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Agronomic and Technological Factors Affecting Tunisian Olive Oil Quality

Ines Gharbi[1*], Manel Issaoui[1], Sounira Mehri[1], Imed Cheraief[1], Samira Sifi[1,2], Mohammed Hammami[1]

[1]Laboratory of Biochemistry, LR 12ES 05 Lab-NAFS "Nutrition-Functional Food & Vascular Health", Faculty of Medicine, University of Monastir, Monastir, Tunisia
[2]National Oil Office, Tunis, Tunisia
Email: [*]inesgharbi27@yahoo.fr, manel-issaoui@voila.fr, mohamed.hammami@fmm.rnu.tn

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Abstract

Olive oil is a very versatile product. It has distinctive virtues in the fields of health and nutrition. For this reason olive oil quality has attracted attention and become the focus of many studies. Olive oil quality depends on several factors such as ripening, extraction method, soil type, climatic conditions, harvesting time, varieties and storage conditions. Quality assessment of olive oil is linked to an important series of physicochemical parameters including free fatty acid content, peroxide value and sensory evaluation. The main objective of this study is to investigate using statistical analysis, the main factors influencing the quality of Tunisian olive oils. Physicochemical analysis of 89 samples of olive oil produced in the region of the Sahel and central Tunisia. This study demonstrates that the main factors influencing Tunisian olive oil quality are: olive ripening, harvesting methods, olive pre-processing storage, olive washing, leaf removing, mixing, separation systems and crushing time. The data also shows that the commercial qualitative parameters of virgin olive oil such as free fatty acids, peroxide value, specific spectrophotometric absorptions in the UV region and sensorial assessment depend on the cultivar and quality of olives before processing. The application of good olive-growing practices complemented by studies similar to this would improve the quality of olive oil produced in Tunisia. This will contribute to the promotion and value of these oils as a regional product.

Keywords

Olive Oil, Quality, Sensorial Assessment, Olives, Pressure, Centrifugation, Harvest

[*]Corresponding author.

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1. Introduction

Virgin olive oil (VOO) is a foodstuff extracted from the fruit of Olea europea L. and, therefore, it is a valuable product majority produced in the Mediterranean basin. Olive oil plays an important role in the Tunisian agronomy and economy. Olive trees cover an area of 1,611,200 ha and account for more than 4% of the olive oil produced in the world. Indeed, Tunisia is the fourth largest exporter of olive oil [1]. Only mechanical methods are used to extract the olive oil in order to preserve its characteristic properties responsible for its nutritional, health benefits and pleasant flavor.

The International Olive Oil Council [2] and the European regulations [3] have defined the quality of olive oil, based on parameters that include free fatty acid (FFA) content, peroxide value (PV), UV specific extinction coefficients (K232 and K270) and sensory score. In particular, the quantity of FFA is an important factor for classifying olive oil into commercial grades [4] [5]. Some parameters that are not included in the IOOC and EC standards [2] [3], such as phenolic content, are known to have a significant effect on the stability and sensory characteristics of olive oil.

VOO quality depends on many factors related to olive tree cultivation and to the harvesting, storage and olive processing steps [6]. Of particular importance for olive oil quality are the olive cultivar, the pedoclimatic conditions of cultivation, as well as the pruning, fertilization and irrigation of olive trees. In reality, the good quality of olives is a decisive, but not the only factor ensuring a good quality of the olive oil. It is important, however, that the quality does not deteriorate during processing. Therefore irrational operations should be avoided [6].

Many studies concerning these factors were carried out, in particular, the influence of technological operations of olive processing on oil yields and quality [4]-[7]. The aim of this work was to determinate by statistical means the main factors in olive processing that influence Tunisian olive oil quality.

2. Experimental

2.1. Olive Oil Sampling

A total of 89 olive oil samples were collected during the crop seasons 2006/2007 and 2009/2010 from 60 industrial oil mills located in the region of Sahel and Central Tunisia.

The methodological approach consists on:

- A study investigating the effect of the raw material, technological aspects of industrial oil mills and techniques related to olive oil processing, packaging and storage on olive oil quality.
- Physical-chemical analyses in the laboratory

2.2. Physical and Chemical Parameters of Oil

Regulated physicochemical quality parameters such as free fatty acids (FFA), peroxide value (PV) and the absorption values at 232 and 270 nm of the oils were assessed following the analytical methods described by the Regulation and EEC 142992 of the Commission of the European Union [3].

2.2.1. Fatty Acids Analysis

Fatty acid methyl esters (FAMEs) from the oil samples were prepared as described by Issaoui *et al*. (2008) [7]. Individual FAMEs were separated and quantified by gas chromatography using a Model 5890 Series II instrument (Hewlett-Packard, Palo Alto, CA) equipped with a flame ionization detector and a column silica column HP-Innowax (30 m × 0.25 mm × 0.25 μm).

2.2.2. Pigments

Oil (7.5 g) was accurately weighed, dissolved in Cyclohexane and taken to a final volume of 25 ml. Carotenes and chlorophylls pigments were determined by measuring the absorbance at 470 and 670 nm, respectively. The results were expressed as mg of pheophytin "α" and lutein per kg of oil, respectively [8].

2.2.3. Total Phenols

Total phenol compounds were isolated by extraction of a solution of oil in methanol/water mixture (80:20) and 2% Tween 20, twice. Folin-Ciocalteau reagent and sodium carbonate were added to a suitable aliquot of the combined extracts and the absorbance of the solution were measured at 765 nm. Values are reported as mg of

hydroxytyrosol per kg of oil [9].

