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SHORT COMMUNICATION

Effect of electric field on the characteristics of crude avocado oil and virgin olive

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Abstract The objective of this study was to analyze the effect of an electric field treatment (voltage 9 kV cm^{-1}, frequency 720 Hz and time of 5 and 25 min) as method of preservation on two edible oils. Unsaturated fatty acid oxidation in the crude avocado oil and virgin olive oil was analyzed by Fourier transform infrared spectroscopy in the mid infrared region and by quality parameters (acidity, peroxide and iodine). The electric field is a suitable method to preserve the crude oils composition with minimal modifications without the synthetic antioxidant addition.

Keywords Crude avocado oil · Electric field · Fatty acids · Fourier transform infrared spectroscopy · Virgin olive oil

Introduction

One the problems for preserving avocado pulp products is their oxidation, that affects its shelf life and its nutritional quality (Dorantes et al. 2004). 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 (Giner et al. 2002). Emerging technologies such as an electric field treatment may provide a solution to this issue, since it is a non-thermal preservation method that inactivates enzymes and microorganisms. This technology leads to reversible or irreversible damage to microbial membranes and also changes the structure conformation of enzymes such as lipoxygenase, polyphenoloxidase (Giner et al. 2000; Castro et al. 2004; Ying-Qiu et al. 2008).

The lipids are the second major compound of avocado and are a potential source of oil (Ortiz-Moreno et al. 2003). Its oil is a rich source 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). Studies on virgin olive oil (Abenoza et al. 2013) and peanut oil (Xin-an et al. 2010) have shown that oil quality and nutritional value can be maintained by electric field treatment. The effect of electric field on avocado oil has not been studied. Hence, the aim of this study was to analyze the effect of an electric field (voltage 9 kV cm^{-1}, frequency 720 Hz, treatment time 5 and 25 min) as method of preserving oil extracted from avocado pulp and its comparison with virgin olive oil.

Materials and methods

Samples

Three undamaged avocado (*Persea americana* Mill *var.* Hass) fruits free of defects were selected, in the stage of commercial ripeness of the Puebla State, Mexico. After, the fruits were washed and the epicarp and the seed were manually removed. The pulp was homogenized in a blender (Braun Food Processor Multipractic) during 20 s. The homogenized samples were poured into glass Petri

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plates, until form a thin film, and were deposited in an oven Memmert (ICP-400 model) at 70 °C for 30 min until their dehydratation (50%), was used 100 g of avocado pulp dehydrated and these were deposited in eppendorf tubes (50 mL) for extracting avocado oil by centrifugation. The centrifugation conditions were realized at 15,557 × gravity (11,000 rpm) at 40 °C for 10 min (Eppendorf centrifuge, model 5804 R, Eppendorf AG, Hamburg, Germany).

The virgin olive oil was purchased from local market in Puebla City, Mexico. The virgin olive oil was elaborated and was imported from Spain, was obtained by cold pressing with a maximum acid value of 2.0% of oleic acid; in the nutritional information indicates 5 g of total lipid content, 3.6 g of monounsaturated fatty acids, 0.7 g of polyunsaturated fatty acids, 0.7 g of saturated fatty acids and 0 g of *trans* fatty acids.

Electric field treatment

Electric field was applied on the samples in a scale unit of electric field designed by the Research Center for Applied Biotechnology of the National Polytechnic Institute located in the Municipality of Tepetitla, belonging to the State of Tlaxcala, México. The parameters (voltage 9 kV cm^{-1}, frequency 720 Hz and time of 5 and 25 min) were similar to those used by Castorena (2008) to inactivate polyphenol-oxidase enzyme in avocado pulp. The scale unit of electric field consisted of a generator (where high-voltage is produced). The generator is connected to a unit (model 9412A, Quantum Composers, Inc., Bozeman, MT) where the required waveform could be selected (a square form was selected for this work). The unit was connected to a chamber with two stainless steel connectors (acting as electrodes). Both electrodes are screwed to the final section of the chamber. Samples were collected after these treatments and were stored in a closed container at 25 °C, and measurements of the chemical parameters (acidity, peroxide and iodine) were done. All treatments were performed in triplicate.

Characterization of the crude oils

The crude avocado oils and the virgin olive oils were characterized by the following chemical analysis: acidity value, defined as the quantity in mg of KOH necessary to neutralize the free fatty acids in 1.0 g of oil or fat. Peroxide value, expressed as the mEq of O_2 in the form of peroxide per kg of fat or oil and iodine value, determines the quantity of unsaturated fatty acids in fats and oils in cg of I_2 absorbed per g of sample (AOAC 2012). Each analysis was performed in triplicate.

Fourier transform infrared spectroscopy

Bruker spectrometer (model Vertex 70 Bruker Optics-Bruker Corporation, Billerica, Massachusetts, USA) with fast Fourier transformer in the measurement mode called Attenuated Total Reflectance (ATR) was employed. The crystal used was a ZnSe of one reflection. The infrared absorbance was measured in the mid-infrared region from 600 to 4000 cm^{-1}, with a resolution of 4 cm^{-1} and an integration time of 60 s (1 s/scan). The acquisition and processing of the data were performed by using the OPUS software, version 6.0 (Bruker Optics, USA). Only 20 µL of each sample were deposited on equipment crystal.

