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Impact of Moringa Leaf Extract, Olive Leaf Extract, and Calcium Chloride on Quality Attributes of Peach Cultivars during Cold Storage

W. Abidi[1*], R. Akrimi[1], and M. Gouiaa[2]

ABSTRACT

This study aimed to evaluate the impact of dipping solutions [Moringa Leaf Extract 5% (MLE), Olive Leaf Extract 5% (OLE) and Calcium Chloride 5% ($CaCl_2$)] on fruit quality of two peach (*Prunus persica* L. Batsch) cultivars (Blanvio 10 and Plagold 15). The treatments consisted of dipping fruits for 5 min in the corresponding solution followed by 30 minutes drying at room temperature. Then, fruits were stored at 5°C and 95% relative humidity for 2 and 4 weeks of cold storage followed by 2 days at room temperature. Physicochemical traits, antioxidant compounds, sugar content and chilling injury symptoms were analyzed. There were significant improvements in fruits storability resulting from the $CaCl_2$, MLE (5%) and OLE (5%) dipping solutions. These treatments improved firmness, maintained the Soluble Solids Content, and increased the ripening index (SSC/TA). The lowest fruit weight loss was observed in the OLE treatment, whereas the untreated fruits showed the highest loss. The flavonoids, total phenolics, vitamin C and antioxidant capacity showed a gradual decrease during the storage periods. Mealiness and internal browning were the major chilling injury symptoms observed in the two peach cultivars after 4 weeks of cold storage. The applied treatments were efficient and delayed the presence of chilling injury symptoms and fruit decay during the two cold storage periods.

Keywords: Antioxidants, Chilling injury, Fruit decay, *Prunus persica* L.**,** Ripening index**.**

INTRODUCTION

Peach **(***Prunus persica* L. Batsch**)** is a climacteric fruit that deteriorate quickly at ambient temperature showing a short storage life period (Lurie and Crisosto, 2005). Generally, cold storage is used as an effective technology to delay deterioration of the fruit in terms of nutritional value and consumer perception (Tsantili *et al*., 2010). However, storage of peaches at low, nonfreezing temperatures (2.2-7.6°C) is limited due to the development of physiological disorder identified as Chilling Injury (CI) confirmed by several studies (Crisosto *et al*., 1999; Lurie and Crisosto, 2005). The CI symptoms were divided into mealiness characterized by dry and sandy fruit mesocarp, internal and external browning, reddish discoloration, loss of ability to ripen, off-flavor and increased incidence of decay as reported by Abidi *et al*. (2015). Crisosto *et al*. (1997) reported that the onset of CI symptoms determines storage/shipping potential because their development reduces consumer acceptance.

Today, the global challenge is how to find alternative ways to control postharvest losses, to prioritize healthy methods, and to avoid negative effects of pesticides on

[1] CRRA Sidi Bouzid Rue Gafsa km6, 9100- Regional Center of Agricultural Research of Sidi Bouzid (CRRA) PB 357, 9100, Tunisia.
[2] Higher Institute of Agronomy of Chott Mariem, Sousse, Tunisia.
*Corresponding author; e-mail: abidi_k@yahoo.fr

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human health. Thus, coatings and dipping fruits may maintain appearance and texture of the product and control the internal atmosphere of the fruit in a fashion similar to the modified atmosphere storage (Turhan, 2009). Herbal solutions such as olive and moringa leaves extract have been reported as efficient alternatives for coating and dipping fruits. Olive leaf extract is characterized by an antimicrobial and antioxidant effects against pathogens (Lee and Lee, 2010). Moringa leaf extract possess antimicrobial and antioxidant activity contributed by a high concentration of phenolics, vitamins and carotenoids (Tesfay *et al*., 2016). Calcium Chloride ($CaCl_2$) is a naturally occurring compound, edible, and approved by the U.S. Food and Drug Administration for pre- and post-harvest use in agriculture. Lester and Grusak (2004) reported that postharvest application of calcium in fruits may delay deterioration with no detrimental effects on consumers. In this line, Chauhan *et al*. (2008) evaluated the potential of "neem" plant extracts for increasing the postharvest shelf life of apple fruits. Moreover, Bakhsh *et al*. (2020) reported that pulp weight, fruit size and fruit weight were notably improved in trees sprayed with 2% MLE because of potassium and zinc presence in the moringa leaves. In addition, Nasir *et al*. (2016) and Sheren and El-Amary, (2015) reported that aqueous spray of moringa improved fruit weight and size of mandarin and pear fruits, respectively.

The purpose of this study was to investigate the effect of the Olive Leaf Extract (OLE), Moringa Leaf Extract (MLE), and Calcium Chloride ($CaCl_2$) treatments on peach fruit quality and to reduce postharvest losses during storage and shipment to distant markets.

MATERIALS AND METHODS

Fruit Origin

Fruits from fifteen years old peach cultivars (Blanvio 10 and Plagold 15) grafted on "Garnem" rootstock were used. Trees were grown in a private orchard located in the region of Regueb (34° 47' 45.1'' N; 9° 47' 54.1'' E; 150 m above sea level), Sidi Bouzid, Tunisia. Trees were trained to the standard open vase system, planted at a spacing of 6×3 m and grown under standard conditions of irrigation, fertilization, and disease control. Plagold-15 has round fruit shape whereas Blanvio-10 has plat fruit shape; all cultivars have red skin color. Plagold-15 has yellow-flesh, whereas Blanvio-10 has white-flesh. Fruits were handpicked at commercial maturity and assessed by peel color and flesh firmness. At harvest, the ripening index was 10.0 and 11.2 for the cv. Blanvio 10 and Plagold 15, respectively, with corresponding maturity dates of 25 April and 5 May.