2.2.4. Sensorial Evaluation

Sensorial evaluation of the oils was performed according to the Panel test method [3] by the analytical Panel Test of the ONH using nine trained tasters. Panelists classified the samples by flavor descriptors in a profile sheet, and then a final score on a nine-point scale, was given. The profile sheet of the EU regulation is divided into two types of sensory attributes, "positive" and "negative". A 6.5 final score on the scale, indicates a good olive oil quality.

2.3. Statistical Analysis

All the experiments were performed in triplicate and the statistical analysis of the data was done by analysis of multivariate logistic regression, correlation and variance (ANOVA) using a SPSS program release 11.0 for Windows (SPSS, Chicago, IL, USA). A probability value at $p < 0.05$ was considered statistically significant.

3. Results and Discussion

3.1. Effect of Ripeness

The maturation of olives lasts several months and development varies according to the growing area, olive variety, temperature and cultural practices. During ripening, important chemical changes occur inside the drupe [4] and may affect the quality of the olive oil [10] [11]. In this study, we have found that the free acidity, the rate of polyunsaturated fatty acid synthesis and the sensory evaluation are affected by the ripeness of the pressed olives.

The degree of ripeness had a significant effect on the FFA level ($p = 0.024$). No significant relationship was recorded with other quality parameters. Indeed, **Figure 1(a)** shows a significant increase of the FFA content de-

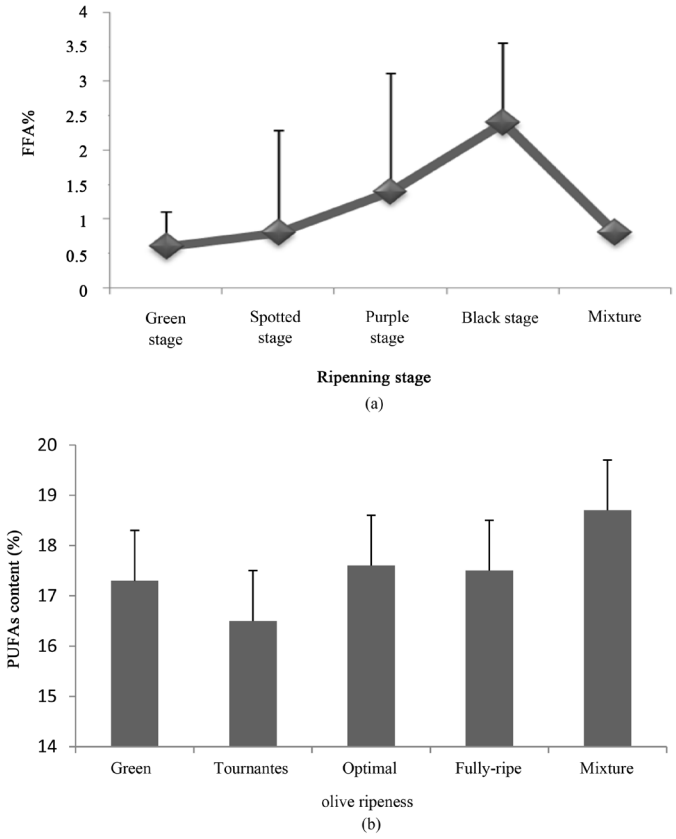


Figure 1. (a) Effect of olive ripeness on free fatty acids (FFA) content (n = 41); (b) effect of olive ripeness on PUFAs content (n = 86).

pending on the ripeness degree of the olives. Oils were shown to move from extra virgin olive oil to VOO when the olives were beyond the optimum stage of ripeness. This agrees with the results published by Rotondi *et al*. (2004) [12]. In contrast, Gimeno *et al*. (2002) [13] reported that the stage of ripeness was not associated with significant differences in the quality parameters of olive oil including the FFA content.

The fatty acid composition was not affected by the ripeness stage of olives when oils were extracted from the same olive variety. This result is consistent with results obtained by other authors [13] [14]. However, Gutierrez *et al*. 1999 [15] described an increase in linoleic acid during ripeness because of oleate desaturase, which converts oleic acid into linoleic acid.

According to the multivariate analysis of data, only the rate of PUFAs showed a remarkable variation depending on the ripeness of olives. A higher rate of increase was recorded with mixed olives from different stages of ripeness. Oils extracted from olives at the optimal stage of ripeness, which correspond at mature green ripe olives reaching their full size, had a higher rate of PUFAs compared to those extracted from olives at other stages of ripeness (**Figure 1(b)**).

Salvador *et al*. (2001) [16] showed that in addition to an increase described for stearic acid (C18:0) and linoleic (C18:2) and a decrease in oleic acid (C18:1), a linear relationship is recorded between maturity and MUFAs and PUFAs. Increased levels of PUFAs may result in a reduced resistance to oil oxidation [17]. No significant relationship was described between the maturity and the rate of total phenols. These results are in contrast with those published by other researches [13] [15] which showed that, at an early stage of ripeness (green stage); the olives are not rich in oil and provide a finished product very susceptible to oxidation because of its exceptionally high content of chlorophyll pigments, promoting oxidation in the presence of light. Oil obtained from green olives is also less rich in phenolic compounds which have antioxidant properties [18]. At fully ripe (black stage), there is a negative influence on the amount of minor compounds responsible for sensory attributes of oil (aromatic compounds, polyphenols) and its oxidative stability (polyphenols). These olives give less flavored oils, less rich in phenolic compounds with antioxidant activity, and tend to be more acidic [19].

