Some Technological Pretreatments Applied During Olive Oil Extraction: Impacts on Quality Parameters and Minor Constituents

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Abstract: The mechanically extraction of olive oil has three main steps: preparation of the paste (crushing with a mechanical metal crusher and kneading with malaxer), solid-liquid and liquid-liquid separation (horizontal-axis centrifugal separator (decanter)). For every extraction process (solid-liquid separation type), the factors such as temperature, time, adjuvants, amount of processing water oxygen and processing type can be changed. Moreover, the need to production of high-quality virgin olive oil at the highest yield and minimum cost, as well as using an environmentally friendly olive oil production encourages the processing of olive oil in different forms and research of new technologies. The main goal for this purpose is to reduce the process time and increase the extraction yield along with transform the discontinuous malaxing step in a continuous phase and improve the working capacity. Another important aspect to consider is the reduction of energy requirements of the process, thereby reducing both environmental and financial costs. This trend triggered the rapid progress in the application of emerging technologies in olive processing. Ultrasounds (US), microwaves (MW), and pulsed electric fields (PEF), flash thermal conditioning (FTC) are emerging technologies that have already found application in the virgin olive oil extraction process on pilot scale plants. This paper aims to describe the basic principles of these technologies as well as the results concerning their impact on virgin olive oil yields. In this review, different technological processes being implemented in recent years to prevent the loss caused by the conventional methods in the production of olive oil and effects of these technological treatments on quality and chemical characteristics of the olive oil is gathered.

Keywords: Extraction, enzyme, microwave, technological process, ultrasonics, olive oil.

1. INTRODUCTION

Olive is a member of the *Oleaceae* (Oleaceae) family which has many genders. Olive tree is usually found in sub-tropical and tropical climate regions, on the world's middle belt and where Mediterranean climate dominates. Olive oil is liquid at room temperature (20-25°C) and obtained by squeezing only mature fruit of olive tree (*Olea europea L.*) using physical procedures. This property gives olive oil the only oil feature that can be renewed in raw form among all vegetable oils, ie without refining. Olive oil, which is a source of high calorie, essential fatty acids and soluble in oil, is an important oil source that is highly digestable and can be consumed naturally, preferred to other vegetable oils with its unique sensory and health [1]. It is the main lipid source in the Mediterranean diet [2,3,4,5]. Olive oil is more resistant to oxidation because it contains 75-85% of oleic acid, a monounsaturated fatty acid. This feature also makes it the most suitable oil for frying.

The olive oil extraction process has changed little in the last 20 years. The quality of VOO is strictly related to the concentrations of phenolic and volatile compounds strongly influenced by the operating conditions of the VOO mechanical extraction process [6].

Nowadays, the visible and concrete effects of olive oil on biological and nutritional value and human health are well known. However, these features can be further improved by optimization of production techniques. In addition, minor components such as phenolics have also been used in analytical determinations such as the origin of olive oil, extraction method, refining process, and imitation-adulteration. The phenolic compounds present in olive juice are found in oil, in vegetable waste water and in solid phase and somewhat attached to colloidal oil droplets. The concentration of the phenols in the olive fruit ranged from 1.0 to 3.0 % (w/w), and this concentration varied, such as agricultural practices, environment, maturity level, storage conditions, It depends on various factors [7]. Olive oil is also influenced by the phenolic composition in terms of sensory properties as it gives olive oil a particularly bitter and sharp (burning) flavor [8].

The altered micro-components found in olive oil are found together with micro-components naturally present in the olive. Besides olive oil to the last of these ingredients, they did in water or oil, the relative amounts of olive oil that undergoes biotransformation which components while extracting and they become what components and research on their amounts

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subject is reviewed, no adequate study yet on these issues. The mechanism that explains the quantitative modification of the secoiridoids found in olive oil during kneading is not yet known. During fermentation, the endogenous enzymes peroxidase (POD) and polyphenoloxidase (PPO) can oxidize the secoiridoids and reduce the concentration of fat phenolics, thereby reducing pain and stiffness properties and oxidative stability of the resulting oil [9,10].