Extract Preparation

The MLE and OLE was performed according to Samad *et al*. (2019). Moringa leaves were provided from the Superior Institute of Agriculture Chott Meriem, Tunisia. Olive leaves were collected from 'Chemleli' olive cultivar planted in the experimental orchard of the Regional Center of Agriculture Research of Sidi Bouzid. Leaves were washed, dried in oven for 24 hours at 70°C and ground in a blender. Then, 50 g of leaf powder was macerated in 1,000 mL absolute ethanol and the prepared solution was shaken for 48 h using electrical stirrer (Model SP 18420-26 Barnstead thermolyne USA). After that, the supernatant was filtered and the filtrate was concentrated in a rotary evaporator under reduced pressure. The dried extract residue was reconstituted in sterile distilled water to give final concentration of 5%. The MLE and OLE were analyzed for antioxidants compounds content and osmoprotectants and its composition is presented in Table 1. Calcium chloride ($CaCl_2$ 5%) (w/v) solution was prepared by dissolving 50 g of edible grade $CaCl_2$ in 1,000 mL distilled water. The solution was constantly stirred using a

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Table 1. Approximate components of antioxidants and osmoprotectants in Moringa Leaf Extract (MLE) and Olive Leaf Extract (OLE). [a]

Component	MLE	OLE	Unit
Antioxidants			
Anthocyanins	10.50 ± 1.2	12.75 ± 2.3	mg C3GE kg^{-1} DW
Flavonoids	20.50 ± 2.4	23.30 ± 4.1	mg CE 100 g^{-1} DW
Total phenolics	120.45 ± 4.6	123.53 ± 4.6	mg GAE 100 g^{-1} DW
Vitamin C	1.60 ± 0.2	1.78 ± 0.2	mg AsA 100 g^{-1} DW
Relative antioxidant capacity	340.50 ± 21.6	412.35 ± 15.5	µg Trolox Eq g^{-1} DW
Osmoprotectants			
Carotenoids	2.50 ± 0.5	1.55 ± 0.2	mg g^{-1} DW
Chlorophylls	7.50 ± 1.1	13.50 ± 2.4	mg g^{-1} DW
Proline	0.35 ± 0.1	0.81 ± 0.6	µmol g^{-1} DW
Soluble sugar	350.20 ± 12.4	251.46 ± 10.2	µg g^{-1} DW

[a] AsA= Ascorbic Acid;; $CaCl_2$= Calcium Chloride; CE= Catechin Equivalents; C3GE= Cyanidin-3-Glucoside Equivalents; DW= Dry Weight, GAE= Gallic Acid Equivalents. Values are the means (n= 3)±standard error.

magnetic stirrer for 30 minutes until fully dissolved.

Applied Treatments

Harvested fruits were dipped in the solutions (H_2O, MLE, OLE and $CaCl_2$) for 5 minutes according to the treatment and left for 30 minutes in the laboratory to dry at room temperature. The distilled water was used as control. Sixty randomly selected fruits were used in each dipping solutions and then divided into three groups. The first group served for the physicochemical and biochemical qualities of fruits at harvest. The other two groups were used for the assessment of physicochemical, biochemical traits and chilling injury symptoms after two cold storage periods (2 and 4 weeks). The fruits were transferred to the cold room at 5°C and 95% RH simulating a shipment of 15 and 30 days. After which, fruits were removed from the cold room and ripened in the laboratory at room temperature for two days.

Physicochemical Traits

Fruit weight (g) was measured in a sample of ten fruits. The fruit weight loss was calculated by measuring the sample weight after dipping in the respective treatment and at the end of each storage period using a digital balance as described by Ali et al. (2019). Flesh firmness (N) was measured with a penetrometer equipped with an 8 mm diameter flat tip probe. Soluble Solids Content (SSC, °Brix) was measured in the juice using a digital hand-held refractometer (Atago, Tokyo, Japan). The Titratable Acidity (TA, g malic acid per 100 g fresh weight sample) were measured in juice by titration using NaOH 0.1 N. The Ripening Index (RI) was determined as the ratio between Soluble Solids and Titratable Acidity (SSC/TA).

Biochemical Extraction

Regarding phenolic compounds analysis, frozen flesh samples (5 g) were homogenized in a polytron (T25D Turrax; IKA Works, Inc.; Wilmington, NC) with 10 mL of 0.5N HCl in methanol/distilled water (80% v/v). The solution was then centrifuged (SIGMA Laboratory centrifuges 3K18, UK) for 20 minutes at 4°C and 5000 rpm and the supernatant was recovered and measured. This extract was used for anthocyanins, flavonoids, total phenolics and antioxidant capacity determinations as described by Abidi *et al*. (2015). For the

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ascorbic acid extraction, 5 mL metaphosphoric acid 5% were added to the frozen flesh samples, thawed on ice, homogenized with a polytron, and centrifuged at 5,000 rpm for 20 minutes at 4°C. The supernatant was measured and used for vitamin C analysis. Regarding carotenoids content, 5 g of flesh samples were extracted with 5 mL of ethanolic butylated hydroxyl toluene (Ethanol/BHT–100:1, v/w). For the determination of sugars, the frozen fruit material (5 g) was homogenized in a Polytron with 10 mL of extraction solution consisting of ethanol/distilled water (80% v/v). The mixture was centrifuged at 5,000 rpm for 20 minutes at 4°C. The supernatant was recovered and used in the High-Performance Liquid Chromatography (HPLC) as described by Abidi *et al*. (2015).

Antioxidants Analysis

The antioxidants analyses were performed using a spectrophotometer (Jenway 6300, UK). The anthocyanins content was measured at the absorbance of 535 and 700 nm and expressed in mg of Cyanidin 3-Glucoside Equivalents (C3GE) kg^{-1} FW using the molar extinction absorptivity coefficient Ɛ= 25,965 cm^{-1} M. Regarding flavonoid content, the absorbance of the mixture was measured at 510 nm and results were expressed in mg of Catechin Equivalents (CE) 100 g^{-1} FW as described in Zhishen *et al*. (1999). Total phenolic content was determined based on the chemical reduction of Folin-Ciocalteu reagent according to the colorimetric method reported by Singleton and Rossi (1965). The absorbance was done at 725 nm and the results were expressed in mg of Gallic Acid Equivalents (GAE) 100 g^{-1} FW. Vitamin C was determined at the absorbance of 525 nm and results were expressed in mg of Ascorbic Acid (AsA) 100 g^{-1} of FW as described in Okamura (1980). Total Carotenoid Content (TCC) was determined using the method of Sanusi and Adebiyi (2009), at the absorbance of 450 and 503 nm. TCC was calculated using the following equation (Song and Xu, 2013):

$$TCC\ (\mu g\ mL^{-1}) = 4.642 \times A_{450} - 3.091 \times A_{503}$$

The Relative Antioxidant Capacity (RAC) was determined using the 1,1-Diphenyl2-Picrylhydrazyl (DPPH) test (Brand-Williams *et al*., 1995). The method consisted of mixing 100 µL of extract with 2.9 mL of DPPH. The reaction was put in darkness at room temperature for 10 min. Absorbance was measured at 515 nm and results were expressed in µg of Trolox Equivalents (TE) g^{-1} FW.

