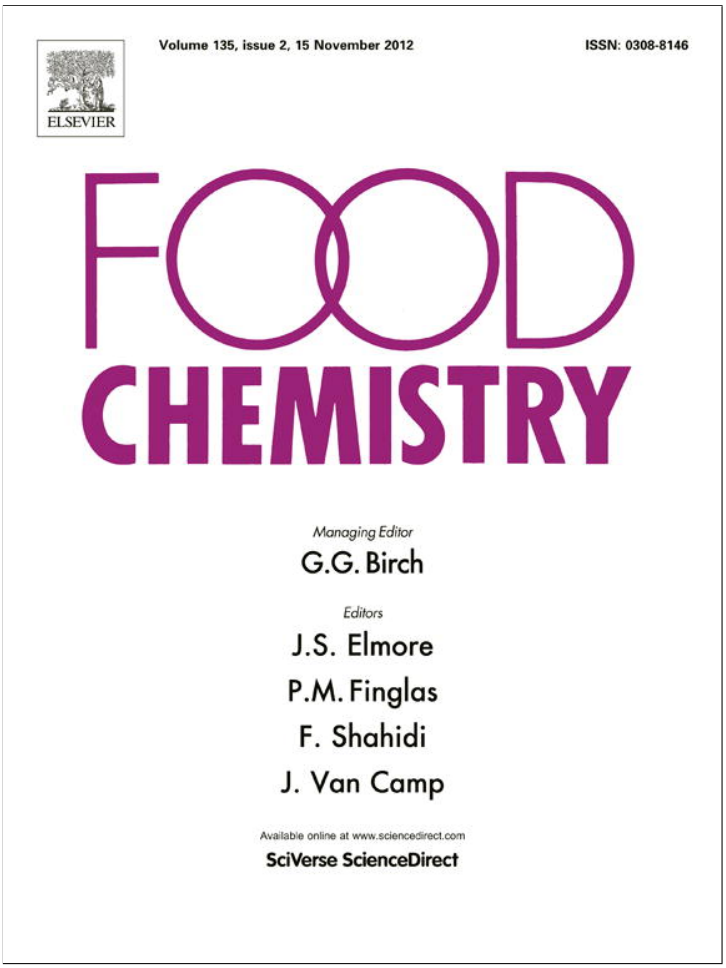

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Effect of harvest date on the nutritional quality and antioxidant capacity in 'Hass' avocado during storage

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ABSTRACT

The effect of harvest date on nutritional compounds and antioxidant activity (AOC) in avocado (*Persea americana* Mill. cv Hass) fruit during storage was determined. The fruits were harvested at seven different dates and ripened at 25 °C following 21 or 35 days of cold storage. The results indicated that the phenolic and glutathione contents were increased and the ascorbic acid content was not significantly different in early harvested fruit (January to March), and the phenolic, ascorbic acid and glutathione contents were increased slightly and then decreased on late harvested fruit (April to June). Similar trends were observed in the changes of AOC. Furthermore, AOC in early harvested fruit after storage for 35 days was much higher than that in late harvested fruit after storage for 21 days. Therefore, avocado can be harvested earlier for economic benefits according to the market and can keep high nutritional value for human health benefits.

1. Introduction

High consumption of fruits and vegetables is consistently correlated with lower incidence of some types of cancer and cardiovascular diseases (Steinmetz & Potter, 1996; Toor, Savage, & Lister, 2006). These protective effects are attributed to their high contents of antioxidant compounds that quench free radicals and thus, prevent abnormal oxidative changes in human body (Sun, Chu, Wu, & Liu, 2002). Avocado fruit contain high levels of bioactive compounds including vitamin E, ascorbic acid, carotenoids and soluble phenolics (Corral-Aguayo, Yahia, Carrillo-Lopez, & Gonzalez-Aguilar, 2008; Lee, Koo, & Min, 2004). However, the antioxidant capacity of fruits could be affected by diverse factors, such as cultivar, agronomic conditions, postharvest manipulation and fruit maturity (Kevers et al., 2007).

