Comparative Study of the Physicochemical and Organoleptic Characteristics of Several Olive Oil Varieties from the Kabylie Region: Tizi Ouzou, Bejaïa, and Bouira

Hassina Hadjadj [1*] , Hafidh Zemour [2], Maghnia Djamila [3], Wissem Abdelaziz [1], Nesrine Kaoudj[1] Mokhtar Amirat [4].

[1]Laboratory of Pharmacognosy, Bio Toxicology and Biological Valorization of Plants; Department of Biology Moulay Tahar University, Saida, ALGERIA.
[2]Faculty of Natural and Life Sciences, Ibn Khaldoun University, BP 14000, Tiaret, Algeria
[3] Laboratory for Experimental Biotoxicology of Biodepollution and Phytoremediation, University of Oran Ahmed Ben Bella 1. ALGERIA.
[4] Institute of veterinary sciences Ibn Khaldoun University, BP 14000, Tiaret, Algeria
Corresponding author: hassinahadjadj@univ-saida.dz

Received: 01/07/2023; Accepted: 18/10/2023; Published: 28/10/2023

Abstract

The purpose of this study is to conduct a comparative analysis of the physicochemical and organoleptic parameters of the quality of five samples of olive oil from the dominant cultivar (Chemlal) in the national olive grove in different regions of Kabylie, specifically Tizi Ouzou (Ouacif, Ouadhia, and Michlet), Bejaia (Akbou), and Bouira (Ait Laziz). In this study, we determined the quality indices of olive oil, including acidity, peroxide value, chlorophyll content, carotenoids, refractive index, pH, water content, and performed sensory analysis.

The results indicate that all five samples meet the standards established by the International Olive Council (2019), with variations in the results observed, such as acidity ranging from 1.9 to 3.1, acidity levels between 0.95 and 1.86%, peroxide value ranging from 8.15 to 14.2 meq O2/kg, chlorophyll content between 0.65 and 1.63 ppm, carotenoid content ranging from 0.25 to 1.47 ppm, refractive index between 1.468 and 1.469 (nd20), pH levels between 5.35 and 6.36, and water content between 0.01 and 0.005%. These results categorize all five samples as extra virgin olive oil.

In terms of sensory analysis, the olive oil from the Ouacif region is ranked as the best and most appreciated among the samples, with its fruity taste, good flavor, and pleasant aroma.

Keywords: olive tree, acidity index, organoleptic quality, extra virgin olive oil.

Tob Regul Sci. ™ 2023 ;9(2): 1320-1337
DOI: doi.org/10.18001/TRS.9.2.81

Introduction

Olive tree (Olea europaea L.) is one of the most significant fruit-bearing trees loaded with symbols such as peace, victory, strength, and hope (Airoudj, Boubenia, and Souyad, 2021). The olive tree has a broad geographical distribution due to its adaptability to various soil conditions and topographies (Lehara and Mouheb, 2021). This ancient tree deeply rooted in Mediterranean and Arab-Muslim civilizations has always served as a factor in mitigating cultural divisions among the peoples of the Mediterranean basin (Abd Elkebir, Diafi, and Djmiate, 2020).

Olive and its oil have been integral components of the Mediterranean diet for a long time, owing to their high nutritional quality and positive health effects (Metlef, S. 2021). Olive cultivation predominates in Mediterranean countries (90%). The most productive olive oil regions are located in Spain and Italy. In Algeria, olive oil plays a significant economic, social, and environmental role. The majority of olive groves are traditional (90%), located in mountainous and marginal lands, with the Tizi-Ouzou province ranking second in Algeria after Bejaia.

The cultivated olive varieties include Olea europea var. chamlal (90%) and O. europea var. azaradj and O. europea var. lemli (10%) (Airoudj, Boubenia, and Souyad, 2021). There are olive varieties suitable for preservation as table olives, such as Sigoise in Algeria, those suitable for oil production, such as Chemlal in Algeria, and dual-purpose varieties that can be used for both oil extraction and table olive production (Lehara and Mouheb, 2021).

Olive oil is the fat extracted from olives (the fruit of the olive tree) during the milling process in an olive mill (Elimen, B. 2022). It is highly regarded for its taste and its health benefits (Mechroure, 2018). Its health benefits and biological properties are linked to its composition of fatty acids, particularly oleic acid, as well as the presence of minor compounds such as vitamins and natural antioxidants that have a protective effect against cellular damage caused by free radicals.

Various phenolic compounds have been identified in olive oil, including phenolic alcohols, lignans, and flavonoids. These compounds represent the most important antioxidants that give olive oil its organoleptic properties and contribute to its stability against oxidation during storage (Attafi et al. 2022).

The quality of olive oil, according to the International Olive Council (I.O.C.), is determined by a set of physicochemical and organoleptic characteristics that classify oils into different categories. All these parameters require in-depth study and mastery to produce high-quality olive oil (Tighiouart and Layadi, 2020).

The beneficial effects of olive oil on human health are attributed, among other factors, to its content of phenolic compounds. These compounds continue to gain increasing importance in the context of health, with their natural antioxidant properties drawing more interest for the prevention and treatment of cancer, inflammatory diseases, and cardiovascular conditions (Kadri and Ziaina, 2020).

Materials and Methods

Objective of the Study

The objective of our work is to assess the quality of several varieties of olive oil consumed in Kabylie by determining and characterizing their physicochemical and organoleptic compositions. The entire study was conducted in the biochemistry laboratory of the Faculty of Sciences at the University of Saida Dr. Moulay Tahar, providing us with valuable learning experiences.

Sampling

Study Area Presentation

The olive oil samples used in our study were collected during the 2022-2023 olive oil campaign from several olive processing units located in the central regions, which are the most predominant in olive oil production in Algeria. These regions include Tizi Ouzou, Bouira, and Bejaïa, all of which are known for the Chemlal olive variety.

- Sample A: Olive oil from the Akbou region in the Bejaïa province.
- Sample B: Olive oil from the Ait Laziz region in the Bouira province.
- Sample C: Olive oil from the Michelet region (Aïn El Hammam) in Tizi-Ouzou (North-Central Algeria).
- Sample D: Olive oil from the Ouadhia region in Tizi-Ouzou (North-Central Algeria).
- Sample E: Olive oil from the Ouacif region in Tizi-Ouzou (North-Central Algeria).

