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**Impact of variety and extraction process on physico-chemical and sensory characteristics of
virgin olive oil**

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Abstract: *The aim of this study was to evaluate the effects of variety and extraction system on the physico-chemical and sensorial characteristics of olive oils produced from three dominant varieties of Algeria (Azeradj, Chemlal and Sigoise). The olive oils were extracted by three different processes (pressure system, two-phase centrifugation and traditional process). Physicochemical parameters including free acidity, peroxide value, absorbance in ultra violet (K_{232} , K_{270} , ΔK) and sensory evaluation were studied. The results show that free acidity, peroxyde value and K_{270} were influenced by the extraction system and variety. Olive oils obtained from the two phases centrifugation and Chemlal cultivar were characterized by higher oxidative stability. Sensory characteristics of olive oils were mainly influenced by the variety and extraction system. Olive oils obtained from the two phases centrifugation, traditional cold process and Sigoise variety were characterized by the lower mean values of negative attributes.*

Keywords: Olive oil, varieties, extraction system, physico-chemical, sensory

Introduction

Olive (*Olea europaea* L.) is one of the oldest agricultural tree crops and has been an important source of oil since ancient times. Olive belongs to the Oleaceae family, which includes about 30 genera and 600 species. The genus *Olea* L. consists of more than 30 species, which are distributed in Europe, Asia, Oceania

and Africa, with only *Olea europaea* being cultivated [1]. Olive oil is essential fruit oil, which we get from the olive tree crop found mainly in the Mediterranean regions. It has been used by mankind for many centuries. It is used for cooking purposes, developing cosmetic products and soaps, for medicinal purposes, and as pharmaceutical supplements. It can also be used as fuel and for lighting lamps [2]. Virgin olive oil is obtained from the fruit of the olive tree only by mechanical or other physical means under conditions that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decantation, centrifugation or filtration to the exclusion of oils obtained from using solvents or re-esterification processes and any mixtures with oils of other kinds [3].

Algeria is a country that has a Mediterranean climate that is excellent for the cultivation of olive trees. This tree was present before, during and after the Roman civilization with the production of olive oil on the Greek Land through Italy to Spain, Turkey and stretching as far as the countries of North Africa [4]. Algeria has a great history and tradition in the cultivation of olive trees and is among the main actors in the African continent. It has 450 thousand hectares of olive trees for the production of olive oil. It has a specific strategy for the development of the olive sector [5]. Algeria is the ninth biggest olive oil producer in the world. The principal variety of olive grown in Algeria is Azeradj which mainly used for oil production; other varieties are also used in oil production like Bouricha, Limli and Chemlal. Physico-chemical characterization of Algerian olive oil is well documented Moussaoui et al. [6]; Benabid et al. [7]; Benrachou et al. [8]; Idoui [9]; Zegane et al. [10] and Sadoudi et al. [11] however the extraction process and the sensorial evaluation has not been extensively studied [12, 13].

Virgin olive oil quality depends on many factors related to the systems of cultivation, varieties of the olives, method of harvesting, olive storage and oil extraction technique [14, 15, 16, 17].

The aim of this work was to study the influence of variety and process of extraction on the physico-chemical and sensory quality of olive oil. In this study three dominant Algerian varieties were chosen: Azeradj, Chemlal and Sigoise. Olive oils were extracted by three processes: pressure system, two-phases centrifugation and traditional process.

Materials and methods

Olives and olive oils samples

The olives were collected from the demonstration farm of the Technical Institute of tree and wine growing, situated in Skikda province (region of Algeria). The olives were harvested by hand in November during the 2015-2016 crop years. The plant material used was from three Algerian varieties: Azeradj, Chemlal and Sigoise.

Azeradj: exist in the Kabylie region (the east center), it occupies 10% of the national area for oliviculture, often associated with Chemlal for pollination. It is a seasonal cultivar, resistant to drought and characterized by an early flowering with weak intensity, small rate of knotting (0.70%), a high ratio pulp/stone (8.70%), a difficult separation of the pulp from the stone and a medium and alternate productivity [18].

Chemlal: in the Kabylie region, it occupies 40% of the national area for oliviculture, cultivated for olive oil extraction. It is a rustic and late, self-sterile variety, always together with other cultivars, so ensuring pollination like Azeradj and Sigoise. It has a high productivity almost every year. The olive oil yield is between 18 to 22%. It is more often confused wrongly with “Chemlali” Tunisian cultivar [18].