Sugars Analysis

Determination of sugar content was performed by High Performance Liquid Chromatography (HPLC). The homogenized extract (0.2 mL) was incubated at 80°C for 15 minutes in 200 µL of 80% ethanol and filtered through a microfilter as described by Jiménez *et al*. (2011). The extract (20 µL) was injected into the HPLC system (Aminex HPX-87C column, 300×7.8 mm; Bio-Rad, Barcelona, Spain) with a refractive index detector (Waters 2410). The flow rate of the mobile phase (deionized water) was 0.5 mL min^{-1} at 80°C. The sucrose, glucose, fructose and sorbitol contents were converted to the fresh weight of fruits and expressed as (mg mL^{-1}).

Chilling Injury (CI)

Chilling injury susceptibility was evaluated in the studied cultivars after storage of samples (20 fruits) per cultivar at 5ºC and 95% RH during 2 or 4 weeks and subsequent ripening at room temperature for 2 days according to Crisosto *et al*. (1999). The weight loss, lack of juiciness (flesh mealiness), flesh browning, flesh bleeding, leatheriness and off-flavor were evaluated. Observations were made on the mesocarp and the area around the pit immediately after the fruit were cut into two halves through the suture plan. Browning was

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visually scored in the flesh fruit on a scale of 1 (no browning) to 6 (severe browning). Bleeding described as red color in flesh fruit was scored on a scale of 1 (no bleeding) to 3 (more than 50% of the flesh). The Chilling Injury index (CI) was assessed according to the fruit appearance, from no symptoms (1) to severe symptoms (6). Decay in the peach fruits was defined as the number of fruits showing signs of fungal growth and bacterial lesions to the total number of fruits in each treatment, expressed in percentage.

Statistical Analysis

All data were subjected to a one-way Analysis Of Variance (ANOVA) to test the effect of dipping solutions on fruit postharvest quality, using SPSS Statistics 20.0 for Windows. Means were compared using the Duncan's multiple range test at the 5% significance level.

RESULTS

Physicochemical Traits of Fruit Quality

Evolution of the fruit weight, weight loss, firmness, soluble solid content, titratable acidity and ripening index throughout the storage periods is shown in Table 2. Fruit weight decreased gradually, although treated fruits exhibited significantly ($P< 0.05$) lower weight loss than the control. The applied treatments ($CaCl_2$, MLE, OLE) significantly ($P< 0.05$) reduced the weight loss as compared to the control (H_2O). Hence, low weight loss values (2.4 and 2.3%) were recorded in the OLE treatment after two weeks of cold storage for the cv. Blanvio 10 and Plagold 15, respectively. Fruit firmness decreased for both treated and control fruits. The dipping solutions (MLE, OLE, $CaCl_2$) were effective and maintained fruit firmness during the first cold storage period. Soluble solids content showed an increasing trend during cold storage periods whereas the titratable acidity showed a gradual decrease. The ripening index (SSC/TA) increased over the two storage periods and the subsequent 2 days at room temperature, being significantly higher in the control than in treated fruits. The postharvest application of $CaCl_2$, MLE and OLE reduced the rate of decay in peach fruit during storage.

Biochemical Traits of Fruit Quality

The effects of postharvest treatments on antioxidant compounds content were evaluated [Figure 1 (a-f)]. The anthocyanins (Figure 1-a) content increased gradually during the first cold storage period and then decreased until the end of the experiment. The highest anthocyanins content was observed in the MLE treatment, whereas the lowest content were observed in the control (H_2O). Flavonoid content (Figure 1-b) decreased during the cold storage period in all the applied treatments. Fruits treated with the $CaCl_2$, MLE and OLE dipping solutions showed similar pattern of flavonoids and presented statistically significant ($P< 0.05$) difference with the control. The total phenolics content (Figure 1-c) presented similar trend with flavonoids being higher in the treated fruits. Total phenolics values ranged from 39 to 61 mg GAE 100 g^{-1} FW in the cv. Blanvio 10 and from 48 to 87 mg GAE 100 g^{-1} FW in the cv. Plagold 15. The vitamin C content (Figure 1-d) decreased greatly throughout the cold storage periods independently of the applied treatment. The carotenoid content (Figure 1-e) decreased during the second cold storage period showing statistically significant differences ($P< 0.05$) among treatments. The relative antioxidant capacity (Figure 1-f) decreased over the 2 cold storage periods with values ranging from 205 to 314 µg Trolox g^{-1} FW. In general, the three postharvest treatments maintained the antioxidant capacity during storage as compared to the control.

Sugar Analysis

The content of sucrose, glucose, fructose and sorbitol in flesh fruit of the two cultivars