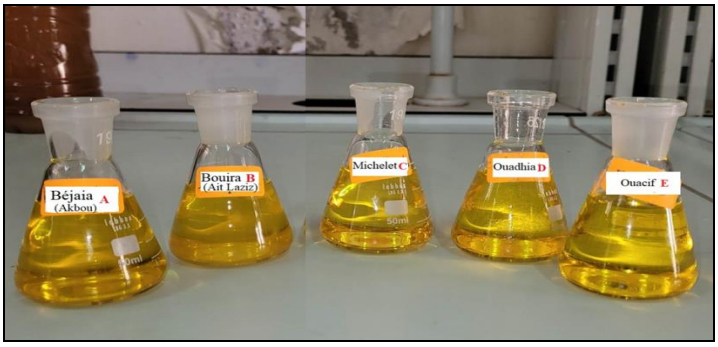

Figure n°01: Olive Oil Samples (at the Time of Analysis)

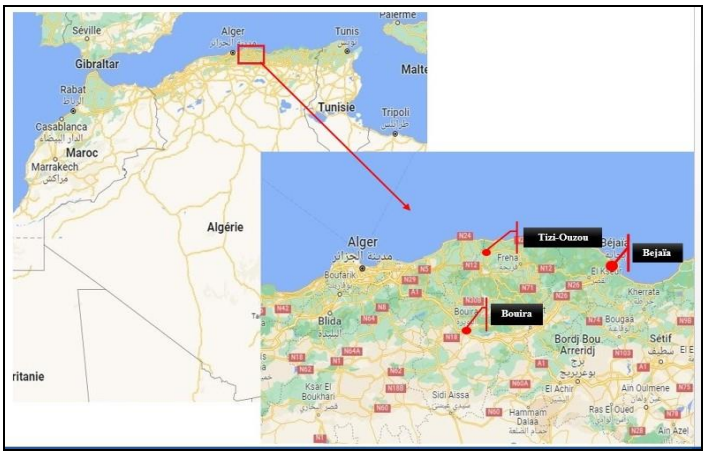

Figure n°02: Sampling Locations Map

Materials and Methods

Glassware and Equipment Used

Able n° 01 below provides a list of the glassware and materials utilized during the physicochemical analysis.

Table n° 01 :Glassware and Consumables Used in the Physicochemical Analysis**

Glassware	Equipment Used
- Glass beakers of various volumes: 50, 100, and 250 ml	- Distilled water spray bottles.
- Graduated burette of 25 ml	- Bulbs (pipettes).
- Glass Erlenmeyer flasks of various volumes: 100, 200, and 250 ml	- Forceps.
- Glass test tubes of various volumes: 10, 25, 50, and 100 ml	- Magnetic stir bars.
- Funnel	- Spatula.
- Watch glass	- Support stand (potence).
	- Aluminum foil.
	- Pipette.
	- Clean gloves.
	- Type 2 masks (respirators).

The following Table n°02 presents the list of equipment used to conduct the physicochemical analysis of the various olive oil samples.

Table n°02: Equipment Used in the Physicochemical Analysis

Equipment	Function
- Magnetic stirrers/heating plates.	- Magnetic stirring and heating.
- Analytical balance.	- Precise weighing.
- pH meter.	- pH measurement.
- Refractometer.	- Refractive index measurement.
- Thermometer.	- Temperature measurement.
- Drying oven.	- Heating and drying.

Reagents

Table n°03 below provides a list of the reagents employed in conducting the physico-chemical analysis of the various samples of olive oil.

Table n°03 : Reagents used in the physico-chemical analysis.

Reagents	Molecular Formula	Molecular Weight
- Ethanol	C_2H_5OH	46,07 g/mol
- Potassium hydroxide	KOH	56,1056 g/mol
- Phenolphthalein	$C_{20}H_{14}O_4$	318,32 g/mol
- Acetic acid	CH_3COOH	60,052 g/mol
- Chloroform	$CHCl_3$	119,38 g/mol
- Sodium thiosulfate pentahydrate	$Na_2S_2O_3,5H_2O$	158,11 g/mol
- Starch	$(C_6H_{10}O_5)n$	
- Potassium iodide	KI	166,0028 g/mol
- Cyclohexane	C_6H_{12}	84,16 g/mol
- Distilled water	H_2O	18,01528 g/mol

Analysis of the Physico-Chemical Characteristics of Oils

The olive oil samples obtained from the varieties studied in this research underwent physico-chemical analyses, including:

Physical Parameters

- Determination of pH (Hydrogen Potential)
- Determination of Moisture and Volatile Matter Content
- Determination of Refractive Index
- Determination of Chlorophyll and Carotenoid Content

Chemical Criteria

- Acidity Index and Free Acidity
- Peroxide Value

Organoleptic (Sensory) Characteristics

Sensory evaluation or analysis comprises a set of techniques used to assess sensory perceptions elicited by a product through the five senses (sight, hearing, smell, taste, touch). An "Expert" approach, involving a panel of individuals trained in sensory description, was employed. This approach allows for the description of products from an organoleptic perspective (Guerfi and Bechani, 2019).

The assessment of the sensory profile by the tasters

The evaluation of the organoleptic characteristics of our five olive oil samples was conducted by 15 volunteers. Each taster is required to smell and taste the oil under examination, assessing it for various sensory parameters, including color, appearance, odor, flavor, and taste.

Subsequently, the taster must record on a sensory profile sheet the intensity at which they perceive each of the positive and negative attributes. In the event that any unlisted negative attributes are detected, these should be noted under the "other" category.

Statistical Analysis

The analysis results were processed using Excel 2013.

Results and discussion

Results

Physico-Chemical Characterization

Physical Characteristics

pH Value

The distribution of olive oil samples based on pH.

The pH values range between 5.34 and 6.36.

The pH values of the samples are depicted in the following table and graph:

Table n°04: Distribution of olive oil samples based on pH.