The changes in the fatty acids in the crude oils samples were obtained by comparing using a standard of 37-components (Food Industry FAMEs Mix, Restek). The standard product used was a mix of methyl esters with chains C4:0, C6:0, C8:0, C10:0, C11:0, C12:0, C13:0, C14:0, C14:1, C15:0, C15:1, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1n9c, C18:1n9t, C18:2n6c, C18:2n6t, C18:3n6, C18:3n3, C20:0, C20:1n9, C20:2, C20:3n6, C20:3n3, C20:4n6, C20:5n3, C21:0, C22:0, C22:1n9, C22:2, C22:6n3, C23:0, C24:0 and C24:1n9.

Statistical analysis

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

Results and discussion

Figure 1a and Table 1 shown the spectrograms of Fourier transform infrared spectroscopy and the chemical values of the crude avocado oils and the virgin olive oils without and with an electric field treatment.

The wavenumber at 723, 1417, 1658 and 3006 cm^{-1} (Figures B, C and D) corresponds to the *cis* double bond with a mode of vibration of bending out and stretching (Guillén and Cabo 1998). Thus there was no significant change in these wavenumbers in the absorption peaks of both oils studied, to corroborate this, these oils were analyzed for iodine value. According to the International standard from virgin olive oil (75–94 cg I_2 g^{-1}) (CODEX 2001) and Mexican standard NMX-F-052-SCFI-2008 for crude avocado oil (85–90 cg I_2 g^{-1}) (NMX 2008), the results of iodine value obtained in this work were within the range specified by these standards. Therefore, there was no change in the double bonds of

