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Effect of DC electric field on yield and quality of olive oil

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Thesis Approval

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Dedication

I dedicate this effort for my great parents

Maram Amjad Ahmad Shawasha

Declaration:

I Certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this study has not been submitted for a higher degree to any other university or institution.

Signed:

Maram Amjad Ahmad Shawasha

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Abstract:

The main aims of this study are to answer some questions about applying DC electric field on the yield of olive oil, the main questions are: Why to use the DC electric field ? What are the factors affecting the yield extraction?, Does the DC electric field affect physical properties of the treated olive oil ? Does the DC electric field has impact on the quality of olive oil?.

Several stages were applied to samples of fruits obtained from Bethlehem – Palestine. Next steps are: cleaning, grinding, applying high DC voltage, pressing and centrifuging to extract oil. The results showed when applied high DC voltage at (16 kv) for time periods of 5 minutes increase in the yield up to 50 % .

This study explains the effect of DC electric field on olive oil extraction yield because there are some previous studies on this subject, and this treatment it emphasis on low-cost.

The quality of oil was examined to see the effect of DC electric field on physical and chemical properties of olive oil such as: refractive index, viscosity, electrical conductivity, thermal conductivity, acidity, peroxide value and K factors K232, K270. All of the olive oil was in the Virgin stage according to EU legal standards (EVOO; extra virgin olive oil).

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CHAPTER 1

1. Introduction

1.1 Background

Pulsed electric field (PEF) is a non-thermal method to provide food that uses short pulses of electricity to increase the extraction yield and reduce the negative impact on the features and quality of the food. The aims of PEF technology is to provide consumers with high-quality foods. For food quality features, PEF is better than traditional thermal treatment methods because it avoids or significantly reduces adverse changes in food sensory and physical properties (Quass, 1997).

PEF technology involves applying high-voltage pulses to olive fruit placed between two poles. 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 (Qin et al.2004). However, while significant research papers on aspects of microbial food conservation by PEF have been published, less information on the impact of this technology on the amount of yield extraction and overall acceptability of quality has been published.

The PEF treatment discussed in this thesis was found to be very effective in increasing efficiency and enhancing the productivity of olive oil extraction, and low-cost process. The electrical pulse field is used as a treatment that includes direct-current high-energy pulses for short periods (5,10 minutes).

1.2 Olive fruits

Olive oil is the main source of fat in Mediterranean diet. High nutritional value of olive oil result from the high proportion of oleic acid and high levels of natural antioxidants (tocopherol, phenols) and the presence of biologically active components such as monounsaturated fatty acids (MUFAs and PUFAs), squalenes, phytosterol, and volatile compounds (GrasasAceites, G.J1998).

There are many factors such as genetic origin and the places of geographical as well agricultural practices, strategies and technologies that affect the phenolic content and basic appearance.

Olive oil contains more oleic acid and less linoleic and linolenic acids than other vegetable oils, that is, more monounsaturated than polyunsaturated fatty acids. This renders olive oil more resistant to oxidation because generally, the greater the number of double bonds in the fatty acid, the more unstable and easily broken down by heat, light. In addition to the health effects (Mediterr. J. Nutr. Metab.2011), the phenolic compounds of olive oil are unique, and represent an important contribution to the oxidation stability of olive oil (Food Chem. 2007).There is a secondary component of another important in extra virgin olive oil which is α-tocopherol, that protects the virgin olive oil from oxidation at elevated temperatures (Eur.J.Cancer, 2000 ,Compos. Anal, 2012).

During storage and thermal treatment, virgin olive oil is subject to fat degradation, oxidation and polymerization leading to a deterioration in the quality (Chem. 2002, the Sci. Hortic, 2009). Although the mechanisms of oxidation processes are the same as for oils, various oils, oxidation rates of interaction vary according to the types of fats and oils (Food Chem.2010). Free fatty acids (FFA), which appear as a result of hydrolysis, are subject to further oxidation reactions. In the presence of oxygen, peroxides and hydroxide are formed (J. Am. Oil Chem. 2002), (Technol. 2011). The conversion of these primary products rapidly to form a variety of secondary products, such as aldehydes, ketones, alcohol, hydrocarbons and polymers, among other products, (J. Am. Oil Chem. Soc. 2002). Aldehydes and other fat oxidation products show toxic effects on the liver, kidneys and spleen. Hydrides can cause extremely rapid oxidation of cellular fat leading to the destruction of cells (W.L. Clark, Technol, 2011). Transfusion of unsaturated fatty acids, toxic compounds may appear, and as a result, absorption of some other nutrients may be limited (Przem. et al, (1991).

One of the goals of this work is to explore the changes in chemical and physical properties: oxidation, viscosity, refractive index, thermal and electrical conductivities of olive oil after the PEF treatment.

1.3 Historical Evolution of PEF Processing

As far as we can tell the first reports on Pulsed Electric Fields have been published by Heinz Doevenspeck in the 1960s (Doevenspeck 1960, Toepfl 2007, Sitzmann et al 2016). He reported a cell disruption effect and suggested its use to improve mass transfer processes such as separation and drying as well as to induce microbial inactivation without a substantial amount of heating. However, since the mid nineties , there was a convergence of the applied research necessary, developments in high voltage equipment, and attention to business operations and transfer of non-thermal PEF technology from the lab to commercial operations.

Waters et al., (2001) stated that technology of pulse electric field (PEF) is one of the most non-thermal used to disable microorganisms in foods. Electric fields in the range of 5-50 kV / cm generated by applying high voltage pulses between two electrodes leads to disruption of microbes at temperatures below those used in thermal processing. The exact mechanisms through which they are given to microorganisms by electric fields of the Pulse are not well understood; however, it is generally accepted that PEF leads to the penneabilization of microbial membranes.

Studies revealed that PEF technology enables inactivation of bacterial and yeast vegetative cells in various foods. On the contrary, bacterial spores cannot be killed by employing pulsed electric fields because spores are resistant to PEF. Thus, applications of PEF are primarily focused on pathogenic and spoilage causing microorganisms in food. In addition to the pronounced effect of this technology in controlling microbiological spoilage of foods in a rapid and uniform manner, PEF also delivers shelf life extension without using heat treatment and preservation of sensorial and nutritional quality of foods. Likewise, PEF is also capable to improve the energy usage in an efficient and economical way. Hence, successful applications of PEF technology propose an alternative to conventional thermal processing techniques for food preservation and processing.

Non-thermal processes have gained importance in recent years due to the increasing demand for foods with a high nutritional value and fresh-like characteristics, representing an alternative to conventional thermal treatments. Pulsed electric fields (PEF) is an emerging technology that has been extensively studied for non-thermal food processing. PEF processing has been studied by a number of researchers across a wide range of liquid foods. Apple and orange juices are among the foods most often treated in PEF studies. The sensory attributes of juices are reported to be well preserved, and the shelf life is extended. Yogurt drinks, apple sauce, and salad dressing have also been shown to retain a fresh-like quality with extended shelf life after processing. Other PEF-processed foods include milk, tomato juice (Min et al., 2003).

To qualify as an alternative method, a new technology should have significant impact on quality while at the same time maintain the cost of technology within feasibility limits. In recent years, several technologies have been investigated that have the capability of inactivating microorganisms at lower temperatures than typically used in conventional heat treatments (Lado and Yousef, 2002). The consumer demands for healthy, valuable, and natural food has lead to new processes for the recovery of ingredients with an higher nutritional value. So called ‘‘functional foods’’ contain an increased nutritive quality and therefore are particularly accepted by the costumers. Besides mechanical processes and enzymatic treatments the application of pulsed electric fields (PEF) provides an highly effective pre-treatment of foods and food ingredients in an ecological and gentle way. Already in 1968 Flaumenbaum investigated an electrical treatment of apple mash, so called electro-plasmolysis, and achieved an increase in yield of about 10–12% (Flaumenbaum, 1968).

Application of pulsed electric fields of high intensity and time duration may cause temporary or permanent permeabilization of cell membranes. The effects of PEF on biomembranes have been thoroughly studied since the use of PEF has attracted great interest in several scientific areas such as cell biology, biotechnology, medicine, or food technology (Zimmermann, 1986; Palaniappan et al, 1990; Prassanna et al, 1997).

Further yield enhancements by the use of PEF were also asserted with carrot juice (Knorr, Geulen, Grahl, & Sitzmann, 1994), as well as at grape and sugar beet juice (Eshtiagi & Knorr, 2000, 2002). PEF-treatment of materials with a sufficient electrical conductivity involves a permeabilization of cell matrices (Angersbach & Knorr, 1999) and improves mass transport across the cell membranes. Thus beside higher juice yields also an advance of nutritional ingredients (Knorr et al., 2003), as well as shorter drying times of plant tissues (Angersbach & Knorr, 1997) can be realized. The application of PEF in the range of period time leads to a permeabilization of biological membranes. Dependent on field strength and pulse duration , the permeabilization achieved can be reversible or irreversible.

In 2012, was the investigation in the electric treatment of olive Arequipa in Northern California, and investigate the effect of the applied electrical pulse. PEF treatments with different intensities (0-2 kV / cm) at different times of malaxation (0 , 15 and 30 minutes) and temperatures (15 and 26 ° C). The extraction yield improved 54 % when the olive paste was treated with PEF compared to the standard paste.

There are different traditional methods of extracting oil from oilseeds such as mechanical extraction through pressure. Overall, extraction of oil with pressure is a simple, safe and economical method. Thus, the advantages of this method make it more efficient than the method of solvent application. The mechanical method is not sufficient to extract large amounts of oil in one runoff oilseed containing a high percentage of oil. For this reason, the high demand for oils obtained from cold pressing has increased (Lambert et al., 2008) .

Modern technologies, are trying to make the extraction process much easier and more effective manner the use of solvents, and can reduce the extraction time and temperature, with improved extraction efficiency (Li, Pordesimo, et al., 2004). In the process of oil extraction, pre-treatment suitable for the seeds before using the oil is the most important steps needed to produce high-quality oil with high efficiency (Azadmard et al., 2010) .

1.4 What is the pulse electric field (PEF) processing

Basic principle is maintaining food below the temperatures normally used for non thermal treatment. PEF technology is the application of short pulses from high electric fields with a short time span and density of about 1-20 kV / cm. The process depends on electrical currents pulse delivered to the product placed between electrodes. The distance between the electrodes is called the processing gap in the PEF room. The high voltage applied in an electrical field lead to cell disruption. (Bendicho., 2003; Puértolas et al., 2004).

