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Protected designation of origin and protected geographical indication: definitions, historic and characteristics of some certified olive oils in the Mediterranean countries

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Abstract

The scan of the studies realized about Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) olive oils of the Mediterranean countries showed that, despite the importance of the literature on food quality labels, reviews dealing with characteristics of labelled olive oil and joining the physicochemical properties with the regulation rules and the instructions of each specification are mainly unavailable. This study aims to consolidate the academic research state in the field of labelled olive oils (PDO and PGI) via determining the meaning of these labels, why they are used and the different regulations and specifications related to labelled olive oils. Moreover, this study takes into consideration many criteria such as varieties, specification instructions, sensorial properties…

Keywords: Olive oils; Protected designation of origin; Regulations, Specification, Physicochemical properties; Mediterranean countries

1. Introduction

The olive oil is a foodstuff extracted from the fruit of *Olea europea* L. The true origin of the olive is not known but is speculated to be Syria or possibly sub-Saharan Africa (Vossen Paul, 2007). It represents a typical high-value agricultural product and an exceptional lipid source. Many scientific studies have proved that olive oil is a healthy food with different uses and multiple benefits for the human body (Preedy and Watson, 2020). Since antiquity, the oil olive health-promoting effects are known due to its high oleic acid content but, currently, it is well established, that these effects are mainly due to its unique bioactive polar phenolic compounds (Kalogeropoulos and Tsimidou, 2014).

The use of oil olive for human consumption was very little recorded. Indeed, it was used primarily, by all cultures, as lamp fuel, which was its greatest value. It was also used to make soap and to consecrate the dead. Many rituals involved the use of olive oil for religious purposes. Fragrant olive oils were used as pharmaceutical ointments to cure diseases and to make the skin and hair appear healthier (Vossen Paul, 2007). Nowadays, both nutritive characteristics and health-promoting effects of olive oil have led to continuous growth in its consumption (Skiada et al., 2019).

Olive oil is constituting a valuable product produced on more than 9.4 million ha in the Mediterranean basin. The latter, which is the cradle of olive cultivation for more than 6000 years, concentrates more than 80% of the world's orchards and its countries generate 98% of the world's production of olive oil. The main producing countries are Spain, Italy, Greece and Tunisia, which concentrates most of the orchards in the Maghreb region (López-Feria et al., 2008, Tekelioglu et al., 2009, Vossen Paul, 2007).

The quality is an important parameter to evaluate olive oils and their classification. Different signs could identify the quality of olive oils. The sensorial properties, the odor, taste and color are the principal parameters, together with physical–chemical ones, for the evaluation of the sensory quality of this product. The origin of these characteristics is linked with the fruit variety, the grown region, the influence of environmental, agronomic and technological factors, etc. (López-Feria et al., 2008). In addition, the geographical indications (GI) are signs of quality used on products that have a specific geographical origin and

possess qualities or a reputation that are due to that origin. They are considered to be among the most powerful marketing tools available as the products bearing such labels attract premium prices (Likudis, 2016).
The protected designation of origin (PDO), one of the GI schemes regulated by the European Union, attributes the unique characteristics of a product to the geographical location in which it was entirely prepared, processed and produced (Pepi et al., 2017). The PDO-labelled products are a crucial strategic tool to enhance rural economy and development, through the added value of the PDO trademark, in terms of the higher price such products can occur (Skiada et al., 2019). As the Mediterranean countries are responsible for the majority of globally produced olive oil; it is, therefore, plausible that these countries have registered the most significant number of PDO and PGI olive oils (Likudis, 2016).

The current review summarizes different research on the PDO and PGI labelled olive oil and gives the reasons for proceeding with getting these certifications. It presents the characteristics of some certified olive oils from the point of view of varieties, regulations, physicochemical properties.

2. What are the official signs identifying quality and origin?
The official signs identifying quality and origin (SIQO) are distinctive European signs resulting from a set of approaches that associate quality and renowned products with their terroir such as the protected designation of origin, the appellation of controlled origin, the protected geographical indications… The SIQO ensure that agri-food products meet specific and controlled characteristics and thus allow consumers and buyers to identify these local products and producers to differentiate these products in the market by obtaining added value and protecting their reputation. The management of the SIQO is entrusted to the National Institute of Origin and Quality (INAO) in France.