Avocado fruit have a long harvesting period depending on cultivar. Fruit maturity and picking time are determined according to external markers (colour and size), or by measuring dry matter and oil content in the flesh (Werman & Neeman, 1987). It was reported that the minimum dry matter ratio should range between 19% and 25% in California (Özdemir et al., 2009). However, determining the commercial maturity of avocado is difficult due to invisible external changes. Undesired eating quality and irregular maturity may occur in early harvested avocado fruit (Özdemir et al., 2009). In the case of late harvesting, cracks can form on the skin because the fruit keeps enlarging, and the flesh may spoil as well as fall (Hofman, Jobin-Décor, & Giles, 2000). The decision when to harvest should also take into account other factors, such as environmental conditions, hand labour availability, market price, potential transportation damage and storage temperature. Therefore, it is important for growers to be able to determine the precise stage of avocado development in order to allow harvest at a time that is optimum for storage.

A unique feature of avocado is that the fruits mature on the tree but only ripen after harvest. The ripening process takes 5 to 7 days at 25 °C (Ozdemir & Topuz, 2004). The maturity stage at harvest is the most important factor that affects fruit quality. In the literature, the main information on the harvest date of avocado is related to the fruit quality such as dry matter, colour, firmness and fatty acids (Ozdemir & Topuz, 2004; Yousef & Hassaneine, 2010). Meanwhile, the main information on the antioxidants of avocado is related to different strains and cultivars, ripening stages or comparisons with other fruits (Corral-Aguayo et al., 2008; Villa-Rodríguez, Molina-Corral, Ayala-Zavala, Olivas, & González-Aguilar, 2011; Wang, Bostic, & Gu, 2010). However, limited information is available on the effect of harvest date on antioxidants in avocado fruit. Investigations on nutritional compounds and antioxidant activity are important for understanding the influences of harvest date on the ripening of avocado. It was observed that the ascorbic acid content in 'Fuerte' avocado decreased by different harvest dates and ripening at 20 °C for a week (Yousef & Hassaneine, 2010). It was shown that harvest date did not have a significant effect on the total phenolic contents or antioxidant capacity, while the ascorbic acid content decreased between harvests on strawberry fruit (Pozo-Imsfran, Duncan, Yu, & Talcott, 2006). It was

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reported that no consistent trends in the ascorbic acid, total phenolic and antioxidant activity were observed in early and late harvested mango fruit (Manthey & Perkins-Veazie, 2009).

The objective of this study was to determine the effect of harvest date on the nutritional compounds and antioxidant activity in 'Hass' avocado fruit during storage. The results could be used to decide when to harvest and maintain high health-promoting compounds in avocado fruit, thus making them more desirable to consumers.

2. Materials and methods

2.1. Plant materials

Avocado fruits (*Persea americana* Mill. cv Hass) were obtained from a commercial orchard in Irvine, USA. Unripe fruits were harvested at seven different dates of the year: January, February, March, April, May and June (2009). The fruits were received at the laboratory within 2–3 h after harvest and were selected for uniform size and shape; those with physical injuries or infections were discarded; then, 35 fruits were stored at 4 °C for 35 days. After storage for every seven days, five fruit were allowed to ripen at 25 °C.

2.2. Measurement of nutritional components

The dry matter percent in avocado fruit was determined and calculated. Each fruit was cut into quarters, one-quarter was peeled, and the seed removed. Avocado mesocarp (10 g) was cut to small slices, and was put into the microwave until the weight did not change.

The ascorbic acid was determined by the method of Kyaw (1978). To prepare the colour reagent, a mixture of sulphuric acid (5 ml) and water (15 ml) was poured slowly into a mixture of sodium tungstate (20 g), disodium hydrogen phosphate (10 g) and water (30 ml), and the content was boiled gently for 2 h. Avocado mesocarp (1 g) was homogenised with 4 ml of distilled water and then centrifuged at 10,000*g* for 20 min at 4 °C, and 2 ml of the supernatant were added to 2 ml of colour reagent and mixed thoroughly. The mixture was left at room temperature for 30 min and then centrifuged at 10,000*g* for 5 min, and the absorbance at 700 nm was measured. The ascorbic acid content in the samples was determined from the standard ascorbic acid and the results were expressed as mg 100 g^{-1} FW.

