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PRESERVATION OF AVOCADO OIL WITH ELECTRIC FIELD TREATMENT

CONSERVACIÓN DEL ACEITE DE AGUACATE CON CAMPO ELÉCTRICO

J.A. Ariza-Ortega[1], E. Ramírez-Moreno[1], M. E. Ramos-Cassellis[2], J. Díaz-Reyes[3]*

[1] *Universidad Autónoma del Estado de Hidalgo, Instituto de Ciencias de la Salud. Área Académica de Nutrición. Carretera Actopan-Tilcuautla, Ex-Hacienda la Concepción, San Agustín Tlaxiaca, Pachuca, Hidalgo. 42086, México.*

[2] *Benemérita Universidad Autónoma de Puebla. Facultad de Ingeniería Química. Avenida San Claudio y Boulevard 18 Sur s/n. Col. San Manuel. Puebla, Puebla. 72570. México.*

[3] *Centro de Investigación en Biotecnología Aplicada-Instituto Politécnico Nacional. Ex?Hacienda de San Juna Molino Carr. Est. Santa Inés Tecuexcomac Tepetitla, Km 1.5. Tepetitla, Tlaxcala. 90700. México.*

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Abstract

The aim of this study was to analyze the effect of different conditions of electric field (voltage 3 kV cm^{-1}, 60 Hz, 10 and 180 s; 720 Hz, 10 and 180 s) as method on preservation up to 365 days on oil extracted of the avocado pulp. Unsaturated fatty acid oxidation in crude avocado oil was analyzed by Fourier transform infrared spectroscopy technique in the mid infrared region and by quality parameters (acidity, peroxide and iodine). The electric field caused minimal changes on unsaturated fatty acid of avocado oils, then is a suitable method to preserve the crude oil composition of avocado with minimal modifications during a long storage.

Keywords: avocado oil, electric field, fatty acids, Fourier transform infrared spectroscopy.

Resumen

El objetivo de este estudio fue analizar el efecto de diferentes condiciones de campo eléctrico (voltaje 3 kV cm^{-1}, 60 Hz, 10 y 180 s; 720 Hz, 10 y 180 s) como método de conservación sobre el aceite extraído de la pulpa de aguacate almacenado hasta por 365 días. La oxidación de los ácidos grasos insaturados en el aceite de aguacate fueron analizados por la técnica de espectroscopia de infrarrojo con transformada de Fourier en la región del infrarrojo medio, y por los parámetros químicos de calidad (acidez, peróxidos y yodo). El campo eléctrico ocasionó mínimos cambios sobre los ácidos grasos de los aceites de aguacate, por lo que es un método adecuado para conservar la composición del aceite de aguacate crudo con modificaciones mínimas durante el almacenamiento.

Palabras clave: aceite de aguacate, campo eléctrico, ácidos grasos, espectroscopía infrarroja con transformada de Fourier.

1 Introduction

Avocado is mainly consumed as a fresh fruit, however, to increase commercialization is important to develop food products derived from this fruit with an extended shelf life (Dorantes *et al*., 2004). Avocado oil is a product very interesting by its high concentration in the fruit. The lipids in this fruit are the second in concentration (21%) being a potential source of oil (Ortiz-Moreno *et al*., 2003). This oil has an important concentration of monounsaturated and polyunsaturated fatty acids (60.28 % of oleic and 13.66 % of linoleic acid), similar to virgin olive oil (Ratovohery *et al*., 1988). However, one the problems for preserving avocado pulp products is the oxidation of fatty acids that affect their shelf life and their nutritional quality (Dorantes *et al*., 2004) and moreover, it exerts adverse biological effects (Bernal *et al*., 2002). Antioxidants can retard oxidation, but not the stop, since the oxidation takes place at low

*Corresponding author. *E-mail*: joel_diaz_reyes@hotmail.com

pressures of oxygen and it is inevitable (Rodríguez *et al*., 2007). The increase of antioxidants in the food industry provides synthetic compounds like butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). However, these compounds have side-effects such as increased cholesterol, hepatomegaly and induction of cancer in rat cells (Lindenschmidt *et al*., 1986).