The release of antioxidants, such as phenols, tocopherols and carotenoids in the oil, is directly related to the extraction process, and exuding greatly affects the quality of the olive oil [11]. The main components of phenolic compounds in olive oil are; oleuropein, tyrosol, hydroxytyrosol, p-hydroxyphenylacetic acid, caffeic acid, p-coumaric acid, ferulic acid and vanillic acid. The secoiridoid derivatives of oleuropein, which are enzymatically hydrolysed, consisting of ligstroside and demethyloleuropein [12], decarboxymethyloleuropein and ligstrosid aglycones have dialdehyde form (respectively 3,4 DHPEA-EDA and p-HPEA-EDA) and oleuropein and ligstrosid the aglycones aldehydic form (3,4-DHPE-EA and p-HPEA- EA,) most abundant phenolics compounds and these include derivatives of oleuropein show the strongest antioxidant activity [13].

The crushing or breaking of olives is a critical step that affects the quality of olive oil as well as being a simple physical process that breaks down the fruit tissues and releases the oil droplets in vacuoles. It triggers the formation and transformation of polar phenols and volatile compounds during crushing [14]. It is claimed that an important enzyme system activated during malaxing, i.e. kneading, which provides the biogeneration of new phenol species, influences the antioxidant properties and taste of natural olive oil.

In olive fruit, a large part of the fat is found in the vacuoles of the cells forming the fruit pulp. Approximately 1% of oil contained in the grain is found in parts of fruit outside the mesocarp. The fat in the vacuoles trapped in the cells by the breakage of the fruit meat can go out [15,16]. Kneading is the second stage in which olive pellets are processed continuously and slowly. Among the process steps, olive oil malaxation is one of the most important elements in the olive oil extraction process. In this stage, kneading time and paste temperature are regulated to obtain high oil quality and optimum process efficiency [17]. The high temperature increases the oil yield because the temperature lowers the oil viscosity and allows the accumulation of oil droplets [18]. Ranalli *et al*. [19] suggests a kneading temperature not higher than 30°C because they found a general degradation in oil quality at 35°C without a significant increase in extraction efficiency. Kalua *et al*. [20] showed that the temperature increase to 45°C resulted in a significant decrease in efficiency compared to temperatures of 15 and 30°C. As reported by Parenti *et al*. [21], there is a negative correlation between the temperature range of 30-36°C and the phenolic content. Studies aimed to increase the extraction efficiency of the kneading process have various effects on virgin olive oil quality parameters, nutritional and sensory properties [9,12,16,22]. The main purpose of kneading is to break up the oil water emulsion and combine oil droplets to form larger droplets [17]. The kneading step makes it easier to separate the oil from the water by increasing the number of oil droplets released from the cell, the conversion of small oil droplets to large oil droplets, and the formation of oil-water emulsions [23,24].

In industrial olive oil processing plants, olive oil yield is between 80-87%, which falls to 70-80% when the oil is trapped in the colloidal cells of the cytoplasm and/or emulsified with wastewater [12].

The main goal for the designers of food machines is to reduce the process time. This goal is closely related to high quality olive oil production and high extraction yield. Another important aspect to consider is the reduction of energy requirements of the process, thereby reducing both environmental and financial costs [25].

An important innovation in olive oil extraction facilities has been the introduction of a horizontal decanter centrifuge that makes solid- liquid separation continuous. Olive oil prevents the oxidation system to provide the benefits of continuous improvement in the quality [1,2,21,26,27]. Time savings relate to the new plant of the factory, which includes a small area to reduce labor and labor costs, faster and easier cleaning of equipment, and proper functioning of kneading [5,28,29]. However, one of the major limitations is control of kneading temparature and time, which is important for extraction yield and olive oil quality.

In recent years, microwave process has emerged food industry as one of the fastest heating techniques available and has been explored in a variety of food processes [22,26,30,31,32,33]. Microwave heating is different from other indirect thermal heating methods.

Microwave energy warms food materials at the molecular level. Because heating is faster than other modes of heating known to depend on conventional modes of heat transfer [23,34,35].