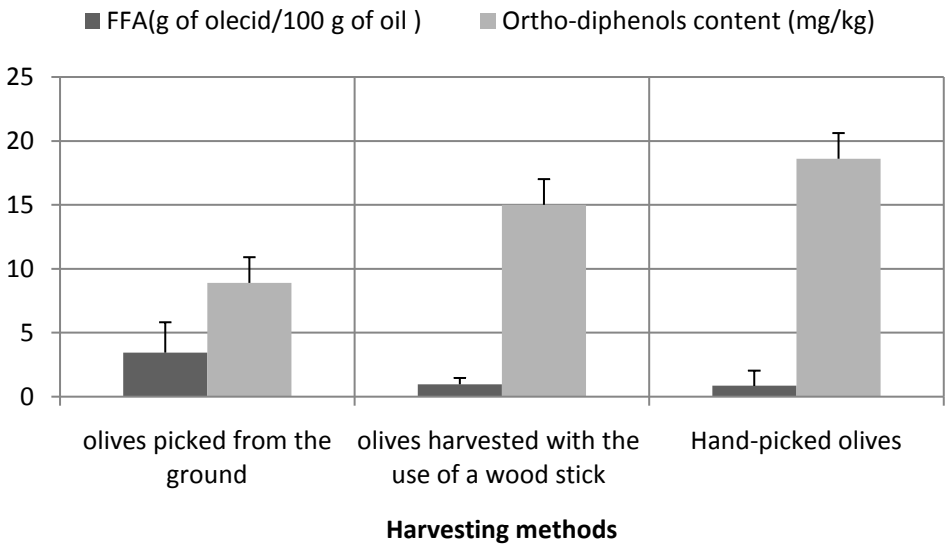
3.2. Effect of Harvesting Methods

The results of multivariate logistic regression showed a significant relationship between harvesting methods and FFA content ($p = 0.041$), the amount of ortho-diphenols ($p = 0.035$) and the results of sensory analysis: category of oil ($p = 0.045$) and musty sensorial defect ($p = 0.014$). The Pearson correlation study confirms these results. The study of **Figure 2(a)** showed that the lowest degree of acidity was obtained with hand harvested olives and the highest level was obtained with olives fallen into the ground (FFA content was 3.5 g of oleic acid/100g of oil). The FFA level of hand harvested olives (0.9 g of oleic acid/100 g oil) was only slightly different from the FFA level of olives harvested using sticks to beat the crown.

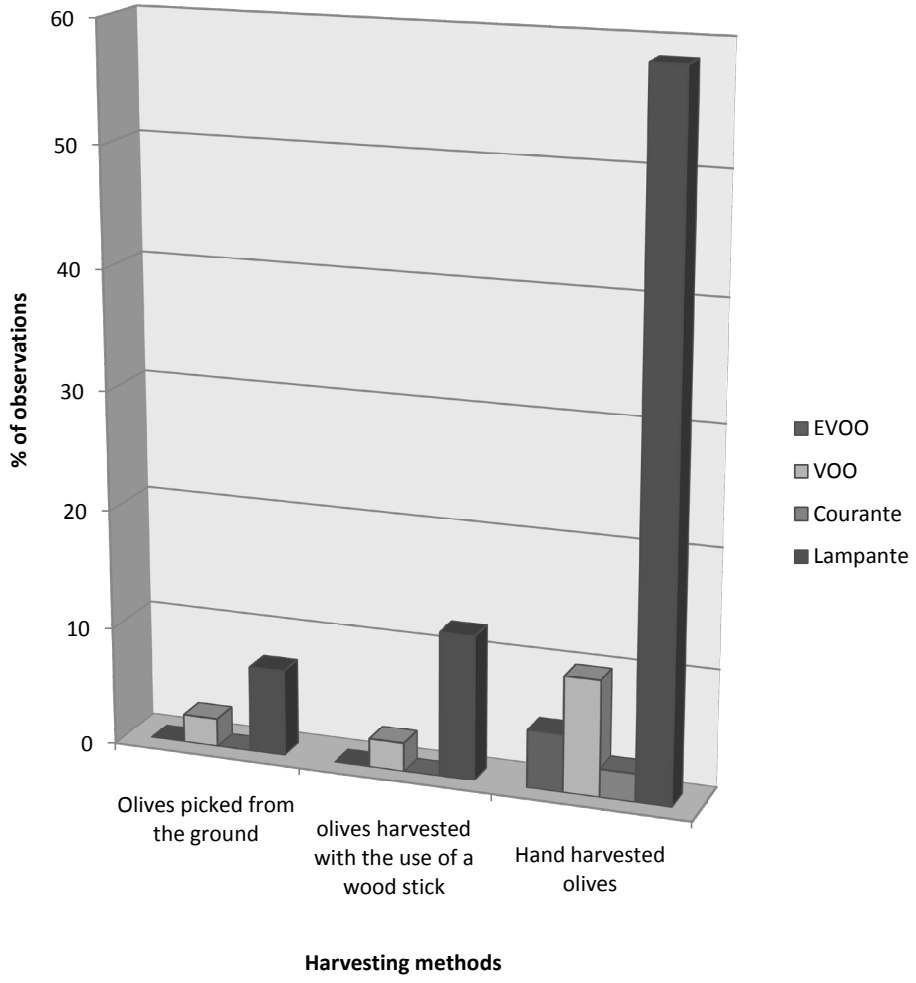
Olives can be picked by hand from the tree. This is the most suitable way to get the best quality (lowest FFA level) of olive oils because the olives are picked selectively according to their maturity [20]. The use of wood stick to knock the fruit is another method of harvesting. Thus, hitting the fruiting branches causes the fall of twigs that must bear fruit the following year. Moreover, the olives fall to the ground which can cause damage to the fruit which can allow as a consequence pest damage. Productivity of the olive tree is compromised and oil quality is altered. The FFA level increased and the profile of taste and aroma changes which explains the significant effect ($p = 0.045$) on sensory analysis. Once maturity is reached, the fruits can fall into ground and the grower simply picks them up. While this method provides a high volume of oil, the quality is altered: the FFA content is high and the sensory characteristics of the oil changed. These results are consistent with those published by Ouaouich (2007) and Chimi (2001) [20] [21].