Samples	A	B	C	D	E
PH	5.34	5.34	5.44	5.86	6.36

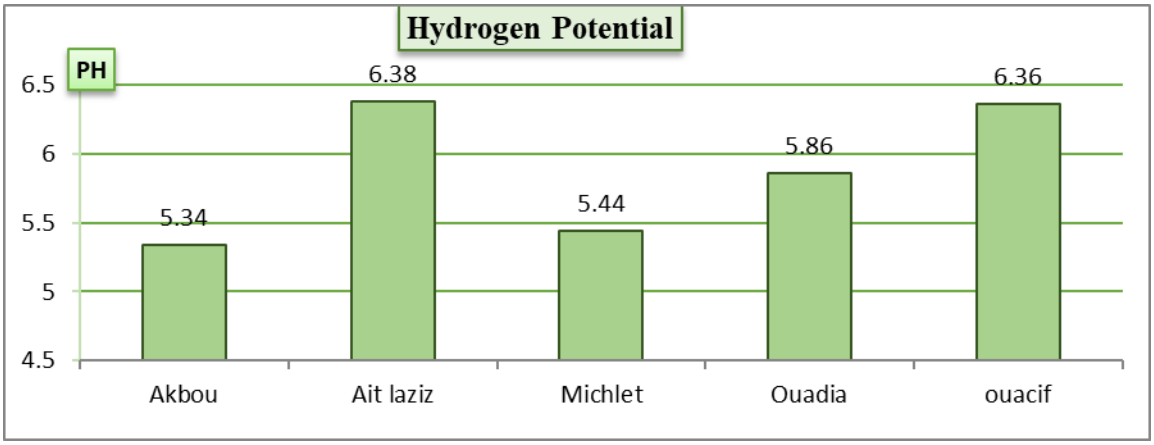

Figure n°03: Graphical Representation of the Distribution of Olive Oil Samples Based on pH

Moisture Content or Volatile Matter (TE)

Results of the moisture content in the six olive oils are provided in the table below.

Table n°05: Moisture Content of Analyzed Olive Oils

Samples	A	E
Moisture Content (%)	0,01	0,005
C.O.I	≤0.2%	

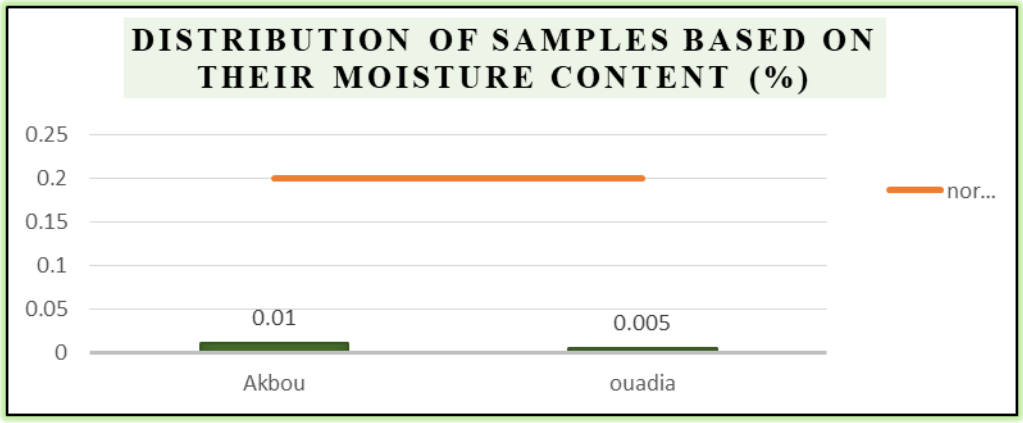

Figure No. 04: Graphical Representation of the Results of Moisture Content in Analyzed Olive Oils.

Chlorophylls and Carotenoids Content

The distribution of olive oil samples based on pigment content is as follows:

The highest content of chlorophylls and carotenoids corresponds to sample (A) from the Akbou region.

The lowest chlorophyll content is found in three samples (C, D, E) from the Michlet, Ouadhia, and Ouacif regions, respectively, all having the same content.

The lowest carotenoid content is found in sample (C) from the Michlet region.

The content of chlorophylls and carotenoids in the studied olive oil samples, expressed in (mg/kg), is represented in the following tables and graphs:

Table n°05: Distribution of olive oil samples based on pigment content.

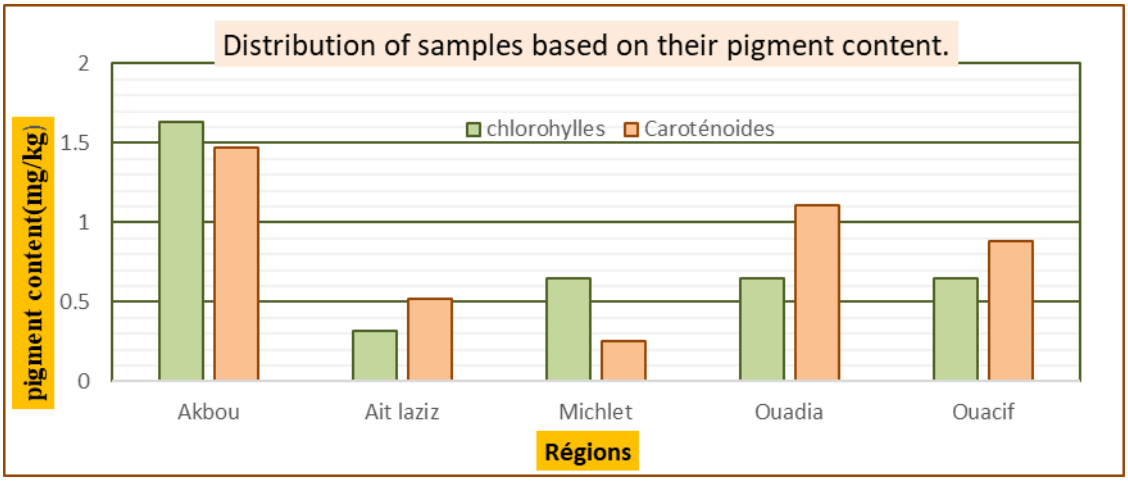

Figure No. 05: Graphical Representation of the Distribution of Olive Oil Samples Based on Pigment Content.