Ultrasonics (US) and microwave (MW) have emerged as technologies that have widespread application in the food industry compared to long-term conventional systems [36,37,38,39]. US technology can be considered as one of the minimum processing techniques because it sends instantaneous sound energy to food. This means that the reduction in the total process time means higher efficiency and lower energy consumption [25]. The US has a mechanical influence. US can break down cell walls of plant tissue containing minor compounds with antioxidant properties such as phenols, tocopherols, chlorophyll and carotenoids [29].

The application of emerging technologies such as PEF, US and MD to extra virgin olive oil (VOO) extraction offers several advantages due to mechanical and thermal effects. Potential advantages such as a continuous system, small operating costs, small capacity limitations, faster return on investment, lower production costs, reduced energy demands, ongoing run times, faster and easier cleaning, real-time quality control and significantly reduced area [29].

In this study, US, PEF, FTC and MW applications were reviewed considering their effects on olive oil phenolic compounds and the quality parameters which have a great influence on the commercial, nutritional and sensory properties of olive oil. The effects of these different technological processes on chemical properties of the olive oil and the oil yield were reviewed.

2. GENERAL INFORMATION ABOUT OLIVE OIL

Three stages are known in the antique age as collecting, pressing and separating, respectively, to produce olive oil. Olive oil is obtained through the crushing of olives, the gathering of the oppressed and the pressing with the aid of a press. This process of obtaining olive oil continued in a similar way during the ages. The raw material, which is crushed and pulverized, is accumulated in the storage reservoir after the pressing stage is over [9].

Olive oil is oil that is squeezed together with the core of olive, which can be consumed in its natural form without any chemical treatment, and has a high prevalence in terms of nutritional value [18]. VOO is produced from olive fruits (*Olea europaea L.*) using physical or mechanical processes and is used without further processing [7,40]. It is an integral part of the culinary and cultural heritage of the Mediterranean countries. Olive oil has nutritive and therapeutic properties as well as organoleptic qualities [18]. Malaxation step contributes to combining large droplets of small oil droplets and contributes to the centrifugation step where the oil is separated [28]. Crushing and malaxation, the oil is the most critical points of the mechanical extraction process [3,4,27,41,42,43].

In this study, it was aimed to determine US and MD application, high hydrostatic pressure application and flash thermal conditioning and their effects on phenolic components passing olive oil. In our study, it was aimed to determine the quantitative change of the major phenolic compounds which have a great influence on the commercial, nutritional and sensory properties of olive oil during the extraction steps. Thus, it has been tried to show which applications have the biggest losses or which pre-processes are more effective.

3. NEW TECHNIQUES USED IN OLIVE OIL PRODUCTION

3.1. Pulsed Electric Field (PEF)

The Pulsed Electric Field (PEF) is expressed as slice-oriented, pulsed, intense electric field [44]. PEF was first used in the pasteurization of fruit juices and it was determined that pasteurized fruit juices had a shelf life of about 4 weeks [45]. Microorganisms and enzymes can also be used for inactivation in potatoes. Inactivation can only occur after a threshold electric field density value has been exceeded. According to the dielectric breakdown theory, an externally applied electric field creates an electrical potential difference called transmembrane potential across the cell membrane. When this potential reaches a critical value, porosity or electroporation in the cell membrane begins and permeability increases. The protective properties of the cell membrane are gone and the living materials in the cell are disappearing. In order to avoid exceeding the critical value in genetic studies, the process is carried out under controlled conditions. Pulsed Electric Field (PEF) is used for pasteurization of fruit juices, yogurt and liquid egg. It is more suitable for foodstuffs with no air bubbles inside and low electrical conductivity. PEF is also used to facilitate extraction as it protects the food product and causes pores in the cell membrane of plant cells. Sugar extraction from sugar beet, extraction of nutraceutical and functional components from plants can be given as an example. Similarly, PEF treatment may be applied prior to drying to reduce the drying rate and energy costs [46]. It has been determined that when the PEFs are used as a pretreatment in the food, the actual processes applied to the food increase in speed and speed and at the same time the changes in food nutrition are decreased. Researches on this subject are mostly done in Germany and France.