The Protected Designation of Origin (PDO) designates agricultural products or foodstuffs that all the manufacturing stages (production, processing and development) are carried out using recognized know-how in a specific geographical area, which gives the product its characteristics. It guarantees that there is a link between the particular features of the production process and the geographical origin of the designated product (Dias and Mendes, 2018) (Parra-López et al., 2015)

The appellation of controlled origin AOC (Appellation d'Origine Contrôlée). is the French version of the PDO. It designates products that meet the criteria of the PDO. It is a step towards the European PDO label allowing the protection of the product on French territory, pending its registration and protection at European level.

The protected geographical indications (PGI) identify agricultural products or foodstuffs, raw or processed, which quality, reputation or other specific characteristics are closely linked to a determined geographical area. It consists that at least one of the stages of production, processing or preparation occurs in that area to be eligible for obtaining this official sign related to the quality and origin (Dias and Mendes, 2018, The National Institute of origin and quality, n.d.). The geographical indications in a globalized world play an important role in indicating the perfect link that is established between original region of a product and the product itself and in certifying a certain level of quality that is related to it. (Aboujeib and D'Auria, 2017).

Figure 1: Logos of signs identifying quality and origin PDO; (2) AOC; (3) PGI

3. Why using the official signs identifying quality and origin?
The official SIQO are used thanks to their numerous advantages as ensuring food differentiation and quality guarantee (Erraach et al., 2014). They enable the development of a differentiation strategy (as an alternative to the low cost) based on unique local factors born of tradition, know-how, and special agro-ecological endowments (Hadjou et al., 2013). For example, the specificity of the PDO or AOC is the protected notion and makes the identity of the product (Hadjou et al., 2013). The geographical indications are considered as means of protection for informal innovation as the protected subject matter is related to the product itself and not dependent on a specific right holder (Aboujeib and D'Auria, 2017). Additionally, The PGI could not be licensed,

assigned or transferred in the sense of most intellectual property rights. On the contrary, they may be used exclusively by those directly connected to the mentioned territory (Aboujeib and D'Auria, 2017).
It is to note that the SIQO are competitive tools that ensure several benefits for both producers and consumers as well as contributes to increasing the local economy.
In fact, the main benefits for consumers are that the food labels including PDO, AOC and PGI help them to judge a product correctly by delineating original products from fake or imitation ones and thus guaranteeing that the products are authentic articles (Aboujeib and D'Auria, 2017, Hajdukiewicz, 2014, Menapace et al., 2011). As it is known, labelled products are produced in accordance with the detailed specification mentioned in the scope statements which provides reliable information about the origin of products, their characteristics and their methods of production (Hajdukiewicz, 2014).

On the other hand, producers could take advantages from the use of food labels as these latter enable them to adapt production in order to meet consumer demands and expectations, promoting social or economic objectives (Menapace et al., 2011). Moreover, by using food labels, producers will be protected against unfair competition, able to offer more guarantees to final consumers (the product fit well with the instruction in the scope of statements and its traceability is guaranteed) and able to differentiate their products in foreign and international markets, especially by using geographical indications, and so improve their competitiveness and profitability (Hajdukiewicz, 2014).

As regards the local economy, the growing interest of consumers in quality leads to the growing demand for agricultural products and foodstuffs with identifiable and specific characteristics (in particular those which are linked to their geographical origin and their production method) and consequently, the labelled foods contribute to increasing sales through the same international distribution channel and allow the opening of new distribution channels (Hajdukiewicz, 2014). In addition, the market inadequacies associated with the supply of high-quality goods under asymmetric information could be resolved by the use of labelled food (Menapace et al., 2011).