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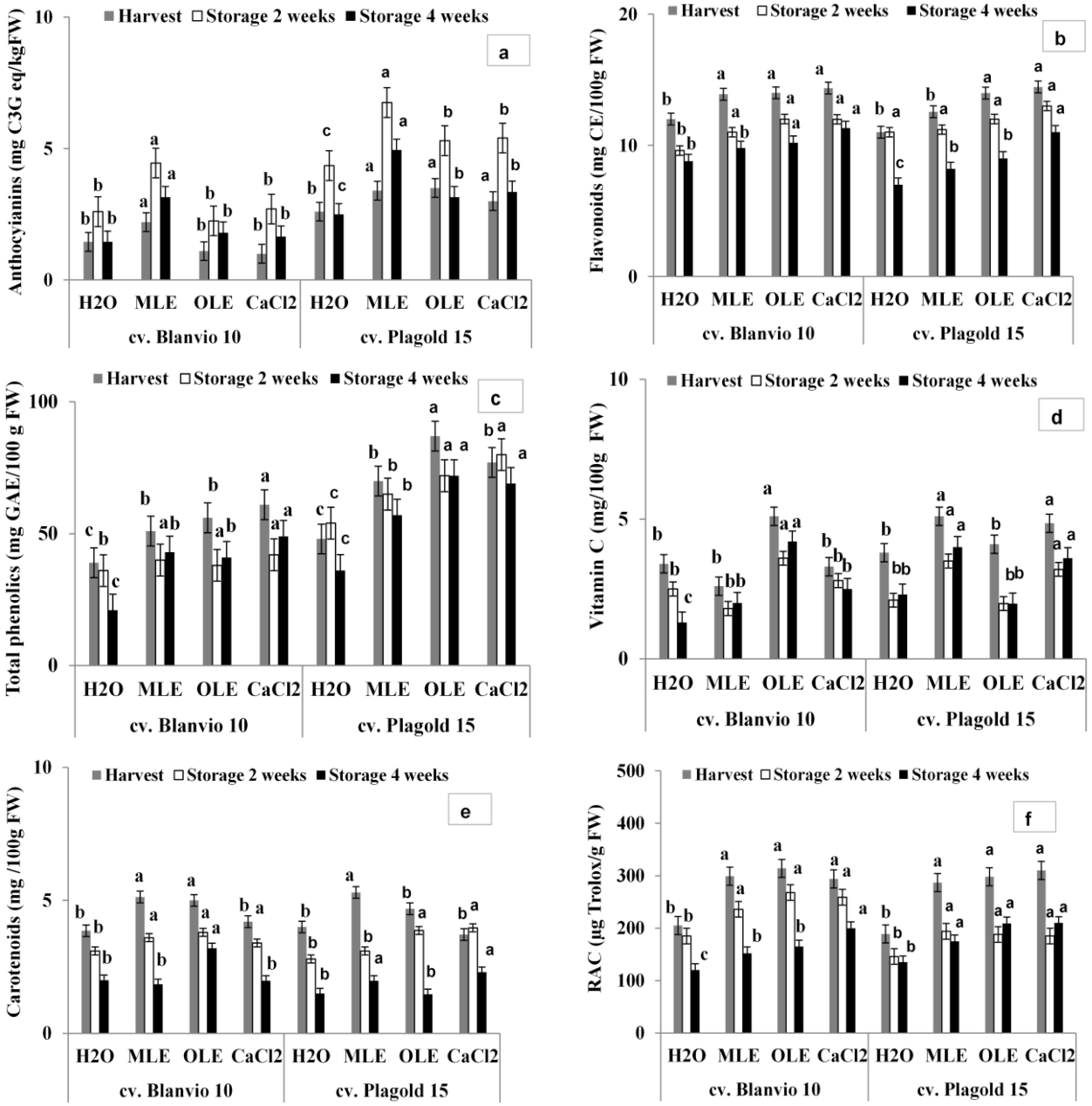
Table 2. Influence of dipping solutions on fruit weight, weight loss, firmness, SSC, TA and RI in Blanvio 10 and Plagold 15 peach cultivars during harvest, 2 and 4 weeks cold storage periods at 5°C and 95% RH.[a]

Treatment	cv. Blanvio 10						cv. Plagold 15					
	FW	FWL (%)	Firmness	SSC	TA	RI	FW	FWL	Firmness	SSC	TA	RI
	Harvest											
H_2O	93.2 ± 5^{a}	-	57.6 ± 1.4^{a}	9.80 ± 0.4^{a}	0.9 ± 0.2^{a}	10.9 ± 2^{c}	120.8 ± 1^{a}	-	55.0 ± 2^{a}	9.10 ± 0.5^{b}	0.8 ± 0.1^{a}	11.4 ± 1^{b}
MLE	85.0 ± 1^{b}	-	50.3 ± 1.5^{b}	9.70 ± 0.5^{a}	0.7 ± 0.6^{b}	13.9 ± 5^{b}	114.7 ± 2^{b}	-	52.2 ± 4^{a}	10.5 ± 0.3^{b}	0.7 ± 0.2^{a}	15.0 ± 2^{a}
OLE	93.1 ± 2^{a}	-	49.8 ± 2.6^{b}	9.00 ± 0.7^{b}	0.8 ± 0.4^{a}	11.3 ± 5^{c}	128.3 ± 2^{a}	-	49.4 ± 3^{b}	11.5 ± 0.2^{a}	0.7 ± 0.1^{b}	16.4 ± 1^{a}
$CaCl_2$	89.6 ± 2^{b}	-	49.5 ± 1.7^{b}	9.70 ± 0.5^{a}	0.6 ± 0.1^{c}	16.2 ± 1^{a}	110.5 ± 2^{b}	-	50.7 ± 2^{b}	10.6 ± 0.3^{b}	0.6 ± 0.2^{b}	17.7 ± 1^{a}
	2 weeks cold storage											
H_2O	89.4 ± 2^{a}	4.1 ± 0.5^{a}	38.5 ± 1.8^{b}	10.7 ± 0.9^{a}	0.7 ± 0.1^{a}	15.3 ± 5^{b}	115.4 ± 1^{b}	4.5 ± 0.4^{a}	35.4 ± 5^{b}	11.2 ± 0.5^{b}	0.5 ± 0.3^{b}	22.4 ± 3^{a}
MLE	82.4 ± 5^{b}	3.1 ± 0.2^{b}	42.5 ± 1.1^{a}	10.0 ± 0.8^{b}	0.6 ± 0.1^{b}	16.7 ± 3^{b}	111.2 ± 1^{b}	3.1 ± 0.3^{b}	45.0 ± 4^{a}	11.6 ± 0.7^{b}	0.6 ± 0.3^{a}	19.3 ± 2^{b}
OLE	90.9 ± 2^{a}	2.4 ± 0.4^{c}	44.8 ± 1.5^{a}	10.1 ± 0.7^{b}	0.5 ± 0.1^{b}	20.2 ± 5^{a}	125.3 ± 3^{a}	2.3 ± 0.5^{c}	42.9 ± 2^{a}	11.9 ± 0.4^{a}	0.6 ± 0.2^{a}	19.8 ± 1^{b}
$CaCl_2$	86.4 ± 5^{b}	3.6 ± 0.3^{b}	45.1 ± 2.6^{a}	10.3 ± 0.4^{b}	0.7 ± 0.1^{a}	14.7 ± 1^{b}	107.2 ± 2^{c}	3.0 ± 0.8^{b}	47.6 ± 4^{a}	12.0 ± 0.5^{a}	0.5 ± 0.1^{b}	24.0 ± 1^{a}
	4 weeks cold storage											
H_2O	86.5 ± 5^{a}	7.2 ± 0.6^{a}	17.2 ± 1.4^{b}	10.1 ± 0.3^{b}	0.6 ± 0.2^{a}	16.8 ± 4^{b}	112.5 ± 1^{b}	6.9 ± 0.5^{a}	10.3 ± 4^{c}	11.6 ± 0.3^{b}	0.3 ± 0.2^{b}	38.7 ± 2^{a}
MLE	80.2 ± 5^{b}	5.6 ± 0.4^{b}	25.5 ± 1.4^{a}	10.4 ± 0.5^{b}	0.5 ± 0.2^{b}	20.8 ± 5^{a}	108.5 ± 2^{c}	5.4 ± 0.9^{b}	26.5 ± 2^{a}	11.9 ± 0.2^{b}	0.5 ± 0.3^{a}	23.8 ± 2^{b}
OLE	88.0 ± 2^{a}	5.5 ± 0.3^{b}	24.4 ± 2.8^{a}	10.2 ± 0.4^{b}	0.4 ± 0.2^{b}	25.5 ± 10^{a}	123.1 ± 2^{a}	4.1 ± 1.0^{c}	18.6 ± 2^{b}	12.7 ± 0.4^{a}	0.5 ± 0.1^{a}	25.4 ± 2^{b}
$CaCl_2$	84.5 ± 3^{b}	5.7 ± 0.2^{b}	23.3 ± 1.1^{a}	10.8 ± 0.2^{a}	0.6 ± 0.1^{a}	18.0 ± 5^{b}	105.3 ± 3^{c}	4.7 ± 0.3^{c}	20.4 ± 1^{a}	11.9 ± 0.8^{b}	0.4 ± 0.3^{b}	29.7 ± 2^{b}
ANOVA												
Treatment (T)	Ns	*	*	*	ns	*	ns	*	*	*	ns	*
Storage period (SP)	*	*	*	*	*	*	*	*	*	*	*	*
T*SP	Ns	ns	ns	ns	ns	*	ns	*	ns	ns	ns	*