PEF emerging as an alternative to thermal or enzymatic treatment, less energy and can be used for the development of the time consuming process efficiency "cold food and Technology." PEF has been applied in cell disruption and non-thermal food preservation technology while maintaining fresh food characteristics.

Pulse electric field (PEF) technology involves the application of high voltage between 20-80 kV/cm to food placed between two electrodes When exposed to PEF, cell membrane pellets, which can be permanent or continuous, are developed depending on density and processing conditions. Increasing membrane permeability resulting in loss of cell content or unauthorized entry of the environment into the pore formation (Figure **1**) [47].

PEF technology has been successfully used to extend the shelf life of apple juice, liquid egg, orange juice, milk and sacks. Compared to traditional thermal processes, both physicochemical and sensory properties are better protected and less energy is consumed. Foods which the PEF method is applied are generally liquid and there have not been studies on viscous foods yet. In addition, this method may involve the degradation of the physical properties of the food when the food-and-drink or the liquid-gas mixture is mixed together [48].

PEF allows continuous processing, which facilitates the integration into the existing processing line with short process times. By adjusting the field strength and the number of pulses, the PEF can be presented as a defined grade of tissue permeability, so biological systems, can be improved in terms of metabolic activity and recovery of valuable components. Moreover, the PEF energy requirements are rather moderate for conditions outside of biological activity. PEF thermal or less energy and time-consuming process as an alternative to enzymatic processes can be used to increase the yield is a food emerging technologies. The pilot plant is being implemented as a comprehensive cell disruption technology for food products at scale and for commercial non-thermal food preservation while maintaining fresh food characteristics. Extra virgin olive oil production involves the breakage of olives and the separation of oil from solid matter and from the juice of the fruit. However, existing processes in olive oil yield, have limitations in the quality and energy use. Oilpuls technology in existing and new facilities in equipment to reduce these limitations by introducing the pulsed electric field system [47].

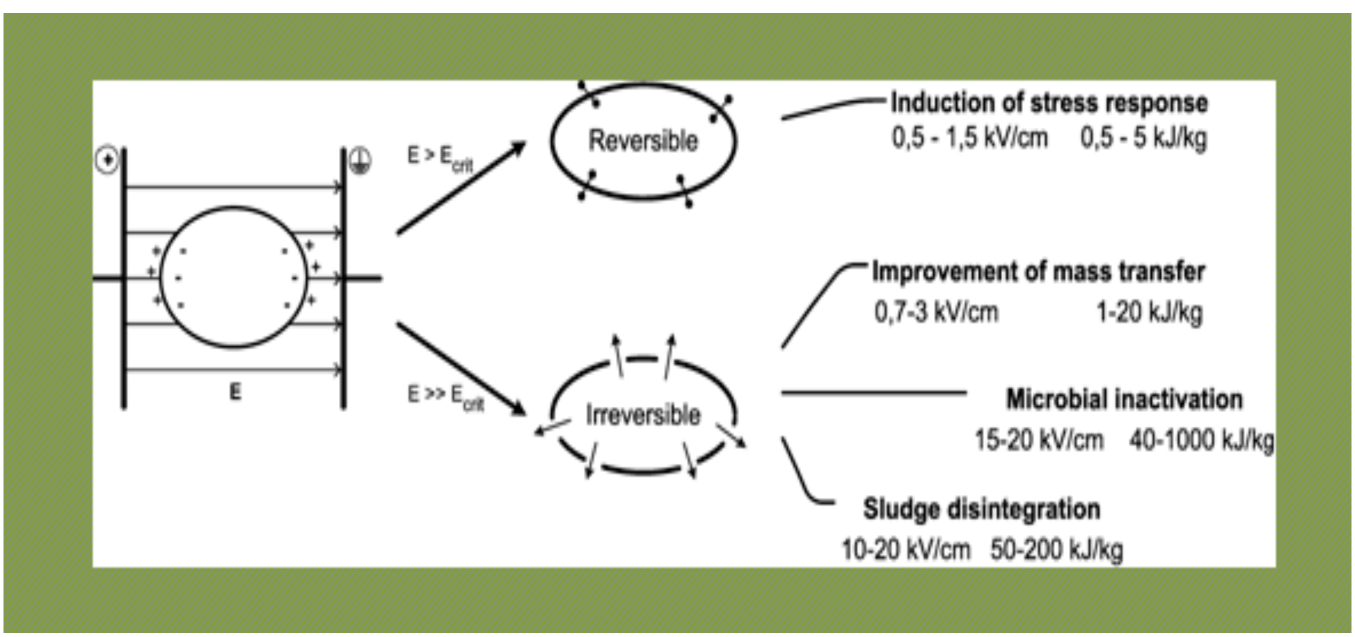

Figure 1: Electric field strength and a function of energy as pef application [47].