4. Historic

The concept of “designations of origin” was created from the beginning of the 20th century to fight against fraud and to get out of the wine crisis. Thus, the “Controlled Designation of Origin” (AOC) was implemented to defend essentially the wine market by the decree-law of 1935 which formalizes the creation of AOCs as well as the body responsible for their definition, protection and control “INAO” (Institut national de l’origine et de la qualité). Thereby, France is the cradle of birth of the appellations of origin. Then, it was not until 1990, that the field was opened to all agricultural and food products to enable them to access this precious status, this recognition of know-how, an undeniable link to the soil. It was in 1992 that the European Union was inspired by the French approach of the AOC and have announced the creation of a common policy for the enhancement of agricultural production, the AOP which is the European equivalent of AOC and concerns all agricultural products excepted wines and spirits. As regards the PGI, it was implemented by European regulation in 1992 (Gautier et al., 2019, Paris, 2018, The National Institute of origin and quality, n.d.). In the olive oil field, the history of official designations of origin began in Spain in the 1970s when the olive oil crisis reached a critical point. So, in reaction to this crisis, Certain olive-growing areas, in Catalonia and Andalusia, have tried to react by opting for recognition of quality labels. Thus, successful initiatives were undertaken to promote a qualitative approach and the establishment of appellations for high-quality olive oils (Angles, 2007). These steps lead, in December 1974, to an extension of the legislation on appellations of origin in favor of olive production. The first AOC for olive oil was granted in October 1975 to a Catalan region under the name “Borjas Blancas” followed by the second one “Siurana” in the same region. In fact, oils of Catalan regions have a very old reputation for high quality due to their sweetness and the characteristic almond taste of the Arbequina variety. Thus, before the European Community instituted in 1992 its regulations on Protected Designations of Origin (PDO) and on Protected Geographical Indications (PGI), Spain had for some years 4 appellations of origin for olive oil with a well-established legislative and administrative framework. The European directive of July 1992 was a turning point in the development of designations of origin for olive oil because it offers a protective regulatory framework at the international level and marks a desire to promote quality agricultural production (Angles, 2007).

In Africa, the Maghreb countries, especially Morocco, Tunisia and Algeria, are working on the valorization and labeling of olive oil and trying to initiate designations of controlled origin or indications of source for their oils (Bajoub et al., 2014, Hadjou et al., 2013, Oueslati and Khaldi, 2009).

Moroccan oils are gaining a noteworthy international reputation. However, the process for adopting geographic indications systems in Morocco is still in its earliest stages. In fact, till October 2013, there was only one recognized PDO for the extra virgin olive oil (Tyout-Chiadma, located in the South of Morocco) and one official PGI (Ouazzane, located in the North of this country). Another PDO for the olive oil produced in Meknès territory is in the process of characterization of its typicality and it is expected that will enlarge the list in the near future (Bajoub et al., 2014, Bajoub et al., 2016).

The Tunisian olive oil varietal patrimony distinguishes itself by its richness. More than 50 different cultivars are found throughout Tunisia (Wali et al., 2021). Tunisia is currently aiming at the niche market of labels as these latter are considered to be among the most powerful marketing tools available and is seeking to establish origin-labelled olive oils from potential geographical indications (GI) areas (Laroussi-Mezghani et al., 2015, Mnasri Rahmani and Saddoud Debbabi, 2019).

The efforts made to enhance the value of Tunisian olive oils enabled the first quality sign for oils to emerge in the region of Monastir (Eastern coast Tunisia), obtaining the label of "IP" (Indication de Provenance) indication of Origin, and be published in the Official Journal of the State in December 2010. Later on, in 2018, the olive oil produced in Téboursouk (north-western Tunisia) was registered for the first time as a protected designation of origin (PDO). Other attempts are being carried out to implement new GIs for olive oil and not particularly for organic olive oil (Clodoveo et al., 2021, Grati Kammoun and Laroussi, 2013).
Algerian olive oil has some advantages that can be beneficial if they are valued within the framework of a geographical indication: orchards which mainly extend in mountain terroirs, differentiated and quality product, varietal diversity, a good image at the national level and oil from extensive cultivation that respects the environment, Nevertheless, these assets seem insufficient to allow a better valuation of the products. There by, Algeria still trying to overcome weaknesses in the olive sector. It is to note that certain attempts at collective coordination on the basis of a specific quality enhancement (AOC, label, organic production) were initiated. However, and in the absence of immediate positive fallout, these attempts remain in an embryonic and experimental state (Boudi et al., 2013, Hadjou et al., 2013).

5. Principle characteristics of PDO/PGI olive oils in the Mediterranean countries

The Mediterranean countries registered a large number of PDO/PGI olive oils and that thanks to their huge production of olive oil as reported by Likudis (2016).
The labelled olive oils especially those certified PDO or PGI have typical characteristics which are attached to the terroir and constituting the added value of a PDO/PGI product. The origin of these characteristics is linked to many reasons mainly the fruit variety, as each variety had its typical volatile compounds responsible for smell and taste, the grown region, the agronomic and environmental factors, etc. (López-Feria et al., 2008).

