HEALTH CLAIM & EXCELLENCE ON OLIVE OIL FROM ALL PERSPECTIVES

Capacity Building for Health Claim Olive Oil Stakeholders

ARISTOIL CAPITALIZATION

ΙΔΡΥΜΑ ΚΡΑΤΙΚΩΝ ΥΠΟΤΡΟΦΙΩΝ IKY

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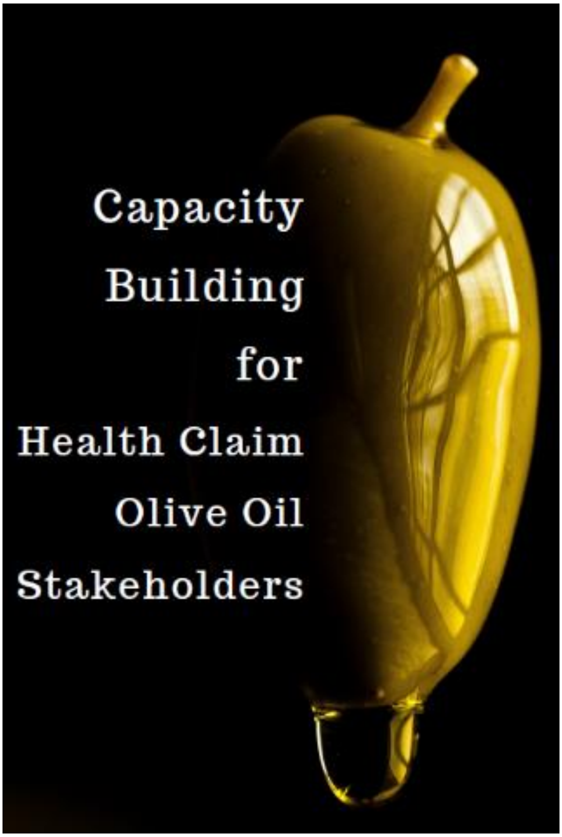

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PREFACE

This book was written within the scope of Aristoil Capitalisation project in order to provide useful information to farmers, industrialists, marketers and consumers beyond the known and repetitive informations by approaching olive cultivation and olive oil production/marketing/consumption with different perspectives.

Forehead is the most valuable input for every production. Every process from olive cultivation to olive oil production is a process that requires a high degree of effort and care and involves risks. It is necessary for this effort, investment and effort to reach the consumers in the most valuable way and for the sustainable existence of production. It is precisely at this point that high quality olive oil production works like a key, opening up impossibilities and constraints. High quality olive oil also provides beneficial effects for consumers as it can provide labeling with a health claim. In addition, the health claim provides the quality of being even higher in both marketing and quality products. In this way, the producer can increase the profit and the consumer can increase the health benefits from olive oil.

Although there are difficulties in olive cultivation and olive oil production and there are high competitive conditions, producers should not lose hope and insist on producing ordinary products. It should not be forgotten that each difficulty can be transformed into new opportunities and advantages with scientific–based solutions. In this context, production of olive oil of quality that may contain a health claim will provide new opportunities.

It is not possible to solve the problems of the olive cultivation and olive oil industry only with this book. However, the world still needs as much benefit as those who read this book can produce.

We hope this book will be useful for all readers…

CHAPTERS

BASIC INFORMATION ABOUT OLIVE OIL

Olive oil is one of the most reputative traditional foods in the world. Indeed, the cultivation of olives to produce olive oil has deep roots in the history of the Mediterranean region. Olive oil extraction has a unique history from traditional to modern systems than other edible oils. (Secmeler & Galanakis, 2019). The tradition of olive oil production represents a very important asset for many countries, not only in terms of culture and health, but also in spite of wealth. Therefore, olive oil production increased over the last few decades as a valuable source of antioxidants and essential fatty acids in the human diet and constitutes one of the most important dietary trends worldwide (Souilem et al., 2017). There are 860 million olive tree and hundreds of olive cultivars having different fruit or oil characteristic were reported in the world (Figure 1).