The Refractive Index

Measurements are conducted using a refractometer at a fixed temperature of 20°C. The table below summarizes the results of the refractive index of the analyzed oils.

Table n°06: Distribution of samples of analyzed oils according to the refractive index.

Samples	A	B	C	D	E
Refractive Index	1,46882	1,46878	1,46974	1,46892	1,46872
Standard (European Commission, 2013)	1,4677 – 1,4705 (nd20)				

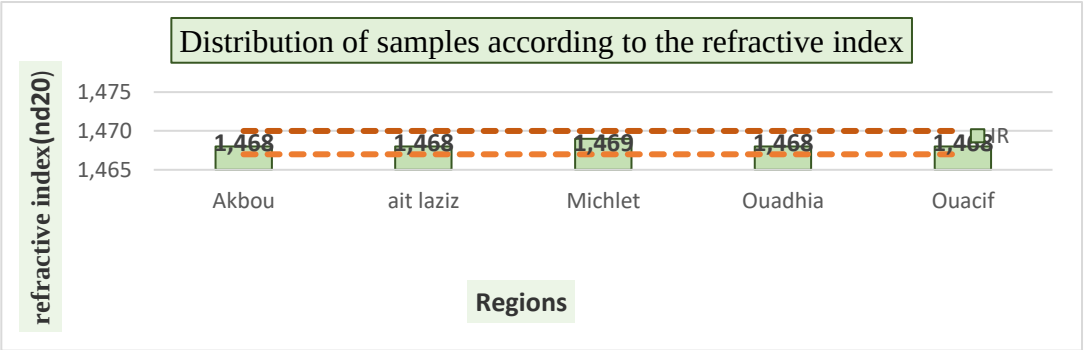

Figure No. 06: Graphical Representation of the Distribution of Olive Oil Samples According to the Refractive Index.

Chemical Characteristics:

Acid Value (AV) and Free Acidity (A)

Distribution of olive oil samples according to the acid value:

The highest acid value corresponds to sample D from the Michlet region, and the lowest to sample A from the Akbou region.

The results of the acid values for the samples are presented in the following table and graph:

Table n°07: Distribution of Olive Oil Samples According to the Acid Value.

Samples	A	B	C	D	E
Acid Value	1 ,90	2,8	3,7	3,3	3 ,1
Standard	< < 4.0 mg of NaOH per gram of oil				

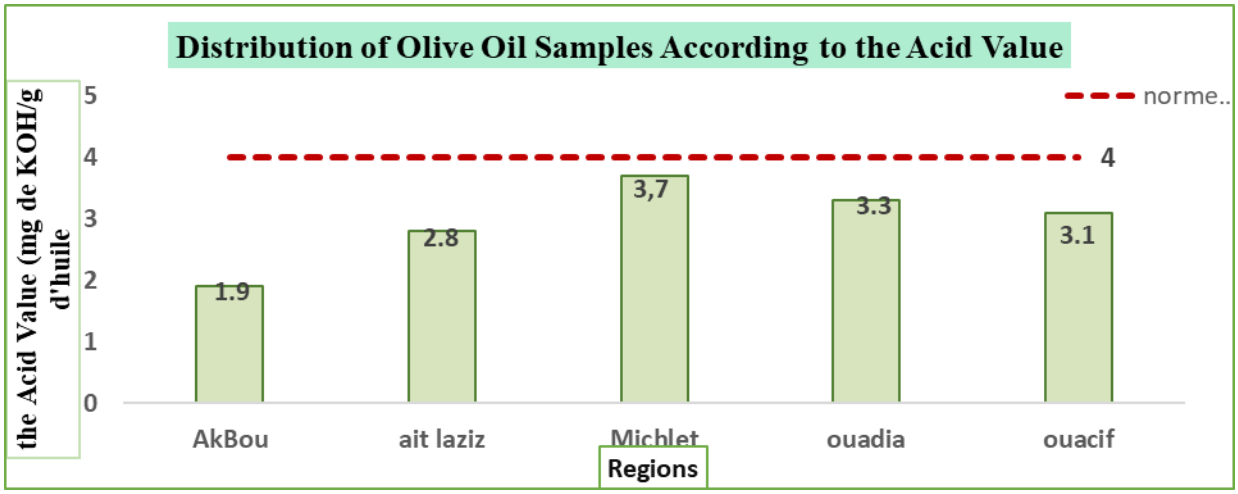

Figure No. 07: Graphical Representation of the Distribution of Olive Oil Samples According to the Acid Value.

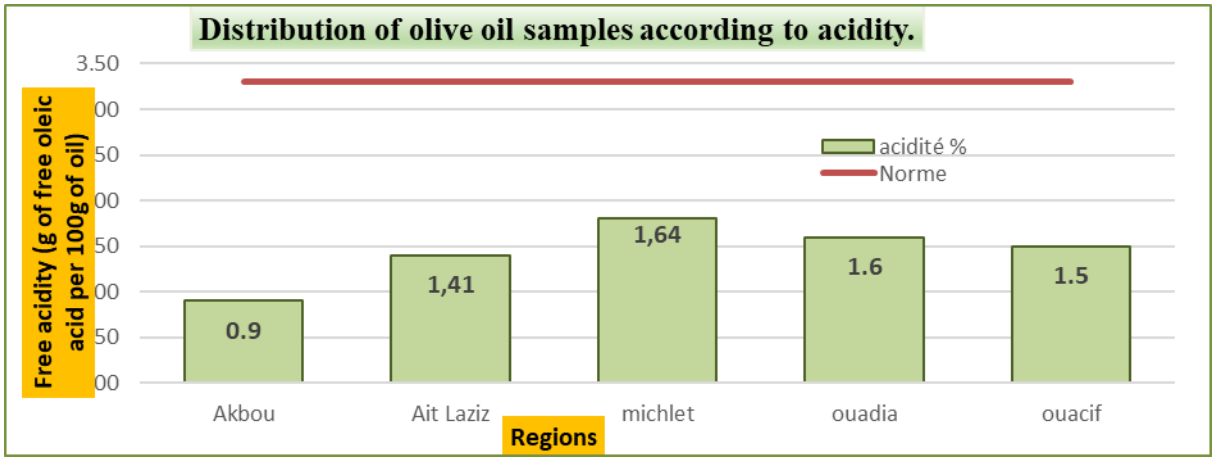

Figure No.08: Distribution of olive oil samples according to acidity.

