Tocopherol Contents of Pulp Oils Extracted from Ripe and Unripe Avocado Fruits Dried by Different Drying Systems

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Abstract: The tocopherol contents of unripe and ripe avocado fruit oil extracted from Pinkerton, Hass and Fuerte varieties were determined after drying fruit using air, microwave or oven drying methods. The α -tocopherol content changed between 13.70 mg/100 g (microwave-dried) and 28.06 mg/100 g (air-dried) in oil from unripe Pinkerton fruit; between 14.86 mg/100 g (microwave-dried) and 88.12 mg/100 g (fresh) in oil from unripe Hass fruit and between 13.31 mg/100 g (microwave-dried) and 17.35 mg/100 g (oven-dried) in oil from unripe Fuerte fruit. The α -tocopherol contents in oil from ripe Fuerte fruit changed between 13.21 mg/100 g (fresh) and 17.61 mg/100 g (oven-dried). In addition, γ -tocopherol contents varied between 11.55 mg/100 g (air-dried) and 14.61 mg/100 g (microwave-dried) unripe "Pinkerton" fruit; between 11.52 mg/100 g (air-dried) and 15.01 mg/100 g (fresh) in unripe Hass fruit and between 12.17 mg/100 g (air-dried) and 15.27 mg/100 g (microwave-dried) unripe Fuerte fruit. The γ -tocopherol contents ranged from 12.71 mg/100 g (fresh) to 17.40 mg/100 g (oven-dried) in ripe Hass fruit; from 10.29 mg/100 g (fresh) and 17.20 mg/100 g (microwave-dried) ripe Fuerte fruit. α -, β -, γ - and δ -tocopherols could not be detected in ripe fresh Pinkerton fruit. In general, β - and δ -tocopherol could not be detected in most of the unripe and ripe avocado fruit oils. α -Tocopherol and γ -tocopherol contents of dried ripe Fuerte fruit oils were found to be higher compared to those of dried unripe Fuerte fruits.

Key words: avocado varieties, fruit drying, fruit oil, tocopherols, HPLC

1 Introduction

Fruit from avocado (*Persea americana* Mill.) tree has gained significance from nutritional and commercial aspects. Among different tropical and subtropical fruits, avocado fruit has prominent market value and it is cherished due to high nutritional value, especially due to, its edible fibre and lipid contents^{1,2}. Presence of high levels of bioactive compounds, including vitamin E, carotenoids and soluble phenolics is also being recognized in different studies³⁻⁶. The current trends of consumption of avocado fruit include as vegetable in the form of salads along with onions and cheese, as a soup containing salt and pepper and as canned products⁷. Medicinal uses of avocado fruit also include treatment of hypercholesterolemia, hypertension, type 2 diabetes mellitus, and dyslipidemia. It is gener-

ally regarded as beneficial in maintaining cardiovascular health^{8,9}. Lu *et al.*¹⁰ observed inhibition of prostate cancer cell growth using a lipophilic extract of avocado fruit.

Hence, different uses of avocado fruit require application of appropriate processing techniques that maintain its functional properties in the final product. Drying is a commonly used and well-known postharvest technology aimed at increasing the shelf life of fruits or vegetables, preserving their quality and stability by reducing water activity and moisture content thereby avoiding spoilage and contamination during storage and making possible their utilization in different products including spices, folk medicine¹¹. The content of avocado oil is used as an indicator of the fruit maturation stage prior to harvest¹ and the ripening stage of avocado fruit and the variety can influence the

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Accepted September 28, 2020 (received for review August 24, 2020)

Journal of Oleo Science ISSN 1345-8957 print / ISSN 1347-3352 online

<http://www.jstage.jst.go.jp/browse/jos/> <http://mc.manuscriptcentral.com/jjocs>

composition and contents of different nutrients in avocado oil²⁾. It would be interesting to carry out detailed analytical study of tocopherols in relation of fruit maturation, varieties and drying method used to process the avocado fruit. Therefore, current study was aimed at characterization of tocopherol contents of unripe and ripe avocado fruit oils extracted from three different varieties (Fuerte, Hass and Pinkerton) after drying using three distinctive techniques, namely air-, microwave- and oven-drying methods.

2 Material and Methods

2.1 Material

Avocado fruits were harvested from Fuerte, Hass and Pinkerton varieties at two different maturity stages (unripe and ripe) in Antalya, Turkey. Avocado fruits were cut to separate pulp from seed and peel fractions.