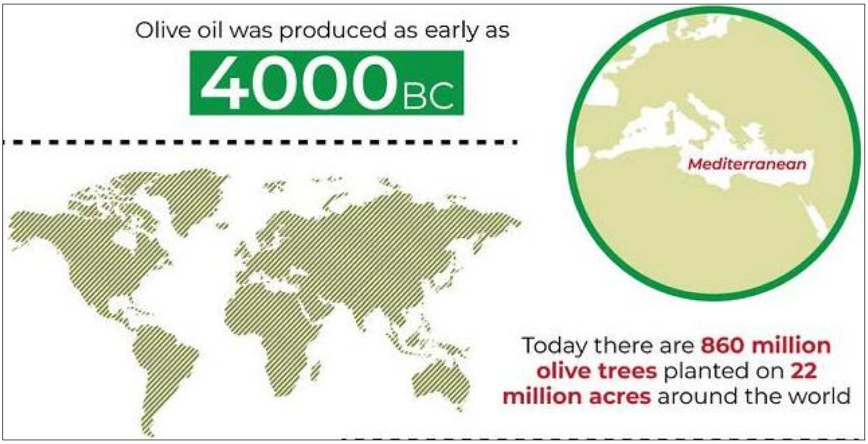


Figure 1. Olive tree plantation in the world (Anonymous, 2020)

Worldwide olive oil production was about 3,1 million tons in 2019/2020 crop year, the majority of them come from Mediterranean countries. Spain, Italy, Greece, and Turkey (followed by Tunisia, Portugal, Morocco, and Algeria) are the biggest olive oil producing countries. Outside the Mediterranean basin, olives are cultivated in the Middle East, the United States, Argentina, and Australia (Secmeler & Galanakis, 2019). Top nine producer countries and their share in world olive oil production (2007–2016) were given in Figure 2. More than 95% of olive oil supply and 80% of olive oil consumption are centered in the Mediterranean countries (Atamer Balkan & Meral, 2017).

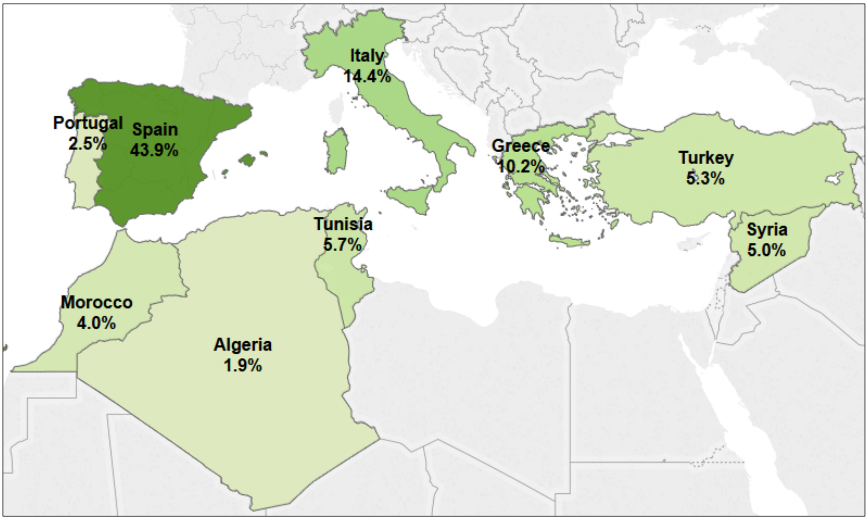


Figure 2. Top nine producer countries and their share in world olive oil production (2007–2016) (Atamer Balkan & Meral, 2017)

Although it accounts for less than 4% of the edible oil market worldwide, olive oil is attracting growing interest from new consumer countries (Roselli et al., 2016). This consumption trend is also driven by the results of scientific research confirming the positive attributes of this “liquid gold” (Caporaso et al., 2015). Participants of the global olive oil consumption are not limited with the producer countries. Most of the recent increases in olive oil consumption figures are observed in non–producing countries (Lynch et al., 2013). United States is the top consumer and importer outside of the European Union. Olive oil import behavior of United States was given in Figure 3. United States also invests in olive growing and olive oil production; hence its role as a producer country is expected to expand in the following years. China, Canada, Japan, Brazil and Australia are other examples of growing markets in the World (Atamer Balkan & Meral, 2017).

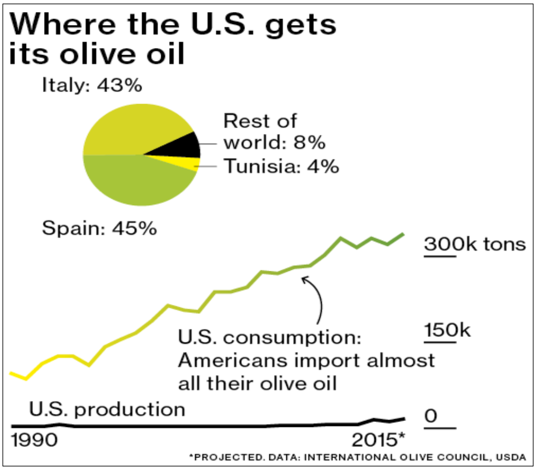


Figure 3. Olive oil imports behavior of United States (Peter Robison & Vernon Silver, 2016)

