_1$ | 54.7a | 52.9a | 50.2a | 43.6a | 50.3A | 54.7a | 52.9a | 50.2a | 43.6a | 50.3A |
| | $P_2$ | 48.9b | 44.9b | 40.8b | 36.2b | 42.7B | 48.9c | 44.9c | 40.8b | 36.2b | 42.7C |
| Saturated lime | $P_1$ | 53.3a | 51.7a | 48.7a | 43.6a | 49.3A | 53.36a | 51.7a | 48.7a | 43.6a | 49.3A |
| | $P_2$ | 46.3c | 42.6cd | 37.1c | 32.7cd | 39.7C | 46.3d | 42.6d | 37.1c | 32.7c | 39.7D |
| Ethephon 500 ppm | $P_1$ | 40.7de | 34.8e | 30.2d | 26.4e | 33.0E | 43.8e | 40.5e | 35.8cd | 30.5d | 37.6DE |
| | $P_2$ | 36.6gh | 31.5f | 26.0e | 21.8f | 28.9F | 43.7e | 32.3g | 26.8f | 23.5e | 31.6G |
| Ethephon 750 ppm | $P_1$ | 41.0de | 34.5e | 29.6d | 25.8e | 32.7E | 40.6f | 40.9e | 36.2cd | 29.7d | 36.8DE |
| | $P_2$ | 35.3h | 30.8f | 24.1e | 22.0f | 28.1F | 40.9f | 32.5g | 27.2f | 23.6e | 31.0G |
| Ethanol 25 % | $P_1$ | 48.6b | 44.6bc | 40.7b | 34.3bc | 42.0B | 51.3b | 47.3b | 42.5b | 36.9b | 44.5B |
| | $P_2$ | 39.9ef | 35.4e | 30.0d | 26.4e | 32.9E | 46.8d | 40.8e | 36.4cd | 32.7c | 39.15D |
| Ethanol 30 % | $P_1$ | 48.9b | 40.7d | 37.8c | 32.7cd | 40.0B | 50.8b | 46.5bc | 41.9b | 35.9b | 43.8B |
| | $P_2$ | 37.8fg | 34.8e | 30.7d | 26.9e | 32.5E | 45.7d | 40.7e | 34.5d | 30.3d | 37.8DE |
| CaC2 at 10 g | $P_1$ | 42.6d | 36.1e | 36.4c | 30.7d | 36.5D | 48.9c | 45.6bc | 42.7b | 32.9c | 42.5C |
| | $P_2$ | 38.3fg | 35.1e | 28.9d | 26.7e | 32.2E | 43.3e | 36.9f | 28.9e | 30.2d | 34.8EF |
| CaC2 at 20 g | $P_1$ | 40.7 de | 35.3e | 30.1d | 26.0e | 33.0E | 41.2f | 39.3e | 35.5cd | 30.2d | 36.5E |
| | $P_2$ | 35.5h | 31.8f | 24.0e | 22.2f | 28.4F | 40.7f | 31.9g | 36.8c | 22.8e | 33.0F |
| ***Main*** | | 43.1A | 38.6B | 34.1C | 29.9D | | 46.3A | 41.7B | 37.6C | 32.2D | |
| Initial value $P_1$ | | 56.7 | | | | | 55.2 | | | | |
| Initial value $P_2$ | | 50.5 | | | | | 49.8 | | | | |

*Means followed by different letter are significantly different within columns by Duncan's multiple range tests, $P \leq 0.05$.*

**$P_1$**= harvesting at 50% coloration, **$P_2$**= harvesting at 75% coloration, **control** =Fruits dipped in water for 5 days, **Saturated lime** =Fruits dipped in saturated lime for 5 days, **Ethephon 500 and 750 ppm** =Fruits soaked in ethephon solutions for 5 min, **Ethanol 25 and 30%** =Fruits soaked in ethanol solutions for 5 min, **CaC2 at 10 and 20g** =Fruits exposed to CaC2 at 10g + 40 ml water or 20g + 40 ml water for 1 day.

where it decreased from 43.1 to 29.9 and from 46.3 to 32.2 after 15 days of shelf life in both seasons, respectively. Moreover, fruits dipped in different chemical treatments had significantly lower ascorbic acid content than that dipped on tap water (control) in both seasons.