Total phenolic was measured using the Folin–Ciocalteau method (Spanos & Wrolstad, 1990). Avocado mesocarp (1 g) was homogenised with 4 ml of distilled water and then centrifuged at 10,000*g* for 20 min at 4 °C, and 1.58 ml of distilled water was added to 0.02 ml of the supernatant; then 0.1 ml of Folin–Ciocalteau's reagent was added. The reaction was neutralised by adding 0.3 ml of 20% (w/v) sodium carbonate. The mixture was incubated at 75 °C for 10 min and the absorbance at 760 nm was measured. Gallic acid was used as a standard, and the results were expressed as milligrams of gallic acid equivalents (GAE) 100 g^{-1} FW.

To measure glutathione (GSH), avocado mesocarp (2 g) was homogenised in 4 ml 5% (w/v) trichloroacetic acid (TCA) containing 5 mM EDTA–Na_2, and then centrifuged at 10,000*g* for 20 min at 4 °C. The supernatant was collected and assayed colorimetrically for GSH contents using 5,5′-dithio-bis-2-nitrobenzoic acid (DTNB) as described by Brehe and Burch (1976). The reaction mixture contained 0.2 M phosphate buffer pH 7.7 (1 ml), 6.33 mM DTNB (0.5 ml, DTNB in 0.1 M phosphate buffer pH 6.8) and crude extract (1 ml). The reaction was run at 30 °C for 10 min. The absorbance at 412 nm was measured; 0.1 M phosphate buffer pH 6.8 (0.5 ml), replacing DTNB, was used as the blank. The GSH content was expressed as μmol g^{-1} FW.

2.3. Measurement of antioxidant activity

The ferric ion reducing antioxidant power (FRAP) assay was performed according to Thaipong, Boonprakob, Crosby, Cisneros-Zevallos, & Byrne (2006) with some modifications. To prepare the FRAP reagent, a mixture of 0.3 mM sodium acetate (pH 3.6), 10 mM 2,4,6-tripyridyl-2-triazine (TPTZ) and 20 mM ferric chloride (10:1:1, v:v:v) was made. An aliquot of 0.06 ml of avocado extract (0.25 g ml^{-1} in distilled water) was added to 1.8 ml of FRAP reagent and mixed thoroughly. After the mixture was left at 37 °C for 10 min, the absorbance at 593 nm was measured. Quantification was carried out based on a calibration curve (25–1600 μM ferrous ion), constructed using freshly prepared ammonium ferrous sulphate.

A test of the 2,2-diphenyl-1-picrylhydrazyl (DPPH) free-radical scavenging effect was performed according to Rosales et al. (2006). Aliquots of 0.2 ml of ethanolic avocado extract and 2.5 ml of freshly prepared 0.1 mM DPPH methanolic solutions were thoroughly mixed and kept for 30 min at room temperature in the dark. The absorbance of the reaction mixture was measured at 517 nm in a spectrophotometer. Ethanol (0.2 ml), replacing the extract, was used as the blank. The capability to scavenge the DPPH radical was calculated using the following equation:

$$\text{DPPH scavenging effect}(\%) = [1 - (A_{517}\text{sample}/A_{517}\text{blank})] \times 100.$$

2.4. Statistical analysis

Each treatment was carried out in three replicates and all experiments were performed at least twice with similar results. This analysis was performed using the General Linear Model procedure of the SAS 9.2 statistical program (SAS Inst., Inc., Cary, NC). Analysis of variance was used to test the treatment effects on cold storage for a specific date. The means were separated using Fisher's Protected LSD test at $P = 0.05$. The Pearson's correlation coefficient was calculated to determine the relationship between nutritional compounds and antioxidant activity.

3. Results

3.1. Effect of harvest dates on the days to ripen and the dry matter of avocado fruit during storage

The time to reach the ripe stage of avocado fruit at 25 °C following cold storage was inversely related to the storage duration (Table 1). All fruits were softened properly after storage and showed a dark-purple peel with characteristic flavour and aroma. The rate of ripening at 25 °C dropped first, and then rose and reached a peak on June 30th after 21 days of cold storage (Table 1). Similar results were observed after 0 and 35 days of cold storage at different harvest dates (Table 1).