The regression analysis ($p = 0.035$) completed by a study of correlation ($r = +0.289$) shows that the rate of ortho-diphenols is influenced by harvesting methods. Several studies have focused on studying the variation of ortho-diphenols level with various factors influencing virgin olive oil quality. However, no study has considered the influence of harvesting systems on the ortho-diphenols rate.

An improved method of harvesting is the installation of nets under the trees, which avoids direct contact of olives with pathogens and metallic residues (iron and copper) from the ground. This greatly reduces the potential for contamination and alteration of oil, because the levels of these two elements in the edible olive oil must be respectively less than or equal to 3.0 and 0.1 mg/kg. In our study, hand harvested olives produced olive oil which could be classified as EVOO (**Figure 2(b)**).



(a)



(b)

Figure 2. (a) Effect of harvesting methods on free fatty acids and ortho-diphenols content; (b) changes on olive oil category with the harvesting methods (n = 41).

3.3. Effect of Washing Operation and Leaf Removing

Free fatty acids are significantly affected (p = 0.003) by the presence or absence of the washing operation of olives as preliminary step preceding the actual extraction. This FFA% were shown to increase when olives are not washed and the leaves are not removed (**Figure 3**). Leaf removal and olive washing are important operations for the mechanical safety of the olive extracting equipment which operates at high speed and for the sensorial quality of olive oil.

The presence of leaves during olive processing can produce oil which is greener due to the increased presence of chlorophyll pigments decrease oil oxidation (photo oxidation) in the presence of light reducing the oxidative stability of the oil [6]. According to Chimi (2001) [21], transition metals coming from impurities (soil, dust) in contact with olives can act as initiators and can reduce oils quality.

3.4. Effect of Olive Fruit Storage

FFA and the K232 value are affected with olives storage conditions according to the results of logistic regression with p values corresponding respectively to 0.041 and 0.035. According to **Figure 4**, free acidity increases with the extension of olives storage time in the oil mill. After 2 days of storage, the oils produced pass from EVOO category to VOO. In order to improve olive oil quality, many studies attempt to identify the best conditions for olives storage prior to crushing to preserve or to improve the quality of the olive oil contained in the fruit [22]. According to the study of Vichi *et al*. (2009) [23] conducted on three different varieties “Arbequina” “Arbosana” and “Leccino”, a marked increase of free acidity was recorded in oils of both varieties “Arbequina “and “Arbosana” during the fruit storage, whereas slight variations were observed with the “Leccino” variety. After twelve days of storage, acidities level of “Arbequina” and “Arbosana” exceeded the limits set by the European regulations for EVOO.

After harvest, and prior to crushing, olives should not be stored for longer than 24 - 48 hours. Inadequate storage affects the olive oil quality in two ways: the hydrolysis of triglycerides resulting on oil characterized by a high content of free fatty acids. This occurs due to the action of lipases, moisture and heat. To remedy this situation, olives and olive oils should be stored in somewhere dry and clean place. The second type of alteration involves in rancidity by oxidation, which occurs especially when the fruit is injured and in the presence of air [21].

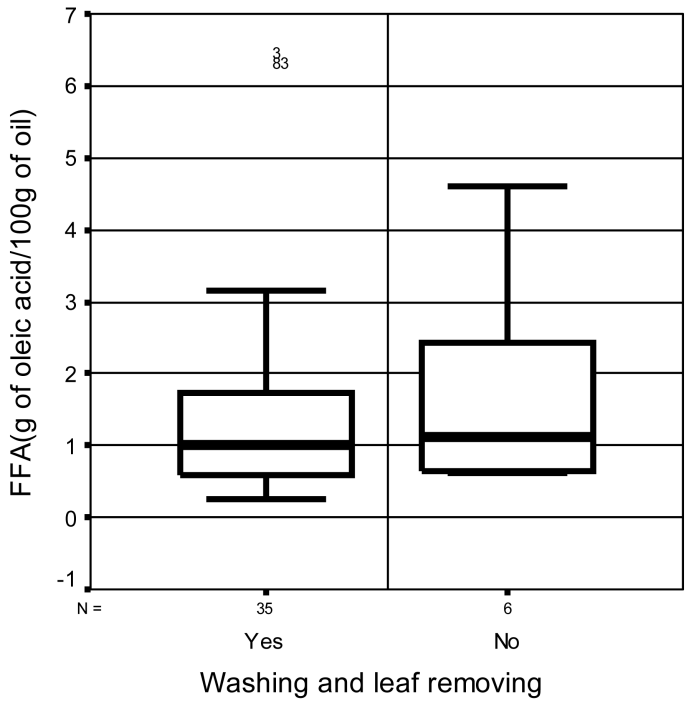


Figure 3. Effect of olive washing and leaf removing on free fatty acids content (n = 41).