2.2 Methods

2.2.1 Samples

Avocado fruit pulp samples from each variety (ripe and unripe) were divided into 4 groups:

Group 1: Control group consisting of untreated pulp

Group 2: Room temperature dried pulp

Group 3: Microwave oven (540 W, 15 min) dried fruit pulp

Group 4: Oven (60°C, 19 h) dried pulp

These experimental conditions were selected after preliminary drying treatments in which the final pulp moisture content was maintained at less than 5%.

2.2.2 Analysis for tocopherol contents

Quantification for tocopherol contents was carried out following Spica *et al.*¹²⁾ procedure. Oil was extracted from pulp samples from different varieties using Soxhlet system and 0.1 g of it was mixed with 5 mL of *n*-hexane followed by filtration using 0.45 µm nylon filter. Tocopherol analyses was accomplishing using a Shimadzu-HPLC system that consisted of a PDA detector and LiChroCART Silica 60 (4.6 × 250 mm, 5 µ; Merck, Darmstadt, Germany) column. An isocratic chromatographic separation of tocopherols was carried out using 0.7% propan-2-ol in *n*-hexane as mobile phase which set to flow at 0.9 mL/min rate. The sample injection volume was set as 20 µL and detection and identification of peaks was carried out at 295 and 330 nm wavelength set at PDA detector following a 30 min running time for each sample. Chromatography standards were prepared using 0-100 mg of α, β, γ and δ-tocopherols per 1 L of solutions prepared following same procedure as explained for oil samples. All the chemical used were of analytical grade and each treatment and measurement of tocopherol sample was carried out in triplicates.

2.3 Statistical analyses

The experiments were carried out according to a com-

plete randomized split plot block design and obtained data was subjected to analysis of variance (ANOVA) using JMP software (v 9.0, SAS Inst. Inc., Cary, N.C.U.S.A). All analytical measurements were carried out in triplicates and results were expressed as means ± standard deviations (MSTAT C) for each independent avocado fruit variety sample¹³⁾.

3 Results and Discussion

Tocopherol contents of oils obtained from fruit pulp from three different unripe and ripe avocado varieties ("Hass", "Fuerte" and "Pinkerton") dried using different drying systems are presented in Table 1. The α-tocopherol contents changed between 13.70 mg/100 g (Microwave) and 28.06 mg/100 g (Air drying) in unripe "Pinkerton" fruit pulp oil and between 14.86 mg/100 g (Microwave) and 88.12 mg/100 g (Fresh) in unripe "Hass" fruit oils. In addition, α-tocopherol contents of ripe "Pinkerton" fruit oil were determined between 0.0 (fresh and microwave) and 19.40 mg/100 g (Oven) while α-tocopherol contents of ripe "Hass" fruit oil varied between 0.0 (microwave and oven) and 53.05 mg/100 g (fresh). Similarly, α-tocopherol contents was determined between 13.31 mg/100 g (microwave) and 17.35 mg/100 g (oven) in unripe "Fuerte" fruit pulp oil and between 13.21 mg/100 g (fresh) and 17.61 mg/100 g (oven) in ripe "Fuerte" fruit oils. In addition, γ-tocopherol contents of unripe "Pinkerton" fruits varied between 11.55 mg/100 g (air) and 14.61 mg/100 g (microwave) while that of ripe "Pinkerton" fruit oils were determined between 11.55 mg/100 g (air) and 15.57 mg/100 g (oven). Additionally, γ-tocopherols of unripe "Hass" fruit oils changed between 11.52 mg/100 g (air) and 15.01 mg/100 g (fresh) while that of ripe "Hass" fruit oils ranged from 12.71 mg/100 g (fresh) to 17.40 mg/100 g (oven). The γ-tocopherol contents of unripe "Fuerte" fruit oils were detected between 12.17 mg/100 g (air) and 15.27 mg/100 g (microwave) while that of ripe "Fuerte" oils varied between 10.29 mg/100 g (fresh) and 17.20 mg/100 g (microwave). The α-, β-, γ- and δ-tocopherols in ripe fresh "Pinkerton" oil were not detected. In general, β- and δ-tocopherols could not be detected in most of the oil samples from unripe and ripe avocado fruit. Drying affected tocopherol contents of avocado fruit pulp depending on the varieties and maturation stages. The α and γ-tocopherol contents of ripe "Fuerte" fruits dried by air, microwave and oven were found to be higher compared to their values for unripe "Fuerte" fruits dried using same drying methods. β- and δ-tocopherols were observed in unripe "Fuerte" oil dried by air drying. Statistically significant differences were identified among tocopherol contents of ripe and unripe avocado fruit oils ($p < 0.05$) (Fig. 1a-v). Peraza-Magallanes *et al.*¹⁴⁾ reported that fresh "Hass" pulp oil contained 45.02-