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

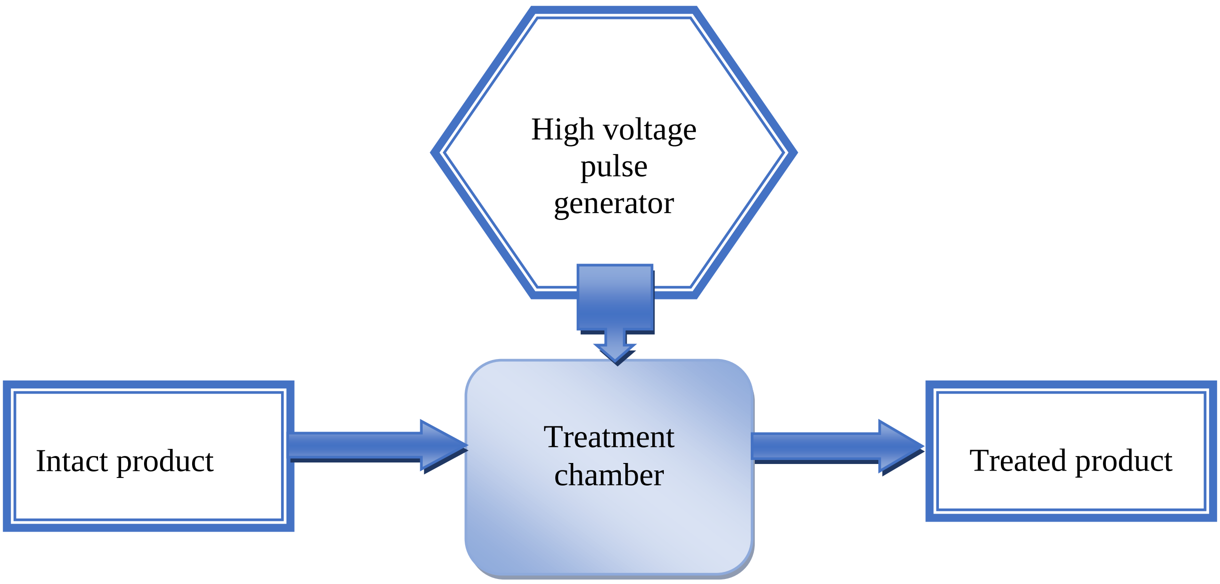


Figure 1. Scheme of a pulsed electric field processing.

1.5 PEF effect

Pulsed electric field technology involves the application of high voltage pulses in the order of 1 to 20 kV. The high voltage pulses applied induce pores in cell membranes, causing a loss of barrier function, leakage of intracellular content and loss of vitality. Treatment is applied continuously in a room, the width between the electrodes (copper plates). The duration of the treatment (pulse duration) is 5 and 10 minutes. The pulses are applied at a rate that allows for adequate processing of all volume elements. Besides electrical parameters such as field strength and specific energy input, product temperature and product recipe also have an impact on treatment intensity.

The overall objective is to obtain high-yield values by maximizing the effectiveness of natural raw materials. Electroporation generates a significant increase in the yield freshness and flavor across a wide range of foods and products.

Loss of barrier function
In the cell , the cytoplasm surrounded by thin layer (semi permeable) and the cell membrane, which acts as a semi permeable barrier allows large ions and molecules move in and out of cells. This cell membrane is a bifurcated phosphorus layer with a thickness of 5 nm.

Pulsed Electric Field (PEF) processing or electroporation works by puncturing the cell membrane, whatever the size of cell. The process is targeted, gentle and clean. As a result, we measure dramatic increases in yield and the preservation of pigments, antioxidants and vitamins. These small pores will be more stable pores when the cell membrane is subjected to more pulses, this called electroporation effect , that mean the cell barrier function is allowing access to valuable cell contents (Food Chem. 2015). Whatever the size of the cell, pulsed electric field (PEF) works piercing the cell membrane. As a result, we measure significant crop increases and maintain pigments, antioxidants and vitamins. PEF makes health products last longer.

Electroporation occurs after a period of time. This process is fast, flexible and energy-saving a since heat generation is minimum, where products benefit from a period of storage longer while maintaining nutritional value better than traditional techniques to tackle food.

In addition, applying PEF provides pre-treatment of highly effective food and food ingredients (Guderjan et al., 2005). The ability of the electric field to damage the cell membrane by removing the cellular component of tissue and exercise the calculated effect on the viscoelastic properties of several plant tissues has been used (Lebovka et al., 2003). Electric treatment for the combined effect of stress and PEF treatment led to the permeability of cellular matrices, and improved mass transport through cell membranes (Angersbach and Knorr, 1999). As a result, liquid treatment enhances the expression of different biological tissues and increases oil productivity (Vorobiev et al.2004); Wang and Sastri, 2002). The application includes the use of electric fields of

1 kV to 20 KV for different time periods 5 and 10 minutes at room temperature, which can be considered a good alternative way against the traditional methods of treatment of plant tissue (Lipovka et al. 2005).

Electroporation increases cell membrane permeability, where any increase in the permeability if the intensity of the treatment is high enough, causes decomposition of the cell membrane (Zimmermann,1986). A generally accepted term describing this phenomenon is "electroporation." Other effects of a high-intensity electric field on cell membranes include membrane fusions, bleb formation, cell lyses... etc. Electroporation and its related phenomena reflect the basic bioelectrochemistry of cell membranes and are thus important for the study of membrane structure and function (Biophys J. 1991) .

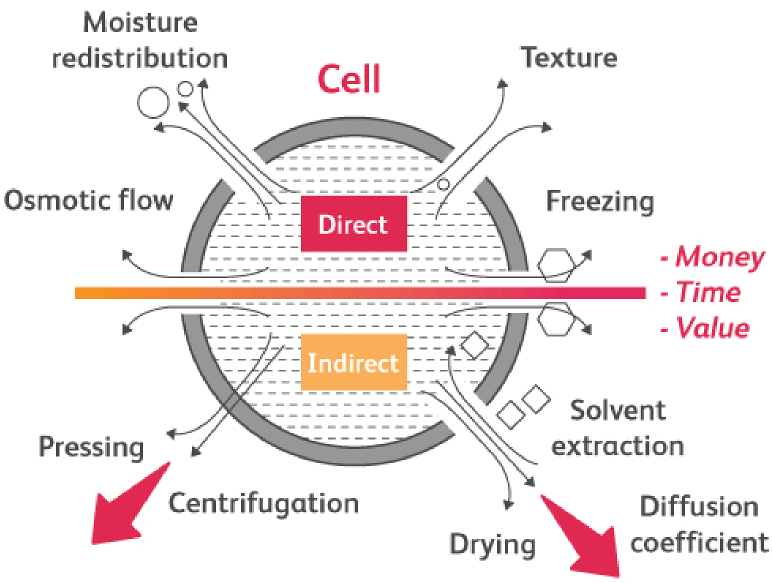


Figure 1. 1 cell exposed to electric field

1.6 PEF Technology and Applications

The effectiveness of the processing of PEF on liquid products, such as olive oil, or any food products have conducted exhaustive research to carry out this process on the industrial level. Freshness of flavor, economic viability, improvements in functional and characteristics and extended shelf life are some of the key points of interest in addition to achieving microbiological safety of food products, PEF has been extensively studied with olive oil (Knorr. 2000).

Each of the nonthermal technologies has specific applications in terms of the types of foods that can be processed. Among these, pulsed electric fields (PEF) is one of the most promising nonthermal processing methods for inactivation of microorganisms, with the potential of being an alternative for pasteurization of liquid foods. Comparable to pasteurization, yet without the thermal component, PEF has the potential to pasteurize several foods via exposure to high voltage short pulses.

The basic definition of PEF technology relies on the use of high intensity pulsed electric fields (l-20 kV/cm) for cell membrane disruption where induced electric fields perforate microbial membranes by electroporation, a biotechnology process used to promote bacterial DNA interchange. Induction of membrane potentials exceeding a threshold value often result in cell damage and death (Zimmermann,1986).

The use of PEF recently in alternative applications including drying, modification of enzyme activity, and keep food products solid, semi-solid, as well as the application of pre-processing to improve the metabolism . PEF's ability to increase permeability means that it can be used successfully to promote mass and heat transfer to help dry plant tissue. Studies have been conducted on plant tissue such as potato (Agersbach and Knorr, 1997) coconut (Ade-Omowaye et al. Rastogi et al. CIT., 1999), and apple slices (Ade-Omowaye et al.2002). In the case of solid foods the improvements in functional and textural attributes and extended shelf life are some of the main points of interest besides achievement of microbiological safety of food products (Dunn, 2001). rupture of mixture of air, contributed to a decrease in the electrical conductivity of the product, and, therefore, do not limit the maximum intensity of the electric field applied. Some studies have been carried out on the diet Model (ZhangEt al. 1994).

1.6 System Components

The high-density electrical field treatment system consists of a high-stress source, an intensive bank, a transformer, and a processing room. Such device able generating of pulse electric fields discharge of electrical energy during a short period of time with voltages (up to 20 KV or more).

1.6.1 Power Supply:

The high voltage pulse generator provides electrical pulses of the desired voltage, shape and duration by using a more or less complex pulse forming network (PFN). More in detail, a PFN is an electrical circuit consisting of several components: one or more DC power supplies, a charging resistor, a capacitor bank formed by two or more units connected in parallel, one or more switches, and pulse-shaping inductors and resistors. The DC power supply charges the capacitors bank to the desired voltage.

A low-energy PEF system, which consists of a high voltage pulse generator (Fig **1. 3**) is used to treat the olive fruits samples. The system consists of a 20 kV DC high-voltage pulse generator, a square treatment chamber.

Figure 1. 2 High voltage pulse generatir

1.6.2 Treatment chamber :

The treatment room is the main component of the PEF direct application system. The electrical field is in contact with treatment champer. Design must be taken into account in the regular distribution of the field with continuous flow applications .Design of treated room was done as parallel plates configurations were used to process PEF and some modifications of these basics. Electrical field homogeneity and avoid low field strength is not only desirable from the standpoint of microbial disruption, the fact is the energy waste and energy consumption will occur in low-level areas without contributing to disable microbes. the design of this room it is simple design consist of parallel plates were produced the most standardized distribution of the electric field (Jeyamkondan et al., 1999), but its low electrical resistance limits the probability of application. The distance between the plates determines the distribution of the electrical field.