As shown in Table 1, the dry matter of avocado fruit changed throughout the harvest dates during storage. The dry matter content increased gradually during the harvest date from January 7th to June 4th, and then decreased. The content on June 4th after 0, 21 and 35 days of cold storage was 18%, 21% and 11% higher than that on January 7th, respectively. Meanwhile, it was 5%, 6% and 5% higher than that on June 30th, respectively. There was no significant difference in the dry matter content during storage except on January 7th; the dry matter content after storage for 35 days

Table 1
Days to ripen and dry matter content of avocado fruit harvested on seven different dates and ripened at 25 °C following 0, 21 or 35 days of cold storage.

Harvest date (2009)	Days to ripen			Dry matter (%)			
	0 day	21 days	35 days	0 day	21 days	35 days	*P*-value
January 7	6	5	5	30.59 f,^{B*}	30.32 f,^{B}	32.52 c,^{A}	0.0019
February 3	7	6	5	31.52 ef,^{A}	31.50 ef,^{A}	31.87 c,^{A}	0.9397
March 10	7	7	6	32.66 de,^{A}	32.71 de,^{A}	33.11 bc,^{A}	0.7361
April 7	7	6	5	33.40 cd,^{A}	33.87 cd,^{A}	33.56 bc,^{A}	0.7552
May 12	6	6	5	34.91 ab,^{A}	35.36 ab,^{A}	34.83 ab,^{A}	0.6097
June 4	6	5	4	35.98 a,^{A}	36.59 a,^{A}	36.10 a,^{A}	0.6310
June 30	5	4	3	34.36 bc,^{A}	34.49 bc,^{A}	34.44 ab,^{A}	0.9901
P-value				<0.0001	<0.0001	0.0035	

* Mean values within a vertical column with different lowercase letters or in a horizontal row with different uppercase superscript letters are significantly different at the specified *P*-value based on Fisher's protected LSD test.

was 6% and 7% higher than that after stored 0 and 21 days, respectively.

3.2. Effect of harvested dates on the nutritional components of avocado fruit during storage

As shown in Table 2, the total phenol of avocado fruit at the early harvest date from January to March was increased during storage. The content after storage for 35 days was 11%, 8% and 20% higher than that after storage for 21 days, respectively. However, the total phenol of the avocado fruit at a harvest date from May to June was increased slightly and then decreased during storage (Table 2). The content after storage for 35 days was 8% lower than that after storage for 21 days. There was no significant difference in the total phenol in April harvested fruit during storage (Table 2). The highest phenolic content was found in January harvested fruit (150.13 ± 2.4) and the lowest was on June 30th (94.22 ± 1.2), after 35 days of cold storage (Table 2).

For a number of specific harvest dates (January, February, March and June 30th), no significant changes in ascorbic acid in the avocado fruit were observed during storage (Table 2). For other specific harvests (April, May and June 4th), the levels of ascorbic acid decreased significantly during storage (Table 2). The content after storage for 21 days was 5%, 17%, 14% and 7% higher than that after storage for 35 days, respectively. No significant difference in ascorbic acid was observed after storage for 0 and 21 days.

The glutathione (GSH) content in avocado fruit changed throughout the harvest date during storage (Table 2). For the fruit harvested on January 7th, February 3rd and June 30th, the GSH content after storage for 35 days was 12%, 28% and 24% higher than that after storage for 21 days, respectively. For the fruit harvested on April 7th and June 4th, the GSH content after storage for 35 days was 25% and 16% lower than that after storage for 21 days, respectively. In all of the other harvest dates, no significant differences in the GSH content were observed after storage for 21 and 35 days.

3.3. Effect of harvest date on the antioxidant activity of avocado fruit during storage

The antioxidant capacity (AOC) measured by FRAP and DPPH assays are shown in Table 3. For the harvest dates from January to March, the levels of AOC in avocado fruit were significantly increased during storage. The rate of increase in the FRAP value was 19%, 13% and 33%, and in DPPH scavenging activity it was 15%, 14% and 39%, respectively. For the harvest dates from April to June 4th, the levels of AOC in avocado fruit increased and then significantly decreased during storage. The rate of decrease in the FRAP values was 21%, 19% and 16%, and in DPPH scavenging activity was 11%, 14% and 14%, respectively. No significant difference in the levels of AOC occurred in relation with the storage duration on June 30th. The avocado fruit harvested on an early date (from January to March) after storage for 35 days contained much higher AOC levels than the fruit harvested on a late date (April to June) after storage for 21 days.