Sigoise: in the west of Algeria, it occupies 25% of the national area for oliviculture, it has double destination (olive oil and table olives). It is a seasonal cultivar, tolerant to salty water, with a medium resistance to cold and drought. It is characterized by an early flowering with a medium intensity, small rate of knotting (0.70%), a high ratio pulp/stone (6.44%), an easy separation of the pulp from the stone and a medium and alternate productivity. It is a variety extending all over Algerian territory [18].

For each variety, 350 kg of olives were collected. They were stored for a period of 15 days before extraction. Each batch was processed by using the three following systems:

Pressure system: After washing olive fruits, they were crushed using a ston-mill. Then, the crushed olives were malaxed for 30 min. The obtained olive paste was then placed on mats, stacked one above the other and pressed using a hydraulic press at a pressure up to 100 kg/cm². The obtained oil was then pumped to a vertical centrifuge to separate the oil from vegetable water and other impurities.

Two-phase centrifugation: Olives were cleaned and washed by a cleaning machine. Then olives were crushed using a steel drum mill. The paste obtained was malaxed. Oil was separated with a vertical centrifuge. In this system no water was added to the paste which there is practically no vegetable waters produced.

Traditional process: The first step was enables to *remove leaves* picked up during the harvesting of the olives. Then *olives were crushed* between two stones. After crushing, olives were treading by foot. The paste obtained was mixed with water. The separation of the two phases in the liquid mixture is accomplished by decantation. In the aim to study *the effect of thermal treatment* on olive oil quality, three samples of olives were treated with water vapor before extraction.

Twelve samples of olive oil from three different cultivars were extracted with three different systems:

Samples A1, C1 and S1 were extracted with a pressure system;

Samples A2, C2 and S2 were extracted by two-phase centrifugation;

Samples A3, C3 and S3 were extracted with a traditional process from fresh olives;

Samples A4, C4 and S4 were extracted with a traditional process, olives were treated with water vapor;

Samples A1, A2, A3 and A4 were from Azeradj cultivar;

Samples C1, C2, C3 and C4 were from Chemlal cultivar;

Samples S1, S2, S3 and S4 were from Sigoise cultivar.

Olive oils samples were stored in dark glass bottles of 250 mL and refrigerated at 4°C.

Determination of analytical indices

Free acidity is expressed as a percentage of oleic acid. It was determined according to the official methods described in the International Organization for Standardization method 660:2012 [19]. Six grams of olive oil was dissolved in 100 ml of mixture of solvents ethanol/toluene (V/V) of equal parts by volume. The free fatty acids present was titrated with an aqueous solution of potassium hydroxide (0,1 N). A blank test (without fat) was carried out under the same conditions.

The peroxide value is the quantity of those substances in the sample, expressed in terms of milliequivalents of active oxygen per kilogram (meq O₂/kg), which oxidize potassium iodide under the operating conditions described in the international standard ISO 3960: 2001 [20]. To measured peroxide value, 2 g of olive oil was diluted in 15ml of acetic acid and 10 ml of chloroform, 1ml of potassium iodide was added and the liberated iodine was titrated with standardized sodium thiosulfate (0,01 N).

The UV spectrophotometric indices (K₂₃₂, K₂₇₀), were measured according to the official method described in Regulation of the International Olive Council [21]. To calculate the K₂₃₂ and K₂₇₀ values, 0.25 g of olive oil was diluted in 25 ml of cyclohexane, placed into a 1cm quartz cuvette, and analysed at the wavelengths of 232 and 276 nm, against a blank of cyclohexane. SPECORD 205 double beam spectrophotometer was used.

Determination of sensory quality

Sensory or organoleptic analyses of olive oil has a significant importance in judging the quality of the final product. In fact, an unacceptable oil from an organoleptic point of view can be downgraded [22]. Sensory evaluation of olive oils was carried out by 9 selected and trained panellists from the Technical Institute of tree and wine growing in Sidi Aich in Béjaia (located in the north of Algeria). The sensory analyses of 12 samples were performed according to the method described in the Regulation IOC/T.20/Doc. N°15/Rév. 8 November 2015 [23]. The olive oil samples were presented in standardised tasting glasses conforming to the standard IOC/T.20/Doc. No 5 "Glass for oil tasting". The glass was containing 15 ml of olive oil, and it was covered with a watch-glass. Each glass was marked with a code made up of digits chosen at random. Samples were kept in the glasses at 28°C.