The industrial yield of olive oil depends on olive cultivar, fruit maturity, processing system and used parameters in this system. This directly effect the income of farmer and processing plant. Virgin olive oil is exclusively extracted from fruits by means of mechanical techniques that include crushing, malaxation and extraction. Each of these technological operations in addition to the olive fruit characteristics (cultivar, maturity stage, etc.), the preprocessing (fruit harvesting and storage) and the post-processing (oil storage, filtering, and bottling) procedures affect the nutritional and sensory properties of the product, in particular the quantity and the types of phenol compounds (Roselli et al., 2017).

The use of the term ‘olive oil’ does not help the average consumer to make an ‘informed’ and ‘meaningful’ choice because it is not clear which of the commercial products available on the shelf contain the authorized ingredients. Not all ‘olive oils’, not even all of the ‘extra virgin olive oils are expected to contain high concentrations of the desirable ingredients to which the claim refers (Tsimidou & Boskou, 2015). Indeed, oil of olive fruit actually means a huge groups consist of extra virgin olive oil (EVOO), virgin olive oil (VOO), ordinary virgin olive oil (OVOO), lampante virgin olive oil (LVOO), refined olive oil, olive oil (blend of refined olive oil and EVOO/VOO), crude olive–pomace oil, refined olive pomace oil and olive pomace oil (Figure 4).

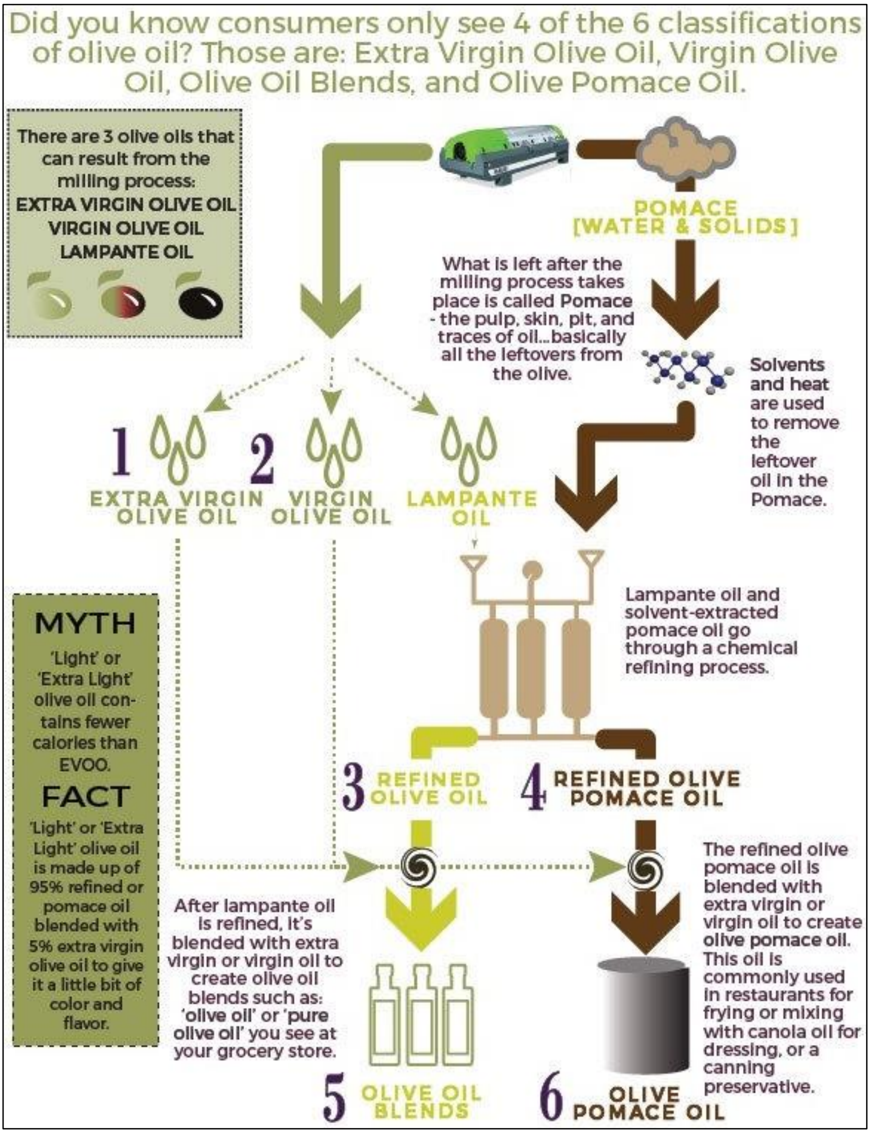


Figure 4. Oil classes of olive (Broaddus, 2017)