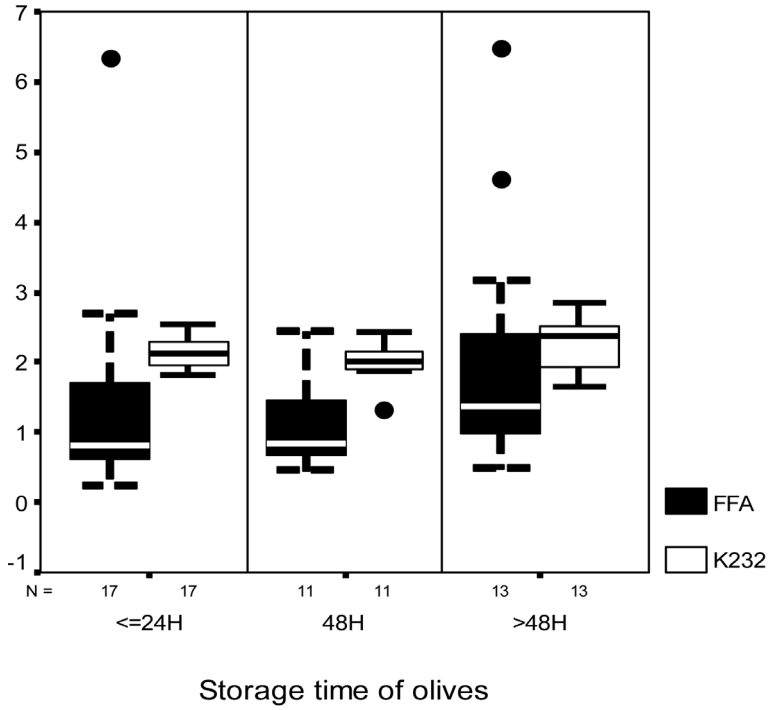


Figure 4. Effect of pre-processing storage time of olives on free fatty acids content and K232 value (n = 41).

In fact, oils produced from fermented olives that have been stored for several days are characterized by fusty defect while oils produced from olives stored at high humidity, are characterized by the musty-humid defect [20].

3.5. Effect of Crushing

The multivariate logistic regression analysis revealed that the peroxide value is significantly affected by the duration of crushing ($p = 0.040$). Similarly, a prolonged crushing time is responsible for the sensory default "musty" ($p = 0.001$). Based on survey data, it appears that crushing time for pressure systems, varied from 20 to 45 min. The extension of the crushing time induced an increase in the peroxide value; however a lower value is obtained with an average crushing duration between 20 and 30 min (**Figure 5**). According to the standard of the International Olive Council [24], crushing time should not exceed 20 to 30 min. If crushing is more prolonged, oil produced oxidizes in presence of air and can lose some of its quality. Moreover, the sensorial characteristics (color, flavor and taste of the oil) are also affected by the duration of the crushing operation [21].

3.6. Effect of Mixing

The olive paste obtained after crushing is mixed to prepare it well for the following oil separation step and produce better extraction yield. The mixing consists of a continuous slow movement of olive paste that provides an increase in the percentage of "free oil" and helps the oil droplets to merge into large drops [25]. In order to continue to improve the quality of olive oil, a great attention is paid to the mixing phase. This is a critical step in the extraction process of olive oil as it is in contact with oxygen of the air and therefore is susceptible to oxidation. Mixing technological parameters (time and temperature) are important because they can affect the extraction yield and some qualitative characteristics of the oil [26] [29]. In this study, the results of multivariate logistic regression show that mixing time influences the K232 value independently from any other quality parameters ($p = 0.012$). It was revealed that when mixing time is extended, the K232 value increases (**Figure 6**).

Di Giovacchino *et al*. (2002) [6] showed that the commercial quality parameters of olive oil such as free fatty acid, peroxide value, absorption values and sensory evaluation, do not change for a mixing times varying from

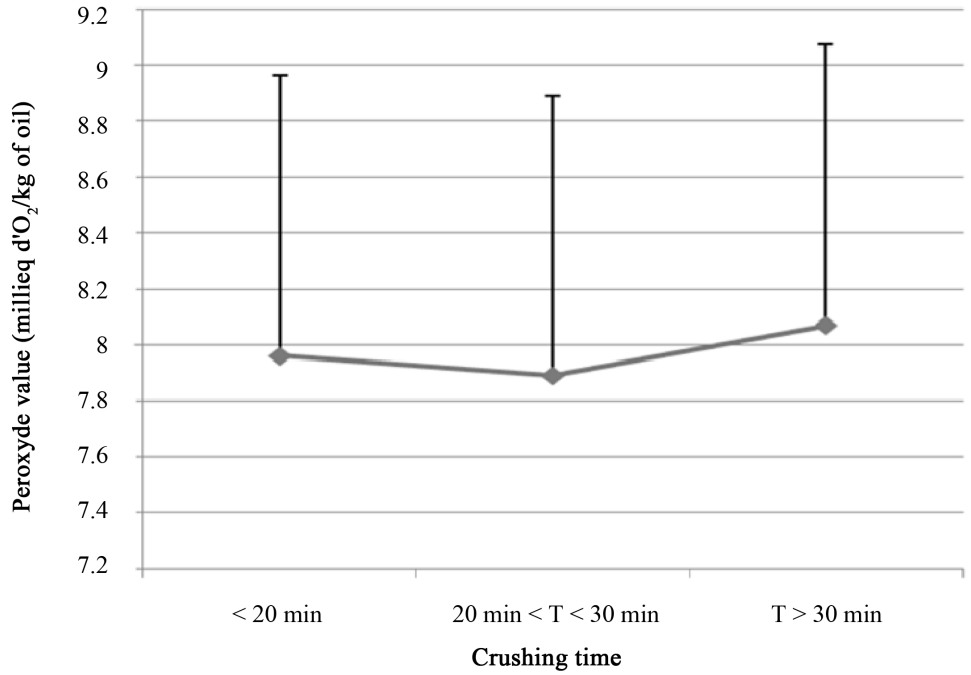


Figure 5. Effect of crushing time on the peroxide value (n = 78).