The sensorial quality of a virgin olive oil is determined by a series of positive (fruity, bitter, and pungent) and negative (fusty, winey-vinegary, musty, muddy, rancid) attributes that characterized it. The panel members tasted the olive oils and marked the intensity of the predominant defect and the presence or absence of the fruity attribute. Attributes were assessed on an oriented 10 cm line scale. The results of the sensory evaluation were estimated by the median. The samples were graded by comparing the median value of the defects and the median for the fruity attribute with the reference ranges given below as reported in IOC/T.20/Doc. N°15/Rév. 8 November 2015 [23].

Extra virgin olive oil: the median of the defects is 0.0 and the median of the fruity attribute is above 0.0;

Virgin olive oil: the median of the defects is above 0.0 but not more than 3.5 and the median of the fruity attribute is above 0.0;

Ordinary virgin olive oil: the median of the defects is above 3.5 but not more than 6.0, or the median of the defects is not more than 3.5 and the median of the fruity attribute is 0.0;

Lampante virgin olive oil: the median of the defects is above 6.0.

Statistical analysis

Statistical analysis of physico-chemical and sensory data was performed with XLSTAT 2009 software (Addinsoft, 2009. XLSTAT statistical data analysis solution, Paris, France). All measurements were done in triplicate and means were compared using analysis of variance and Least Significant Difference (LSD) tests for multiple comparisons at a significant level of 0.05.

Results and discussion

Through regression analyses, it was shown that the different extraction systems and variety have a significant effect ($P \leq 0.05$) on free acidity ($p = 0.0001$), peroxide value ($p = 0.0001$) and K_{270} ($p = 0.0001$), no significant differences ($P \geq 0.05$) for K_{232} ($p = 0.058$) and ΔK ($p = 0.054$).

According to the results (Table 1), free acidity value of olive oils extracted by two-phase centrifugation (A2, C2, and S2) are lower than those of oils extracted with pressure system (A1, C1, and S1) or traditional process (A3, C3, S3, A4, C4, and S4).

In fact, free acidity resulting from the hydrolysis of triacylglycerides as well as the further decomposition of hydroperoxides, is one of the most important indicators of oil deterioration [24]. Chimi [25] compared olive oils extracted by pressure system with the oils produced by two-phase centrifugation. The pressure system oils showed higher values of free acidity.

In pressure system, olive 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 free acidity

[26]. Differences were noted in the free acidity values of olive oils obtained from Sigoise variety (1.12 to 3.8%) which were higher than those extracted from Azeradj (0.78 to 2.29%) and Chemlal varieties (0.8 to 1.69%). These differences can be explained by the influence of the variety. These results are consistent with those found by Charaf-eddine et al. [27].

For Azeradj and Sigoise varieties, olive oils extracted by pressure system and two-phase centrifugation were characterized by higher peroxide value in comparison to those extracted by traditional processes. There were no significant differences between olive oils obtained from Chemlal variety (Table 1).

Table 1. Physico-chemical analysis results for olive oil samples

Samples	Determinations				
	Acidity (%)	Peroxide value (meq O ₂ /kg)	K ₂₃₂	K ₂₇₀	ΔK
A1	1.28±0.02	10.16±0.28	1.60±0.07	0.11±0.01	0.0006±0.0005
C1	0.99±0.04	10.41±0.38	1.49±0.04	0.087±0.009	0.0006±0.0005
S1	1.45±0.04	12.08±1.87	1.43±0.07	0.084±0.005	0.0016±0.0005
A2	0.78±0.02	10.50±0.50	1.41±0.02	0.093±0.009	0.0006±0.0005
C2	0.80±0.01	12.83±0.09	1.44±0.65	0.11±0.020	0.001±0
S2	1.12±0.02	11.50±1.00	1.66±0.12	0.104±0.005	0.0003±0.0005
A3	2.29±0.05	7.00±0.50	138±0.12	0.12±0.01	0.001±0.0005
C3	1.69±0.00	11.91±1.94	1.44±0.17	0.1±0.01	0.0003±0.001
S3	3.30±0.02	6.41±1.66	1.28±0.08	0.17±0.01	0.0023±0.0005
A4	2.11±0.00	3.50±0.86	1.18±0.11	0.17±0.01	0.001±0
C4	1.53±0.01	12.33±1.75	1.30±0.12	0.19±0.02	0.001±0.0005
S4	3.80±0.04	3.91±0.87	1.003±0.04	0.13±0.006	0.0033±0.0005

