

Influence of Pulsed Electric Field on physical properties of olive oil

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(Received: 24 March 2023, Accepted: 10 April 2023)

(2nd International Conference on Engineering, Natural and Social Sciences ICENSOS 2023, April 4 - 6, 2023)

ATIF/REFERENCE: Kitaneh, R., Afaneh, I. M., Hidmi, H. & Shawasha, M. (2023). Influence of Pulsed Electric Field on physical properties of olive oil. *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(3), 172-177.

Abstract – The physical properties (refractive index, viscosity, electrical and thermal conductivities) of olive oil treated with pulsed electric field (PEF) were studied. Results showed that the refractive index of olive oil was not affected by the application of PEF. Dynamic values of viscosity were found to increase with increased applied voltage. Electrical conductivity was not affected by the application of the PEF, while the thermal conductivity was found to increase with increased applied PEF.

Keywords – Pulsed Electric Field, Cell Membrane, Viscosity, Index of Refraction, Electrical and Thermal Conductivities.

I. Introduction:

Olive oil is the main source of fat in the Mediterranean diet. The high nutritional value of olive oil is the result of high oleic acid content and high levels of antioxidants (tocopherol and phenols) and the presence of biologically active components such as mono and poly -unsaturated fatty acids (MUFAs and PUFAs), squalene's, Phytosterols, phenol, and volatile compounds [1]. What makes olive oil different from other oils with contents of high monounsaturated fatty acids, such as sunflower oil, is the presence of phenolic compounds with strong antioxidant properties [2]. In addition to health implications [3], phenolic compounds of olive oils give unique taste, and represent an important contribution to the oxidation stability [4]. The oxidative stability increases the extra virgin olive oil is mainly due to

a concentration of phenolic compounds. Another important minor component of extra virgin olive oil is α -tocopherol, which protects the oil from oxidation at elevated temperatures [5], [6].

The non-thermal processes of extraction are of high importance in recent years due to increased demand for foods with higher nutritional values and freshness. Pulsed electric field (PEF) is an emerging technology that has been widely studied in non-thermal food quality. PEF processing has been studied by a number of researchers across a wide range of liquid foods. It is reported that the organoleptic properties of the juices are well preserved, and so have long shelf-life. Yogurt drinks, apple sauce and salad dressing have also shown to maintain fresh quality with a long shelf life after treatment [7].

Pulsed electric field (PEF) is a procedure that uses short pulses of high voltage electricity to

increase quantities of extraction or yield and minimizes the adverse impact on food quality features. For food quality features, PEF is better than traditional thermal treatment methods because it significantly reduces harmful changes in the sensory and physical properties of food [8].

PEF technology involves applying high-voltage pulses to grinded olive fruits placed between two plates. Most PEF studies have focused on the effects of PEF treatments on discouraging microbes in milk, dairy products, egg products, juice and other liquid foods [9]. These pulses stimulate the production of plant, animal and microbial cells, resulting in the disintegration of cells and the disruption of microbes. The PEF is instant, targeted, flexible, energy-efficient, and because the heat is low, the products have a longer shelf life while maintaining nutritional values [10].

PEF improves oil extraction rates, coloring factors and other active substances and extends significantly the shelf life. Diffusion processes, such as the removal of water from the tissues and auxiliary materials, thus saving valuable time in production processes.

Loss of barrier function:

Cytoplasm is surrounded by a thin semi-permeable layer, the cell membrane. The membrane works as a barrier within and outside cells for large ions and molecules (macromolecules). This cell membrane is a bifurcated phosphorus layer with a thickness The technology of PEF applied on olive paste involving the strength of the electric field of different KV per cm does not lead to any significant differences in the fatty acid composition and organoleptic characteristics to consider. The PEF treatment was very effective in increasing oil yields when compared with standards. The oil yields were high as 14.1% when the olive paste was exposed to PEF at 2 KV / cm and malaxed for 30 minutes at 15 ° C. However, the yield is reduced by 50% when not applying any malaxation to the olive paste compared to those malaxed for 30 minutes [12].

Physical properties of olive oil:

In this work physical analysis were done to specify some important properties of olive oil, mainly:

of 5 nanometers (nm). By exposing the cell to a pulsed electric field, the cell membrane is punctured with small pores of 50-100 nanometers diameter as shown in Figure 1. This effect is called electroporation, which is

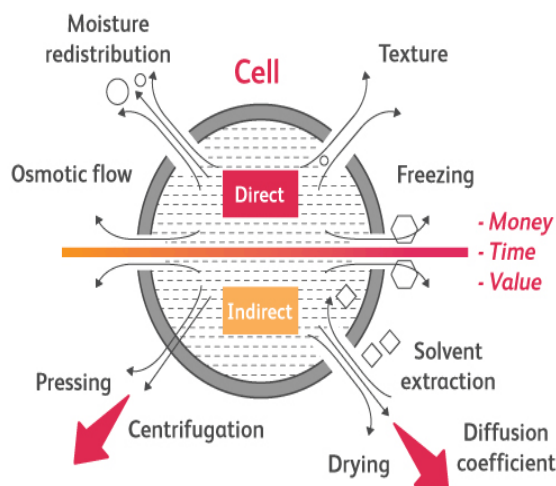


Fig.1 Cell exposed to electric field [11].

the loss of cell barrier function allowing access to valuable cell contents [11].