[a] Units and abbreviations: $CaCl_2$: Calcium Chloride; FW: Fruit Weight; FWL: Fruit Weight Loss; Firmness (N); MLE: Moringa Leaf Extract; N: Newton; OLE: Olive Leaf Extract;) ; RI: Ripening Index (SSC/TA); SSC: Soluble Solids Content (°Brix), TA: Titratable Acidity (mg malic acid 100 g^{-1} FW. Values are means (n= 3)±SE. Letters (a, b, c) indicate significant difference (P< 0.05) between treatments for each storage period (ns, not significant, * P< 0.05) according to Duncan's multiple range test.



ANOVA	Anthocyanins	Flavonoids	Phenolics	Vitamin C	Carotenoids	RAC
Treatment (T)	*	ns	*	ns	ns	ns
Storage period (SP)	*	*	*	*	*	*
T * SP	ns	ns	*	ns	ns	ns

Figure 1. Influence of dipping solutions on contents of anthocyanins (a), flavonoids (b), total phenolics (c), vitamin C (d), Carotenoids (e) and Relative Antioxidant Capacity (RAC) (f) among two peach cultivars at harvest and after 2- and 4-weeks cold storage periods. Abbreviations: AsA= Ascorbic Acid; $CaCl_2$= Calcium Chloride; CE= Catechin Equivalents; C3GE= Cyanidin-3-Glucoside equivalents; GAE= Gallic Acid Equivalents; MLE= Moringa Leaf Extract, OLE= Olive Leaf Extract; Values are the means (n= 3)±standard error. Letters (a, b, c) indicate significant difference (P< 0.05) between treatments for each storage period (ns, not significant, * P< 0.05) according to Duncan's multiple range test.

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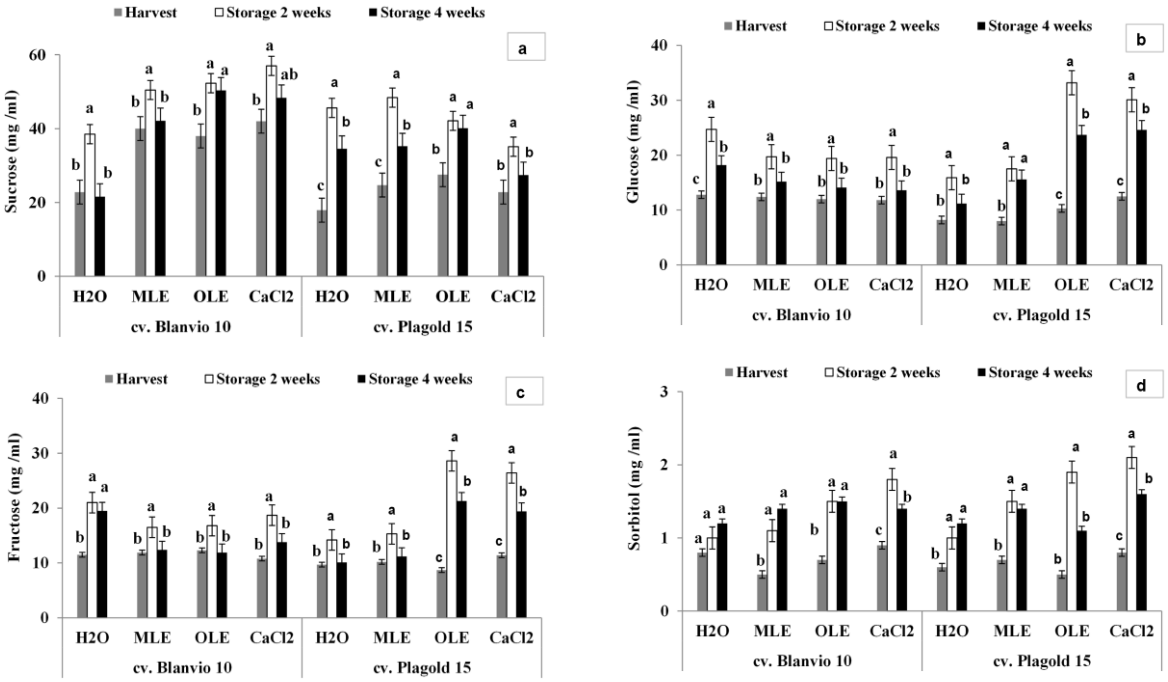

Figure 2. Impact of dipping solutions on sugar content in peach cultivars after storage at 5 ºC for 2 and 4 weeks and then ripening at 25ºC for 2 days. Abbreviations: MLE= moringa leaf extract; OLE= olive leaf extract; $CaCl_2$= calcium chloride; Values are means (n = 3) ± standard error. Letters a, b, c letters indicate difference ($p < 0.05$) among cultivars after 2 weeks of cold storage according to Duncan's multiple range test.