5.1. Varieties

The olive varieties constitute a fundamental criterion since the originality of the oils is based, in part, on the varietal specificities within a terroir (Angles, 2007).
The most influential oil varieties in the world are 'Arbequina' and 'Picual' from Spain, 'Coratina', 'Frantoio', and 'Leccino from Italy, 'Koroneiki' from Greece, 'Aglandau' and 'Picholine' from France and 'Chemlali' from Tunisia. Nevertheless, many of other varieties exist, most of which are confined to small regional areas (Vossen Paul, 2007).
For several years, the 'Arbequina' has been the most widely planted variety. The 'Koroneiki' is the primary oil variety of Greece, producing excellent oil, and having annual heavy cropping (Vossen Paul, 2007).
The "Chemlali" variety is the most important in Tunisia situated in the center and south of the country. It represents 80% of the Tunisian production of olive oil and occupies more than 2/3 of the area reserved for olive growing. (Abaza et al., 2002, Clodoveo et al., 2021).

The olive oils could be classified in two groups which are mono-varietal olive oils which are those that has been crafted from a single variety of olive (with a very low percentage for a few secondary varieties) and multi-varietal or blended olive oils which are those that has been made by mixing a variety of olives.

In the oils labelled "PDO" the olive orchards are often multi-varietal with a few main cultivars (2 to 4 in general) and secondary varieties, which is especially the case of Italy where the mono-varietal appellations are much rarer. On the other hand, in Spain, 50% of the PDO olive oils are mono-varietal, whereas in France two designations recognizing monovarietal olive oils (Tanche and Cailletier for PDO Nyons and Nice, respectively);

two designations recognizing oils with strong dominance of a particular variety (Aglandau and Picholine for PDO Haute-Provence and Nîmes, respectively); and four appellations recognizing multi-varietal oils. As regards to Greece and Portugal a national variety predominates for each country (Koroneiki and Galega for Greece an Portugal, respectively) (Angles, 2007, Paris, 2018).

In Morocco, both PDO and PGI labelled olive oils ("Tryout Chaydma" and "Ouazzane", respectively) are mono-varietals and constituted only from the variety "Moroccan Picholine" (Bajoub et al., 2016).
In Tunisia, the quality signs attributed for oils till now are mainly mono-varietals. In fact, the first PGI "olive oil from Monastir" is constituted from "Chemlali" variety (98%), whereas the first PDO "olive oil of Teboursouk" is constituted mainly from "Chetoui" variety (85 to 94%). It is to note that the most popular cultivars in Tunisia are Chemlali in the central and southern parts and Chetoui in the northern regions and that these two varieties contribute to more than 95% of the national olive oil production (Gargouri et al., 2016, Grati Kammoun and Laroussi, 2013, WIPO, 2020).
Thus, through the appellations process, even unknown or low-yielding varieties gain added value, thanks to their specific characteristics, and will not disappear in favor of more productive varieties (Paris, 2018).

5.2. Regulations
The legal framework and the agricultural policies put in place in the Mediterranean countries contribute to improving the provision of their products and to supplying local and foreign markets with quality products.
Face to health crises, the European solution consisted of promoting quality and origin certifications and reforming the regulatory system in terms of health safety. Thus, in 1992, the European Union adopted a series of regulatory texts relating to systems for the protection and enhancement of agri-food products (Tekelioglu et al., 2009).

The composition of the texts recognizing PDOs constitutes a relevant corpus for comparing the different approaches that each country intends to put in place to obtain this label under the same European regulations (Angles, 2007). For example, in France, the recognition of a PDO goes through a public administration, the National Institute of Designations of Origin (l'Institut national des appellations d'origine : INAO), whereas in Spain, the management of a PDO takes place within the framework of a Regulatory Council (consejo regulador) under the supervision of the Regional Administrative Authority which manages the agricultural sector (Lamani et al., 2015).
The regulatory texts of PDO olive oil seemed similar in general but a comparative study could show the fundamental place given to regulatory advice for Spanish PDOs, the strict regulation of cultivation practices in France and the very precise scientific characterization of oils in Spain and Italy (Angles, 2007). (Table 1)
The European regulations specifically prohibit, for olive oil, any mention of an origin other than the European Union or a third country outside the PDO and PGI designation systems. Indeed, it is generally possible to determine the variety but it is impossible, apart from the control systems for appellations or indications, to establish that the olive oil comes from a particular area (Paris, 2018, Pouyet and Ollivier, 2014).