In the joint central processing room, food is placed between parallel paintings. The design of the treatment room has a major impact on the performance of the PEF treatment. It affects many other process parameters as shown in Figure 1.4.

Figure 1. 3 Treatment chamber

1.7 Objectives of study

The aims of the present work are to evaluate:
The potential benefit of the application of DC electric field on improving the actual extraction process of olive oil.
The effect on yield extraction and quality parameters of oil obtained from olive paste treated by DC electric field at different times (5 and 10 min).

Physical and chemical propitiates of olive oil treated with PEF are to be studied and compared with standard not treated samples.

CHAPTER 2

2.Literature review

2.1 Introduction

There is growing interest in the application of the PEF for food processing, because of the growing consumer demand for healthy, fresh, and nutritionally treated food products with a long shelf life. Although the heat treatment is still the leading technology for food conservation , development of alternative methods to eliminate quality loss are high motivated by the food industry. Innovative technique such as PEF which is a non-thermal technology with the potential to supplement or replace heat pasteurization methods for certain applications.

the high-density of pulse electric field is use in the form of short pulses allows less treatment. Low temperatures compared with traditional methods, with ability to destroy pathogenic micro-organisms with a minimum of lost volatile compounds and colors during processing and storage (Barbosa-Cánovas et al. 1999).

PEF is applied to any food product that includes a groups of phases relating to microbial safety of manufactured products, quality characteristics, storage age, consumer acceptance and cost. The study of microbial decomposition is the first step that has to assess whether the technology is able to achieve the goal of maximum food safety or not. Optimal treatment conditions are determined once the deactivation studies are carried out. The practical variables were performed and determined accordingly (i.e. maximum electrical field, density and number of pulses).

This work helps -to some extent- to cover some weaknesses in understanding the role of application of PEF that helps to extract more oil contents. However, the main factors affecting the quality and quantity of olive oil in these areas will be discussed. The following chapters will add insight and understanding to the extraction treatment.

2.3 Historical Overview

Food processing started by electrical method for inactivation of microorganisms and enzymes in foods as early as the 1920s. Conducted the first attempt using the method of a pure electric in Liverpool (England), with the use of an electric current alternating (220 to 4200 volts), pasteurization of milk (Betty and Louis, 1925), in this process, heated raw milk was exposed to a continuous and heat-covered electric current with heat generated at 70 C° for 15 seconds. Mycobacterium Tuberculosis and Escherichia coli has been successfully disabled with this treatment. Furthermore, the efficiency of the process to disable some bacterial groups resistant to other thermal methods has put forward the idea of using the same electric current (Palaniappan et al.2004). However, the reduced capacity for processing, lack of appropriate equipment for temperature control the most important 62 barrier, which the extent that the technology becomes popular and commercial (Getchell, and 1935).

By the 1950s, a method is electrohydraulic for the first time is used to stop the activity of microorganisms living in the middle of the liquid. Enabled this method of using electric fields pulsed at different levels of energy to discourage E.coli and streptococcus facials and bacillus subtitles and streptococcus creameries and micrococcus durians suspended in distilled water sterilized (Gilliland & spa, 1967).

Finally, by the mid-1960s, Doevenspeck (Germany 1960) reported a variety of equipment and methods for pulsating electric fields. Their extensive work confirmed the non thermal impact of Pulse electric fields on microorganisms as well as the interaction of Pulsar electric fields and the walls of microbial cells. Sela and Hamilton (1967, 1968) were the leading scientists who focused on the non-thermal effects of microbes from pulsating electric fields. In their methodological studies, they reported the deadly effects of homogenous Pulse fields on bacteria such as E.coli, staphylococcus aurous, sarcina iutea, bacillus subtitles, bacillus cereus and candida utilis. Along with this study, when exposed to bacterial cells for electric pulsed, the pulses of direct current causes a loss in the properties of the semi-permeability of cell membranes, and the permanent loss of these properties leads to cell death. Another important outcome of their study concerns the relevant factors involved in the PEF process. They concluded that the effect of PEF is not due to heat generation or electrolysis but is independent of current density and input power, moreover, the strength of electrical fields, pulse duration, and the size and shape of microbes are the most relevant factors that affect the disable activity (Knorr et al., 2011). A series of articles published about this study most of the findings are still valid until now (Sale and Hamilton, 1968).

Zimmermann et al. (1974) first presented the theory of rupture of the insulation using a method developed to promote the integration of the cell, which would provide control over the permeability of the cell membrane in localized areas. This process, which is referred to as electrical collapse or reverse electroporation, is still being used today to explain the Working Mechanism for the electrical pulses.

In the eighties of the last century, managed companies, which finally started in search of the unknown in the technology of PEF. Different from all existing technologies, exploration of PEF technology was complicated without the collaborative work of researchers from different fields of study .Starting in 1987, number of research groups studying PEF technology, in parallel with the number of patents deposited for room designs and specific equipment, increased rapidly worldwide.

2.4 Olive oil extraction

In the Olive fruits, the oil lies in the cells of the core, and this is the mesocarp (Ranali et al.2001). The oil in the cells is partially in a gap (about 76%), where be free, and the other part is located inside the cytoplasm (about 24%), where shares in the form of drops bound minutes of the colloids . The extraction of virgin olive oil begins with the crushing of the olive fruit for the purpose of breaking the envelopes of the mesocarp cells and releasing the oil. After that, the olive dough must be malaxed to facilitate oil extract. After that separated these drops easily from the paste through the centrifuge.

Depending on the nature of the material and the content of oil, there is a different way used to extract oil from oil materials. Continuous mechanical pistons are the most machines commonly used to press oil materials in the oil industry. These mechanical pistons have the following advantages: continuous work, high work capacity, operating without major shocks and vibrations, easy adaptation to work stress, etc. The vegetable oil increases as a result of increasing the number of applications it can have. To meet the demand for vegetable oil, it is essential that the methods of extracting oil be faster and more effective. Operations and phenomena occurring during the pressure process heavy stuff is very complicated. It's good to know major variables affecting oil extraction and oil quality.

The PEF technology was 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. At the point of organoleptic characteristics, the oil associated with PEF less bitter and permeability, compared with oils untreated. PEF treatment has been very effective in increasing oil yields compared to the standard method. 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, extraction yields decreased by 50% when no PEF was applied to Olive dough compared to those who were malaxed for 30 minutes (M. Abenoza et al. 2013).

It was evaluated the effect of PEF on the production of olive oil from the Arroniz in north California of where the productivity of extraction and quality chemical and sensory of by Puértolas and Marañón (Food Chem, 2015). Increased yields of extraction by 13.3% in samples treated by PEF (2 kV / cm, 11.25 KJ / kg) compared with sample control. In addition, the total content of phenol ,total cholesterol and tocoferol has been found. Olive oil extracted by PEF value is much higher (11.5, 9.9 and 15.0% respectively) than the control group.

The processing of olive oil follows a series of mechanical processes to extract oil from a oil, in accordance with European regulation (EU) No. 1348/2013 (J. Eur. Community. 2013). One of the most important, in terms of quality, was the crushing of Olives, which allowed the oil drops to be emptied out of the gaps, destroying the cellular structure of the olive fruit. The taste of the olive paste, which promotes the merger of drops of the oil, with the launch of phenolic compounds at one time in the stage of the oil and increases the smell of olive oil; mechanical centrifuge (continuous process) or pressure (the process is intermittent); and, finally, filtration is used to remove suspended particles and get rid of the remaining water is responsible for the oxidation of the olive oil and the beginning of the flavors during the period of its validity.

It will be one of the major challenges in the field of olive oil and improving plant performance in terms of sustainability, efficiency, regularity and flexibility, which reduces the production costs, with attention to the quality of olive oil and yield.

2.4.1 Solvent extraction:

The choice of solvents to extract oil from olive paste is an important factor. The solvent must have a good extraction capability, a low viscosity and a higher solubility with oil. Is hack proper solvent inside the olive paste is necessary to extract the oil efficiently with the polarity of the almost equal of solvent and oil. In general, organic solvents possess all the above criteria and have been used in oil extraction for many years.

It was noted that oil revenues had increased as time progressed to a maximum of 10 minutes. There are two common steps in extracting oil from the biomass. The first step that includes the use of the oil from the outer surface of the body (the stage at which it melts) is a physical process extremely fast while the second step which involves the use of oil from within the particles (the spread of the control phase) is relatively slower (ZA Manan 2009).

2.6 Factors affected by pulsed electric field treatment

The definition of the time of effective treatment, is the time needed to breakdown the microorganisms in the domain of the electric field. It depends on the number of pulses and pulse width applied. The intensity parameter for the electric field is the main factor to determine the potential impact of PEF on the extraction time, the degree of extraction depend on the nature and structure of the material abstracted (Sale and Hamilton, 1967; Jayaram et al. 1991).

CHAPTER 3

3. Materials and Methods

3.1 Introduction

This chapter provides insight and knowledge for the investigative process applied. Total materials used and the manner in which they will be implemented will be described in details. Methods applied are the tools needed to achieve the methodology designed to investigate the effect of electricity on the productivity and quality of olive oil. However, since this project was genuine, a descriptive type of experiments are designed to evaluate the ability of the electrical field to affect olive oil yield and quality. As well, evaluation of the degree of electrical field impact was measured. Since the field is time-bound, samples to be studied and evaluated. Another key research worker found that an amount of the sample was exposed to electrical field, as is well known, organic matter interacts with the electrical field.

3.2 Materials

Materials and equipments used in this investigation are as follows:

3.2.1 Materials and equipment used in Processing:

Materials were limited to the investigated sample, which was :

1. Olive fruits were collected one time from local farm in Bethlehem city. Around 50kg were brought in by open boxes with sieved walls.

Equipment: Investigation of the extraction of olive oil simulates industrial mills.
The following equipment and tools have been assembled to form the processing line at the laboratory level, as follows:

Table: Made from granite (locally made).

Sieves: Bought from local shop

Big pot: Made from stainless steel, with capacity of 5 L (local).