Table 1 Tocopherol contents of oils from avocado fruit pulp oils (mg/100 g) from ripe and unripe fruits from different varieties dried using different techniques.

Maturity	Process	Variety	α -T	β -T	γ -T	δ -T
Unripe	Fresh	<i>Pinkerton</i>	16.09 $\pm$ 0.23 ^{*c}	—	—	—
	Air-drying	<i>Pinkerton</i>	28.06 $\pm$ 0.00 ^{a**}	14.50 $\pm$ 0.03	11.55 $\pm$ 0.02 ^c	—
	Microwave drying	<i>Pinkerton</i>	13.70 $\pm$ 0.00 ^d	—	14.61 $\pm$ 0.02 ^a	13.05 $\pm$ 0.01
	Oven drying	<i>Pinkerton</i>	18.49 $\pm$ 0.19 ^b	—	12.87 $\pm$ 0.48 ^b	—
	Fresh	<i>Hass</i>	88.12 $\pm$ 0.42 ^a	11.29 $\pm$ 0.00 ^b	15.01 $\pm$ 0.10 ^a	11.00 $\pm$ 0.03
	Air-drying	<i>Hass</i>	15.15 $\pm$ 0.36 ^c	12.65 $\pm$ 0.00 ^a	11.52 $\pm$ 0.01 ^c	—
	Microwave drying	<i>Hass</i>	14.86 $\pm$ 0.05 ^d	—	14.90 $\pm$ 0.02 ^b	—
	Oven drying	<i>Hass</i>	16.66 $\pm$ 0.00 ^b	—	—	—
	Fresh	<i>Fuerte</i>	14.08 $\pm$ 0.00 ^{bc}	—	—	11.81 $\pm$ 0.00 ^a
	Air-drying	<i>Fuerte</i>	14.35 $\pm$ 0.03 ^b	11.52 $\pm$ 0.00	12.17 $\pm$ 0.02 ^c	8.68 $\pm$ 0.00 ^b
	Microwave drying	<i>Fuerte</i>	13.31 $\pm$ 0.02 ^c	—	15.27 $\pm$ 0.04 ^a	—
	Oven drying	<i>Fuerte</i>	17.35 $\pm$ 0.10 ^a	—	14.03 $\pm$ 0.10 ^b	—
Ripe	Fresh	<i>Pinkerton</i>	—	—	—	—
	Air-drying	<i>Pinkerton</i>	14.54 $\pm$ 0.02 ^b	—	11.55 $\pm$ 0.03 ^c	—
	Microwave drying	<i>Pinkerton</i>	—	—	12.76 $\pm$ 0.02 ^b	10.26 $\pm$ 0.00
	Oven drying	<i>Pinkerton</i>	19.40 $\pm$ 0.08 ^a	—	15.57 $\pm$ 0.03 ^a	—
	Fresh	<i>Hass</i>	53.05 $\pm$ 0.32 ^a	11.87 $\pm$ 0.03 ^b	12.71 $\pm$ 0.04 ^d	8.71 $\pm$ 0.00
	Air-drying	<i>Hass</i>	20.38 $\pm$ 0.37 ^b	—	14.44 $\pm$ 0.12 ^c	—
	Microwave drying	<i>Hass</i>	—	12.09 $\pm$ 0.00 ^a	15.32 $\pm$ 0.03 ^b	—
	Oven drying	<i>Hass</i>	—	—	17.40 $\pm$ 0.13 ^a	—
	Fresh	<i>Fuerte</i>	13.21 $\pm$ 0.00 ^d	—	10.29 $\pm$ 0.01 ^d	8.40 $\pm$ 0.03
	Air-drying	<i>Fuerte</i>	15.22 $\pm$ 0.25 ^b	—	12.31 $\pm$ 0.00 ^c	—
	Microwave drying	<i>Fuerte</i>	14.42 $\pm$ 0.08 ^c	—	17.20 $\pm$ 0.03 ^a	—
	Oven drying	<i>Fuerte</i>	17.61 $\pm$ 0.26 ^a	—	14.27 $\pm$ 0.30 ^b	—

*standard deviation; ** values within each column followed by different letters are significantly different at $p < 0.05$.