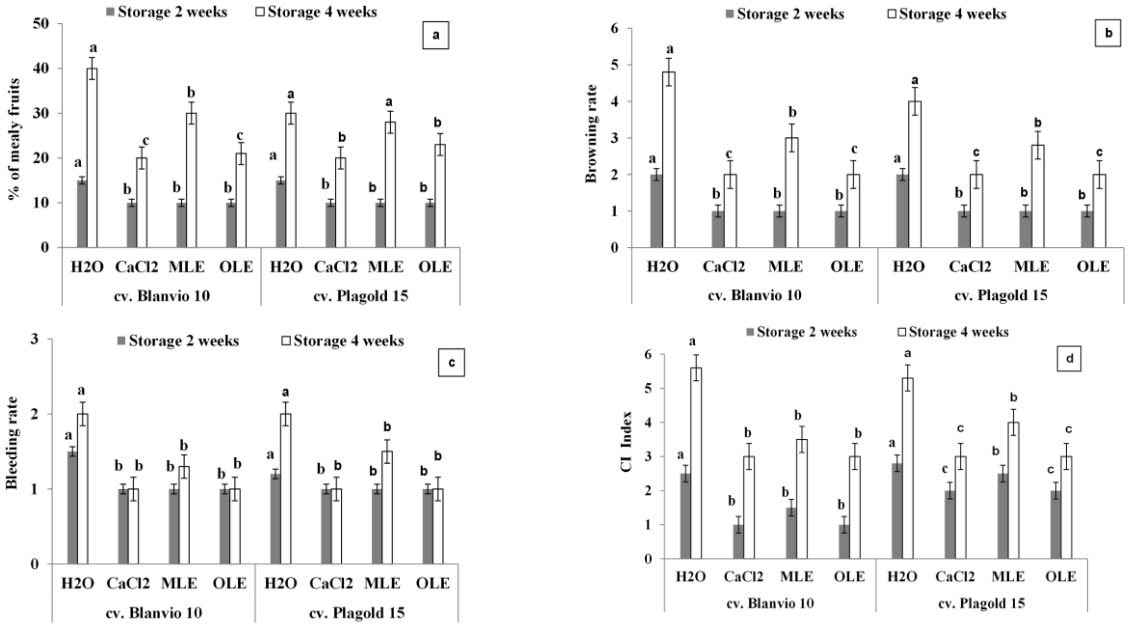

Figure 3. Impact of the dipping solutions on chilling injury symptoms in Blanvio 10 and Plagold 15 peach cultivars after storage at 5ºC for 2 and 4 weeks and ripening at room temperature for 2 days. Units and abbreviations: Mealiness was scored as percentage of mealy fruits in the sample of 20 fruits. Bleeding was scored on a scale of 1 (no bleeding) to 3 (more than 50% of the flesh with bleeding). Browning was scored on a scale of 1 (no browning) to 6 (severe browning). CI (CI index) was visually assessed according to the global fruit appearance of each genotype, from healthy fruit with no symptoms (1) to extremely injured fruit with severe CI symptoms (6). Values are means (n=3)±SE. Letters (a, b, c) indicate significant difference (P< 0.05) between treatments for each storage period (ns, not significant, * P< 0.05) according to Duncan's multiple range test.

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were analyzed at harvest and over the two cold storage periods [Figure 2 (a-d)].

Results showed an increase in sucrose, glucose, fructose and sorbitol under MLE, OLE and $CaCl_2$ treatments after 2 weeks of cold storage showing statistically significant difference ($P< 0.05$) with the values obtained at harvest. The sugar content decreased at the end of the storage period and presented the impact of the applied treatments in maintaining sugar content in fruits after 2 weeks of cold storage as compared to the control.

Chilling Injury Symptoms

The mealiness, browning rate, bleeding rate and CI index are shown in Figures 3a-d as the major chilling injury symptoms identified in the fruits.

Results showed that mealiness and browning were the major chilling injury symptoms observed during the two cold storage periods. The control showed high CI symptoms whereas the MLE, OLE and $CaCl_2$ treatments delayed the presence of these symptoms. The duration of storage (2 or 4 weeks at 5ºC) increased the severity of mealiness (Figure 3-a) in the flesh fruit of the studied cultivars. The mealiness observed after 2 weeks of storage was 10% and 12% for Blanvio 10 and Plagold 15, respectively. After 4 weeks of cold storage, these proportions increased to 15% for Blanvio 10 and 20% for Plagold 15. The browning rating (Figure 3-b) was not observed in the first period of storage (Browning rating= 1). After 4 weeks of cold storage, browning was observed around the pit and generally less than 50% of flesh fruit. The bleeding rating (Figure 3-c) was not enregistered as a major chilling injury symptom during cold storage in all the samples. Hence, the bleeding score was always lower than 50% of flesh fruit. After 4 weeks of cold storage, the CI index (Figure 3-d) increased and varied differently ($P< 0.05$) between treatments.

DISCUSSION

In this study, Blanvio 10 and Plagold 15 peach cultivars were dipped in distilled water, $CaCl_2$, MLE, and OLE to investigate the impact of these treatments on physicochemical traits, antioxidant compounds content, and chilling injury symptoms during two cold storage periods. This study showed significant differences in fruit weight loss during the storage. Fruit weight loss in both peach cultivars increased with the increase in storage time under all the treatments. The highest weight loss was recorded in the control (H_2O) while the lowest loss occurred in fruits treated with OLE. The main reason for the weight loss of fruits is the water loss due to physiological activities such as transpiration and respiration (Magazin *et al*., 2010). Razavi *et al.* (2017) reported that weight loss ranged from 5.1 to 7.4% after 4 weeks of cold storage in peach fruits with postharvest oxalic acid treatment. Arendse *et al*. (2014) reported that the weight loss of pomegranate fruit remained below 10% at 5°C, and no sign of shriveling was observed in fruits even after 2 months of storage.

Fruit firmness is the most important indicator for postharvest quality, storage conditions and market value of the fruits. In our study, firmness indicated a decreasing trend under all treatments in both cultivars throughout cold storage. However, peach fruits kept in the MLE, OLE, and $CaCl_2$ dipping solutions remained with significantly higher ($P< 0.05$) texture as compared to the control (H_2O). The SSC of both cultivars increased throughout the whole storage period in all the treatments whereas the TA showed decreasing trends. Peach is a climacteric fruit with a limited postharvest storage life due to the ripening process leading to pigment changes, softening and increase in SSC during cold storage (Valero and Serrano, 2010). Irfan *et al*. (2013) reported that application of $CaCl_2$

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can maintain fruit quality by inhibiting green pigment degradation and maintaining the fruit texture. Similar findings were reported by Rojas-Grau *et al*. (2007) stating that, by extending fruit ripening, postharvest respiration and starch transformation to sugars were reduced, which is needed for sustaining the fruits' total soluble solid.