Peroxide Value

Distribution of olive oil samples according to the peroxide value:

The highest peroxide value corresponds to sample C from the Bouira 02 region, and the lowest to sample B from the Bouira 01 region.

The results of peroxide values for the studied samples, expressed in milliequivalents of active oxygen per kilogram of oil (meq O2/kg of oil), are presented in the following graph.

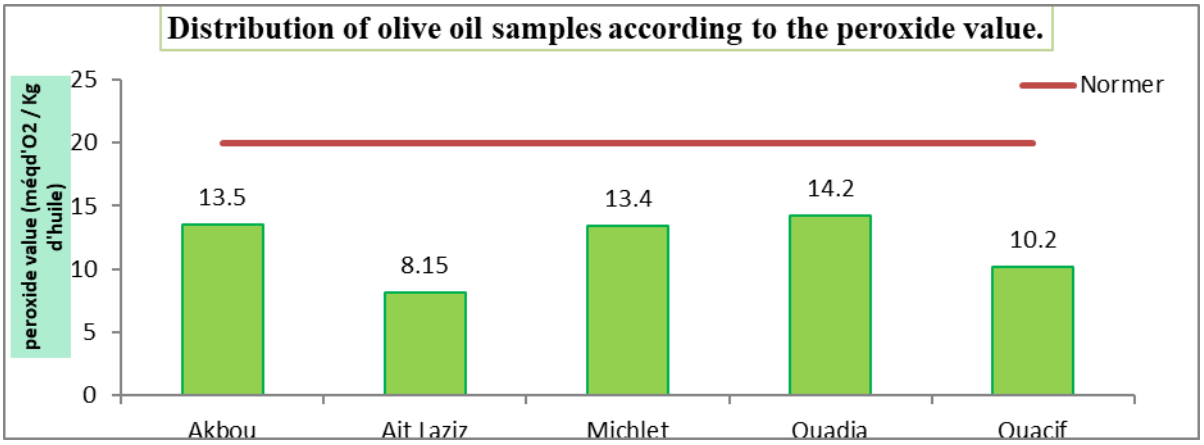

Figure No.09: Distribution of olive oil samples according to the peroxide value.

Sensory Analysis of Olive Oil:

Sensory analysis involves examining the organoleptic properties of olive oil, which include its color, aroma, flavor, and taste, as perceived by the human senses. Our panel of tasters consists of 10 voluntary individuals of Kabyle origin with diverse social backgrounds, adapted to various dietary habits.

The sensory analysis was conducted in accordance with the sensory evaluation method recommended by the International Olive Council (COI/T 20/Doc. N°15/Rev.8/November 2015).

The results of the sensory tests conducted are presented in the following table:

Table n°08: Sensory Analysis of the Studied Samples.

Samples / Characteristics	A Akbou	B Ait Laziz	C Michlet	D Oudhia	E Ouaciif
Color	Light Yellow	Yellow to Green	Light Yellow	Yellow to Green	Dark Yellow
Appearance	Moderate	Low with Sediment	Strong	Moderate	Strong
Odor	Acceptable	Pleasant	Unpleasant	Pleasant	Pleasant
Flavor	Moderate	Moderate	Poor	Good	Good
Taste	Fruity	Pungent, Bitter, and Fruity	Pungent	Fruity, Pungent	Fruity

Discussion

Physico-Chemical Characterization

Chemical Characteristics

Free Acidity and Acid Value (A%)

Free acidity is a quality parameter for olive oil (Lafraxo et al., 2021) that provides information about the condition of the fruit, i.e., how the fruit was handled before processing and the time elapsed between harvesting and milling (Borges et al., 2016).

The results for acid value and acidity in our five samples display values ranging between 1.90 and 3.70 mg of NaOH/g of oil and 0.9% to 1.8%, respectively. These values classify these oils as "virgin" olive oil according to the International Olive Council (IOC) standards (IOC, 2019).

Our findings align with the study conducted in Turkey by Demirag, O., & Konuskan, D.B. (2021), who obtained acidity levels mostly within the range of 0.8% to 2% for their samples.

Similarly, the research by Benrachou (2013), ADDOU S (2017), and Oudina and Baziz (2017) found values that meet the International Olive Council (IOC) standard, ranging from 2% to 3.2%.

However, the study conducted by S. Baghdadi, I. Mecharek (2021) recorded higher values (ranging from 2.26 to 5.81), often exceeding the limits set by the International Olive Council (IOC).

On the other hand, analyses carried out by Hadj, S. T., et al. (2018) on 26 varieties of Algerian olive oil showed acidity levels below 0.5%.

The increase in free fatty acid content can be attributed to several factors, including the hydrolysis of triglycerides that occurs in the olive when the fruit is damaged. Factors contributing to deterioration include mold, fermentation, overripe fruit, and olive fly. To produce low-acidity oil, it is necessary to process healthy olives quickly after harvesting (Kherchi and Mokhtar Ahdouga, 2018).

The acidity of olive oil is not perceived as a sour taste but rather through other organoleptic and sensory characteristics, indicating that the olives have undergone alterations. For instance, a musty taste and high acidity due to mold can elevate the acid content (Aoukli and Chettouhe, 2019).

Peroxide Value

Determining the peroxide content in oils allows for the assessment of primary oxidation levels that occur during storage and/or oil production (Tanouti et al., 2010). It is a highly practical criterion with satisfactory sensitivity to evaluate the initial stages of oxidative deterioration during storage (Gagour et al., 2022).

For "virgin" and "extra virgin" olive oil, the maximum acceptable peroxide value established by the International Olive Council (IOC) is 20 mEq of O2/kg. In our study, all samples displayed values below this limit, ranging from 8 mEq/kg to 14 mEq/kg.