Grinder: Triple phase electrical grinder with coarse die. (Franko, Italy)

Glass tubes:

Electrical source of DC voltage: provide electrical voltage from 1000V to 20000V. German made (model).

Dough mixer: stainless steel pot with different speeds. (Universal model, china)

Olive press: locally made with oil piston of 15 ton power.

Centrifugation device: with adjustable speed up to 4000 RPM.

Test tubes in sizes of 10 ml and 5 ml: (Japan) .

Mixer: a device make malaxation .

Vernier Caliper: Scientific model used to measure the inner radius of test tubes to calculate the volume of oil .

Calculator device: Scientific model (Sony, Japan) .

The following procedure was applied:

The manpower was used to collect olive fruits from Bethlehem city,

Potable water was used to rinse or clean olives,

Sieves were used to remove olive leaves from olives,

Meat grinder to crash olives and get the paste,

Stainless steel mixing container for malaxation

Device of electrical field used to treat of the paste from physics lab,

Hydraulic press for oil extraction was from food processing lab,

designed and made by research team,

Centrifuge device to allow separation of the solid, water, and oil phases.

3.2.2 Physical properties of olive oil:

Physical analysis were done to specify some important properties mainly: refractive index, viscosity, thermal and electrical conductivities.

Viscosity measurements of olive oil are done in analytical lab by viscometer (NDJ-8Sl) at An-Najah National University.

Refractive index, thermal and electrical conductivities measurements of olive oil were done at Al-quds University.

3.2.3 Chemical analysis of olive oil:

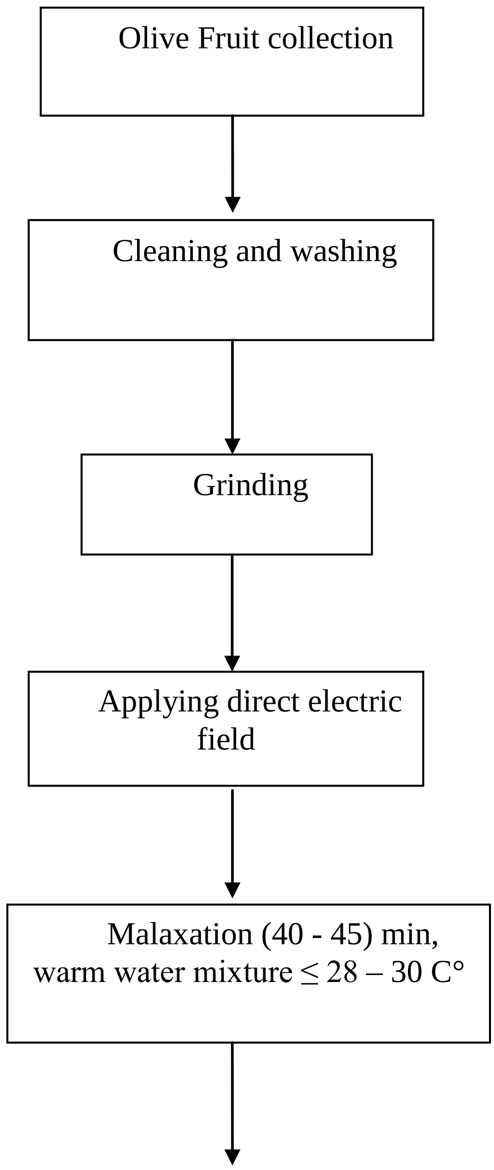
Chemical analysis have been tested including: free acidity , peroxide value (meq O2 / kg), k270 and k232.

Absorption measurements were made to determine purity in 232, 270 nanometers, spectrophotometer (UV-1601) found at analytical lab.

3.3 Methods

3.3.1 Olive oil :

Here is a simplified diagram (flow chart) of olive oil experiment which was adopted for the whole project, as shown in Figure 3.0



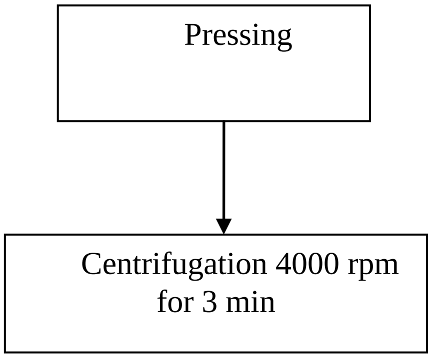


Figure 3.0 Flow chart for olive oil extraction met

3.3.2 Olive fruit collection:

Olive samples were obtained from Bethlehem _ Palestine. The collection was directly from the trees in 20th of October 2018.

3.3.3 Cleaning and washing:

The first step in the process of extraction the oil is cleaning the olives and removing the stems, leaves, twigs and other debris left with the olives. Olives must be washed with water to remove pesticides and dirt, etc. If the crushed olive in hammer mills, the excess moisture from the cleaning water can cause problems in the extraction because the emulsion formed between oil and water.

Figure 3. 1 cleaning and washing

3.3.4 Grinding:

Olive fruits consist of about one third solid, one third water and one third oil. The first step in producing olive oil is crushing olives and producing paste. This type of machine used to grind olive samples is the stainless steel meat grinder in the food laboratory

Every crusher exerting different mechanical action to break down the olive tissue elicits several effects due to variation induced in the olive paste, in terms of temperature, granulometry of fragments, and exposure to atmospheric oxygen. These variations play a crucial role for endogenous enzymatic activities, affecting the final amount of the EVOO as well as its phenolic and volatile profile (Eur. J. Lipid Sci. Technol. 2002). During this phase, in fact, the entire heritage of olive fruit endogenous enzymes (cellulases, hemicellulases, pectinases, polygalacturonases, lipase, β -glucosidase, polyphenoloxidase (PPO), peroxidase (POD), and lipoxygenase (LOX)) is activated and involved in the subsequent phases of the extraction process and the formation and transformation of phenolic and volatile compounds in EVOO (Food . 2015).

Figure 3. 2 Meat grinding to mill olives

3.3.5 Application of direct electric field:

After grinding, the olive paste was treated by direct electric field DC. The DC treatment involved high voltage from 2000 volt to 20000 volt, at a distance of 5 cm between the plates, and different times 5 and 10 minutes.

Pulse electrical field treatment involves the application of high voltage up to 20 kv. The high voltage pulses stimulated to application to the pores in the cell membranes ,then causing loss of barrier function, and content within the cells and loss of vitality. Besides the electrical parameters such as field strength and input power specified, the finish temperature so that one has control over this.

Works PEF or electroporation by piercing the cell membrane, whatever the size of the cell. As a result, one measures massive increases in crops, dye maintenance, antioxidants and vitamins. This process is quick, flexible and because heat is minimized, products have a longer life expectancy while maintaining a better nutritional value than traditional food processing techniques.

The function of the barrier of the cell membrane was damaged by high voltage then this leads to bacterial death. Despite its targeted effect on cell membranes, PEF does not affect vitamins, flavors or proteins. This allows for microbial disinfection of heat-sensitive liquids while preserving their sensory properties and functional value.

Figure 3. 3 treatment of olive oil (direct electrical current).

3.3.6 Malaxation:

Mixing olive paste for 40-45 minutes with warm water (28-30 degrees Celsius) should be done to improve the viscosity of oil and extraction capacity. Malaxation causes the emulsion of water oil to collapse and allows oil drops to form larger drops, which can easily be separated from the water phase during liquid and liquid separation processes.

Figure 3. 4 Malaxation process using stainless steel container (mixer).

3.3.7 Pressing:

The paste is spread into a cloth bag, which is stacked above each other and then placed in a piston. Traditionally hydraulic pressure. Pressure is applied to the disks, resulting in solid phase pressure and liquid phase filtration (oil and vegetation water). Presses are used up to 10 tons.

Figure 3. 5 Hydraulic pressure up to 20 ton for separation of liquids.

3.3.8 Centrifuge:

After the pressure stage, the vertical centrifuge is used, which a speed up to 4000 rpm. It provides four times the power of separation of water and oil. Water is heavier so it goes out and oil is exploited separately from the center.

The centrifugal force is associated with the relative centrifugal force (RCF), which is related to the magnitude of acceleration applied. This depends on revolutions per minute (RPM) and radius of the rotor.

Figure 3. 6 the test tubes after centrifuge (4000 rpm).

3.4 Olives without germs (pits)

When take a peek into the pure essence of olive oil, it has a high quantities of vitamin E, phytosterols, and polyphenols. To study this case, remove the germ from olives by traditional mechanic matter shown in the figure below. The same process is done as in olive fruits and compared it with olives with germ and the results are compared on the yield.

Figure 3. 7 remove germ from olives .

3.5 Quality analysis of oil

This section explains the importance and limitations of analytical tests that are usually encountered in fat and oils hydrogenation. It is a compilation of tests with concentration on the basis of their link to a particular one or more of the basic features of fats and oils, such as peroxide value, acidity and K factors.

3.5.1 Determination of peroxide value (PV):

Peroxide value (PV) is a measure of total peroxides in olive oil expressed as miliequivalent of O2 kg−1 oil (meq O2 /kg oil) and so this value is known as a major guide of quality. The official EU method is based on the titration of iodine liberated from potassium iodide by peroxides present in the oil. In other words, the peroxide value is a measure of the active oxygen bound by the oil which reflects the hydroxyperoxide value, and is one of the simplest measures of the degree of lipid peroxidation. The higher the number means the greater degradation due to oxidation. Peroxide value usually increases gradually over time after pressing. The upper standard value of the peroxide is 20 meq O2 /kg oil. (Nouros, et al. 1999).

Quantity of those substances in the sample, expressed in terms of active oxygen, which oxidize potassium iodide under the conditions specified in this International Standard, divided by the mass of the test portion. Add 25 ml of acetic acid/isooctane solution to 10g of oil in conical flask and replace the stopper. Swirl the flask until the sample has dissolved. Using a suitable volumetric pipette, add 1 ml of saturated potassium iodide solution and replace the stopper. Allow the solution to react for 1 min, thoroughly shaking it at least three times during this period, then immediately add 65 ml of distilled water. Titrate the solution with sodium thiosulfate solution, adding it gradually and with constant, vigorous agitation, until the yellow iodine color has almost disappeared. Add about 1 ml of starch solution and continue the titration with constant agitation, especially near the endpoint, to liberate all of the iodine from the solvent layer, adding the sodium thiosulfate solution drop by drop until the blue color just disappears. PV was determined as follows:

$$\mathbf{PV} = \frac{S * N * 100}{W}$$

Where:-

S :- volume of $Na_2S_2O_3$.