Electroporation takes place after a period of exposure time. This process is fast, flexible and energy-efficient because heat is minimized, products have a longer storage life time while maintaining a better nutritional value than traditional food processing techniques.

refractive index, viscosity, thermal and electrical conductivities.

Viscosity measurements of olive oil have been done in An-Najah National University analytical lab. Refractive index, thermal and electrical conductivities measurements of olive oil are done in Al-Quds University.

II. Methods:

Olive samples were obtained from Bethlehem _ Palestine. Olive samples were the cleaned, removing the stems, leaves twigs and other debris in the samples. Olive fruits consist of about one third solid, one third water and one third oil. The first step after cleaning in producing olive oil is crushing olives and producing paste. Pulsed

electrical field treatment involves the application of high voltage up to 20 KV. The high voltage pulses stimulated the cell membranes, then causing loss of barrier function, and content within the cells and loss of vitality. The effect of the PEF on the cell is to produce pores in the membrane, a process called electroporation, and results in increased oil yield. The paste is malaxed for about 45 minutes with warm water (28-30 degrees Celsius) and then pressed to extract the liquid then centrifuged to separate the oil for other liquids. Finally, the olive oil physical properties are studied.

III. Results:

A. Refractive index:

Refractive index refers to the purity of oils, useful in controlling reactions such as catalyst formation and hydrogenation. It is used to determine oil

oxidation as well. Main factors affecting the refractive index are temperature and saturation. However, different values of refractive index of oils depend on their own break indicators, so this feature is used to determine the purity of the oils. A refractive index is usually a standard for oil purity. Also, it is used to determine oil oxidation as well, [13]. In our experiment the refractive index of olive oil did not extremely change at room temperature, as is depicted in Figure 2.

Refractive index of olive oil after treatment with PEF in a 5 and 10-minute period, gives a nonlinear relationship. The results show that PEF treatment compared to traditional methods does not change the refractive index of olive oil based on comparison between treated samples and standard untreated samples.

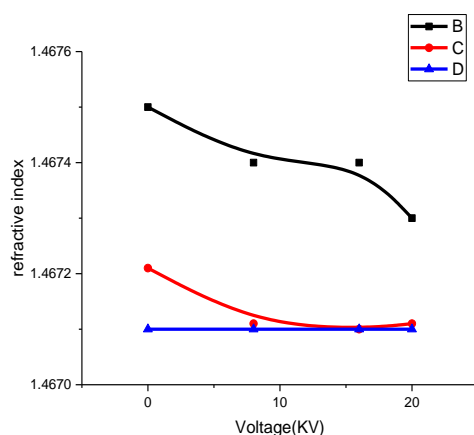


Fig.2 Refractive index of olive oil; B: for 5 minutes, C: for 10 minutes, D: for pitted olives

B. Viscosity of olive oil samples:

The viscosity of olive oil samples treated with PEF at a duration of 5 and 10 minutes at room temperature are plotted as shown in Figures 3 and 4.

The increase of viscosity in olive oil shows the increase of the lipid oxidation [14].

The results show that, viscosity, was changed according to the intensity of voltage, while viscosity (dynamic) values increased with

increasing voltage. The lowest viscosity was found for samples with applied voltage of 8 and 16 kV on olives paste. The reason behind this result can be explained in the sense that the percentage of fatty acids in oil samples increased with the increase of waiting period for olives after treatment, as a result of oxidation due to the exposure of olives to air for a longer time. This situation ensures the prevention of more oxidation of olive oil.

