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Preservation of the crude avocado oil with electric field treatment

José Alberto Ariza-Ortega[1]*, Luis Alberto Juárez-Morán[2], Nelly del Socorro Cruz-Cansino[1], Joel Díaz Reyes[3], Teresita de Jesús Saucedo-Molina[1], Gabriel Betanzos-Cabrera[1] & Eva María Molina-Trinidad[4]

[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, Hidalgo. CP. 42086, México.

[2]Benemérita Universidad Autónoma de Puebla. Facultad de Ciencias Físicomatématicas. Avenida San Claudio y 18 Sur, s/n. San Manuel, Puebla, Puebla. CP. 72570. México.

[3]Instituto Politécnico Nacional. Centro de Investigación en Biotecnología Aplicada. Carretera Estatal Santa Inés Tecuexcomac, Tepetitla. Ex–Hacienda de San Juan Molino Km. 1.5 Tepetitla, Tlaxcala. CP. 90700. Tlaxcala, México.

[4]Universidad Autónoma del Estado de Hidalgo. Instituto de Ciencias de la Salud. Área Académica de Medicina. Carretera Actopan-Tilcuautla, Ex-hacienda la Concepción, San Agustín Tlaxiaca, Hidalgo. CP. 42086, México.

E-mail: jose190375@hotmail.com

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The effect of an electric field (EF) application on crude avocado oils samples was evaluated and presented. Polyphenol oxidase enzyme in avocado pulp is inactivated by the treatment of EF, the conditions of the treatment are a square voltage 9 kV cm^{-1} with a frequency of 60 Hz for 3 min. The aim of this study was to analyze the effect of the EF as a preservation method on crude avocado oil. EF is directly applied on avocado pulp and oil was extracted. The oil is stored in a closed container at room temperature and analyzed at different periods of time with the Fourier transform infrared spectroscopy technique in the mid infrared region. Chemical values like acidity, peroxide and iodine are also reported. The fatty acid composition in avocado oils is not substantially modified by the EF during the storage. EF treatment may decrease the rate of oxidation reaction of unsaturated fatty acids extending the shelf life of avocado oil.

Keywords: Avocado oil, Electric field, Fatty acids, Fourier transform infrared spectroscopy.

The nutritional composition of avocado pulp is a potential source of oil due to the high concentration of lipids "21%"[1]. The avocado oil is characterized by a high content of mono and polyinsaturated fatty acids, mainly oleic "60%" and linoleic acid in lower concentration "13.66%" similar to the virgin olive oil concentration[2].

The oxidation of poly and unsaturated fatty acids directly affects its nutritional quality and it exerts adverse biological effects[3]. Antioxidants can retard oxidation, but not the stop, since the oxidation takes place at low pressures of oxygen and it is inevitable[4]. 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[5].

Emerging methods (high hydrostatic pressure, modified atmospheres, ultrasound, irradiation, microwave, pulsed electromagnetic field, pulsed electric field and electric field) seems to be the solution to inactivate enzymes and produce microbiologically safe foods with fresh-like flavor and taste, without significant loss of nutrients[6]. Some authors have suggested that conformational changes in the enzyme structure may be responsible for the modifications of the enzyme activity when is treated with a pulsed electric field[7]. In other studies the quality of the virgin olive oil (acidity and peroxide values) was not affected by the pulsed electric field treatments and did not generate any bad flavor or taste in the oil[8]. Therefore, the objective of this study was to evaluate the effect of electric field treatment on stability in avocado oil.

Experimental Section

Sample

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

Oil extraction

For the oil extraction, 100 g of avocado pulp was homogenized in a blender during 20 s. Sample was dehydrated at 70°C during 30 min., obtaining the 10% of the original mass. Oil extraction was developed by using solvent (hexane) by the Soxlhet method placing the sample in a porous cartridge at 69±1°C during 4 h[1].

Chemical values

Acidity is defined as the quantity in mg of KOH necessary to neutralize the free fatty acids in 1.0 g of oil or fat[9]. Peroxide indicates the mEq of O_2 in the form of peroxide per Kg of fat or oil[10]. Iodine is the measure of the unsaturated fatty acids in fats and oils and it is expressed in terms of the number of cg of I_2 absorbed per g of sample[11]. Each analysis was performed in triplicate.

Electric field treatment

Avocado pulp was exposed to an electric field with a square voltage of 9 kV cm^{-1}, frequency of 60 Hz and a treatment time of 3 min, and the oil was extracted using the Soxlhet method with hexane as the solvent. Samples were collected and stored in closed containers at 25°C temperature. Measurements of the chemical values at 0, 4, 13, 28, 90 and 365 days were done. The sample treatments were carried out in an electric field treatment system designed by CIBA-IPN. 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 for this work of trademark. The experiments were performed in triplicate.

Fourier transform infrared spectroscopy

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). 20 µL of avocado oil were deposited on equipment crystal.

Statistical analysis

The results 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).

Results and Discussion

Oil content in avocado pulp of Hass variety using Soxlhet method extraction was of 90% of yield. This percentage was higher than that reported by Bizimana ***et al***.[12] with recoveries a 70-80% of avocado oil with centrifugal extraction. The effect of different extraction methods on the cells containing the oil, mainly idioblasts (which are round and have a smooth surface), and at a temperature >100°C the cells are transformed into an irregular form and a rough surface, which it affects oil extraction and the yield[1].