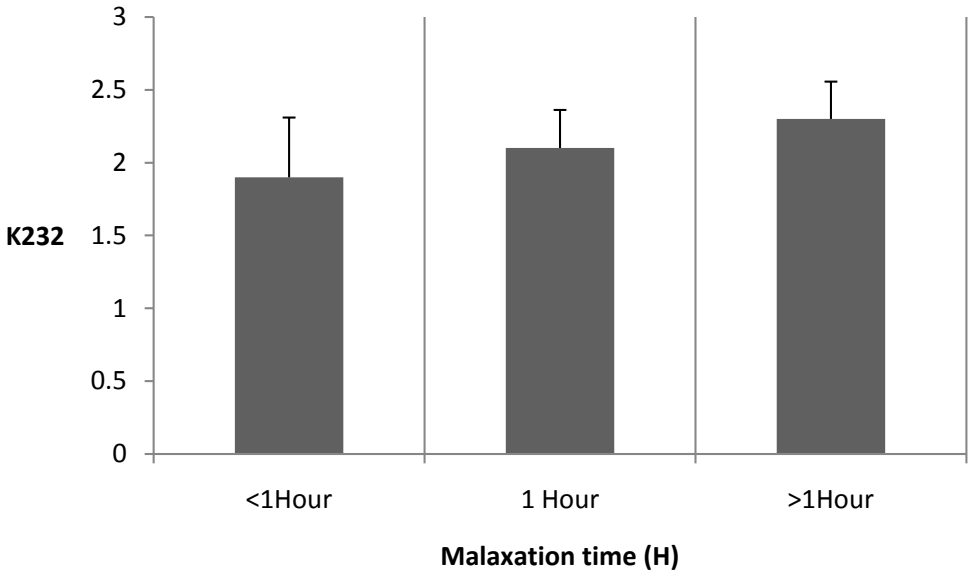


Figure 6. Effect of mixing time on the K232 value (n = 41).

15 to 90 min and these parameters are dependent on the cultivar and the quality of olives prior to their pressing. Others showed that only total polyphenols rate decreased as the mixing time was extended [26] [27]. The temperature of the olive paste during mixing is also important; it can affect the extraction yields and some analytical characteristics of oil. Thus, analysis by multivariate logistic regression in this study showed that %FFA ($p = 0.031$) and results of sensory analysis ($p = 0.017$) were influenced by the mixing temperature. As shown in **Figure 7**, lower acidity was obtained when the mixing temperature was between 25˚C and 35˚C. This is opposed to what has been shown by Di Giovacchino (1991) [28]: an increase in temperature mixing to values above 32˚C has no influence neither on FFA nor on PV. However, the polyphenol content and the volatile compounds can be influenced. Conflicting results were obtained regarding this subject.

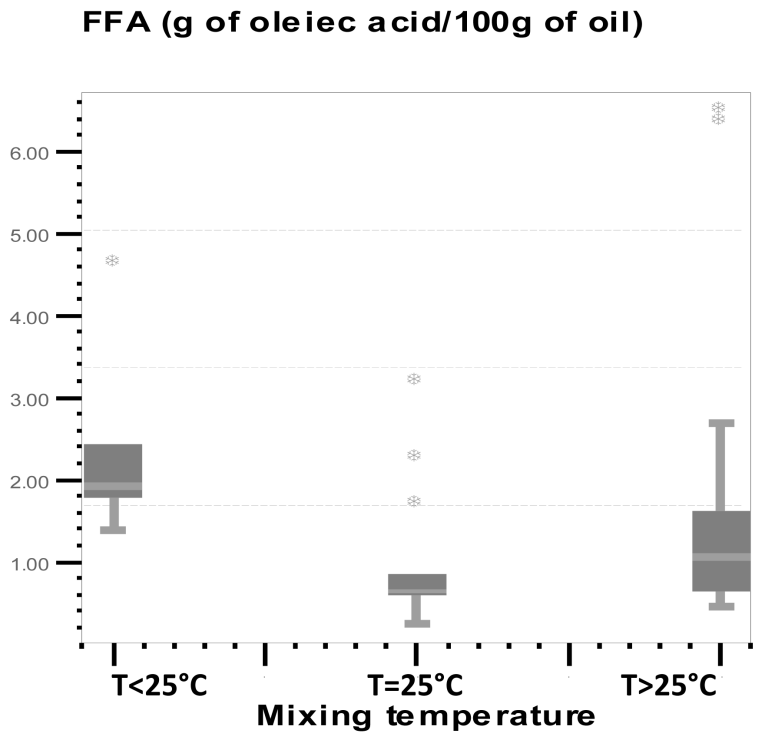


Figure 7. Changes in FFA value depending on the mixing temperature (n = 41).