50.66 μ g/g of α -tocopherol. The α -tocopherol contents in the unsaponifiable fraction of “Fortuna” avocado pulp oils obtained after using different pulp drying techniques and extraction methods changed between 0.55% and 1.25%. In general, α -tocopherol losses can be associated with oxidative stress¹⁵. Saldeen and Saldeen¹⁶ reported that the mixture of α -, γ -, and δ -tocopherols showed better antioxidant and anti-inflammatory effects in comparison to α -tocopherol using animal models in a limited number of preliminary clinical investigations. Tocopherols are commonly used as antioxidants because they donate hydrogen from the hydroxyl group to the peroxy radical¹⁷. Microwave technologies is one of the new techniques for drying of fruits and their pulps and it was furthermore reported to prevent browning of avocado pulp during blanching process¹⁸. The α -tocopherol is considered as a scavenger of free radicals, thereby inhibiting the oxidation of both fats and phytosterols and persevering the oil quality over longer period of time^{15, 19, 20–22}. Results presented in the current study vary from those reported in literature values and these variations can be attributed to the maturation

stage of avocado fruit, geographic location, climatic factors, genetic structure and agricultural factors. Individual tocopherols showed marked variations in terms of their sensitivities to different drying methods. Most of the drying techniques caused reduction in α -tocopherol contents whether in ripe or unripe fruit pulp from “Hass” and “Pinkerton” avocado whereas it showed significant increments in “Fuerte” pulp after drying.

4 Conclusion

The α -tocopherol contents were generally higher in pulp oil from unripe fruit in comparison to ripe ones. “Hass” variety fruit pulp showed higher α -tocopherol contents than other two varieties. Variations in tocopherols sensitivity to drying process in different pulp from different avocado fruits may also depend on the structure of each type of tocopherols and such variations can be related with the structural differences among the four different kinds of tocopherols that may determine their stability. Further

a-Ripe-Fuerte (oven-dried avocado fruit pulp)

b-Ripe-Fuerte (air-dried avocado fruit pulp)

c-Ripe-Fuerte (microwave-dried avocado fruit pulp)

d-Ripe-Fuerte (control, fresh avocado fruit pulp)

Fig. 1 Tocopherol chromatograms of oils from pulp of ripe and unripe avocado fruits from three different varieties and as affected by drying of pulp.

e-Ripe-Hass (oven-dried avocado fruit pulp)

f-Ripe-Hass (air-dried avocado fruit pulp)

g-Ripe-Hass (microwave-dried avocado fruit pulp)

h-Ripe-Hass (control, fresh avocado fruit pulp)

Fig. 1 Continued.

i-Ripe-Pinkerton (oven-dried avocado fruit pulp)

j-Ripe-Pinkerton (air-dried avocado fruit pulp)

k-Ripe-Pinkerton (microwave-dried avocado fruit pulp)

l-Unripe-Fuerte (oven-dried avocado fruit pulp)

Fig. 1 Continued.

Tocopherol Contents of Avocado Fruit Oils Belong to Several Varieties

m-Unripe-Fuerte (air-dried avocado fruit pulp)

n-Unripe-Fuerte (microwave-dried avocado fruit pulp)

o-Unripe-Fuerte (control, fresh avocado fruit pulp)

p-Unripe-Hass (air-dried avocado fruit pulp)

Fig. 1 Continued.

q-Unripe-Hass (microwave-dried avocado fruit pulp)

r-Unripe-Hass (control, fresh avocado fruit pulp)

s-Unripe-Pinkerton (oven-dried avocado fruit pulp)

t-Unripe-Pinkerton (air-dried avocado fruit pulp)

Fig. 1 Continued.

Fig. 1 Continued.

studies may also help in identifying the appropriate drying technique using a range of process time and temperature and in relation to other nutrients present in avocado fruit pulp.

Acknowledgements

The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for its funding the Research group NO (RG-1435-049).

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