N :- normality of $Na_2S_2O_?$.

W :- weight of oil sample (g).

3.5. 2 Determination of acidity:

Weigh into the flask sufficient mass of the test sample, according to the color and the acidic medium. Note: the mass of the test part and nitrate concentration must be such that the nitrate size is not greater than 10 ml. Heat to boiling 35 ml of ethanol containing 1 ml of phenolphthalein index in a second vial. While still the temperature of the ethanol is more than 70 ° C, then neutralized carefully by using a solution of 0.1 mol / 1 sodium hydroxide. Is access to the end point of the titration when addition of one drop of alkali to a slight change, but it's clear in color for at least 15 seconds. Add the equivalent ethanol to the test part of the first bottle and mix it well. Boil the contents in the boiling point calibration using a solution of sodium hydroxide, thereby to move the contents of the flask vigorously during the titration.

The acidity was calculated as: $acidity= V*C*M10*W$

V : the volume of titrated potassium hydroxide solution used, in milliliters.

C : the exact concentration in moles per liter of the titrated solution of potassium hydroxide used.

M :- the molar weight in grams per mole of the acid used to express the result (oleic acid = 282).

W :- the weight in grams of the sample

3.5.3 Determination of ultraviolet spectrophotometric K-values (K232 and K270) :

Determination of the specific absorption coefficients (specific extinction) in the ultraviolet region is needed for estimating the oxidation stage of olive oil. The absorption at specified wavelengths at 232 and 270 nm in the ultra violet region is related to the formation of conjugated diene and triene in the olive oil system, due to oxidation or refining processes. Compounds of oxidation of the conjugated dienes contribute to K232 while compounds of secondary oxidation (aldehydes, ketones etc.) contribute to K270 (Kiritsakis, et al. 2002).

Examination in the ultraviolet region of the spectral (UV-1601) can provide information about quality fat and their conservation status changes of fat resulting from technological processes. Due absorption at the wavelengths specified in the method to the presence of systems of overlapping state and the second (EC, 1991). The fat is dissolved in the solvent desired, and then is determined the absorption at the wavelengths specified (the UV region) with reference to pure solvent. 1 % of the fat was absorbed in the specified solvent from spectral readings based on a standard method (EC, 1991, IOC, 2003). The well-adjusted virgin olive oil (1 mg) were carefully weighed, melted and filled with the mark using spectral cyclohexane in a volume vial (25 ml). The homogenization of crops and extra virgin olive oil, sesame oil, and where noted notice or sour, is to get rid of the crop and preparation of the solution is quite clear. Was mobilized crops extra virgin olive oil, sesame oil arches Quartz rectangular (length optical = 1 cm) and measuring the absorbance using a spectrophotometer (Cary 50 Conc UV-VIS Spectrophotometer, the Varian, the Melbourne, Australia) wavelengths (232 and 270 Nm), using cyclohexane spectral class as a reference. Determines the spectroscopy of olive oil and sesame oil according to the regulations of the International Olive Oil Council, sesame oil (IOOC) and the European Union (IOOC, 2003, the EC, 1991) to determine absorbance at wavelengths of 232 and 270 Nm

Figure 3. 8 measurement of ultraviolet (K232,K270) by spectrophotometric

3.5.4 Measurement of refractive index :

The refraction index is an important visual feature for analyzing light rays that pass through intermediate materials. In the lab, the oily refractors can be used to test for fraud. Is defined as refractive index (n) of the average on that ratio of the speed of light in vacuum to the speed of light in this central , and mathematically is written as:

$$\mathbf{n} = \frac{c}{v}$$

where: **c** is the speed of light in vacuum , **v** is the speed of light in the medium **.**

The refractive index of fifteen selected samples of oil have been determined by refractometer found in the chemistry labs at Al- Quds University.

A process consisting of putting a sample on the prism. While looking through the lens, the control knob is turned until the shadow line is centered in the crosshairs; the reading where it crosses the vertical scale is the refractive index.

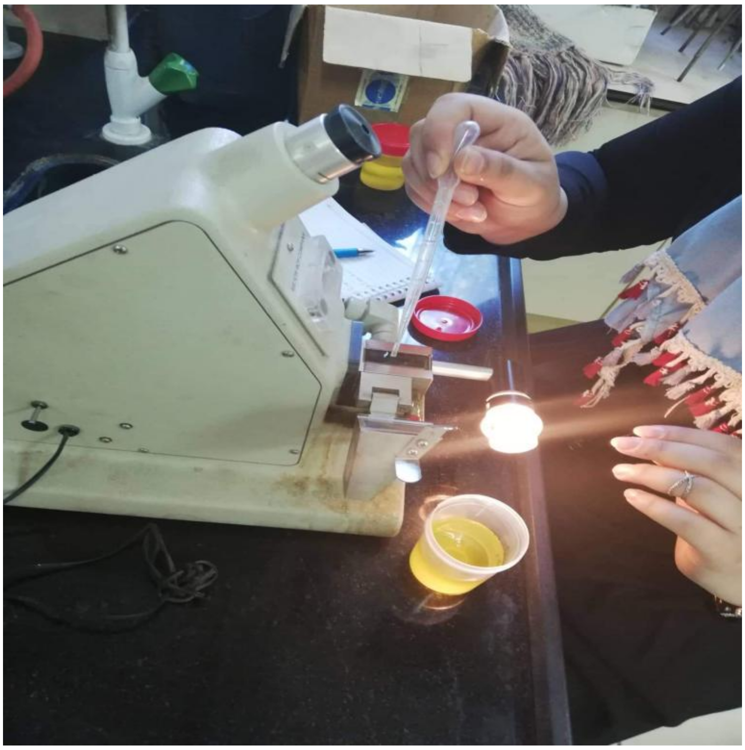


Figure 3. 9 measurement of refractive index by refractometer

3.3. 5 Measurement of viscosity:

The (dynamic) viscosity describes the flow behavior of liquids. It is defined as the internal frictional resistance of a liquid to the application of a pressure or a shearing stress. The dynamic viscosity η (Greek letter eta) is normally given in millipascal-seconds (mPas) and is usually determined in poises (or centipoises, 1 cP = 1 mPas). The dynamic viscosity of vegetable oils determined by using a rotary viscometer (NDJ-8S) is located in the department of physics at the University of An-Najah which was supplied to control unit heat temperature is programmable. The thermal container was set up in the sample room , the spindle. The measured dynamic viscosity was then converted into a kinetic viscosity - using oil density, to compare data from mathematical models.

$$\eta = \nu\rho$$

Where: ν is the kinematic viscosity (mm^2/s), η is the dynamic viscosity (mPa s), ρ the density (g/cm^3) at room temperature.

The viscosity value of a liquid is an important parameter. Measuring the viscosity has played an important role in, to say nothing of the petro-chemistry industry, a wide range of industries such as the food, medical drug, or cosmetics industries, as well as in the quality control during a production process or in various research and development stages for the improvements of quality and performance.

Figure 3. 10 Measurement of viscosity by rotary viscometer.

3.5. 6 Measurement of electrical conductivity :

First, the sample bottles are cleaned before they are filled with olive oil. After some samples are taken from the oil container, the samples are emptied. This procedure aims at reducing the moisture and oils that may be increased by storing oil in a container.

Electro-conductivity measurement is a way of controlling oil quality and as an indicator of changes in new oil or in the service resulting from pollution or damage.

The electrical conductivity is measured in micro Siemens per meter (μS/m). The conductivity of the olive oil is affected by the process temperature of the olive oil treated.

According to Ohm's Law (V = I.R), there is a linear relationship between the voltage, current, and resistance in a circuit. Firstly, the system is calibrated using a standard electrical resistance element for more assurance. For each olive oil samples at the specified temperatures, the measured current is applied to calculate the resistance. Consequently, the olive oil resistivity (ρ) and conductivity (σ) are calculated using the following equations:

R = VI . . . . (1)

R =$\rho \frac{I}{A} \rightarrow \sigma = \frac{1}{\rho}$

I Current, A

l Distance between the plates, m

R Resistance, Ω

V Voltage, V Greeks Letters

ρ Resistivity, Ω m

σ Conductivity, (Ω m)-1

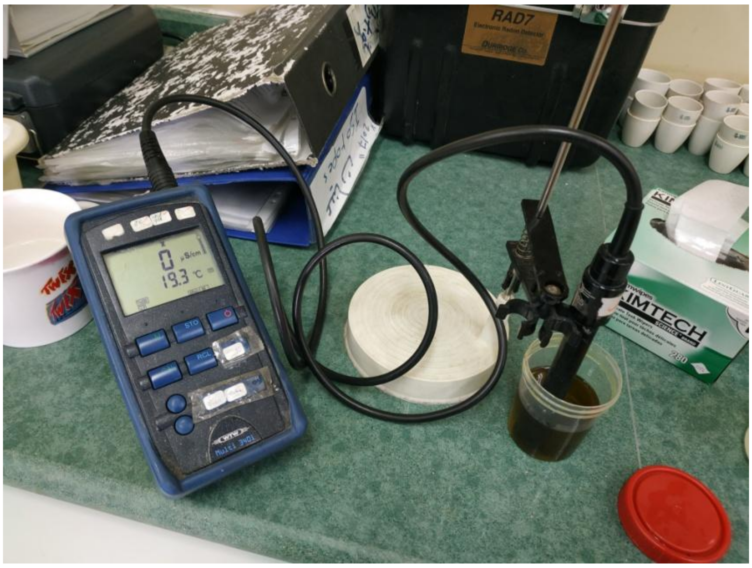


Figure 3. 11 measurement the electrical conductivity .

3.5.8 Measurement of thermal conductivity :

Thermal conduction is the transfer of heat from one part of the body to another on contact. Thermal conductivity k its the ability of a material to transfer heat measured in watts per square meter of surface area the temperature of 1 kg per unit thickness of 1 meter.

Thermal conductivity is the ratio of heat flux density to temperature gradient in a material. It measures the ability of a substance to conduct heat. Thermal resistivity is computed as the reciprocal of thermal conductivity . Namely, it can be formulated as

$$R_s = \frac{1}{ks}$$

Where: Rs is the thermal resistivity of oil samples (m CW^{-1})

and ks is the thermal conductivity of the sample (W m^{-1} C^{-1}).