3.7. Effect of Separation System

The extraction processes may alterate olive oil quality by affecting its stability during storage. In this study, two extraction systems were investigated: the traditional system or batch process and the modern systems or continuous process [29]. Through regression analyses, it was shown that the different extraction systems have a significant effect on %FFA ($p = 0.029$), carotene levels ($p = 0.014$), Ortho-diphenols ($p = 0.022$), PUFAs and sensory analysis results of analyzed olive oil samples ($p = 0.000$). From the statistical analysis of data it was possible to demonstrate the influence of different extraction systems on the free acidity, which coincides with the results published by Torres *et al*. (2005) [30]. The acidity is higher in the oils extracted by pressure systems than those obtained by centrifugation systems.

Di Giovacchino *et al*. (1994) [31] showed no significant differences with % FFA, PV, UV absorption and sensory evaluation, due to the different extraction systems. These results, confirm that qualitative parameters depend on quality and possible enzymatic modifications of olive fruit. Similarly if we compare the two centrifugation systems for good quality olives, the only significant difference was the addition of various amounts of warm water to the olive paste: that should not result in significant differences in quality characteristics of the olive oil [32]. These results may differ when poor quality olives are crushed with the pressure or the centrifugation system: %FFA is influenced and generally better oil quality is obtained by a centrifugation system [32]. As noted by Torres & Maestri (2006) [33], in pressure systems, oil is extracted with vegetation water and remain in contact until they are separated by settling, which can promote the triglycerides hydrolysis, resulting in an increase of %FFA.

The total pigment content of olive oils is an important quality parameter, in addition to its involvement in the mechanisms of auto-oxidation and photo-oxidation [8] [34]; it is correlated with the color, which is a basic attribute for olive oil quality assessment. In our study the chlorophyll pigment content was not affected by the extraction system. A significant difference ($p = 0.014$) was reported for carotene content, which is higher in oils extracted using the pressure system than with centrifugal one (**Table 1**). These results agree well with the findings of Salvador *et al*. (2003) [35].

Regression analysis data revealed no significance of the influence of extraction systems on the total polyphenol content, which is consistent with the results published by other researchers [36] [37]. Other studies have

Table 1. Average values of qualitative characteristics of virgin olive oils obtained from olives processed with different systems.

	Total	Press	Super-press	2 phases centrifugal decanter	3 phases centrifugal decanter	p
FFA [%]	1.01 (0.60 - 1.84)	*nd*	1.92 (1.57 - 3.51)	0.61 (0.54 - 0.74)	1.07 (0.68 - 1.69)	0.029
Peroxyde value [meq O_2/Kg]	7.97 (5.96 - 10.0)	8.64 (8.22 - 9.07)	8.07 (7.03 - 9.93)	7.1 (5.63 - 10.34)	7.28 (5.98 - 10.00)	0.751
K232	2.11 (1.91 - 2.36)	*nd*	2.026 ± 0.33	2.19 ± 0.3	2.13 ± 0.322	0.064
K270	0.19 (0.16 - 0.23)	*nd*	0.18 ± 0.046	0.19 ± 0.03	0.20 ± 0.05	0.082
ΔK	−0.00225 (−0.003175 - 0.001)	*nd*	−0.00105 (−0.002275 - 0.00008)	−0.0032 (−0.0041 - 0.002125)	−0.0021 (−0.003 - 0.0095)	0.113
***β*-Carotenes [mg/kg]**	11.4 (9.78 - 16.34)	*nd*	13.28 (10.19 - 20.24)	10.47 (9.39 - 14.41)	11.83 (9.64 - 16.28)	0.014
Chlorophyll pigments [mg/l as gallic acid]	24.09 (19.8 - 34.03)	*nd*	30.005 (23.36 - 52.69)	21.99 (18.05 - 28.28)	24.88 (19.27 - 34.25)	0.087
Total phenols [mg/Kg]	227.5 (91.28 - 385.03)	66.62 (66.62 - 66.62)	169.57 (55.59 - 245.92)	468.46 (347.34 - 692.50)	228.11 (156.9 - 360.51)	0.062
Ortho-diphenols [mg/Kg]	15.37 (11.28 - 26.06)	*nd*	12.08 (11.28 - 15.365)	31.93 (22.9 - 55.75)	14.84 (10.39 - 19.67)	0.022

p: Significance. *nd*: Not detected. Values are means of replicates ± standard deviations or medians of replicates (standard deviations).

Table 2. Fatty acid composition (%) of virgin olive oils obtained from olive processed with different extraction systems.