3.4. Correlation analysis between AOC and antioxidant compounds

As shown in Table 4, there was a high correlation between FRAP and total phenolics ($r = 0.93$) and between FRAP and ascorbic acid ($r = 0.90$). A similar correlation was found between DPPH and total phenolics ($r = 0.95$) and also between DPPH and ascorbic acid ($r = 0.86$). However, there was no correlation between AOC and GSH.

4. Discussion

Unlike many other fruits, the ripening or softening of avocados does not occur on the tree, but takes place several days after harvest. Our results showed that the days to ripen at 25 °C after harvest were from 3 to 7 days during storage. A previous study

Table 2
Nutritional compounds of avocado fruit harvested on seven different dates and ripened at 25 °C following 0, 21 or 35 days of cold storage.

Harvest date (2009)	Phenolic (mg GAE/100 g FW)				Ascorbic acid (mg/100 g FW)				GSH[a] (μmol/g FW)			
	0 day	21 days	35 days	*P*-value	0 day	21 days	35 days	*P*-value	0 day	21 days	35 days	*P*-value
January 7	123.19 a,^{C*}	135.33 a,^{B}	150.12 a,^{A}	<0.0001	1.96 a,^{B}	1.99 a,^{AB}	2.04 a,^{A}	0.0301	54.05 bc,^{C}	65.72 b,^{B}	73.55 a,^{A}	<0.0001
February 3	106.72 c,^{C}	115.25 c,^{B}	124.66 c,^{A}	0.0022	1.81 b,^{AB}	1.83 b,^{A}	1.74 b,^{B}	0.0586	50.16 c,^{B}	49.90 d,^{B}	63.82 b,^{A}	<0.0001
March 10	100.86 d,^{C}	107.61 d,^{B}	129.33 b,^{A}	<0.0001	1.67 d,^{A}	1.68 d,^{A}	1.72 b,^{A}	0.1565	56.62 b,^{A}	60.17 c,^{A}	58.84 c,^{A}	0.3389
April 7	110.10 c,^{A}	114.21 c,^{A}	110.43 e,^{A}	0.1778	1.74 c,^{A}	1.77 c,^{A}	1.51 d,^{B}	<0.0001	57.39 b,^{B}	65.15 b,^{A}	48.99 e,^{C}	0.0004
May 12	108.95 c,^{B}	115.43 c,^{A}	106.42 f,^{B}	0.0042	1.80 b,^{B}	1.84 b,^{A}	1.62 c,^{C}	<0.0001	64.21 a,^{B}	71.76 a,^{A}	72.60 a,^{A}	0.0009
June 4	116.57 b,^{B}	124.86 b,^{A}	115.25 d,^{B}	0.0134	1.82 b,^{A}	1.83 b,^{A}	1.71 b,^{B}	0.0055	65.93 a,^{B}	72.16 a,^{A}	60.79 c,^{C}	0.0028
June 30	97.03 d,^{B}	101.94 e,^{A}	94.22 g,^{B}	0.0043	1.57 e,^{A}	1.56 e,^{AB}	1.52 d,^{B}	0.0964	43.14 d,^{B}	41.67 e,^{B}	51.71 d,^{A}	0.0004
P-value	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	

[a] GSH: Glutathione.
* Mean values within a vertical column with different lowercase letters or in a horizontal row with different uppercase superscript letters are significantly different at the specified *P*-value based on Fisher's protected LSD test.

Table 3
Antioxidant activity of avocado fruit harvested on seven different dates and ripened at 25 °C following 0, 21 or 35 days of cold storage.