Thermal conduction isn't always stable. The main factors affecting the thermal conductivity is the material density, humidity, material and ambient temperature. As the density and humidity increase, the heat conductivity and temperature increase as well.

In short, the source of the line (the probe) is initially entered into a sample at a constant temperature, T0. Record the temperature adjacent to a heat source line. This method measures thermal conductivity, assuming transverse thermal conductivity from a long, limitless heat source embedded in a homogeneous medium.

Thermal conductivity was measured using a thermo link found at food technology lab.

Figure 3. 12 Measurement of thermal conductivity of olive oil .

CHAPTER 4

4. Results and Discussions

4.1 Introduction

Feature of the (PEF), with its advantages, leads to the preservation of the original color, smell, taste, texture and nutritional value of oils. Furthermore, high-voltage electrical discharge increased the efficiency of oil extraction. The results indicated that when output capacity increases in the high voltage process, the destruction index may increase and both actions may also increase the efficiency of oil extraction. PEF assists the extraction of oil from olive fruit using pistons and an electric field at less than 1 kv / cm . This section will discuss the results obtained during the oil extraction work.

The discussion and comparison with the results mentioned in the scientific studies have been interpreted to obtain the best explanation. It wasn't easy because this was the first study of kind, studies that preceded the study were examined by different side.

This study dealt with two factors affecting the extraction yield. The amount of electrical voltage applied (kv), duration of application of the voltage on the sample (min). Is not only affect the quantity of the harvest but also its quality, namely:

- Physical properties tests performed:
- Refractive index
- Viscosity factor
- Electrical conductivity
- Thermal conductivity
- The treatment was tested for chemical properties tests, including:
- Acidity
- The value of the peroxide (PV)
- UV absorption coefficient: K232 and K270**.**

4.2 Determination of oil extraction

The efficiency of oil extraction was computed through the Equation (Bakhshabadi et al., 2017):

$$\text{Extraction efficiency} = \frac{\text{Oil extraction yield}}{\text{Total oil content}} \times 100$$

4.3 Factors influencing the yield on oil extraction

The results described in this Section focus on predetermined factors prior to extraction: voltage and time.

4.3.1 Effect of voltage on olive oil extracted:

The yield of extraction increases when applying specific high voltage in a fixed time. The result show that comparing with a standard samples. The yield is increased, the reason for this increasing, the PEF processing that may complement the crushing step by the forming pores in cell membranes that have not been disrupted by the crusher.

Deactivating the cell envelopes of the olive paste core, which acts as a physical barrier to facilitate the release of oil during malaxation, is required. Although the crushing step is a highly effective process, in the current extraction process a proportion of the oil remains inside the olive core cells.

Many applications used different ranges of voltage. An intervals of 4KV was used to construct the following App: 4, 8, 12, 16, and 20KV. The results abained are illustrated in Figure 4.1, and showed that the effect of the voltage on olive paste used was very clear. An increase in yield has been detected with an increased voltage applied were revealed in the whole at a fixed time 5 minutes.

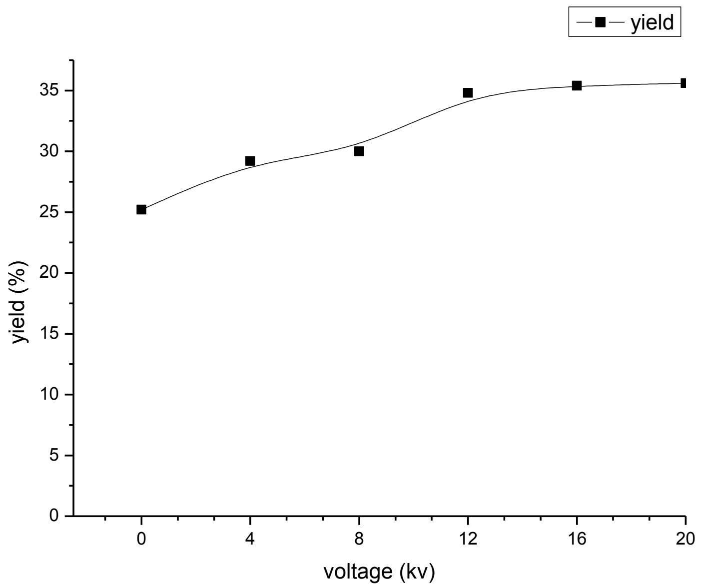


Figure 4. 1 relationship between voltage and extraction yield at duration time 5 min

The above results showed a proportionate increase in the olive oil extraction yield with an increase in the electric power used. The effect of all electrical energy varies according to the time used so, the comparison of each transaction is recorded. Table 4.1.

Table 4. 1 Effect of application of PEF treatments to the olive paste on oil yield at room temperature .

voltage (Kv)	Electric field strength (Kv\ cm)	time duration (min)	Oil Extraction %
(Standard sample) 0	0	5	25.2
		10	20.5
4	0.8	5	29.2
		10	23
8	1.6	5	28.8
		10	27.9
12	2.4	5	34.8
		10	32.4
16	3.2	5	35.4
		10	32.6
20	4	5	29.5
		10	23.5
Error bars SE		5	±1.45

	10	±1.906

Olive fruits samples show that, when different voltages applied, the yield is increasing, compared with the standard sample, as table 4.1 . In the figure 4.2 shows a significant increase in the olive oil yield at different time, which is the second factor effecting of the yield . also believe that in 5 minutes the result was better than in 10 minutes.

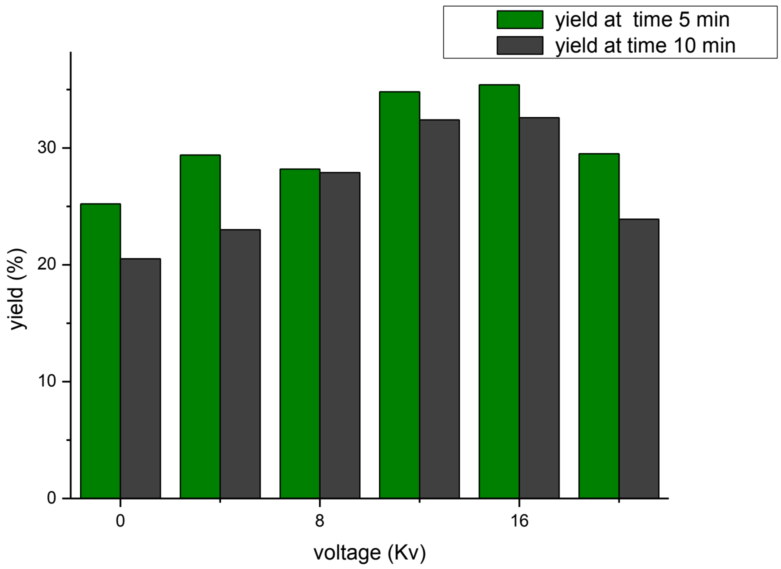


Figure 4. 2

4.3 .2 Effect of the electric field on Olives without germ:

In this section the germs where from olive fruits after which different voltage were applied for a period time 10 minutes. The results in table 4.2 show that compared with the standard sample , the extraction of oil is increased .

Table 4. 2 Effect the application of PEF treatments on the olive paste without germ on yield at room temperature

voltage (Kv)	Electric field strength (Kv\ cm)	time duration (min)	Oil Extraction %
0	0	10	17.3

8	1.6	10	26.4
12	2.4	10	22.4
16	3.2	10	23.3
Error bars SE			±1.35

4.3.3 Effect of time on yield extraction of olive oil :

Cell disintegration is often a prerequisite before the liquid is separated from all the content during the oil extraction, which requires a stay in the treatment room for 5-10 minutes. Depending on the severity of the PEF treatment, considers time the main factor to determine the increase in oil production.

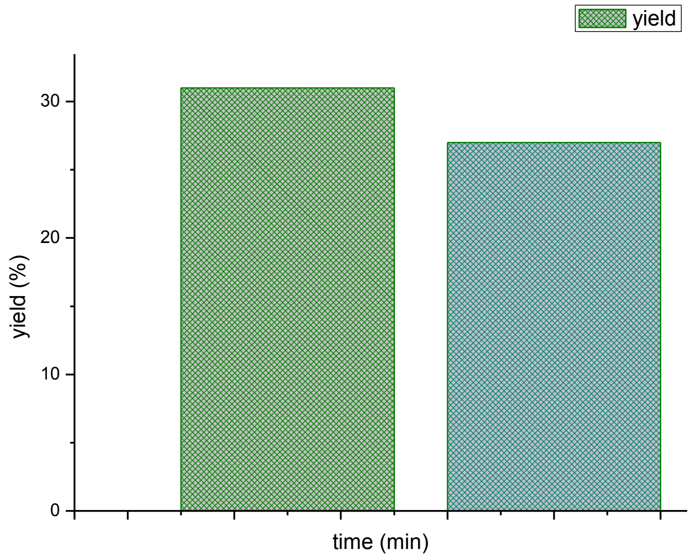


Figure 4. 3 effect the time (5 , 10 min) on yield extraction of olive oil

4.4 The efficiency of oil extraction process after PEF pretreatment

Compared to the data at table 4.1, the results indicated that, use PEF in this research led to an increase in the efficiency of oil extraction from olive fruit, which can be explained by the cells moving and cell disintegration, therefore, extraction is better.

4.5 Influence of PEF pretreatment on physical properties of oil extraction

4.5.1 Refractive index:

Refractive index refers to purity of oils, useful in controlling reactions such as catalyst formation and hydrogenation. Also, it is used to determine oil oxidation as well, some factors affecting refractive index are temperature and saturation.

However, with different oils on their own break indicators, so use this feature to determine the purity of the oils. Also, it is used to determine oil oxidation as well, (Bakhshabadi et al.2014), according to a variety, the index of refractive index of olive oil ranges from 1.4697 to 1.4730 at room temperature , consistent with results.

4.5.1.1 Refractive index of olive oil :

A refractive index is usually a standard for oil purity. Refractive index of olive oil After treatment in a 10-minute period, we see that the relationship is not linear as shown in Figure 4.4. The results show that PEF compared to traditional methods does not change the refractive index of olive oil based on comparison between treated samples and standard samples.