Our results are quite consistent with the work conducted by Vekiari et al. (2010), Oudina and Baziz (2017), and NEKROUF, C. L., et al. (2019) on samples collected in the Tizi-Ouzou region.

Furthermore, our findings align with the research of Benrachou (2013), which presents peroxide levels ranging from 7.46 to 11.4 mEq/kg for three oils from three olive varieties (Limli, Bouricha, and Blanquette) from Eastern Algeria (Jijel, Bejaia, and Guelma).

Similarly, the work carried out by Meftah H. (2014) obtained values between 12.07 and 18.66 mEq/kg in oils from five different areas of the Tadla Azilal region (Morocco).

Additionally, Chalal (2019) reported very low values ranging from 1.72 to 6.32 mEq/kg for oil samples from the El-Adjiba region (Bouira). It's worth noting that a low peroxide value indicates that the oil was extracted quickly after harvesting and has been stored under proper conditions. Conversely, a high peroxide value may suggest issues with oil preservation.

However, the value of this index can decrease due to the decomposition of hydroperoxides into secondary oxidation products (Saidia, S., and Zedadra, N., 2021). It should be noted that the peroxide value increases with olive maturity and inappropriate or prolonged storage (Mohamed, M. Ben, et al., 2015).

Physical Characteristics

pH (Hydrogen Potential)

In the present study, the average pH values obtained from the five samples ranged from pH 5.34 to pH 5.86.

Our results are consistent with those obtained by Benekhama and Bourahla (2018), Oueld Mahieddine and Zireg (2021), and Attafi, Labreche (2022), who found pH values ranging between 5.68 and 5.8.

However, the results obtained by Ouksel and Nouri (2021) and Saidia and Zedadra (2021) were revealed to be higher than our results.

Moisture and Volatile Matter Content

The presence of water in oil can impact its quality and provide a favorable environment for enzymatic activities, especially the hydrolysis of triglycerides and the release of potentially respirable free fatty acids (Chalal, 2019).

The moisture content in the Bouira sample was estimated at 0.01%, and in the Ouadhia sample, it was 0.005%. These values indicate that these two oil samples do not exceed the specified standard of 0.20%. These recorded levels are lower compared to the results of Bouassila and Mayouf (2017), Benbekhma and Guessoum (2019), and Ould Mahieddine and Zireg Sarra (2021), which found values ranging between 0.1% and 0.2%.

However, regarding the analysis of the Bejaia, Bouira, and Michelet samples, we observed an increase in the mass of the test portion after repeated heating, indicating that auto-oxidation of the fat has occurred.

Chlorophyll and Carotenoid Content

Chlorophyll Content

Chlorophylls are responsible for the green-yellow color of olive oil and are used as indicators to assess the quality and longevity of olive oil (Martakos et al., 2019).

According to Gomez-Rico et al. (2007), chlorophyll levels decrease significantly during maturation until they are completely depleted in fully ripe olives.

The values recorded in our study are very low, ranging from 0.32 to 1.63 ppm. These low levels are desirable to prevent the pro-oxidative action of chlorophyll pigments and ensure the good preservation of the oils (Boulfane et al., 2015). Indeed, our results are similar to those reported by Tanouti et al. (2010) in Morocco and those of Louaguenouni, Hadjab (2021) and Baghdadi, I Mecharek (2021) conducted in the Tizi-Ouzou region.

Similarly, the work conducted by Ben Tekeya and Hassouna (2007) on olive oils of the Tunisian "Chétoui" variety mentioned chlorophyll contents ranging from 1.6 to 4.87 ppm.

However, the team of Benrachou (2013) recorded very high chlorophyll contents ranging from 10.03 to 13.53 ppm for three oils from three olive varieties (Limli, Bouricha, and Blanquette) from Eastern Algeria (Jijel, Bejaia, Guelma).

During oil storage, the chlorophyll and pheophytin profiles may undergo further changes. Pheophytinization of chlorophylls, which begins during oil extraction, progresses throughout oil storage, especially in the presence of light, resulting in a drastic reduction of chlorophylls (Díez-Betriu et al., 2023). Normal chlorophyll concentrations in olive oil should range between 0 and 20 ppm, contributing to the "fruity" taste of olive oil (Tanouti et al., 2010).

Carotenoid Content

The carotenoid results for the five oil samples studied in the Kabylie region fall below the range specified by the International Olive Council (IOC) between 2 and 14 ppm. The highest is in the Bejaia sample (1.47 ppm), and the lowest is in the Michelet sample (0.25 ppm).

These results align with those obtained by Ararbi, S., & Rahmani, (G. 2017) and Drici AD. E. (2019). The low recorded levels of these pigments are due to the rapid oxidation of carotenoids because of their high degree of unsaturation and the long chain of conjugated double bonds (Baghdadi, S., & Mecharek, 2021).

Additionally, the main factors affecting the pigment profile of olives are the variety (or cultivar) and the growth conditions. Another influence on the final pigment content in olive oil comes from specific oil production conditions, such as the malaxation step and oil extraction (Lazzerini, C., & Domenici, V. 2017).

Refractive Index

The refractive index values summarized in our study range from 1.4687 to 1.4697. These values meet the standards prescribed by the International Olive Council (IOC, 2019), which limits the refractive index to 1.470. Therefore, we can also conclude that the studied oils are pure.

Our results are close to those found by Mecherour, K (2018), Bouchireb, and Bouraoui (2018), as well as Nekrouf, Mendaci, and Berkoune (2019).

In fact, the refractive index varies depending on the length of the side chain and the degree of unsaturation of the fatty acids that make up the oil. It is also proportional to the molecular weights of the fatty acids, which provides a good indication of the possibility of oxidation (Metlef, 2021).

Sensory Analysis of Olive Oil

The organoleptic characteristics of olive oil are closely related to factors such as fruit variety, the degree of fruit ripeness at harvest, ecological factors, variations in fruit harvesting and storage operations, and the variability in olive oil extraction and storage processes. It's worth noting that the results of organoleptic tests remain subjective, as they require the assessment of a professional and experienced sensory panel for olive oil tasting (Nekrouf, Mendaci, and Berkoun, 2019).