To avoid this deterioration in the avocado pulp, thermal processes are traditional methods usually used; however, the application of heat is not suitable for most fruits and vegetables (Jacxsens *et al*., 2001; Giner *et al*., 2002). Emerging technologies may have a solution to the mentioned problem, because these inactivate enzymes and produce microbiologically safe foods with fresh-like flavour and taste without significant loss of nutrients (Espachs-Barroso *et al*., 2003). Among the emerging technologies are: high hydrostatic pressure, modified atmospheres, ultrasound, irradiation, microwave, pulsed electromagnetic field, pulsed electric field and electric field (Raso and Barbosa-Cánovas, 2003). Electric field is a non-thermal preservation method that uses high voltage 87 kV cm^{-1} and a short burst 60 μs or ms (Zimmermann *et al*., 1980; Ho *et al*., 1997) for inactivation of microorganisms and enzymes (Zimmermann *et al*., 1980; Qin *et al*., 1996; Castro *et al*., 2004). This technology leads to reversible or irreversible damage of microbial membranes (Giner *et al*., 2000) and also changes in the structural conformational of enzymes as lipoxygenase, polyphenoloxidase and others (Castro *et al*., 2004; Ying-Qiu *et al*., 2008). The effectiveness of the electric field treatment depends of several conditions and the food treated (Castro *et al*., 2004). In some studies the fatty acids of beverages add with milk (soya milk, grape juice) were affected by high intensity pulsed electric field (Gade-Cerdán *et al*., 2007; Morales-de-la-Peña *et al*., 2011), while virgin olive oil (Abenoza *et al*., 2013) and in peanut oil (Xin-an *et al*., 2010) the quality of oil was remained by the decreased rate oxidation, and their nutritional value was preserved. For the avocado oil there is no studies about a technology to preserve this product. Hence, the aim of this study was to analyze the effect of different conditions of electric field (voltage 3 kV cm^{-1}, 60 Hz, 10 and 180 s; 720 Hz, 10 s and 180 s) as method on preservation up 365 days on oil extracted of the avocado pulp.

2 Methodology

Avocado (*Persea americana* Mill *var*. Hass) in the stage of commercial ripeness of the State of Puebla, Puebla, Mexico was used. Three undamaged fruits free of defects were selected. After a washing the epicarp and the seed were manually removed.

2.1 Oil extraction

For the oil extraction, 100 g of avocado pulp was homogenized in a blender (Braun Food Processor MultiPractic) during 20 s. Moisture was obtained in a glass petri dish until obtaining a thin film. This sample was dehydrated in a Memmert oven (model ICP-400) under vacuum at 70 °C during 30 min, until obtaining the 10% of the original mass. The solvent extraction was developed by the Soxlhet method placing the sample in a porous cartridge at 69 ± 1 °C during 4 h (Ortiz-Moreno *et al*., 2003).

2.2 Electric field treatment

The samples treatments were carried out in an electric field treatment system designed in the Centro de Investigación de Biotecnología Aplicada del Instituto Politécnico Nacional (CIBA-IPN) in Tepetitla, Tlaxcala, México. The conditions of crude avocado oil treatment were a voltage of 3 kV cm^{-1}, 60 Hz, 10 and 180 s; 720 Hz 10 s and 180 s. The voltage parameter were according with Castorena (2008) to inactivate the polyphenol oxidase enzyme in a 70 %. The system consisted of a cylindric chamber with a diameter of 10 cm with 2 electrodes. The waveform, voltage and intensity in the treatment chamber were fed to a function generator adapted to form the circuit of electric field. Samples were collected after each treatment and stored in a closed container at room temperature. Measurements of the chemical parameters at 0, 4, 13, 28, 90 and 365 days were done. The experiments were performed in triplicate.

2.3 Characterization of crude avocado oil

Crude avocado oil was characterized by the following chemical analysis: acidity (quantity in mg of KOH necessary to neutralize the free fatty acids in 1.0 g of oil or fat) (NM, 1987a), peroxide (mEq of O_2 in the form of peroxide per kg of fat or oil) (NM, 1987b), and iodine (unsaturated fatty acids in fats and oils and it was expressed in terms of the number of cg of I_2

absorbed per g of sample) (NM, 1981). Each analysis was performed in triplicate.

2.4 Fourier transform infrared spectroscopy

20 μL of crude avocado oil were deposited on crystal equipment and analyzed in a Bruker spectrometer (model Vertex 70 Bruker Optics-Bruker Corporation, Billerica, Massachusetts, USA) with fast Fourier transformer and ATR system was employed. The measurement region was the mid infrared (400-4000 cm^{-1}) with a resolution of 4 cm^{-1} and an integration time of 60 seconds (1 second per scan). The acquisition and processing of the data were performed by using the OPUS software, version 6.0 (Bruker Optics, USA).

2.5 Statistical analysis

The data were expressed as mean ± SD. Statistical analysis was performed by using analysis of variance (ANOVA). A value of α = 0.05 was considered statistically significant, with the Statistical Analysis System, version 6.1 (SAS Institute Inc., Cary, NC, USA).