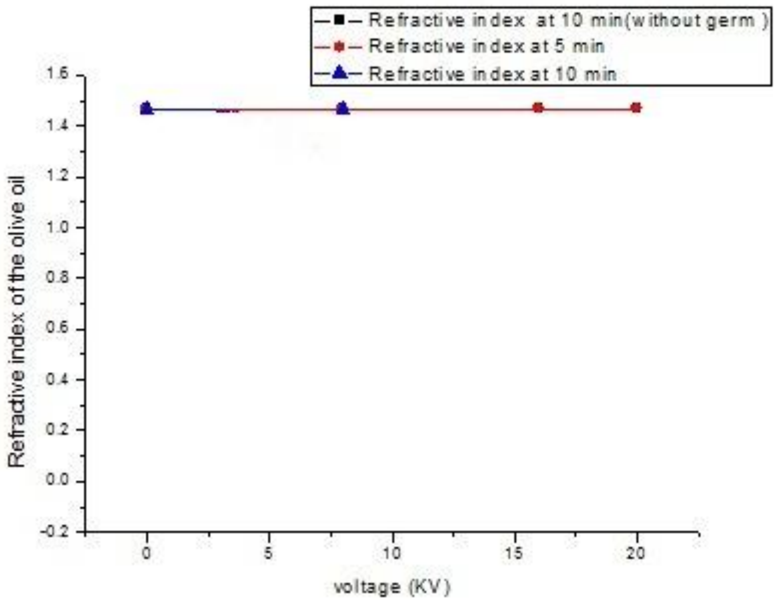


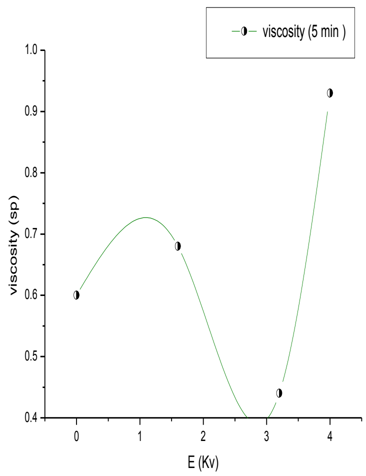
Figure 4. 4 refractive index of olive oil

4.5.2 Viscosity results:

4.5.2.1 Viscosity of olive oil samples:

The viscosity of olive oil samples after PEF treatment at duration time 5 min at room temperature were plotted as shown in Fig4 below .
The increase of viscosity in olive oil shows the increase of the lipid oxidation (Cemeroğlu, B. 2005).

The results shown that ,viscosity, was changed related to the intensity of voltage . While viscosity (dynamic) values increased with the increase of the voltage. The lowest viscosity were found for samples when voltage applied 8 and 16 kv on olives paste . The reason behind this situation can be explained in the sense that the percentage of fatty acids in oil samples increased with the increase of the waiting period for olives after treated 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.



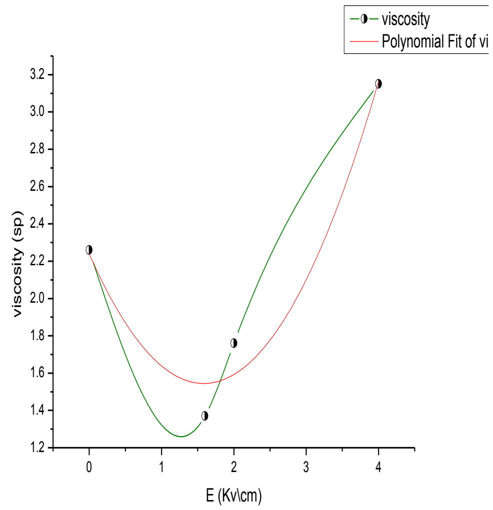


Figure 4 shows (a) the viscosity of olive oil at different voltage at duration time 5 min (b) viscosity of olive oil at10 min

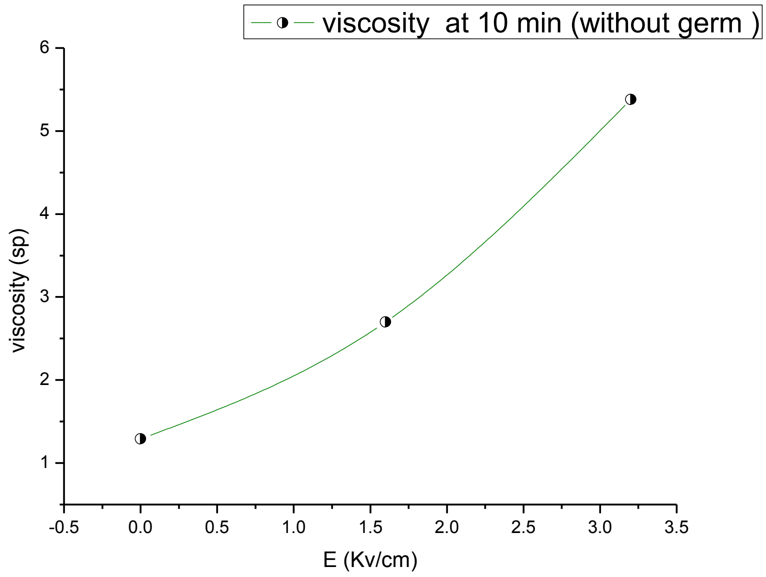


Figure 4. 5 shows the viscosity of olive oil without germ at duration time 10 min

4.5.3 Electrical conductivity ϰ results :

4.5.3.1 Electrical conductivity of olive oil sample :

Most of the liquids work with PEF. What was interesting in this experiment was that olive oil did not produce electricity 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. see the table 4.3.

Olive oil has a capability as the alternative source for transformer insulation. The biggest advantage of olive oil is the non-toxic material 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 less 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 aid capacitance and is economically wise to use because of it less pollutant effect when spill or leak.

Table 4. 3 shown the electrical conductivity of olive oil samples after PEF treatment

Voltage KV	ϰ of Olive oil samples at 5 min μS/cm	ϰ of Olive oil samples at 10min μS/cm	ϰ of Olive oils samples without agam at 10 min μS/cm
0	2	2	1
8	2	1	2
16	2	2	2
20	2	1	2

4.5.4 Thermal conductivity k results :

Thermal conductivity is a physical property describing the ability to make 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 under steady-state conditions"

Thermal conductivity is the measurement of the heat transfer capacity of the substance itself. Affected by the physical and porous Constitution, temperature of the surroundings and current temperature.

4.5.4.1 Thermal conductivity of olive oil sample :

Results of measurements of thermal conductivity of olive oil, shown in table 4.4. For each sample, the reading is repeated 5 times, the average values are calculated to gives thermal conductivity value. From table 4.4, it can be observed that the thermal conductivities increased; this was an increase from 0.156 to 0.1855 W/m.k. It was valuable to connect the thermal oil in this study are similar to previous literature, the difference was more than 3%. Furthermore, the low thermal conductivity with the increased temperature specified in this experimental work is consistent with previous measurements.

Table 4. 4 shown the thermal conductivity 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	$8.45\times10^{-}3$	$\pm4.2\times10^{-3}$	3.23×10^{-4}

4.6 The influence of PEF pretreatment on the chemical compositions of oils

Several chemical testing treatments have been performed to analyze the quality of olive oil: free acidity, peroxide value, and UV absorption characteristics at 232 and 270 nm (K 232 and K 270 ,respectively) .

4.6.1 Acidity Test:

4.6.1.1 Free Acidity after Treatment Condition of olive oil at fixed time 5 min :

The acidity values of the olive oil samples have been shown in the time period 5 min at room temperature in Table 4.5.

Different voltage of different duration has been used. Table 4.5 shows the effect of olive oil derived from electrical processing and we see better results than acidity value for sample treated compared to untreated sample. This was a simple discrimination in pH between the standard value and the value of processing, which wasn't great as we see that the value at 16 KV was the best but it is great compared to the value of 20 KV. in general, the treatment is electric effective in improving quality is an important issue to be taken into account, expansion in the value of processing the electrical value of the voltage between the minimum value and the maximum value in a period of 5 minutes, but the improvement in PH was close that the difference was not significant and this is a good signal. Is testing an important issue to consider in the effectiveness of electrical therapy in contrast, however, these differences between the samples indicate that the voltage applied to the load, is a factor in treatment.

Table 4. 5 Free acidity at different values of voltage, time 5 min.

Voltage kv	Free acidity
Standard	0.93 %
8	0.82 %
16	0.80 %

20	0.81 %
Error pars SE	±0.026 %

4.6.1.2 Free Acidity after Treatment Condition of olive oil at fixed time 10 min :

In this case the effect of different electrical energy is studied with a significant period of time of 10 minutes in this part of the investigation. As shown in Table 4.6. It was the period of time large significant effect on the acidity of the sample processing that observed in the table, the difference is noticeable in the effect of voltage on the pH of these samples after increasing time period

So, the focused on the time effect of the acid test on the olive oil samples. The table shows an increase in the acidity of olive oil.

The cause of this increase in protection is that the olive oil has the special ability to withstand the high voltage and electric power for a long time which creates noticeable changes in the olive oil fatty acids .

Table 4. 6 Free acidity at different values of voltage, time 10 min.

Voltage kv	Free acidity
Standard	0.95 %
8	0.99 %
16	1.2 %
20	1.3 %
Error bars SE	±0.07

4.6.1.3 Free Acidity after Treatment Condition of olive oil without germ at fixed time 10 min :

In this part of investigation, the treatment of electric power was studied in the samples of olives with extracted the content from them .

Table 4.7 shows a relatively well difference between standard sample acidity and other treated samples. When the application was through treated olive fruit without germ , the acidity developed for the resulted olive oil was much better . This, in turn, decreased the limited harsh effect of electrical current on skeletal structure of triglycerides. Therefore, the fatty acids exist in this structure kept its bounds with the structure and even more it became stronger. This positive effect of electrical current on strengthening the bond between fatty acids and triglycerides was possible through altering the net-charge of these fatty acids. Another explanation , the content when exposed for a long period of high voltage the structure of the triglycerides of the fat becomes free fatty acid causes high acidity.

Table 4. 7 Free acidity at different values of voltage, time 10 min.