The results of sensory analyses have revealed that all the oils studied have a yellowish color, except for the oil from Bouira, which has a greenish-yellow color. Their viscosity varies, with low viscosity accompanied by sediment, medium viscosity for the Bejaia (A) and Ouadhia (D) samples, and high viscosity for the Michelet (C) and Ouacif (E) samples.

In terms of taste, the Ouadhia (D) and Ouacif (E) samples are of high quality, exhibiting a good and fruity flavor, while the Michelet (C) sample has a poor taste with a bitter flavor and an unpleasant odor.

Conclusion

Through this study, we conducted a comparative physico-chemical and sensory analysis of olive oils produced in three provinces: Bejaïa, Bouira, and Tizi-Ouzou, originating from six regions. The physico-chemical characteristics of the olive oils were assessed through measurements of free acidity, peroxide value, chlorophyll and carotenoid contents, pH, moisture and volatile matter content, providing an initial assessment of the quality of olive oil consumed in the Kabylie region.

Based on the results obtained, we can conclude that the olive oils studied, originating from the five regions (Akbou, Lakhdaria, Michelet, Ouadia, Ouacif), exhibit certain physicochemical characteristics that conform to the standards of the International Olive Council, classifying them in the category of "virgin" olive oils, with the exception of sample E (C), which falls into the category of "ordinary virgin olive oil."

The acidity index of all samples complies with the standards established by the International Olive Council (IOC) for "virgin" olive oils.

The peroxide values of the samples meet international standards, indicating that these olive oils were extracted promptly after harvest and stored under proper conditions.

The analyzed oils exhibit low chlorophyll and carotenoid contents, likely due to advanced harvest stages and unfavorable conditions for olive storage and milling (temperature and milling duration).

Refractive index, moisture content, and pH conform to international standards for all the samples studied, indicating that all the analyzed olive oils are of good quality.

Finally, sensory analyses show that all the oils analyzed are suitable for consumption, but from the tasters' perspective, the olive oils from the Ouadhia and Ouacif regions in the Tizi Ouzou province are considered the best.

This work has allowed us to assess the quality of olive oils consumed, focusing on some physico-chemical characteristics. To evaluate the true quality of our oils and secure their place in the global olive oil market, it is essential to select the best olive varieties and cultivate them across the national territory, leading to Algerian Controlled Designation of Origin (AOC).

We also hope to expand this work with more comprehensive analyses, such as phenolic compounds, spectrophotometric absorption K232 and K270, sterol levels, volatile compounds, tocopherols, fatty acid profile determination, assessment of oxidative stability, and more.

References

[1] ABD ELKEBIR, O. E. D. L., & SAADIYA, D. (2020). Caractérisation morphologique de la variété Chemlal d'olivier (Olea europaea) de deux régions (M'sila et Bouira) et évaluation de la qualité de l'huile d'olive (Doctoral dissertation, UNIVERSITE MOHAMED BOUDIAF-M'SILA).

[2] Addou, S. (2017). Etude des paramètres physico-chimiques et organoleptiques de l'huile d'olives de la variété Siguoise dans la région de Tlemcen (Doctoral dissertation).

[3] Airoudj, S., Boubenia, M., Souyad, I., & Bekka-Hadji, F. E. (2021). Qualité, composition et activité antioxydante de l'huile d'olive vierge extra de quelques variétés algériennes (Doctoral dissertation, Université de Jijel).

[4] certaines huiles végétales (Doctoral dissertation, Université Mouloud Mammeri).

[5] ANOUAR, OUDINA Mohammed et ANIS, BAZIZ. Etude des caractéristiques physico-chimiques et biochimiques de trois échantillons d'huiles d'olives Algérien.

[6] Aouadi, A., & Arhab, R. (2020). Valorisation nutritionnelle et environnementale d'un sous-produit oléicole marginesvia la réduction de la méthanogènes ruminale.

[7] AOUKLI MANEL, N. O. R. E. L. D. J. I. H. A. N. E., & SOUAD, C. (2019). Etude et qualitative des huiles d'olive de la région de DJAAFRA (Doctoral dissertation).

[8] Ararbi, S., & Rahmani, G. (2017). Étude comparative des caractéristiques physico-chimique des deux variétés d'huile d'olive Azeradj et Chemlal dans deux régions de la wilaya de Tizi-Ouzou (Doctoral dissertation, Université Mouloud Mammeri).

[9] Baghdadi, S., & Mecharek, I. (2021). Etude de quelques caractéristiques physico-chimiques de quatre échantillons d'huile d'olive de la wilaya de Tizi-Ouzou (Doctoral dissertation, Université Mouloud Mammeri).

[10] Benbekhma, F., & Guessoum, M. (2019). Etude des propriétés physico-chimiques et de la stabilité oxydative d'une huile d'olive additionnée de quelques extraits naturels (Doctoral dissertation).

[11] BENRACHOU N. (2013). Etude des caractéristiques physicochimiques et de la composition biochimique d'huiles d'olive issues de trois cultivars de l'Est algérien. (Université Badji Mokhtar Annaba)

[12] BOUASSILA, L., & MAYOUF, M. (2017). Etude physicochimique et évaluation de l'activité antioxydante et antibactérienne de trois types d'huile d'olive issus de différentes méthodes d'extraction dans les régions de Kadiria et Lakhdaria de la Wilaya de Bouira.

[13] BOULFANE S., MAATA N., ANOUAR A., HILALI S. (2015). « Caractérisation physicochimique des huiles d'olive produites dans les huileries traditionnelles de la région de la Chaouia-Maroc ». Journal of Applied Biosciences. 87 (1) : 8022–8029.

[14] CODEX ALIMENTARIUS. (1981). Norme codex pour les huiles d'olive vierges et raffinées et pour l'huile de grignons d'olive raffinée. Codex STAN 33-1981 (Rév. 1989,2003, 2015).

[15] COI (Conseil Oléicole International). (1998). Edition et Diffusion par le Conseil Oléicole International. p 11-13.

[16] Commission Regulation (EEC) No. 2568/91 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis.