Regards to varieties mention, it differs from a country to another. For example, in French and Italian regulations, the percentages of olive varieties are very strict whereas in Spanish, Portuguese and Greek texts these percentages are indicative. In the five cited countries, the varietal indication, generally quantified as a percentage of the number of olive trees, is precise and respectful to the rules of place indication (Angles, 2007).
The cultivation methods appear in the regulatory texts of PDO olive oils with the main aim of keeping traditional olive growing (Angles, 2007).

But each country has specifications containing different instructions for good agricultural practice that differ from a country to another as mentioned in Table 1. It could be concluded that, in France, the specifications are very strict in terms of cultivation practices in order to offer additional quality guarantees to consumers and to give confidence to producers to maintain their know-how and their culinary and social heritage (Lamani et al., 2015).

For African countries containing PDO olive oils such as Tunisia and Maroc, their regulatory texts and specifications are similar to those in France where the regulation of oils is mainly based on what to do and how to obtain the product (from harvesting the olives to crushing) (Lamani et al., 2015, WIPO, 2020).

Table 1: The PDO regulations in France, Spain and Italy

Country	PDO regulations
France	Informative and detailed texts • Delimitation of the area and orchards • Accuracy of numerous arboricultural indications (density, irrigation, varieties, yields, harvests) • Indication of oil standards (manufacturing methods, acidity rate) • Mention of the rules on labeling and presentation of the label.
Spain	Very complete collections • A chapter on production (delimitation of the area, varieties of olive trees, cultivation practices) • A chapter on the production of oils • A chapter on a precise description of the characteristics of the oils • A chapter on the registration of olive growers • A last and long chapter on the organization of the regulatory council.
Italy	Short texts • The varietal inventory • A detailed description of the appellation area • The cultivation practices • The production of oils • The organoleptic and chemical characteristics of the oils • The labeling information.

5.3. Physicochemical and sensorial characteristics

To get an idea about the physicochemical and sensorial characteristics of some PDO olive oils in the Mediterranean countries, the authors choose to select an example of a PDO olive oil from each Mediterranean country to elucidate its properties.

- **Spain**

According to Spanish regulations, the evaluation of a PDO olive oil is based on 5 chemical criteria which are acidity, peroxide value, extinction coefficient K270, moisture and impurities (Angles, 2007). The example chosen to be detailed in the current study is the labelled oil olive “Siurana” which is made from the ‘Arbequina’ variety. This latter is characterized by a very aromatic oil with a clean, fresh, herbal olive flavor, often with apple, sweet almond, and artichoke undertones, and with a very light pungency and bitterness. (Tous et al., 1997), Vossen Paul (2007) analyzed the PDO olive oil “Siurana” and showed that it was characterized by a free acidity in the range of 0.2, a K270 between 0.16 and 0.17 and a stability reaching 6.16 to 8.55 hours in 120°C. in fact, the oxidative stability is a parameter that measures the resistance to oxidation of an oil, and is of great importance to assess its state of conservation and commercial quality. The composition of Siurana PDO olive oil in fatty acids was between 69.5 and 72.4% for oleic acid (C18:1), between 13.82 and 15.3% for palmitic acid (C16:0), between 10.2 and 11.4% for linoleic acid (C18:2), between 1.82 and 1.99% for stearic acid (C18:0), and between 1.14 and 1.59% for palmitoleic acid (C16:1) (Tous et al., 1997). Becerra-Herrera et al. (2018) proved that a high phenolic content was found in the Arbequina cultivar from PDO Siurana (181 mg/Kg) and that Hydroxytyrosol, 3,4-DHPEA-EDA and Secoiridoids 3,4-DHPEA-EA were the main phenolic compounds, showing high concentrations with values of 42, 93 and 122 mg/kg, respectively. The findings of Tous et al. (1997) showed that Siurana oils could reach 205 to 319 mg/Kg of polyphenol content. This parameter is closely related to sensory characteristics, as it is responsible for the itching and bitterness of virgin olive oils (Ojeda and Fernández, 1994).