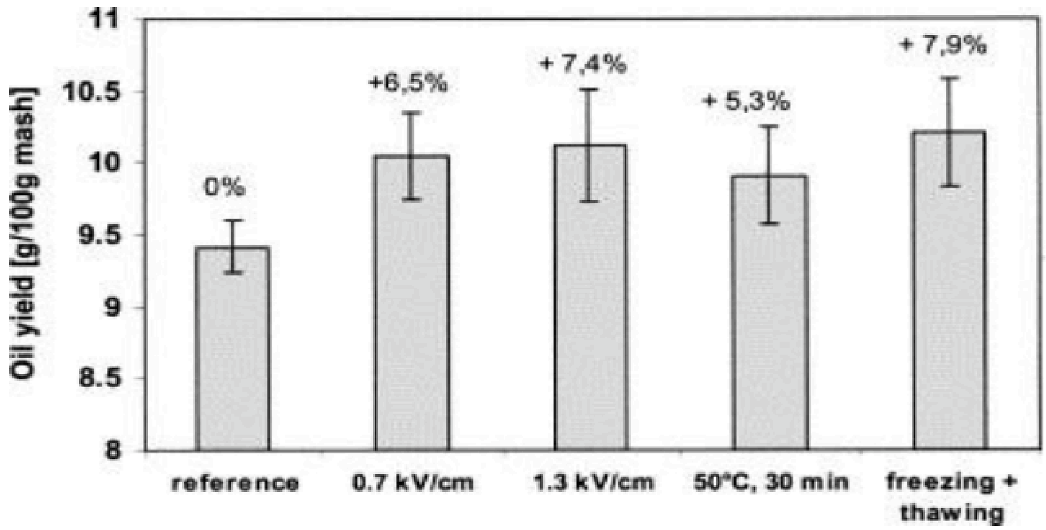

Figure 2: Oil yield increased graphics determined on olive by pef implement [49].

It was observed that extraction efficiency increased 7.4% by applying PEF to the kneading stage at different times and temperatures (Figure **2**). PEF infiltration by administration of olive oil determined to measure the level of quality is unaffected legal limits. Results have also revealed bad taste and flavor generation by applying PEF [49].

3.2. Ultrasound (US)

Ultrasound can be defined as sound waves that can pass through solids, liquids and gases and can not be detected by the human ear, whose frequency is more than 20 kHz. According to another definition, it is the process of generating energy by 20,000 or more sound waves in a second. Two different types of sound wave are used in ultrasonication, low and high intensity ultrasonics [24].

Low intensity (energetic) ultrasound is defined by low power level (1W/cm2) and high frequency (0.1-20 MHz). High frequencies between 0.1-20 MHz and low energy levels (100 mW) are used for food applications [24,50].

High energy ultrasonics can be identified with a high energy level (10-1000 W/cm^2) and a relatively low frequency (0.1 MHz). In applications with this type of ultrasonic waves, physical and chemical changes occur in the applied material. Therefore this type of ultrasonic is widely used in mainly dead materials. Different theories on the breaking mechanism of high power ultrasound on structure of the material has been noted [16,24].