Harvest date (2009)	FRAP[a] (μmol Fe^{2+}/g FW)				DPPH[b] (%)			
	0 day	21 days	35 days	*P*-value	dpph	dpph	dpph	*P*-value
January 7	2.46 a,[C*]	2.72 a,[B]	2.93 a,[A]	<0.0001	60.29 a,[C]	65.28 a,[B]	69.59 a,[A]	0.0018
February 3	1.92 c,[C]	2.03 b,[B]	2.24 b,[A]	<0.0001	45.63 c,[C]	49.84 c,[B]	54.15 c,[A]	0.0012
March 10	1.62 e,[B]	1.66 d,[B]	2.18 b,[A]	<0.0001	39.42 ef,[B]	41.12 e,[B]	56.87 b,[A]	<0.0001
April 7	1.77 d,[B]	1.87 c,[A]	1.48 de,[C]	<0.0001	42.01 de,[A]	43.07 e,[A]	38.39 ef,[B]	0.0311
May 12	1.80 d,[B]	1.88 c,[A]	1.52 d,[C]	<0.0001	43.57 cd,[B]	46.88 d,[A]	40.34 e,[C]	0.0032
June 4	1.97 b,[B]	2.06 b,[A]	1.75 c,[C]	0.0001	49.64 b,[B]	52.88 b,[A]	45.59 d,[C]	0.0032
June 30	1.42 f,[A]	1.46 e,[A]	1.44 e,[A]	0.2519	37.29 f,[A]	37.03 f,[A]	38.04 f,[A]	0.5110
P-value	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	

[a] FRAP: Ferric reducing antioxidant power.
[b] DPPH: 2,2-diphenyl-1-picrylhydrazyl.
[*] Mean values within a vertical column with different lowercase letters or horizontal row with different uppercase superscript letters are significantly different at the specified *P*-value based on Fisher's protected LSD test.

Table 4
Correlation coefficients (r) and probability level (*P*) for the relationship between the individual antioxidant constituents and the antioxidant activity measured by FRAP[a] and DPPH[b].

	Phenolic		Ascorbic acid		GSH[c]	
	r	*p*	r	*p*	R	*p*
FRAP	0.93	<0.0001	0.90	<0.0001	0.47	<0.0001
DPPH	0.95	<0.0001	0.86	<0.0001	0.48	<0.0001

[a] FRAP: Ferric reducing antioxidant power.
[b] DPPH: 2,2-diphenyl-1-picrylhydrazyl.
[c] GSH: Glutathione.

showed that avocado completed its ripeness within 5–7 days at 25 °C after harvest (Ozdemir & Topuz, 2004). The reason for the difference is that the avocado fruits in our study were stored for 21 or 35 days at 4 °C and then ripened at 25 °C. Moreover, our results showed that the days to ripen of the avocado fruit were inversely related to the storage duration, which is in agreement with the study on cherimoya (Alique & Zamorano, 2000). In our study, the rate of ripening at 25 °C following cold storage decreased first and then increased. However, some studies reported that the rate of ripening of avocado fruit during storage at a later harvest date was faster than that at an earlier harvest date (Yousef & Hassaneine, 2010; Zauberman, Fuchs, & Akerman, 1986). The study on cherimoya fruit showed that the rate of ripening during storage was inversely related to harvest date (Alique & Zamorano, 2000). The reason for these contradictory results may be associated to the use of different cultivars, or fruit maturity, or preharvest factors such as the temperature.

Avocados are picked when they are physiologically mature but unripe, and their composition may vary when fruits are harvested at different times during the year. Ripening after harvest significantly affects the dry matter of avocado (Villa-Rodríguez et al., 2011). Our results showed that the dry matter content increased gradually and then decreased throughout harvest dates during storage. This behaviour was also observed by other authors (Ozdemir & Topuz, 2004; Yousef & Hassaneine, 2010). It may be due to the inactivation of acetyl-CoA carboxylase, a key enzyme for the production of long chain fatty acid from 14C acetate in avocado fruit tissues, once avocado has been picked. It was previously reported that a rapid increase was observed for the dry matter content in January harvested fruits during storage (Ozdemir & Topuz, 2004). This view was further supported by the present study. However, there was no significant difference in the dry matter content at other harvest dates during storage. No literature reports exist on the change of dry matter after January harvest during storage; therefore these present results could not be compared to the existing literature.