3 Results and discussion

3.1 Fourier transform infrared (FTIR) spectroscopy and chemical values

Figure 1 shows the FTIR spectrograms of crude avocado oils treated with electric field using different conditions. In all studied conditions of treatment and during storage until 365 days there were no significative changes in the unsaturated fatty acids. Therefore, we suggest minimal conditions for the conservation of the avocado oil 3 kV cm^{-1}, 60 Hz and a time of treatment of 10 s. Therefore only it was described the results of this condition.

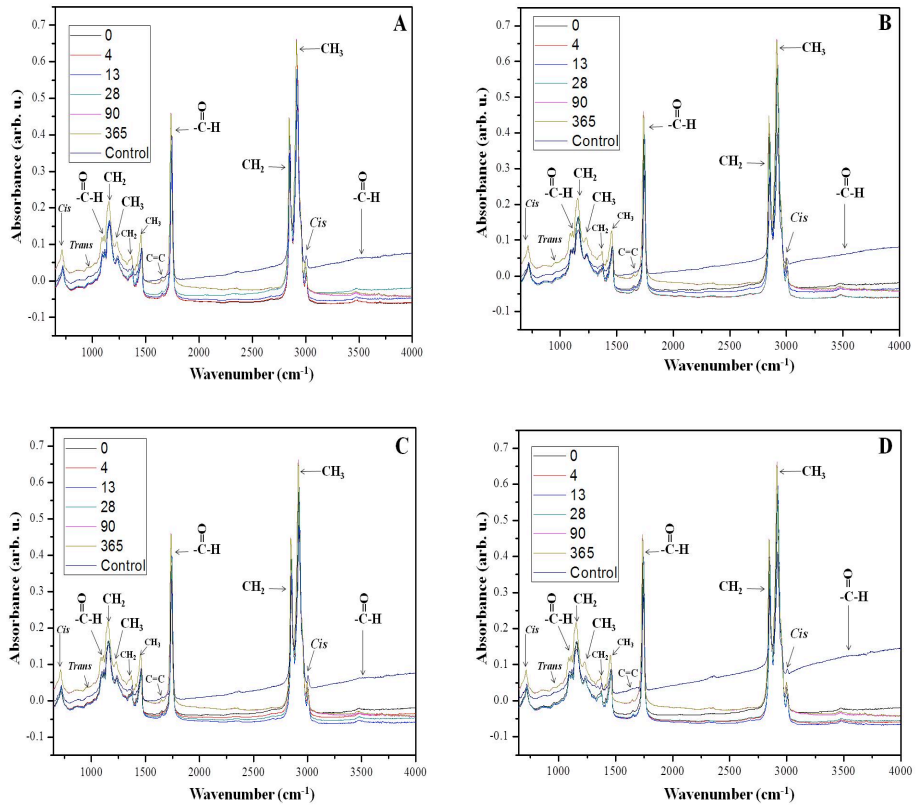

Fig. 1. Fourier transform infrared spectrograms of crude avocado oils treated with electric field: A (3 kV cm^{-1}, 60 Hz and 10 s), B (3 kV cm^{-1}, 60 Hz and 180 s), C (3 kV cm^{-1}, 720 Hz and 10 s) and D (3 kV cm^{-1}, 720 Hz and 180 s).

Figure 1A shown the wavenumber at 3468 cm^{-1} that corresponds to carboxyl functional group of the triglyceride ester, in it can see that all samples had low intensity. However, the control had a wide band compared with samples treated with electric field treatment indicated oxidation of unsaturated fatty acids. An alternative to reduce to minimal values the oxidation of fatty acids in the treated samples could be to minimize contact of the light exposure during handling of the oil and storage in dark bottles (Ceballos-Moyano *et al*., 2003; Psomiadou and Tsimidou, 2002).

On the other hand, in Fig. 1A the wavenumbers 1749 and 1654 cm^{-1} correspond to carboxyl functional group of the triglyceride ester and the *cis* double bonds respectively, the treatments did not show differences with each application time of electric field and during the storage according with other studies in peanut oil (Xin-an *et al*., 2010). Ying-Qiu *et al*., (2008) indicated in studies with soy milk that there was no an increase in the deterioration of the unsaturated fatty acids due to decreased lipoxygenase enzyme activity.