- **France**

In the French regulations, the characteristics of the oils are reduced to a rather high fixation of the maximum acidity (expressed as oleic acid) between 0.8 and 1.5 % g/100 g of oil. The French texts do not specify any evaluation for the panel-test (Angles, 2007). The other physico-chemical data of the AOC oils are not fixed except for the acidity which is very insufficient to characterize them from a physicochemical point of view (Ollivier et al., 2003). The AOC "Huile d'olive de Nyons" is the oldest of the French olive oil appellations of origin. It was recognized as a Protected Designation of Origin (PDO) at the European level in 1996 (Ollivier et al., 2003). Oils bearing this designation must come exclusively from the "Tanche" variety with the possibility of having a maximum of 5% by weight of olives from pollinating varieties. The specific extinctions in the ultraviolet (K232 and K270) of the AOC "Huile d'olive de Nyons" present generally low values clearly lower than the limits

of the category "virgin olive oil". These oils are characterized by a high level of oleic acid (79.44%) and low in palmitic (8.68%) and linoleic (5.80%) acids. The triglyceride composition is also characterized by high levels of triglycerides consisting of oleic acid: triolein (OOO), palmityldiolein (POO) and linoleyldiolein (LOO). The β-sitosterol is the main sterol of the oils accompanied by Δ5-avenasterol (Ollivier et al., 2003).

- **Italy**

The Italian regulations differ according to the appellations but they insist above all on the following criteria: the acidity which must be between 0.5 and 1%, the peroxide value, the specific extinction coefficients (K270 and K232), the minimal content in oleic acid, impurities and polyphenols (Angles, 2007). The Brisighella PDO extra virgin olive oil is obtained from the Nostrana di Brisighella, a variety exclusively grown in Brisighella area of the Emilia-Romagna region, in the north of Italy, which must make up at least 90% of the olive groves (Barbieri et al., 2019). The chemical quality parameters such as free acidity, peroxide value, and specific extinctions (K232, K270) are valuable olive oil freshness indices that confirm the good overall quality of these oils. The values of Brisighella PDO olive oil were under the respective limits established for EVOOs and, specifically, under the stricter limits established by the product specification of Brisighella PDO, which confirms the excellent quality of the raw material (Barbieri et al., 2019). In fact, the studied samples showed free acidity, peroxide value, K232 and K270 lower than the fixed limits for Brisighella PDO (0.5%, 13 mEq kg^{-1}, 2.0 and 0.20, respectively) (Barbieri et al., 2019). The fatty acid composition confirmed that all the samples belong to the Extra virgin olive oil category and highlights the high values of oleic acid (between 74.56 and 77.88%) and rather low values of the main polyunsaturated fatty acid, linoleic acid (lower than 7.59%) (Barbieri et al., 2019). The sensory profile of samples obtained from Nostrana di Brisighella cultivar showed a medium intensity of fruity, a medium-intense perception of bitter and an intense sensation of pungent, Regarding the secondary positive attributes, these samples showed clear notes of artichoke, grass and tomato (Barbieri et al., 2019). Regarding the total content in phenolic compounds, Barbieri et al. (2019) reported that values were ranged between 256.34 and 433.83 mg of tyrosol kg^{-1} of oil whereas Antonini et al. (2015) reported that Brisighella PDO oil showed the highest phenolic content and met the EU health claim for phenol concentration.

- **Greece**

The oil of Greece is mostly from Koroneiki variety, which is a very hardy drought resistant variety that sets a very heavy crop almost every year and does very well in the hot dry summer climate. Its fruit are very small and well attached to the tree (Vossen PM, 1999). The 'Koroneiki' oils are high in polyphenols, very stable, and very aromatically fruity with herbaceous and green banana characteristics (Vossen Paul, 2007).

Geographically speaking, the Koroneiki cultivar is the indigenous variety in Messinia, a small seaside village southeast of Messinia, which is the dominant olive-growing area of Peloponnese. The "Kalamata"olive oil is an oil produced in the province of Kalamata and situated in the area covered by the PDO (Skiada et al., 2019). The Kalamata olive oil should response to the PDO status limits. In term of acidity, it must not exceed the threshold of 0.50%, for the peroxide value the upper limit for Kalamata PDO olive oils is 14 meq O2 kg^{-1}**.** Likewise, K232 and K268 values had to not exceed 2.2 and 0.2 respectively. In general, these parameters depict the highest quality of Kalamata olive oil (Skiada et al., 2019). An important parameter for the quality and characterization of olive oil is the fatty acid composition. This latter must be within the normal range expected for the EVOO category and obeying to the PDO kalamata olive oil limits which are between 70 and 80% for oleic acid (C18:1), between 10 and 15% for palmitic acid (C16:0), between 4 and 11% for linoleic acid (C18:2), between 2 and 4% for stearic acid (C18:0), and between 0.6 and 1.2% for palmitoleic acid (C16:1). The percentage of the monounsaturated oleic acid depicts the beneficial health impact and the competitive profile of Kalamata PDO olive oils to the olive oil market (Skiada et al., 2019).