[17] CONSEIL OLÉICOLE INTERNATIONAL, Norme commerciale applicable aux huiles d'olive et aux huiles de grignons d'olive, COI/T.15/NC nº 3/Rév. 14 Novembre 2019

[18] Demirag, O., & Konuskan, D. B. (2021). Quality properties, fatty acid and sterol compositions of East Mediterranean region olive oils. Journal of Oleo Science, 70(1), 51-58.

[19] DRICI ADIL, D. E. (2019). Etude de qualité de l'huile d'olive algérienne: effet des conditions de stockage.

[20] Drici Salah Eddine et Drici Addil(2019).Etude de qualité de l'huile d'olive algérienne :Effet des conditions de stockage. Mémoire de master : Chimie-physique. Université de Guelma, p 1.

[21] Foscolou, A., Critselis, E., & Panagiotakos, D. (2018). Olive oil consumption and human health: A narrative review. Maturitas, 118, 60-66.

[22] Gagour, J., Oubannin, S., Bouzid, H. A., Bijla, L., El Moudden, H., Koubachi, J., ... & Gharby, S. (2022). Physicochemical characterization, kinetic parameters, shelf life and its

prediction models of virgin olive oil from two cultivars ("Arbequina" and "Moroccan Picholine") grown in Morocco. OCL, 29, 39.

[23] Hadj, S. T., Rebiha, K., & Terki, D. (2018). Caractérisation physico-chimique et organoleptique des huiles d'olive vierges de quelques variétés algériennes. Revue Agrobiologia, 8(1), 706-718.

[24] ISO 660 : 2020(F)

[25] Journal officiel de la république Algérienne N° 65, (2012), p13

[26] KADRI Chaima, Z. B. (2020). Etude comparative de la composition et l'activité antioxydante de l'huile d'olive disponible sur les marchés algérien et italien (Doctoral dissertation).

[27] KHERCHI Kaouthar, M. A. H. (2018). Caractérisation physico-chimique de l'huile d'olive issu des Maassaras de la région de Bordj Bou Arreridj (Doctoral dissertation).

[28] Lafraxo, H., Bakour, M., Laaroussi, H., El Ghouizi, A., Ousaaid, D., Aboulghazi, A., & Lyoussi, B. (2021). The synergistic beneficial effect of thyme honey and olive oil against diabetes and its complications induced by alloxan in wistar rats. Evidence-based Complementary and Alternative Medicine: eCAM, 2021.

[29] Lehara, H., & Mouheb, S. (2021). Effet du traitement thermique sur les caractéristiques physico-chimiques de l'huile d'olive « Traditionnelle » (Doctoral dissertation, Université Mouloud Mammeri).

[30] Lehouche, R. E., & Bouzidi, H. (2018). Evaluation de la qualité physicochimique de l'huile d'olive aromatisée.

[31] Louaguenouni, H., & Hadjab, B. (2021). L'effet de mode d'extraction sur la qualité d'huile d'olive de la variété Chemlal dans la région de Boudjimaa et Draa El Mizan (Doctoral dissertation, Université Mouloud Mammeri).

[32] Martakos, I., Kostakis, M., Dasenaki, M., Pentogennis, M., & Thomaidis, N. (2019). Simultaneous determination of pigments, tocopherols, and squalene in Greek olive oils: A study of the influence of cultivation and oil-production parameters. Foods, 9(1), 31

[33] MECHEROUR, K., & IDOUI, T. E. (2018). Huile d'Olive: Qualité, Activité Anti-oxydante et Anti-inflammatoire in vitro et in vivo (Doctoral dissertation, Université de Jijel).

[34] MEFTAH H., LATRACHE H., HAMADI F., HANINE H., ZAHIR H., EL LOUALI l M. (2014). Comparaison des caractéristiques physicochimiques des huiles d'olives issus de différentes zones de la région Tadla Azilal (Maroc). Journal of Materials and Environmental Science. 5 (2): 641-646.

[35] METLEF, S. (2021). Caractérisation et étude des activités antioxydantes et antibactériennes de l'huile d'olive algérienne (Doctoral dissertation).

[36] Mohamed, M. B., Boudiche, S., Kachouri, F., & Bornaz, S. (2015). Impact de la production biologique sur la qualité des produits agricoles et agro-alimentaires : Cas de l'huile d'olive et des tomates. J New Sci Agricult Biotechnol, 16, 932-936.

[37] NAHLA, Attafi, FATIMA ZOHRA BOUGHAMSSA ILYES, Labreche Bouchra, et FARIS, Mouhallel. Contribution à l'étude de la qualité d'huile d'olive de trois régions : Guelma

[38] NEKROUF, C. L., MENDACI, N., & BERKOUNE, O. (2019). Contrôle qualité de l'huile d'olive de la wilaya de Tizi-Ouzou.

[39] Niaounakis, M., & Halvadakis, C. P. (2006). Olive processing waste management: literature review and patent survey. P92

[40] Ouksel, H., Nouri, D., & Hamdouche, N. (2021). Etude de quelques caractéristiques physico-chimiques et l'activité anti oxydante de trois variétés de l'huile d'olive algérienne.

[41] Saidia Sana, Z. N. (2021). Contribution à l'étude de la qualité d'huile d'olive produite dans la région de Guelma.

[42] Tanouti, K., Elamrani, A., Serghini-Caid, H., Khalid, A., Bahetta, Y., Benali, A., ... & Khiar, M. (2010). Caractérisation d'huiles d'olive produites dans des coopérative pilotes (lakrarma et kenine) au niveau du Maroc Oriental. Les technologies de laboratoire, 5(18).

[43] Tekaya, M., Amel, M. B., Mechri, B., Ayadi, M., Aouina, M. B. S., Mkada, J., ... & Mezghani, M. A. (2022). Biochemical characterization of olive oil samples obtained from fruit mixtures and from oil blends of four cultivars grown in Central Tunisia. OCL, 29, 5.

[44] TIGHIOUART NEDJMA, L. R. (2020). Comparaison entre la qualité de l'huile d'olive disponible sur les marchés Algérien et Italien (Doctoral dissertation).