The avocados are harvested mostly from March to the end of June in California and have high nutritional values due to the presence of bioactive compounds such as fatty acids, soluble phenol and ascorbic acid. The protective effects of the nutritional compounds are, in part, due to their ability to quench free radicals, thus prevent abnormal oxidative changes in the human body (Toor et al., 2006). To our knowledge, the effects of harvest dates on hydrophilic nutritional compounds in avocado fruit during storage have not been previously investigated. Our results showed that the total phenolic content increased and the ascorbic acid content was not significantly different during storage at an early harvested fruit (from January to March); also, the total phenolic content increased slightly and then significantly decreased and the ascorbic acid content decreased during storage at a late harvested fruit during storage (from April to June). Similar trends of total phenol and ascorbic acid at different harvest dates were observed in mango (Manthey & Perkins-Veazie, 2009), strawberry (Pozo-Imsfran et al., 2006) and 'Fuerte' avocado fruit (Yousef & Hassaneine, 2010). The mesocarp discoloration is related to phenol (Hershkovitz, Saguy, & Pesis, 2005). This view was further supported by the present study. The highest phenolic content was observed in January harvested fruits (Table 2), and the mesocarp discoloration was also observed in January harvested fruits but not found in the other harvests after storage for 50 days (data not shown). The lowest phenolic and ascorbic acid contents were observed on June 30th.

Ascorbic acid and glutathione (GSH) are the two major low molecular weight antioxidants to prevent oxidative damage in fruit (Noctor & Foyer, 1998). In antioxidative defense, GSH can react with free radicals, or react to regenerate ascorbic acid as a reductant. Our results showed that the GSH content increased at early harvested fruits and finally decreased in late harvested fruits during storage. A similar trend was observed in the changes of ascorbic acid in our study. The mechanisms regulating the pool sizes of the two components are not yet fully understood, but high levels of GSH, as the reducing substrate in the regeneration of ascorbic acid, may be associated with the high levels of ascorbic acid in the fruit.

Antioxidant activity (AOC) is an important parameter to establish the health functionality of fruits and there are many methods employed for its measurement. The antioxidant activities of avocado fruit were evaluated using the DPPH radical scavenging and FRAP assays. Both methods are recommended by many authors as easy and accurate assays for measuring the antioxidant activity of fruits. Our results showed that the FRAP values and DPPH radical scavenging activity in early harvested fruits increased and at late harvested fruits increased slightly and then decreased during storage. The reason for these phenomena may be associated with the fact that the ascorbic acid and total phenolic contents and the antioxidant activity were influenced by the harvest date of the avocado

fruits during storage. Ascorbic acid is generally a minor component compared with the phenol present in the fruits (Vinson, Su, Zubik, & Bose, 2001) as in avocado. A previous study on cabbage and broccoli showed that ascorbic acid may contribute 10–12% to the total antioxidant capacity (Chu, Sun, Wu, & Liu, 2002). It was reported that the phenol is a stronger antioxidant than ascorbic acid (Kim & Lee, 2004). Most of the studies demonstrated a high linear correlation between the total phenol and AOC and also between the ascorbic acid and AOC by different methods in fruits and vegetables (Corral-Aguayo et al., 2008; Mahattanatawee et al., 2006; Thaipong et al., 2006). Those are consistent with our study. Moreover, the positive synergistic interactions of ascorbic acid and total phenol may be responsible for the observed increase or decrease of AOC in different harvested fruits during storage. The low correlation between the GSH content and AOC also indicated that the GSH was not the major antioxidant compound in avocado fruit.

5. Conclusions

Considering the potential health benefits of avocado in protecting against various diseases, the results of this study would be of interest to both industry and the consumers. These results showed that the early harvested fruits can be stored for a longer period (35 days in our study) and have positive effects on the accumulation of nutritional compounds and the retention of AOC. Moreover, for late harvested fruits, storage for a shorter period (21 days in our study) was much better for the retention of nutritional compounds and AOC. However, the later harvested fruits (June 30th) had poor nutritional qualities and lower AOC during storage. Our results also showed that the avocado fruit harvested in the early dates after storage for 35 days contained much higher AOC levels than the fruit harvested in later dates after storage for 21 days. Therefore, avocado fruits can be harvested earlier for economic benefits according to the market and can retain a high nutritional value for human health benefits. Further studies are necessary to clarify their bioavailability once they are consumed in order to know the real health benefits that these compounds can offer.

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