Phytosterols are important components of the unsaponifiable fraction of olive oil beneficial for the human health and nutrition. Sterol composition and content are broadly used for the control of olive oil authenticity and adulteration. Moreover, it was proved that each variety has a characteristic sterol "fingerprint" (Mohamed et al., 2018). The total sterol content should exceed, according to the PDO limits status of Kalamata olive oil, the value of 1100 mg/Kg and the apparent β-Sitostérol, which is the most abundant phytosterol of the total sterol content) should exceed the value of 93.0% (Skiada et al., 2019).

- **Portugal**

Portugal is one of the ten largest olive oil producers in the world. The chemical rules of the Portuguese appellations appear to be more exhaustive: absorbance with K270, K232 and delta K; content of waxes, sterols, cholesterol, brassicasterol, campesterol, sigmasterol, betasitosterol, stigmasterol; detailed composition of fatty acids including the percentage of free oleic acid (less than 1%) (Angles, 2007). Trás-os-Montes, located in the northeast of Portugal, is among the most productive regions of olive oil. Several factors comprising the region

climate conditions, the existence of dominant varieties, the soils, the traditional production techniques and the high quality of the final product led to the creation of a PDO olive oil with the designation of "Azeite de Trás-os-Montes" (Amaral et al., 2010). Four olive varieties are authorized for the production of this PDO olive oil, namely Cobrançosa, Madural, Verdeal Transmontana (also known as Verdeal) and Cordovil. These varieties, except Cordovil, account for more than 90% of olive cultivation in the region (Amaral et al., 2010, Matos et al., 2007). Casal et al. (2010) reported that the PDO Azeite de Trás-os-Montes showed a free aciditiy, a peroxide value, K232, K270 and an oxidative stability in the order of 0.2%, 11 meq O2 kg^{-1}, 1.66, 0.20 and 16h24min, respectively. Regards the physicochemical characteristics of the PDO Azeite de Trás-os-Montes, Albuquerque et al. (2019) showed that for the polyphenols content, the α-tocopherol, the total vitamin E and the β-carotene the values were in the range of 128 to 188 mEq gallic acid /kg, 95 to 260 ppm, 102 to 270 ppm and 2.96 to 7.97 ppm, respectively. In the same context, Casal et al. (2010) found the following values: 204 mEq caffeic acid/kg, 179.9 ppm, 189 ppm and 5.2 ppm, respectively. For the acidic composition, expressed in g/100 g of fatty acids, the oleic acid (C18:1) was between 72.7 and 77.3, the saturated fatty acids between 13.4 and 14.9 and the trans fatty acids were found in very low quantities which should not exceed 0.03 (Albuquerque et al., 2019, Casal et al., 2010). The PDO Azeite de Trás-os-Montes is characterized by its fresh and fruity taste, with hints of almond and notable sensations of sweetness, some bitterness and spiciness (Albuquerque et al., 2019). The Portuguese appellation, as well as the Spanish and Italian appellations, specify a minimum score in the test panel (above 6.5 to 7), while the French and Greek appellations do not require any evaluation for this panel (Angles, 2007).