	Pressure	Super-pressure	2 phases centrifugal decanter	3 phases centifugal decanter	p
C16:0	17.78 (17.67 - 17.9)	18.03 (17.13 - 18.65)	17.46 (17.03 - 18.35)	18.77 (17.56 - 19.79)	0.755
C16:1	2.57 ± 0.12728	3.05 (2.73 - 3.21)	2.63 (1.02 - 3.09)	3.31 (3.08 - 3.50)	0.823
C17:0	0.0205 (0.17 - 0.24)	0.065 (0.06 - 0.08)	0.07 (0.065 - 0.135)	0.06 (0.06 - 0.07)	0.485
C17:1	0.25 (0.23 - 0.27)	0.125 (0.11 - 0.14)	0.13 (0.12 - 0.23)	0.11 (0.11 - 0.13)	0.202
C18:0	2.125 (2.06 - 2.19)	1.195 (1.11 - 1.22)	1.27 (1.16 - 1.42)	1.2 (1.21 - 1.35)	0.107
C18:1	56.665 (56.5 - 56.83)	59.05 ± 1.48	62.03 ± 3.96	57.94 ± 4.457	0.340
C18:2	18.32 (17.74 - 18.9)	15.46 ± 1.0026	15.24 ± 1.466	15.95 ± 2.176	0.467
C18:3	0.935 (0.8 - 1.07)	0.986 ± 0.195	0.96 ± 0.1123	0.89 ± 0.117	0.250
C20:0	0.405 (0.38 - 0.43)	0.575 (0.55 - 0.6)	0.59 (0.43 - 0.66)	0.513 (0.58 - 0.61)	0.918
C20:1	0.495 (0.32 - 0.67)	0.34 (0.32 - 0.42)	0.4 (0.36 - 0.56)	0.36 (0.33 - 0.41)	0.594
C22:0	0.16 (0.07 - 0.25)	0.1550 ± 0.02510	0.1767 ± 0.06384	0.1267 ± 0.06788	0.277
C22:1	*nd*	0.1417 ± 0.04997	0.1211 ± 0.11505	0.1481 ± 0.06845	0.673
C24:0	*nd*	0.4600 (0.44 - 0.50)	0.5800 (0.45 - 0.62)	0.4600 (0.43 - 0.57)	0.633
SFAs	21.25 (20.59 - 21.91)	20.61 (19.86 - 21.545)	20.85 (19.645 - 21.6)	21.65 (20.81 - 22.835)	0.734
MUFAs	59.805 (59.71 - 59.9)	61.68 (60.11 - 63.935)	61.71 (59.0256 - 63.50)	60.81 (58.63 - 62.265)	0.840
PUFAs	18.94 (18.19 - 19.7)	17.55 (16.305 - 19.01)	18.10 (16.69 - 19.05)	17.9 (15.955 - 18.825)	0.000
O/L	3.145 (2.99 - 3.3)	3.56 (3.165 - 4.02)	3.36 (3.055 - 3.93)	3.35 (3.075)	0.508

p: Significance. nd: Not detected. PV: Peroxide Value. SFA: Saturated Fatty Acids. MUFA: Mono-Unsaturated Fatty Acids. PUFA: Poly-Unsaturated Fatty Acids. O/L: 0leic acid/Linoleic acid.

shown the complete opposite; the phenolic content is significantly affected by the extraction systems [31] [32]. Indeed, the polyphenol content of virgin olive oil extracted by centrifugation 3-phase is significantly lower than that of oil extracted by pressure. This low content is due to the amount of warm water used (40 - 60 l/100 kg of

olives) to dilute the olive paste before extraction with the centrifuge decanter which causes reduction of oil phenolic compounds responsible for its stability during storage because of their high solubility in the aqueous phase [31] [38] [39]. But, in pressure systems, water is not added to the olive paste. However, in some studies conflicting results have been reported about the differences in the phenolic content because of extraction system. Numerous variables involved in the extraction process, such as method of crushing, malaxation conditions and the amount of water added during the phases's separation by centrifugation or pressure can have a significant effect [31] [36] [37].

The results of statistical analysis ortho-diphenols indicate a variation dependent on the extraction system (**Table 1**). The content of in oils obtained with the 3-phase decanter centrifuge was lower than that of oil extracted by 2-phase decanter centrifuge. These results agree with the results published by several authors [17] [29]. These results are due to the high amount of warm water added to olive paste treated with a 3-phase decanter centrifuge wich wash away some of the orthodiphenols.

Table 2 showed no significant relationship between the extraction system and the fatty acid composition, except for a significant p-value ($p = 0.000$) that was recorded with the rate of PUFA content. Other researchers have shown that oils obtained from the same batch of olives by an extraction system for 2- and 3-phase or by other systems have the same fatty acid composition. These substances are highly soluble in oil and poorly soluble in water, therefore their content does not change when different amounts of water (0 to 60 l/100 kg of olives) are added to the olive paste.

4. Conclusions

From this study, it can be concluded that olive oil quality depends on many factors related to olive tree cultivation as well as the harvesting, storage and olive processing. The commercial qualitative parameters, such as %FFA, PV and UV absorptions, depend on the quality of olives. The phenol content of olive oil depends on the crushing method, mixing conditions and water addition during the separation of oily must by the vertical centrifuge. All systems can provide good-quality oil if olive fruits are sound and at the correct ripeness, but the centrifugation system helps to avoid or minimise the risk of a reduction on organoleptic quality. New centrifugal decanters, operating without adding water (or only a minimal amount of water) to olive paste, save heat energy and the oils obtained are fruitier and have a higher content of natural phenolic antioxidants [6].

Processing parameters can be altered to optimize oil production that is achieved through good management practices, including:

- Determination of the optimal harvesting period based on the maximum oil content in the fruit of the different varieties in the grove;
- Suitable preprocessing storage conditions of the olives;
- Olive washing and leaf removing before the crushing operation;
- Reducing the duration of crushing of the olives;
- Leading the mixing operation in good conditions by replacing the addition of water by addition of technological adjuvants, avoiding excessive temperatures knowing that the optimum temperature should not exceed 25˚C, avoid high speeds of rotation; the recommended speed is between 15 and 20 rpm and avoiding prolonged mixing; the optimal mixing time depends on the characteristics of the olive paste.
- Reducing oil and others phases separation time;
- Ensure good storage conditions;
- Providing basic hygiene.

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Abreviations

VOO: Virgin Olive Oil
EVOO: Extra Virgin Olive Oil
FFA: Free Fatty Acids
PV: Peroxide Value
UV: Ultra Violet
IOOC: International Olive Oil Council
EC: European Commission
FAME: Fatty Acid Methyl Esters
NOO: National Olive Office
PUFA: Poly-Unsaturated Fatty Acid
MUFA: Mono-Unsaturated Fatty Acid
N: Number of Samples
H: Hour