Figure 1 shows the FTIR spectrograms of crude avocado oils treated with electric field using different times. Figure 1 shows the functional groups

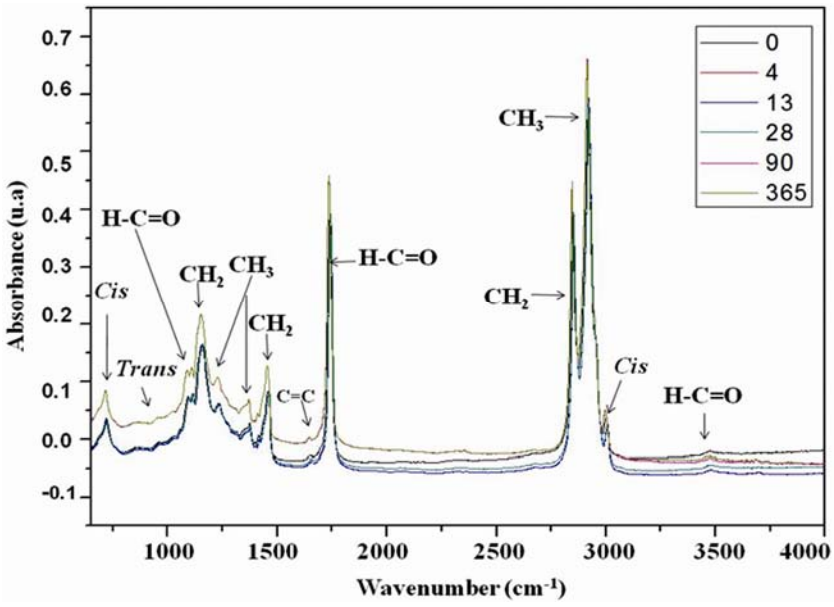

Fig. 1 — Fourier transform infrared spectrograms of crude avocado oils treated with electric field treatment (square voltage of 9 kV cm^{-1}, frequency 60 Hz and time of 3 min.). Oil was extracted using hexane (Soxlhet method) at 69±1°C during 4 h.

containing crude avocado oil and it can be seen that there was no significant change in the different bands, therefore, the exposure time of treatment with the electric field with these experimental conditions does not affect to the oil.

Figure 1 illustrates the wavenumber at 3468 cm^{-1} that corresponds to carboxyl functional group of the triglyceride ester, in it can be seen that all samples FTIR spectra had this band indicating the oxidation of unsaturated fatty acids. However, the intensity band is minimal. High concentration of chlorophyll in avocado oil (40-60 ppm) may be a factor that generated the auto-oxidation of unsaturated fatty acids by singlet oxygen[13]. Karp[14] indicated that the singlet oxygen can be produced at four sites within the chloroplast, site where it find the chlorophyll. The normally photoactivated chlorophyll transfers its excitation energy to the reaction centers of photosystems under conditions that prevent the capture of light energy, which uses the electron transport system, and this energy can excite and bring oxygen to singlet. This molecule has a reaction with the double bonds of the unsaturated fatty acids due to the proton abstraction allylic position, and forms an exciplex (oxide epoxide) that abstracts hydrogen and originates allyl hydroperoxide[15]. An alternative to reduce the oxidation of fatty acids could be a bleaching refining method, however, studies of avocado oil acceptability by consumers[1] indicated that the green color in oil is desirable similar to extra-virgin olive oil. Therefore, it is suggested to minimize contact of the light exposure during handling of the oil and have to be bottled in glass bottles dark color[16,17].

For other hand, in Fig. 1 in the wavenumbers at 1749 and 1654 cm^{-1} that correspond to carboxyl functional group of the triglyceride ester and the ***cis*** double bonds, respectively, the treatments did not show differences with each storage time of electric field technique. Ariza-Ortega ***et al***.[18] analyzed different avocado oils of the varieties Hass, Fuerte and Criollo with FTIR. The Fuerte variety presents a wide band with a shift to lower wavenumber with respect to the other oils. It was attributed to the formation of free fatty acids and that behavior was not found in these treated samples (Fig. 1).

The FTIR spectra do not show an increase in the deterioration of the unsaturated fatty acids in oil and this could be due to decreased lipoxygenase enzyme activity that degrades the unsaturated fatty acids of oils according with other studies in milk[19] and peanut oil[20], (Fig.1).

Furthermore, chemical values determined on crude avocado oil treated with electric field and without treatment during 0 - 365 days were from peroxide value 2.46 ± 0.1 - 3.7 ± 0.3, and 2.46 ± 0.1 - 5.3 ± 0.2 mEq O_2 kg^{-1} of oil, respectively. Acidity value was 0.74 ± 0.01 - 0.81 ± 0.01, and 0.74 ± 0.01 - 0.97 ± 0.1% oleic acid, respectively, and iodine value was 88.67 ± 1.14 - 84.2 ± 1.0, and 88.67 ± 1.14 - 81.1± 1.0 cg I_2 g^{-1}, respectively, in according with Mexican standards NMX-F-052-SCFI-2008[21] and lower than standards for international olive oil[22]. The results in control treatment was similar to the chemical values reports for the same avocado variety and extraction methods conditions (hexane, 70°C for 4 h) with 10.68 mEq O_2 kg^{-1} of oil, 0.65% oleic acid and 81.1 cg I_2 g^{-1}[11], respectively. These chemical values corroborated the results of FTIR technique, that electric field treatment on avocado pulp preserved to the unsaturated fatty acids and contains a minimal oxidation.

Fourier transform infrared sspectroscopy in the mid-infrared region comprise fundamental and characteristic bands which frequencies and intensities where clearly determine the relevant functional chemically reactive. The changes in intensity of the bands determinated 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 can be a suitable method to increase the shelf life of crude avocado oil, without the addition of a preservative.

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