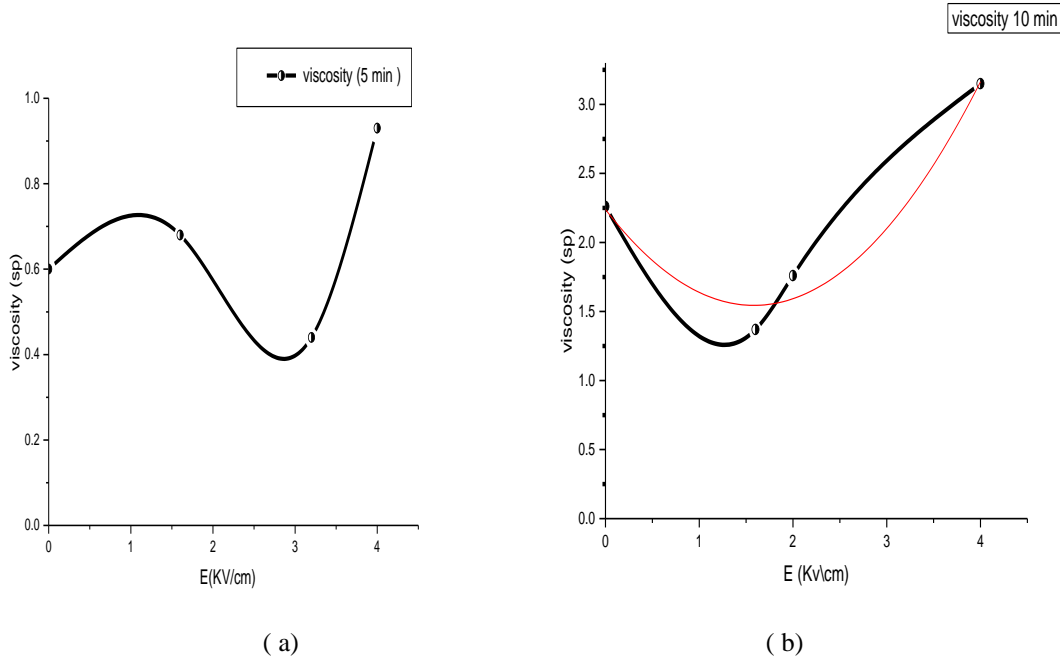


Fig. 3 The viscosity of olive oil at different voltages: (a) at duration time 5 min (b) viscosity of olive oil at10 min

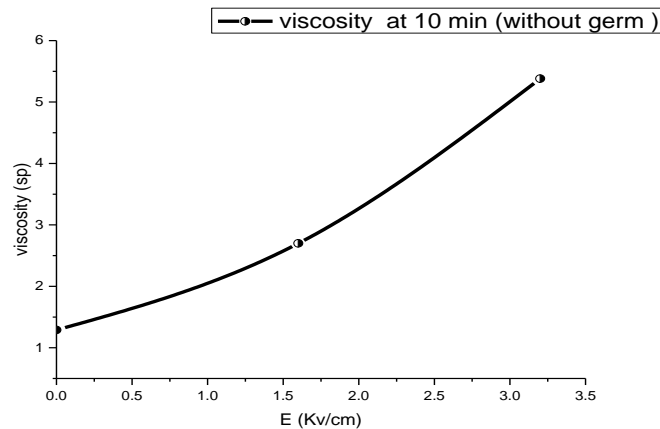


Fig. 4 The viscosity of olive oil from pitted fruites at duration time 10 min

C. Electrical conductivity κ results:

What was interesting in this experiment was that olive oil did not conduct electricity, a result that was surprising because it comes from very salty vegetables such as olives. At the same time, a high voltage of 20 kV was applied. The value of electrical conductivity obtained indicates that olive oil is truly an insulator as seen in Table 1.

Olive oil has a capability as an alternative source for transformer insulation. The biggest advantage of olive oil is the non-toxic characteristic which

will not produce any dioxin or toxic product during fire. Carbon dioxide and water are the only products that are formed during the biodegradation process. They are also fewer flammable liquids with a minimum flash point above 300°C.

Olive oil can be said to be very bad conductor of electricity. Finally, olive oil can be used in the fabrication of capacitors in order to increase capacitance and is economically wised to be used because of its less pollutant effect when spill or leak.

Table 1 The electrical conductivity κ (in micro Siemens per centimeter) of olive oil samples after PEF treatment

Voltage KV	κ of Olive oil samples at 5 min $\mu\text{S/cm}$	κ of Olive oil samples at 10min $\mu\text{S/cm}$	κ of Olive oils samples without seeds at 10 min $\mu\text{S/cm}$
0	2	2	1
8	2	1	2
16	2	2	2
20	2	1	2

D. Thermal conductivity k results:

Thermal conductivity is a physical property describing the ability to conduct or transfer heat. Thermal conductivity can be defined as "The amount of heat transmitted through a unit thickness of the material - in the direction of the normal to a surface of unit area - due to the temperature of the unit area under steady-state conditions". Thermal conductivity is the

measurement of the heat transfer capacity of the substance itself.

Results of measurements of thermal conductivity of olive oil, are shown in Table 2. For each sample, the reading is repeated 5 times, the average values are calculated. From Table 2, it can be observed that the thermal conductivity changed with changing applied voltage. Our results were different from other studies by only 3% [15].

Table 2 Thermal conductivity (K) of olive oil samples after PEF treatment.

Voltage KV	K for olive oil samples at 5 min W/m.k	K for olive oil samples at 10 min W/m.k	K for olive oil without germ samples at 10 min W/m.k
0	0.1563	0.1341	0.1169
8	0.1449	0.1345	0.1172
16	0.1810	0.1181	0.1182
20	0.1855	0.1169	-
Error bars SE	8.45×10^{-3}	$\pm 4.2 \times 10^{-3}$	3.23×10^{-4}

IV. Conclusion:

The results showed that processing had no significant effect on some physical properties,

namely: refractive index, electrical conductivity. On the other hand, thermal conductivity and viscosity were slightly affected by the PEF. Based

on the results obtained from this study, it can be said that the application of PEF to treat the olive fruits was effective in saving the physical properties of oil extracted. This means that applying PEF for other useful processes such as increasing the yield will not affect the physical properties of olive oil.

Acknowledgment:

It is our pleasure to acknowledge those who helped us to accomplish part of this work, especially An-Najah National University analytical lab personnel, and the farmer from Hoosan village in Palestine who gave us the olive fruits.

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