Flavonoids, total phenolics, vitamin C, carotenoids and antioxidant activity showed a gradual decrease during fruits storage. Mditshwa *et al*. (2017) reported that antioxidant compounds decreased during storage due to its oxidative breakdown. Our results of antioxidant activity are in accordance with the findings of Galani *et al*. (2017) who mentioned a decrease of antioxidant activity during storage attributed to a decreased level of total phenolics, vitamin C, anthocyanins, carotenoids, and flavonoids during storage.

Regarding sugars profile, our results are in accordance with the findings of Zhang *et al*. (2021) reporting that sucrose, sorbitol, glucose, and fructose were the major soluble sugars in peaches stored at 5°C for 24 days. The decrease in total sugar content observed at the end of the trial is in accordance with the results of Borsani *et al*. (2009) reporting that sugar content increased continuously during peach development up to full maturity, and remained constant or slightly decreasing during postharvest storage.

Mealiness and browning were the major chilling injury symptoms observed in the studied cultivars. These findings are in accordance with the study of Peace *et al*. (2006) in a clingstone melting flesh progeny. Hence, the observed chilling injury symptoms showed that these disorders are triggered by the cold storage duration, as previously reported by Lurie and Crisosto (2005).

CONCLUSIONS

Based on our results, the postharvest treatments with MLE, OLE and $CaCl_2$ maintained the fruit quality attributes due to their antioxidants and antibacterial effects. Storage duration affected the antioxidant compounds and the chilling injury symptoms. The antioxidants compounds showed a gradual decrease during cold storage periods, different pattern was observed in the anthocyanins. The herbal solutions reduced chilling injury symptoms and improved the marketability of peach fruits during storage. Our results concerning fruit decay clearly indicate a significant role of the applied postharvest treatments in reducing the decay rate. The OLE and MLE solutions can be considered an effective and environment-friendly treatment for delaying ripening process and retaining peach fruit quality during storage.

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REFERENCES

1. Abidi, W., Cantín, C., Jiménez, S., Giménez, R., Moreno, M. A. and Gogorcena, Y. 2015. Influence of Antioxidant Compounds, Total Sugars and Genetic Background on the Chilling Injury Susceptibility of a Non-Melting Peach (*Prunus persica* (L.) Batsch) Progeny. *J. Sci. Food Agric.*, **95:** 351-358.
2. Ali, S., Khan, A.S., Nawaz, A., Anjum, M. A., Naz, S., Ejaz, S. and Hussain, S. 2019. Aloe Vera Gel Coating Delays Postharvest Browning and Maintains Quality of Harvested Litchi Fruit. *Postharvest Biol. Technol.*,**157:110960**.doi.org/10.1016/j.postharvbio.2019.110960.
3. Arendse, E., Fawole, O. A. and Opara, U. L. 2014. Influence of Storage Temperature

[DOI: 10.22034/jast.25.3.609]

and Duration on Postharvest Physicochemical and Mechanical Properties of Pomegranate Fruit and Arils. *CyTA – J. Food*, **12(4)**: 389-398.
4. Bakhsh, A., Javaad, H. W., Hussain, F., Akhtar, A. and Raza., M. K. 2020. Application of Moringa oleifera Leaf Extract Improves Quality and Yield of Peach (*Prunus persica*). *J. Pure Appl. Agri.*, **5(2):** 42- 51.
5. Borsani, J., Budde, C. and Porrini, L. Lauxmann, M. A., Lombardo, V. A., Murray, R., Andreo, C. S., Drincovich, M. F. and Lara, M. V. 2009. Carbon Metabolism of Peach Fruit after Harvest: Changes in Enzymes Involved in Organic Acid and Sugar Level Modifications. *J Exp. Bot.*, **60:** 1823–1860.
6. Brand-Williams, W., Cuvelier, M. E. and Berset, C. 1995. Use of a Free Radical Method to Evaluate Antioxidant Activity. *Lebensm.- Wiss. u.- Technol.*, **28:** 25-30.
7. Chauhan, S. K., Thakur, K. S., Dwiwedi, S. K. and Bhanot, A. 2008. Storage Behavior of Apple as Affected by Pre and Postharvest Treatments of Neem Based Formulations, Plant Extracts and Leaves. *J Food Sci Tech*., **45**: 484–489.
8. Crisosto, C. H., Mitchell, F. G. and Ju, Z. 1999. Susceptibility to Chilling Injury of Peach, Nectarine, and Plum Cultivars Grown in California. *HortScience*, **34(6):** 1116–1118.
9. Crisosto, C. H., Johnson, R. S., DeJong, T. and Day, K. R. 1997. Orchard Factors Affecting Postharvest Stone Fruit Quality. *Hort Sci*., **32**: 820–823.
10. Galani, J.H.Y., Patel, J.S., Patel, N.J. and Talati, J.G. 2017. Storage of Fruits and Vegetables in Refrigerator Increases Their Phenolic Acids but Decreases the Total Phenolics, Anthocyanins and Vitamin C with Subsequent Loss of their Antioxidant Capacity. *Antioxidants* (Basel), **6(3):** 59.
11. Irfan, P. K., Vanjakshi, V., Prakash, M. N. K., Ravi, R. and Kudachikar, V. B. 2013. Calcium Chloride Extends the Keeping Quality of fig Fruit (*Ficus carica* L.) during Storage and Shelf-Life. *Postharv Biol. Technol*., **82**: 70–75.
12. Jiménez, S., Ollat, N., Deborde, C., Maucourt, M., Rellán-Álvarez, R., Moreno, M. A. and Gogorcena, Y. 2011. Metabolic Response in Roots of Prunus Rootstocks Submitted to Iron Chlorosis. *J. Plant Physiol.*, **168**: 415–423.
13. Lee, O. H. and Lee, B. Y. 2010. Antioxidant and Antimicrobial Activities of Individual and Combined Phenolics in *Olea europea* Leaf Extract. *Bio. Tech.*, **101:** 3751-3754.
14. Lester, G. E. and Grusak, M. A. 2004. Field Application of Chelated Calcium: Postharvest Effects on Cantaloupe and Honeydew Fruit Quality. *Hort Technol.*, **14:** 29-38.
15. Lurie, S. and Crisosto, C. H. 2005. Chilling Injury in Peach and Nectarine. *Postharvest Biol. Technol.*, **37:** 195-208.
16. Magazin N, Gvozdenovic D, Keserovic Z, Milic B. 2010. Fruit Quality of Granny Smith Apples Picked at Different Harvest Times and Treated with 1-MCP. *Fruits*, **65(3)**: 191–7.
17. Mditshwa, A., Magwaza, L. S., Tesfay, S. Z. and Opara, U. L. 2017. Postharvest Factors Affecting Vitamin C Vontent of Vitrus Fruits: A Review. *Sci. Hort.*, **218(1):** 95-104.
18. Nasir, M., Khan, A. S., Basra, S. M. A. and Malik, A. U. 2016. Foliar Application of Moringa Leaf Extract, Potassium and Zinc Influence Yield and Fruit Quality of "Kinnow" Mandarin. *Sci. Hort.*, **210:** 227-235.
19. Okamura, M. 1980. An Improved Method for Determination of l-Ascorbic and l-Dehydroascorbic Acid in Blood Plasma. *Clin. Chim. Acta*, **103:** 259-268.
20. Peace, C. P, Crisosto, C. H., Garner, D. T., Dandekar, A. M., Gradziel, T. M. and Bliss, F. A. 2006. Genetic Control of Internal Breakdown in Peach. *Acta Hort.*, **713:** 489–496.
21. Razavi, F., J. Hajilou, Gh. Dehgan and R. Nagshi Band Hassani. 2017. 'Effect of Postharvest Oxalic Acid Treatment on Ethylene Production, Quality Parameters, and Antioxidant Potential of Peach Fruit during Cold Storage'. *Iran. J. Plant Physiol.*, **7(2)**: 2027- 2036.
22. Rojas-Grau, M. A., Tapia, M. S., Rodrı´guez, F. J., Carmona, A. J., and Martın-Belloso, O. 2007. Alginate and Gellan Based Edible Coatings as Support of Antibrowning Agents Applied on Fresh-Cut Fuji apple. *Food Hydrocol.*, **21**: 118–127.
23. Samad, M., Sajid, M., Hussain, I., Samad, N. and Jan, N. 2019. Influence of Herbal