US practices in olive oil processing technology are receiving increasing attention in terms of increasing oil yield. Olive oil extraction was investigated on laboratory scale to determine the effect of continuous application of high power US on the quality of olive oil quality and process efficiency of olive paste. Jimenez *et al*. [44] reported that cause changes in high-strength US oil quality parameters (free acidity value, peroxide value, K_{270} and K_{232}); significant changes were observed in bitterness, polyphenol, tocopherol (E vitamin), chlorophyll and carotenoid levels, and US application increased carotenoid and chlorophyll contents of oil. Jimenez *et al*. [45], the oil obtained from high-strength US and olive pulp was found to be richer in terms of tocopherols, chlorophyll and carotenoids. A decrease in phenolic content and bitterness index was observed. The final application rate is 1% of industrial yield. The extra amount of oil that can be actin increasing by 5.74%. Clodoveo and Hbaieb [28] compared the US and MW processes with conventional method and reported that the crushing time is significantly reduced and the extraction efficiency is increased. The basic legal parameters (acidity, peroxide value and specific extinction coefficients (K_{232} and K_{270}) established for evaluating the quality of extra virgin olive oil were not affected by US and MW applications [28]. The results of their study were compared with those obtained by using the traditional approach regarding the MW application suitability and olive oil quality and yield and they did not show any significant difference regarding extraction yield [29,51]. Reduced process time compared with the conventional method, less oxidation of the olive oil and thus result in a reduction in peroxide value were reported [25]. Also, when MW prototype system was used, electric power consumption was found to be 24% higher than the conventional hammer [51].

Better extraction was observed with direct sonication for high moisture olives (>50%), whereas indirect sonication gave higher extractability for low moisture olives (<50%). The optimum application of the ultrasound is; through direct sonication within 4 minutes and through the indirect sonication at the time of crushing.

3.3. Microwave (MW)

Microwave is regarded as one of the most important inventions of food science and technology in the last 50 years. The first time in the 1950s used to dry the chips, and in later years been involved in various heat treatment applications. Nowadays, the use of microwaves in homes, restaurants, hospitals, and more widespread in other units engaged in the food service industry and the consumer, and thus MW can be offered as a more economical treatment and reveals high quality products.

The microwave (MW) word defines frequencies where the electromagnetic wave's wave length is shorter than 1 meter. The "millimetric wave" name is given to frequencies (range 30-300 GHz) where the wavelength is shorter than 1 cm. Frequencies (300-3000 GHz) where the wavelength is shorter than 1 mm that are called "submilimetric wave".

Microwave frequencies include frequencies generally between 300 to 300,000 MHz. Microwaves are spread as electromagnetic waves, microwave frequencies are used in radars, microwave ovens, mobile phones, wireless internet access, bluetooth headsets, store security systems. Today, it is widely used in microwave ovens. The microwaves sent over the material to be cooked resonate with one of the natural rotation frequencies of the water molecules and energy is transferred to the water. So the food is cooked inside [10].

The microwave assisted system has been applied and developed in industrial scale olive oil extraction operations and it has identified the advantages of ensuring the continuity of the process. Particularly designed for industrial application, this device has been evaluated in terms of electrical and thermal energy consumption and olive oil extraction efficiency. It has also been observed that olive oil extraction is a continuous system [51].

In conventional heating, the material’s surface is first heated followed by the heat moving inward. This means that there is a temperature gradient from the surface to the inside. However, microwave heating generates heat within the material first and then heats the entire volume [14]. MW technology presents also a mechanical effect due to the heating which determines an increasing of the vegetal tissue volume and, in this way, cells explode releasing their content into the liquid phase [52]. Moreover, when the liquid phase absorbs the MW, the kinetic energy of its molecules increases, and consequently, the diffusion rate increases too [53,54]. Whenever ultrasonic energy is propagated into an attenuating material, such as a vegetal tissue, the amplitude of the wave decreases with distance [55]. This attenuation is due to either absorption or scattering [52].

Ultrasound (US) and Microwave (MW) are developing technology that already exists in the food industry. However, the application is examined in the raw olive oil sector. US technology can be more sustainable than MW, which is seen as an energy consuming method in a pilot scale plant [28].