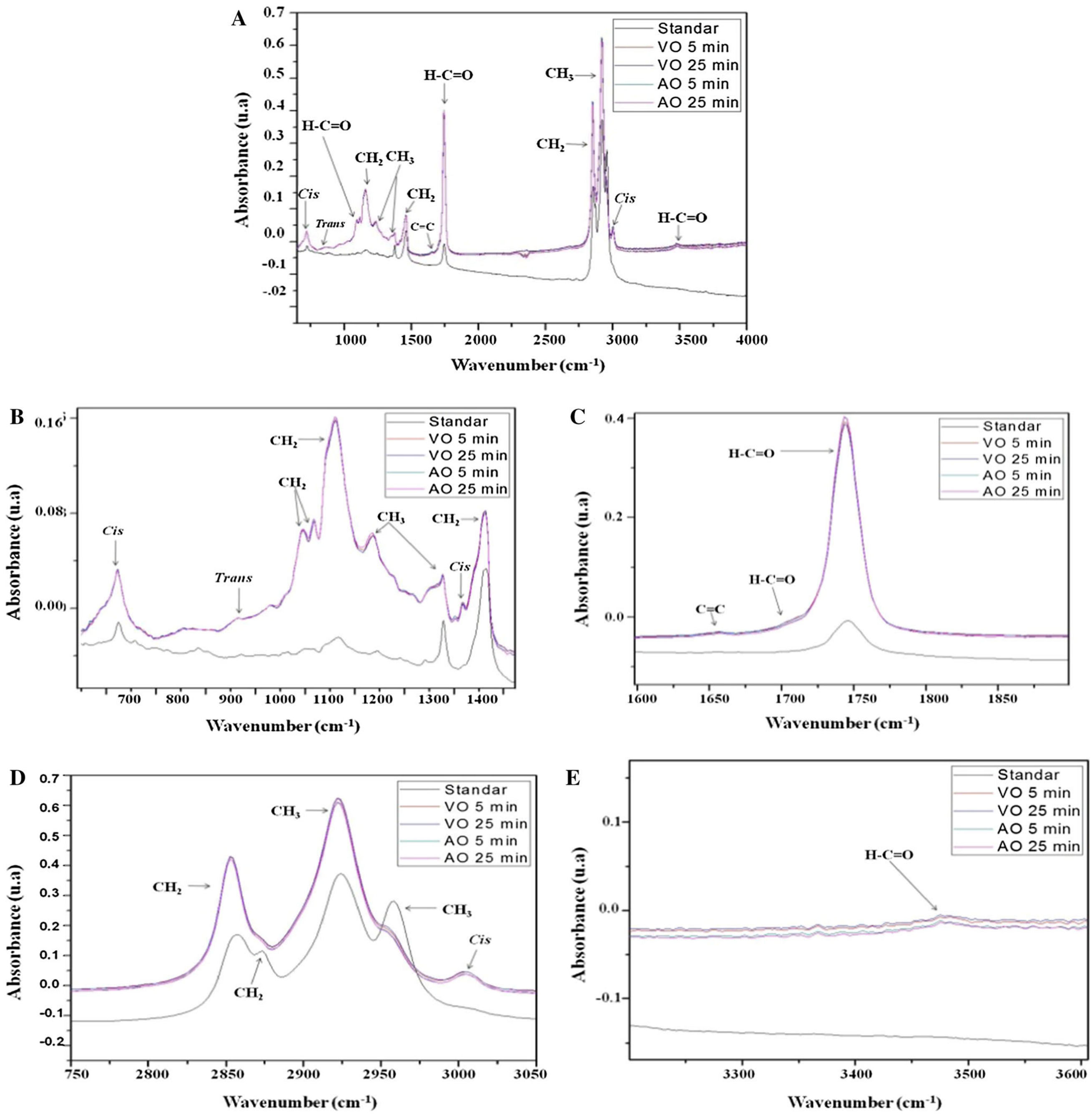

Fig. 1 Spectrograms of Fourier transform infrared of crude avocado oil and virgin olive oil without treatment and with electric field treatment (9 kV cm^{-1}, 720 Hz, application time of 5 and 25 min) and their comparison with the standard

the unsaturated fatty acids of the oils on application of an electric field.

Figure 1c shows the wavenumbers at 1750 and 1700 cm^{-1} that corresponds to the vibration, stretching and overtone of the carboxyl functional group of triacylglyceride esters (Guillén and Cabo 1998). The oil samples showed a lower concentration of free fatty acids, corroborated with the results of acidity value. On the other hand, the International standard for virgin olive oil and Mexican standard NMX-F-052-SCFI-2008 from crude avocado oil, fixes a maximum value of 3.3 and 1.5% of oleic acid respectively (CODEX 2001; NMX 2008), so post-processing values were within acceptable range as well, showing that the electrical field treatment preserved the nutritional quality of the oils (Table 1). This may be due to the decrease in lipoxygenase enzyme activity on application of an electric field. This enzyme degrades oil to the triacylglicerols and forms free fatty acids, according to

Table 1 Characterization of crude avocado oil and virgin olive oil without and with an electric field treatment

Crude avocado oil			
Time treatment (min)	0	5	25
Peroxide value (mEq O_2 kg^{-1} of oil)	1.60 ± 0.1[a]	1.61 ± 0.1[a]	1.62 ± 0.1[a]
Acidity value (% of oleic acid)	0.74 ± 0.1[a]	0.75 ± 0.1[a]	0.78 ± 0.1[a]
Iodine value realized by reagent of Wijs (cg I_2 g^{-1})	88.60 ± 1.1[a]	88.50 ± 1.0[a]	88.46 ± 1.2[a]
Virgin olive oil			
Time treatment (min)	0	5	25
Peroxide value (mEq O_2 kg^{-1} of oil)	3.70 ± 0.5[a]	3.74 ± 0.7[a]	3.76 ± 0.6[a]
Acidity value (% of oleic acid)	2.10 ± 0.1[a]	2.70 ± 0.3[a]	2.71 ± 0.6[a]
Iodine value realized by reagent of Wijs (cg I_2 g^{-1})	91.60 ± 1.0[a]	91.50 ± 1.1[a]	91.40 ± 1.2[a]

Sample of 3 replicates ± SD

Different letters in superscripts in the same row indicate significant differences between treatments ($p < 0.05$)

studies in soymilk, peanut oil and olive oil (Ying-Qiu et al. 2008; Xin-an et al. 2010; Abenoza et al. 2013).

Figure 1d indicates an increase of intensity of the functional groups of CH_2 and CH_3 at 2874 and 2960 cm^{-1} due to the chemical composition of the oils, that only showed traces of long-chain fatty acids compared with the standard (C22:1n9, C22:2, C22:6n3, C23:0, C24:0, and C24:1n9).

Figure 1e shows the vibration, stretching and overtone of the carboxyl functional group in triacylglyceride ester (Guillén and Cabo 1998). Oil samples exhibited a weak intensity peak at 3468 cm^{-1}, and no significant changes in shift or curve intensity were observed. However, electric field treatment did not prevent oil oxidation by hydrogen peroxide, as was quantified by peroxide value. Brühl (1996) indicated that the exposure of the oils to oxidants such as atmospheric oxygen and to light, produce singlet oxygen species which initiate the cascade of reactions leading its oxidation and brought configuration changes in the double bond from *cis* to *trans* form (Coolbear and Keough 1983). These were identified with a lower intensity in the wavenumber at 968 cm^{-1} in all samples (Fig. 1b). To prevent the oxidation of fatty acids in the treated samples, exposure to light should be minimized during oil handling, and the product should be stored in non-transparent containers (Psomiadou and Tsimidou 2002).

Conclusion

The crude avocado oil extracted by centrifugation its yield was 80.3%, its green color was maintained similar to virgin olive oil. The electric field application on crude avocado oil and virgin olive oil preserved to the unsaturated fatty acids, in both oils there are formation of free fatty acids and a minimal oxidation of the unsaturated fatty acids characteristic to chemical composition of each of they. By the above, we suggest these conditions: 9 kV cm^{-1}, 720 Hz and a time of treatment of 5 min for the conservation of the oils studied in this work. Therefore, the electric field processing can be a good prospects for being used in the oil industry as a preservation method.

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