[DOI: 10.22034/jast.25.3.609]

Extract and Storage Duration on Fruit Quality of China Lime. *Hortic. Int. J.*, **3(3):** 153–158.
24. Sanusi, R. A. and Adebiyi, A. E. 2009. Beta Carotene Content of Commonly Consumed Foods and Soups in Nigeria. *Pakistan J. Nutr*., **8:** 1512–1516.
25. Sheren, A. A. and El-Amary, E. 2015. Improving Growth and Productivity of "Pear" Trees Using Some Natural Plants Extracts under North Sinai Conditions. *J. Agri. Vet. Sci.*, **8:** 1-9.
26. Singleton, V. L. and Rossi, J. A. 1965. Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents. *Am. J. Enol. Vitic*., **16:** 144–158.
27. Song, Y. and Xu, B. J. 2013. Diffusion Profiles of Health Beneficial Components from Goji Berry Alcohol Concentration and Steeping Time. *Foods*, **2(1):** 32–42.
28. Tesfay, S., Modi, T. and Mohammed, F. 2016. The Effect of Temperature in Moringa Seed Phytochemical Compounds and Carbohydrate Mobilization. *South Afri. J. Bot.*, **102:** 190–196.
29. Tsantili, E., Shin, Y., Nock, J. F. and Watkins, C. B. 2010. Antioxidant Concentrations during Chilling Injury Development in Peaches. *Posthar. Biol. Technol.*, **57:** 27- 34.
30. Turhan, S., Temiz, H. and Koca, A. F. 2009. Oxidative Stability of Brined Anchovies with Extracts from Blueberry (*Vaccinum* sp.) Fruits and Leaves. *J. Food Qual.*, **32(4):** 411-424.
31. Valero, D. and Serrano, M. 2010. *Postharvest Biology and Technology for Preserving Fruit Quality*. CRC Press, Taylor & Francis Group, Boca Raton, FL, USA, 288 PP.
32. Zhang, X., Xin, L., Wang, C., Sun, S. and Lyu, Y. 2021. Short-Term Hypobaric Treatment Enhances Chilling Tolerance in Peaches. *J. Food Process Preserv*., **45:** e15362.
33. 32. Zhishen, J., Mengcheng, T. and Jianming, W. 1999. The Determination of Flavonoid Contents in Mulberry and Their Scavenging Effects on Superoxide Radicals. *Food Chem.*, **64:** 555-559.

اثر عصاره برگ مورینگا (Moringa) ، عصاره برگ زیتون، و کلرید کلسیم روی ویژگی-های کیفیتی کولتیوارهای هلو در سردخانه

و. عبیدی، ر. آکریمی، و م. گویا

چکیده

این پژوهش با هدف بررسی تأثیر فروبردن (dipping) در محلول‌های عصاره برگ مورینگا ۵% (MLE)، عصاره برگ زیتون ۵% (OLE) و کلرید کلسیم ۵% ($CaCl_2$) بر کیفیت میوه دو کولتیوار (Blanvio 10 و Plagold 15) هلو (*Prunus persica Batsch* L.) انجام شد. تیمارها شامل فروبردن میوه ها به مدت ۵ دقیقه در محلول مربوطه و سپس خشک کردن ۳۰ دقیقه در دمای اتاق بود. سپس، میوه ها در دمای ۵ درجه سانتی گراد و رطوبت نسبی ۹۵% به مدت ۲ و ۴ هفته در سردخانه و سپس ۲ روز در دمای اتاق نگهداری شدند.صفات فیزیکوشیمیایی، ترکیبات آنتی اکسیدانی، محتوای قند و علائم سرمازدگی مورد تجزیه و تحلیل قرار گرفت. بهبود قابل توجهی در انبارداری میوه‌ها در اثر محلول‌های غوطه‌وری $CaCl_2$، MLE (۵%) و OLE (۵%) بود.این تیمارها سفتی را بهبود بخشید، محتوای جامدات محلول را حفظ کرد و شاخص رسیدن

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میوه (SSC/TA) را افزایش داد. کمترین کاهش وزن میوه در تیمار OLE دیده شد، در حالی که میوه های تیمار نشده بیشترین کاهش را نشان دادند. فلاونوئیدها، فنولیک کل، ویتامین C و ظرفیت آنتی اکسیدانی در طول دوره‌های انبارداری کاهش تدریجی نشان دادند. آردی بودن (mealiness) و قهوه ای شدن درونی علائم اصلی سرمازدگی بود که در دو رقم هلو پس از ۴ هفته نگهداری در سردخانه مشاهده شد. تیمارهای اعمال شده کارآمد بودند و حضور علائم سرمازدگی و پوسیدگی میوه را در طول دو دوره نگهداری درسردخانه به تاخیر انداخت.

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