3.4. Flash Thermal Conditioning

Puértolas *et al*. [56], Leone *et al*. [31] and Toschi *et al*. [57] investigated the use of a pulsed electric field, a continuous microwave-assisted system and a vibration system to increase the amount of extracted oil respectively, whereas Esposto *et al*.[6] described the impact of a new technology, based on the use of a heat exchanger, on VOO quality, due to the quantitative and qualitative concentration of phenolic and volatile compounds. The heat exchanger was placed in front of a traditional, covered malaxer to rapidly thermally condition the olive paste and improve the concentration of the volatile fraction, with a consequent optimal effect on the VOO organoleptic notes. The quality of virgin olive oil (VOO) was reported to be influenced by several factors, which were directly and indirectly involved in phenolic release and aroma generation.

The impact of the flash thermal conditioning (FTC) of the olive pastes was tested on five Italian olive cultivars (*Ottobratica, Cellina di Nardò, Peranzana, Coratina* and *Moraiolo*) characterized by various origin area. Instead of heating it with the traditional malaxation processes, the first step was to analyze the effects of the FTC of the olive paste, on the parameters associated with the yield extraction. The thermal modification applied to the mechanical extraction process does not modify the normal chemical and biochemical processes of oil degradation, with a specific reference to residual lipase activities [60].

The results from the combinations of 30°C and 20 min of malaxing time applied after FTC treatment, which enabled the highest concentrations of phenolic compounds to be extracted, indeed showed a great variation between the cultivars, with increases in the total phenols of 9.9%, 17.5%, 18.5%, 25.5% and 37.3% for *Cellina di Nardò, Peranzana, Moraiolo, Ottobratica* and *Coratina* cvs, respectively. On the contrary, the lignans such as (+)-1-acetoxypinoresinol and (+)-pinoresinol showed the lowest variability under the different operative conditions applied, validating a general stability of these compounds to almost all the technological parameters involved in the mechanical extraction process of VOOs [9,58,59].

Esposto *et al*. [6] studied the impact of a new technology such as flash thermal conditioning (FTC) on olive paste structural modification and on VOO quality. The evaluation of olive paste structure modification by cryo-scanning electron microscopy (cryo-SEM) showed that the application of FTC after crushing produces significant differences in terms of the breaking of the parenchyma cells and aggregation of oil droplets in comparison to the crushed pastes.

The traditional malaxation process performs paste mixing and thermal conditioning at the same time, but the thermal transfer efficiency is generally low, and for this reason, the thermal conditioning of olive pastes is relatively long compared to the optimal processing temperature. This aspect influences the activity involved in oil extraction of the endogenous enzymes, such as pectinases, hemicellulases, and cellulases, as well as the polyphenoloxidase (PPO), peroxidase (POD), and LOX that affect the phenolic and volatile composition of VOO.

The fast heating technology applied to the thermal conditioning of the olive pastes before malaxation is a new approach to the oil mechanical extraction process, which can revise the traditional thermal conditioning applied to the olive pastes during the oil's mechanical extraction process.

In fact, as observed in Peranzana cv., malaxing the FTC pastes at 30°C for 0,5, or 10 min resulted in lower phenol content (expressed as sum) in the relative VOOs, respectively of 19.4, 15.1, and 8.1% than that of VOO-C. These results can be explained by considering differences in terms of the activation period of depolymerizing enzymes between the FTC and the traditional process. As reported in previous papers, in fact the endogenous pectinases, hemicellulases, and cellulases, hydrolyzing the cell wall, improve the amount of phenolic compounds released in the oil and vegetation water during processing [30,41]. In this context, the time and temperature of malaxation show a strong impact [61]. The oil extraction from the olive pastes, performed immediately after the FTC process, reduced the time for cell wall hydrolytic degradation, catalyzed by the depolymerizing enzymes and, as a consequence, the corresponding release of phenolic compounds in the oil; for that reason, a significant improvement of phenolic concentration in the oil after FTC treatment was achieved.

The reported results show the effect of flash heating of olive pulps on the phenolic composition of extra virgin olive oil, which exhibits the same behavior, characterized by a higher phenolic concentration in extra virgin olive oil after FTC application in all varieties. These results can be explained by the improved efficiency of thermal applications in endogenous enzymes that the depolymerization of the cell walls and improve the release of phenols in oil. The effect of FTC administration on the lipoxygenase pathway is dependent on the variety [59]. The VOO flash thermal condition (VOO-FTC) ended up with a higher volatile compound concentration compared to the control, especially the phenolic concentration of all saturated and unsaturated aldehydes and esters is higher in the VOO obtained from the conventional process [9].