- **Tunisia**

Tunisia is among the leading producing countries of olive oil as it is the fourth world producer (6%) and the fourth world exporter (8.2%) of olive oil after Spain, Italy and Greece(Laroussi-Mezghani et al., 2015). So far, Tunisia has only one olive oil labelled AOC which is the olive oil of Teboursok. This oil is an extra virgin olive oil obtained exclusively from indigenous varieties mainly made up of the Chetoui variety (from 85% to 94%), the Jerboui variety (from 5% to 10%) and other indigenous varieties (from 1 to 5%) (Clodoveo et al., 2021, WIPO, 2020). The geographical area conferring the granting of this AOC covers the geographical zone bounded by the Zeldou mountain to the north, the Chid mountain to the south-east and the Thibar relief to the north-west and south-west (WIPO, 2020). Regarding the physicochemical properties of the Teboursok olive oil, and in addition to the characteristics set by the decree of May 26, 2008, the free acidity expressed as a percentage of free oleic acid must be less than 0.5%. The acidic composition expressed as a percentage (m/m of methyl esters) must obey certain limits. In fact, the composition of major fatty acids such as palmitic acid and linoleic acid must be less than 14% and 16%, respectively, whereas the oleic acid must exceed 65% (WIPO, 2020). The Teboursok olive oil must not present any taste defects and is characterized by a very aromatically fruity with one or more particular aromas is detected: forest fruits, aromatic herbs and blackcurrant. The organoleptic properties of this oil are measured by the taste evaluation scale ranging from 1 to 10 with the fruity medians located in the light medium to medium categories (from 3 to 6) the bitterness medians in the light to medium categories (from 1.5 to 4.5) and the medians of spiciness in the light to medium category (from 1.5 to 3.5) (WIPO, 2020).

- **Morocco**

The Moroccan oils show a wide range of peculiar characteristics which mainly depend on the pedoclimatic conditions and the production process of the predominant olive variety 'Picholine Marocaine' cultivated in this country (Bajoub et al., 2014, Bajoub et al., 2016). The Tyout-Chiadma extra virgin olive oil from the region of Essaouira was the first receiving the designation PDO in Morocco in 2010 (Bajoub et al., 2016). The geographical area of the TYOUT-CHIADMA olive oil PDO covers a part in the South of the rural commune of Meskala (Chiadma tribe) and a part in the North of the rural commune Zaouita (Haha tribe) (RAIF et al.). The orchard concerned by the product Tyout-Chiadma is characterized by its cultural history and the quality of its oil. It presents a cultivated surface of only 100 ha, which includes more than 12,000 centenarians' olive trees and corresponds to a very limited production (approximately 20 tons of 'Picholine Marocaine' extra virgin olive oil per year) (Hmida, 2016). The olive production is conducted under the irrigated system, and oil extraction is made by means of a peculiar production process (Bajoub et al., 2016). The experience of the Tyout-Chiadma PDO is in line with international regulations. The specifications of this oil are very precise in terms of conduct and method of obtaining the product (from the harvesting of the olives to the crushing). These conditions are similar to those of the Nyons PDO in France (Lamani et al., 2015). The PDO olive oil Tyout Chiadma respect the following chemical characteristics: a free acidity less than 0.4%, a peroxide value less than 15 mEq kg^{-1} and a moisture less than 0.2%. Regards the acidic composition, the palmitic acid (C16:0), the oleic acid (C18:1) and the linoleic acid (C18:2) should be in the ranges between 10% to 12%, 65% to 70% and 14 to 18%, respectively. The linoleic acid (C18:3) must not exceed 1% whereas the saturated, the monounsaturated and the

polyunsaturated fatty acids must be in the ranges of 11% to 14%, 67% to 72% and 15% to 18%, respectively (Bendriss, 2010). Sensory profile of Tyout Chiadma olive oil is medium fruity (3 to 4.5) and medium balanced in bitterness (2.7 to 4) and in spiciness (2.5 to 3.7) with pronounced aroma of tomato and cardoon (Bendriss, 2010).

Conclusion

The current review is interested in the Mediterranean olive oil such it is one of the most essential elements of the diet in the Mediterranean basin. It put into relief the importance of labels linked to origin such as the protected designation of origin and protected geographical indication as they provide means of promotion and protection for quality olive oils in the face of a very competitive oil market. France is the cradle of birth of the appellations of origin. Thus, the "Controlled Designation of Origin" (AOC) was implemented to defend the wine market essentially via the national institute of origin and quality "INAO". In the olive oil field, the history of official designations of origin began in Spain in the 1970s when the olive oil crisis reached a critical point then this process of protection and labelling spread to several countries Each State has established its PDOs with its own regulations and these allow us to perceive various approaches and approaches within European olive growing. Thus, in the European countries, the labels linked to the origin of the olive oil have multiplied with detailed specifications. On the other hand, the African countries of the Mediterranean remain in development and are still in their first step to obtain labels for their oils which are of good quality.

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