Voltage kv	Free acidity
Stander	0.94 %
8	0.97 %
16	0.99 %
Error bars SE	±0.12

4.6.2 Peroxide Test:

4.6.2.1 Peroxide after Treatment Condition of olive oil at fixed time 5 min :

The impact of electric power was visible and clear in five minutes and amazing compared to the peroxide values in standard samples. The table shows a significant decrease in the value of peroxide, indicating the efficacy of PEF treatment.

Table 4. 8 Results of peroxide value

Voltage kv	Peroxide value
Standard	20.01
8	11.34
16	10.06
20	8.94
Error bars SE	±0.22

4.6.2.2 Peroxide after Treatment Condition of olive oil at fixed time 10 min:

In this part of the analysis, a longer period of treatment is applied to study the value of peroxide in olive oil samples. Table 4.9 shows a decrease in the value of peroxide between the standard value and the treated values. The direct correlation between the duration of treatment and the peroxide value in olive oil increased time, which means that the time in the treatment affects the quality of the chemical (peroxide value) in the olive oil compared with the standard sample.

Table 4. 9 Results of peroxide value

Voltage kv	Peroxide value
Standard	13.6
8	11.65
16	11.47
20	10.53
Error bars SE	±0.56

4.6.2.3 Peroxide after treatment conditions of olive oil without germ at fixed time 10 min:

The results of treatment are still amazing coming with high quality and quantity which shows that the olives without germ gives us amazing results.

The treatment at long times give high peroxide value, but with extracting the germ and increasing in time treatment , the results still very good as seen in Table 4.10

Table 4. 10 Results of peroxide value

Voltage kv	Peroxide value
Standard	10.23
8	9.32
16	8.49
Error bars SE	±0.41

4.6.3 K factors During Treatment Condition:

The presence of oil oxidation by-products such as aldhdide and ketone compounds is detected by absorption at 270 and 232 nanometers by a spectrophotometer and can be used to determine if the oil is refined.

4.6.3.1 K factors During Treatment Condition of olive oil at fixed time 5 min:

In this Investigation. Table 4.11 shows the effect on olive oil extracted from electrical treatment. In this section, we observe that with the persistence of the time period and the different voltage applied, the value of k factors increased modestly compared to those of a standard sample.

As shown in the table below, we find that the value stabilized at high voltage, we note that the role of treatment a significant role in the stability of triglyceride and its components. In both cases, K232 and K270 are in line with the values recommended in (EU Regulation 16) With regard to the characteristics of the quality of virgin olive.

Table 4. 11 The K232 and K270 of olive oil at different values of power, time.

Samples of olive oil treated (power ,time)	K232	K270
Standard	2.923	0.587
8kv , 5 min	2.946	0.655
16kv , 5min	1.593	0.666
20kv ,5min	1.472	0.668
Error bars SE	±0.35	±.0165

4.6.3.2 K factors During Treatment Condition of olive oil at fixed time 10 min:

A different time period was used with high electrical power to investigate. As shown in Table 4.12, it can be noted that K232 and K270 have been increased when applying PEF. All samples compared standard sample over a larger period of time. This effect of the energy source was co-operating with a high period of time used with olive fruit. This marked increase in K232 indicates that the voltage impact on the stability of olive oil was negative. At the same time, the gradual increase in K232 was a slightly lower voltage increase. The observed effect of time was more than electricity.

Table 4. 12 The K232 and K270 of olive oil at different values of power, time.

Samples of olive oil treated (power ,time)	K232	K270
Standard	1.808	0.733
8kv , 10 min	1.777	0.746
16kv , 10 min	1.841	0.812
20kv , 10 min	2.529	0.791

4.6.3.3 K factors During Treatment Condition of olive oil without germ at fixed time 10 min:

A different time period was used using high electric power and the olive fruit did not contain the germ for investigation. As shown in Table 4.13, we observe that the increase in the K232 and K270 when applying the electrical energy current of all the samples compared to the sample standard barely noticeable. This effect of electric current was cooperating with the time period used high with the olive fruit without spores. This increase in K232 refers to the effect of electricity on the stability of olive oil. At the same time, the additional increase in K232 by increasing the voltage was slightly low. The effect of time was not great without mass inside the fruit.

Table 4. 13 The K232 and K270 of olive oil at different values of power, time

Samples of olive oil(without germ) treated (power ,time)	K232	K270
Standard	1.505	0.742
8kv , 10 min	1.497	0.705
16kv , 10 min	1.477	0.684
Error bars SE	$\pm 6.9\times10^{-3}$	±0.014

4.6 Quality assurance test

As show in the table presented, the error values for each value were very low. These numbers are limited. Figures reveal that the error that occurred during the investigation between all of the range was very small, and if there is any effect, it didn't affect the quality of the yield, so the value of the production of olive oil is very reliable.

Table 4.14 values of error of the quality and nutritional parameters of oil (malaxated at room temperate for 40 min) and oil obtained from olive paste treated by PEF (16 kV/cm, applied at period time for 10 min)

Parameter	Olive oil	Olive oil without germ
Refractive index	±0.0027	±0
Viscosity	±0.094	±0.33
Electrical conductivity	±0.5	±0.5
Free acidity	±1.14	±1.83
Peroxide	±1.7	±0.07
K232	±0.029	±0.05
K270	±0.14	±0.015

Quality indices of olive and sesame oils obtained by different processing systems .Each value represents the mean of three determinations (n=3) ± standard deviation.

Chapter 5

5. Conclusions and recommendations

5.1 Introduction

PEF has been proposed to promote or assist various processes, such as solid and liquid extraction, and mechanical extraction. From the public point of view, we can summarize the benefits of PEF in:
(1) Improve yields of the process,
(2) Increase the speed of the process,
(3) Improve the quality of food (for example, reduce fat absorption, reduce the impact on the organoleptic characteristics, the increase of health related compounds),
(4) Reduce the severity of variables of other processings (for example, temperature, and degree of milling),

5.2 Conclusions

By examining the results obtained in this work and their main analysis the conclusions were as follows:

First, the electric field of the DC type proved by maturity that it has a clear increase in oil extraction productivity as well.

Second, electric power caused a significant increase in oil extraction in the company the duration and amount of olive and exposed to electrolysis are applied.

Thirdly, the period of time has a very crucial role in promoting better oil extraction in quality and quantity.

Fourthly, the results showed that processing had no significant effect on the refractive index and electrical conductivity, of the oil. However, had positive effect on thermal conductivity of oil , while viscosity for oil treated had positive effect at some voltage (8,16 KV). Based on the results obtained from this study, it can be said that the application of PEF to treat the olive oil before using oil was effective in improving the properties of quantity and quality of oil extracted.

Fifth, the acidity of olive oil, and peroxide was positively developed (no change noticeable) for olive which is electrically treated.

Sixth, the quality factors for olive oil were significantly affected by electrolysis

5.3 Recommendations

- ✓ From the results obtained in this research, we suggest to study the effect of PEF on 8 and 16 kv at especial conditions because in this voltage applied have good results although several missing information were considered to be very important for analyzing the data. At the same time several aspects of other factors can be investigated and would help in solidifying and supporting the idea of this new technique used.

- ✓ However, it is very important in the future to study more physical properties such as melting point , freezing point and relative density.

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الملخص

تأثير التيار الكهربائي المستمر في عملية استخراج زيت الزيتون

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تكمن الأهداف الرئيسية لهذه الدراسة في الإجابة على بعض الأسئلة حول تطبيق المجال الكهربائي المستمر وتأثيره على غلة زيت الزيتون المستخرج ، والأسئلة التي تتبادر الى اذهاننا هي : لماذا نستخدم حقل كهربائي ذو تيار مستمر ؟ ، ما هي العوامل التي تؤثر على استخراج المحصول ؟ ، هل يؤثر المجال الكهربائي المستمر على الخصائص الفيزيائية لزيت الزيتون المعالج ؟ ، هل يؤثر المجال الكهربائي المستمر على جودة زيت الزيتون؟.

توضح هذه الدراسة التأثير الواضح للمجال الكهربائي المستمر على غلة استخراج زيت الزيتون. كون ان هناك القليل من الدراسات السابقة حول هذا الموضوع ، وهي تؤكد على تكلفتها المنخفضة.

تم الحصول على ثمار الزيتون من بيت لحم - فلسطين . وكانت خطوات الاستخراج كالتالي : التنظيف ، الطحن ثم تطبيق المجال الكهربائي المباشر ثم الضغط وأخيرا الطرد المركزي لاستخراج الزيت . و النتائج تظهر زيادة في المحصول عند تطبيق جهد عالي (١٦ كيلو فولت) لفترة زمنية ٥ دقائق ، العائد يصل إلى ٥٠ % .

تم إجراء اختبارات فيزيائية و كيميائية للزيت المعالج لتحديد جودته : معامل الانكسار ، اللزوجة ، الايصالية الكهربائية ، الايصالية الحرارية ، الحموضة ، قيمة البيروكسيد وعوامل K232 ، K270 ، وكان معظم زيت الزيتون في مرحلة الزيت البكر الإضافية وفقا للمعايير القانونية للاتحاد الأوروبي (EVOO) .؛ زيت الزيتون البكر الممتاز.

الملخص

تأثير التيار الكهربائي المستمر في عملية استخراج زيت الزيتون

اسم الطالبة : مرام امجد احمد شوشة

اسم المشرف الاول : د. رشدي كتانة
اسم المشرف الثاني: د. ابراهيم عفانه

تكمن الأهداف الرئيسية لهذه الدراسة في الإجابة على بعض الأسئلة حول تطبيق المجال الكهربائي المستمر وتأثيره على غلة زيت الزيتون المستخرج ، والأسئلة التي تتبادر الى اذهاننا هي : لماذا نستخدم حقل كهربائي ذو تيار مستمر ؟ ، ما هي العوامل التي تؤثر على استخراج المحصول ؟ ، هل يؤثر المجال الكهربائي المستمر على الخصائص الفيزيائية لزيت الزيتون المعالج ؟ ، هل يؤثر المجال الكهربائي المستمر على جودة زيت الزيتون؟.

توضح هذه الدراسة التأثير الواضح للمجال الكهربائي المستمر على غلة استخراج زيت الزيتون. كون ان هناك القليل من الدراسات السابقة حول هذا الموضوع ، وهي تؤكد على تكلفتها المنخفضة.

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