The highest ascorbic acid content was showed by fruits harvested at 2nd date ($P_2$) which dipped in tap water (control) and fruits soaked in saturated lime without significant difference between them in both seasons., whereas, fruits of $P_2$ which treated by ethephon at 500 and 750 ppm as well as calcium carbide 20g produced the lowest values of ascorbic acid in most cases in both seasons. So, it can be concluded that ethephon and calcium carbide at 20g application led to loss fruits their content of ascorbic acid during
repining and shelf life period. The same trend was also observed in the previous study by Gomez and Lajolo (2008) they concluded that reduction in fruit ascorbic acid content during ripening could be attributed to the increase in ascorbate oxidase activity and ethephon treatment increases such oxidation process.

## CONCLUSION

In light of this study it can be concluded that, "Costata" persimmon fruits harvested at 75 % coloration soaked in ethephon at 750 ppm for 5 min as well as fruits that exposed to gases resulted from mixing of calcium carbide at 20g with 40ml water in a small closed chamber (8 $m^2$) for 24 h are found to be more effective artificial astringency removal methods in maintaining firmness, titratable acidity, ascorbic acid, soluble solids content and SSC/acid ratio of Costata persimmon fruits for 15 days in shelf life and removes the astringency. So it could be recommended to use one of the above mentioned treatments for removing the astringency of Costata persimmon fruits with maintains the quality during shelf life.

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# تأثير طريقة إزالة المادة القابضة خلال مراحل النضج جودة ثمارالكاكى أثناء فترة العرض

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تعتبر إزالة المادة القابضة من أهم العوامل التي تؤثر على النضج والجودة وفترة العرض التسويقية لثمار الكاكى. لذلك تم إجراء هذه الدراسة لتقييم استخدام كل من الإيثون ، الإيثانول ، كربيد الكالسيوم ومحلول الجير المشبع في ازالة الماة القبضة من الثمار التى تم حصادها في موعدين الاول عند وصول الثمرة الى 50% تلوين والثانى عند وصول الثمرة الى 75 % تلوين وتأثيرها على جودة ثمار الكاكى صنف كوستاتا المخزنة على درجة حرارة الغرفة. وكانت المعاملات هي غمس الثمار في ماء الصنبور لمدة 5 أيام كمعاملة المقارنة، والغمس فى محلول الجير المشبع لمدة 5 أيام، والغمس فى الإيثيفون بتركيز 500 و 750 جزء في المليون لمدة 5 دقائق، والغمس فى الإيثانول بتركيز 25 و 30٪ لمدة 5 دقائق وتعريض الثمار للغازات الناتجة من خلط كربيد الكالسيوم بمعدل 10 و 20 جرام مع 40 ملتر ماء داخل غرفة صغيرة (8 متر$^3$) مغلقة لمدة 24 ساعة ثم تم تخزين الثمار في درجة حرارة الغرفة 23 ± 1 درجة مئوية و 60 ± 5٪ رطوبة نسبية لمدة 15 يومًا.

أظهرت النتائج المتحصل عليها ان المعاملة بالإيثون بتركيز 750 جزء في المليون لمد 5 دقائق والمعاملة بكربيد الكالسيوم بمعدل 20 جرام +40مللتر ماء كان لهما تأثير أفضل في تقليل الفقد فى وزن الثمار، وتقليل نسبة الثمار التالفة، والحفاظ على الصلابة وخفض محتوى التانينات الكلى مع زيادة المواد الصلبة الذائبة الكلية وتحسين نضج الثمار مقارنة بالمعاملات الأخرى ، ايضا هتان المعاملتان كانتا الأكثر فاعلية في إزالة المادة القابضة من الثمار خاصة عند حصاد الثمار عند 75% من التلوين.

و بشكل عام، وجد أن المعاملة بالإيثيفون بتركيز 750 جزء في المليون وكربيد الكالسيوم بمعدل 20 جرام أكثر فاعلية في الحفاظ على الصلابة والحموضة وحمض الأسكوربيك ومحتوى المواد الصلبة الذائبة ونسبة المواد الصلبة الذائبة / الحموضة في ثمار الكاكى صنف كوستاتا لمدة 15 يومًا وازالة المادة القابضة بغض النظر عن ميعادي الحصاد.

**التوصية:** يمكن التوصية باستخدام احدي المعاملتان المذكورتان سابقا لازلة المادة القبضة من ثمار الكاكى صنف كوستاتا التى تقطف عند 75% تلوين مع الحفاظ على جودة الثمار اثناء فترة العرض.