A heat exchanger was placed in front of a conventional malaxer to examine the effect of flash thermal conditioning (FTC) on olive paste in VOO quality, which is quite influenced by phenolic release and aroma production. The FTC application has a differentiated effect on the volatile fractions associated with the genetic rooting of olives [60], while the intense olive oil flash thermal conditioning (VOO-FTC) of the five major Italian varieties has a higher phenol concentration than the control experiments (VOO-C).

4. EFFECTS OF APPLICATION OF TECHNOLOGICAL PROCESSES ON OIL YIELD AND QUALITY PARAMETERS

The kneading process at different times and at different temperatures, extraction efficiency by applying

PEF was observed 74% increase [49]. Microwave processing; fast processing time and high olive oil quality have been approved as an attractive alternative to traditional crushing [62]. When the US and MD procedures were compared with the control; when the oils are extruded without kneading, the duration of crushing is significantly reduced and the extraction yield is increased [28]. The use of FTC in olive pulps during the mechanical extraction process of the oil reduces the oil separation efficiency compared to the conventional process. However, the residual oils obtained after application of FTC are lower than the control group and increase the process time and process temperature of pulp after FTC application. After crushing, pulp flash heating can eliminate the erosion time required for thermal conditioning, which significantly affects the plant's operating capacity, oil efficiency and VOO quality [9].

PEF infiltration by administration of olive oil determined you measure the level of quality is unaffected legal limits. It is also revealed that sensory bad taste and flavor generation by applying PEF [49]. The effect of high-power ultrasound was not found significant on the oil quality parameters (free acidity value, peroxide value, K_{270} and K_{232}); significant changes were observed in bitterness, polyphenol, tocopherol, chlorophyll and carotenoid levels [44]. Low-molecular weight food compounds such as HHP application, aroma substances, pigments and some vitamins are not changed, they maintain nutritional value leaving only a minimal effect on the product quality and sensory properties of fruits and vegetables because covalent bonding is not affected by pressure [63].

While the secoiridoid derivatives at lower rates were 3,4 DHPEA-EDA and 3,4 DHPEA-EA, lignans did not show any significant change. However, after the application of the FTC, while malaxation time increased, these losses are reduced. In comparative VOOs, the phenol contents of VOO (expressed as total) were 19.4%, 15.1% and 8.1% lower than that of VOO-C [6].

A higher concentration of volatile compounds in the oil and a lower content of the phenolic compounds were achieved, while no significant differences were found with extraction efficiency by microwave use [62]. In the sonication process, there were no non-flavor volatile components related to sensory characteristics in oil [44]. In some Italian olives examined, the phenolic concentration of oils obtained by FTC application has always been higher than that excreted by the conventional process. The increase in phenolic compounds was influenced by process parameters such as the temperature and time of the malaxation applied after the FTC [60]. Both types of VOO-FTC examined showed a lower phenolic concentration than the VOO obtained by the conventional method. The most significant changes observed in the *Gentile* cv. showed that the sum of the phenolic fractions of VOO-FTC decreased by 81.7mg/kg at 30°C relative to VOO-C (extra virgin olive oil control) [9].

The VOO plant manufacturers are interested to the searching for new alternative extraction processes able to increase the yield reducing the producing cost of the resulting product [64]. They have to respond to the changed market needs by offering highly efficient plants for supporting and increasing income of olive millers restricting the plant investment (with a minor number of malaxer) and reducing the working time optimizing the plant working capacity.

If every single step of the mechanical process is not rationally conducted, it can lead to a dramatic reduction of antioxidants, particularly phenols, which are molecules susceptible to chemical and biochemical oxidation reactions, and consequently reducing the keep ability of the final product.

Thus, the recently offered emerging technologies, such as pulsed electric fields, microwave, high hydrostatic pressure, ultrasound and flash thermal conditioning which are promising tecniques suitable for plant improvement and optimization, should also be comprehensively evaluated in terms of cost, energy consumption and applicability as well as the quality of the final product.

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