Spectrophotometric analysis in the ultraviolet gives additional information about the oxidative state of an oil. Primary and secondary products of oxidation are detected at 232 and 270 nm, respectively [28]. In all cases K₂₃₂, K₂₇₀, and ΔK (Table 1) did not exceed the limit value established by the IOC regulation [29]. In this study, we have found that the free acidity, peroxide value and K₂₇₀ are affected by variety and processing system. These results are in agreement with those obtained by Douzane et al. [30], Khdaïr et al. [31] and Gharbi et al. [26]. There were significant differences between olive oil samples in free acidity, peroxide values and K₂₇₀. However there were no significant differences between olive oil samples in K₂₃₂ and ΔK.

Results of sensory analysis

The results of sensory analysis showed that the median of fruity was equal to zero for all samples. No positive attribute was reported. The median of negative attributes were represented in Figure 1. According to the sensory analysis, samples A1, C1, S1, A2, C2, S2, A3, C3, S3, and S4 were classified as virgin olive oil. However samples A4 and C4 were defined as ordinary virgin olive oil.

Figure 1. Medians of defects of different olive oil samples

The olive oils obtained from Sigoise cultivar were characterized by low median of defects than those obtained from Azeradj and Chemlal varieties. The sensory characteristic of virgin olive oil depend mainly on the concentrations of phenolic compounds [32, 33, 34]. Douzane et al. [30] studied phenolic compounds isolated from virgin olive oil from several Algerian varieties. Higher amount of phenolic compounds are detected in oils from Sigoise variety than those of oils from Azeradj and Chemlal varieties. The independent odours and tastes of different volatile and phenolic compounds contribute to various and typical virgin olive oil flavours [35]. Flavor components within each cultivar come from the water-soluble polyphenols, tocopherols, and esters that make up the bitter flavor of olives fruits. These compounds are also naturally occurring antioxidants that extend oil shelf life by reducing rancidity [36].

Defects were perceived at light intensity in olive oil extracted by two-phase centrifugation and traditional cold process however olive oil extracted by pressure system and traditional hot process showed medium intensity. These defects may be due to fermentation of the olives, degradation phenomena of residues of pulp and prolonged contact with the vegetable water.

The amount of water residue in olive oil causes rapid hydrolysis and oxidation of the oil resulting in increasing volatiles and lower sensory properties [37, 38].

Sensory properties are largely affected by phenolic composition. In particular, these compounds were associated to the bitter and pungent sensory profile of the virgin olive oil [39]. Experience has shown that the two phase centrifugation has a better retention of polyphenols because no water is added [36].

Conclusion

From this study, it can be concluded that the variety and extraction system influence significantly the physicochemical and sensorial characteristics of virgin olive oil. Physicochemical parameters (FA, K270, K232 and PV) of olive oil samples were analyzed to determine their oxidative stability. Samples were differentiated according to free acidity, peroxide value and K_{270} , no significant effect was found with K232 and ΔK . Olive oils extracted by two phases centrifugation were characterized by the higher oxidative stability compared to those extracted by pressure system and traditional process. Oxidative stability was affected by variety. Olive oils extracted from Chemlal cultivar were characterized by the higher oxidative stability in contrast to those obtained from Azeradj and Sigoise cultivar. Polyphenols are fundamental for protecting triacylglycerols from oxidation and the higher oxidative stability was mainly due to the higher polyphenol content of olive oil. Several authors have reported that variety affects the polyphenol contents.

In this study, we have found that extraction system and Variety have a significant impact on the sensory properties. Olive oils obtained from Sigoise varieties were characterized by low median of defects in comparison to those obtained from Azeradj and Chemlal variety. The low median of defects was mainly due to the high polyphenol and pleasant volatiles contents. Differences were noted in the medians of defects of olive oils extracted by pressing system and traditional hot process which were higher than those extracted by two phase centrifugation and traditional cold process. The High median of defects is mainly due to the higher fermentation and unpleasant volatiles contents.

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