Table 1 shows the functional groups of crude avocado oil with electric field treatment. As can be seen there were no significant changes in the different bands. These results were according with other studies for soybean oil (Guillén and Cabo, 1998) and for lard (Yang *et al*., 2005) without treatment (Table 1). Table 2 shows chemical values determined on crude avocado oil treated with electric field and without treatment during 365 days. The chemical values of the samples with electric field treatment had lower values than the control. All these parameters of the treated sample at the end of the storage (peroxide value 3.75 mEq O_2 kg^{-1} of oil, acidity value 0.8% oleic acid, and iodine value 84.2 cg I_2 g^{-1}) were according with Mexican standards NMX-F-052-SCFI-2008 (NM, 2008) and were lower than international standards for olive oil (CODEX, 1999). These chemical parameters corroborated the results of FTIR technique, electric field treatment on crude avocado oil preserved to the unsaturated fatty acids causing a minimal oxidation.

Table 1. Characteristics of FTIR spectrograms of crude avocado oils treated with electric field

[1]Wavenumber (cm^{-1})	[1]Functional group	[1]Mode of vibration	Intensity		
			*Crude avocado oil	[1]Soybean oil	[2]Lard
3468	-C=O (ester)	Overtone	W	W	W
3009	=C-H (*cis*-)	Stretching	M	M	W
2955	-C-H (CH_3)	Stretching (asym.)	W	W	W
2929	-C-H (CH_2)	Stretching (asym.)	S	S	S
2856	-C-H (CH_2)	Stretching (sym.)	S	S	S
1749	-C=O (ester)	Stretching	S	S	S
1654	-C=C- (*cis*-)	Stretching	W	W	W
1465	-C-H (CH_2, CH_3)	Bending (scissoring)	S	S	S
1419	=C-H (*cis*-)	Bending (rocking)	W	W	W
1378	-C-H (CH_3)	Bending (sym.)	M	M	M
1239	-C-O, -CH_2-	Stretching, bending	W	W	W
1165	-C-O, -CH_2-	Stretching, bending	S	S	S
1120	-C-O	Stretching	W	W	-
1100	-C-O	Stretching	W	W	W
1035	-C-O	Stretching	W	W	W
967	-HC=CH- (*trans*-)	Bending out of plane	W	W	W
914	-HC=CH- (*cis*-)	Bending out of plane	W	W	W
724	-$(CH_2)_n$-, -HC=CH- (*cis*-)	Bending (rocking)	M	M	M

W, weak band; M, moderate band; S, strong band. *Crude avocado oil treated with electric field. [1](Guillén and Cabo, 1998). [2](Yang *et al*., 2005).

Table 2. Chemical values of crude avocado oil without and with electric field (EF) and stored at different times

Chemical value		
Storage time (days)	Control PV (Crude avocado oil)	Oil treatment -EF PV
0	2.46^{a}	2.46 ± 0.1^{a}
4	2.49^{a}	2.48 ± 0.2^{a}
13	2.6^{a}	2.49 ± 0.4^{a}
28	2.7^{a}	2.66 ± 0.3^{a}
90	4.1^{b}	2.95 ± 0.2^{a}
365	5.3^{c}	3.75 ± 0.3^{d}
Storage time (days)	Control AV (Crude avocado oil)	Oil treatment -EF AV
0	0.74^{e}	0.74 ± 0.01^{e}
4	0.75^{e}	0.75 ± 0.02^{e}
13	0.79^{e}	0.78 ± 0.04^{e}
28	0.81^{f}	0.79 ± 0.05^{e}
90	0.90^{g}	0.80 ± 0.03^{h}
365	0.97^{g}	0.81 ± 0.01^{h}
Storage time (days)	Control IV (Crude avocado oil)	Oil treatment -EF IV
0	88.6^{i}	88.67 ± 1.1^{i}
4	88.7^{i}	88.50 ± 1.3^{i}
13	88.6^{i}	88.46 ± 1.2^{i}
28	88.9^{i}	88.67 ± 1.1^{i}
90	83.6^{j}	85.2 ± 1.1^{k}
365	81.1^{l}	84.2 ± 1.0^{ll}

PV: Peroxide value expressed as the $mEqO_2kg^{-1}$ of oil. AV: Acidity value expressed as the percentage of oleic acid. IV: Iodine value realized by reagent of Wijs and expressed as the cg I_2 g^{-1}. Sample of 3 replicates ± SD. Superscript letters indicate significant difference (p <0.05).

However, it is necessary studies of other compounds with antioxidant activity of the sample to establish the compatibility differences between the bioactive species and free radicals that causing pro-oxidation (García-Márquez *et al*., 2012). The changes in intensity of the bands determinate by FTIR provide information on qualitative and quantitative aspects of the sample, and it had advantages for the simplicity of sampling and the nondestructive nature.

Conclusion

Electric field treatment (3 kV cm^{-1}, 60 Hz and 10 s) can be a suitable method to increase the shelf life of crude avocado oil without the addition of a preservative.

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