EVOO, VOO, OVOO and LVOO are the oils obtained from the olive fruit only by mechanical process, which do not lead to change on characteristics of oils of olives as possible as. Refined olive oil is the LVOO by refining methods which do not cause changes on the initial glyceridic structure. Pomace oils (crude olive–pomace oil, refined olive–pomace oil and olive–pomace oil) produced by extraction of oils from pomace with solvents and refining process. This group may not be called or labelled as olive oil. Quality, health beneficial effects and price of these olives oils groups can be order from high to low as EVOO > VOO > OVOO

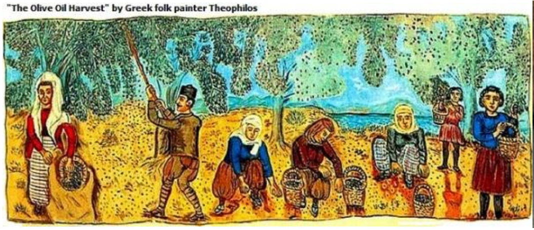
> LVOO. In EVOO category there is also different quality of oils such as EVOO with health claim or EVOO with excellence quality. They are superior characteristics than other EVOO. Detailed informations for these two EVOO types were given in "Excellence in extra–virgin olive oil", "Health claim labelling of olive oil and its effect on consumer preferences" and "Legislation on olive oil and its health claim" section of this book. Figure 5 shows the quality scale of olive' oils.

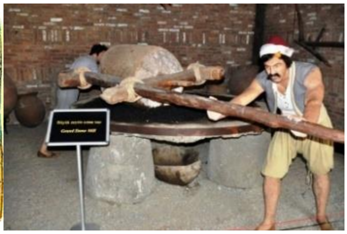
The phenol degradation kinetic depends on the availability of oxygen and is promoted by light, heat, metals and enzymes. It is important to underline that a direct consequence of applying best practices to increase the polyphenol content of the product during the olive tree cultivation and oil extraction processes is the optimization of the legal parameters necessary for the classification, thus raising the overall quality of the product (Clodoveo et al., 2015).

Figure 5. Shows the quality scale of olive oils

The EVOO is one of the most important health–protective foods in the Mediterranean diet and the EFSA has admitted the health claim after the secoiridoids certification. Actually, many farmers possess basic agronomic and technological abilities, as a result of information campaigns, made by the institutional organisms to reach the standard quality for the EU health claim. However, this does represent yet neither a quality parameter for consumers nor a resource for increasing the economic income of the farmers (Lanza & Ninfali, 2020).

Under adequate extraction conditions, extra virgin olive oils are always produced when healthy olives are used, whichever the olive cultivar processed. Only olives attacked by pests and diseases, or fallen to the ground before harvesting, produce olive oils with off–flavors. Other defective sensory notes in VOO are due to inadequate harvesting, post-harvesting, processing or oil storage (Alba et al., 2008). Olive oils health claim and quality excellence should be take consider as a whole from orchard to the table. Thus olive storages at market place and house or restorante should be air, light and heat preserved. For cooking practices must be performed with minimum heat stress and selected best cooking condition to minimize the phenol losses. Olive oil is also an integral part of the cultural and culinary heritage of the Mediterranean countries (Figure 6). It is a product that is set apart by its undeniable organoleptic qualities as well as by its nutritional and therapeutic properties, which are being increasingly corroborated by science (Paricio & Harwood, 2013).





a b

Figure 6. a: "The olive oil harvest" by Greek folk painter Theophilos, b: Oleatrium olive and olive oil history museum

EXCELLENCE IN EXTRA VIRGIN OLIVE OIL

In the future market, the food nutrient level will be increasingly important, because of the demand for high–quality products required by EU citizens (Lanza and Ninfali, 2020). However, the olive oil market is characterized by increasing price competition based on cost reduction strategies that have negative effects on profitability. Because of consumers' difficulties in evaluating the quality of olive oils and recognizing a premium price for the highest quality EVOO. The price war cannot last forever, and competing for quality is likely to be the only viable strategy (Roselli et al., 2017).

If a company aims at producing an EVOO of excellent quality, it should be presumed that all the basic conditions for quality are met, such as an appropriate system for olive harvesting and handling, including a short interval of time between harvesting and milling, a modern milling plant and good control of the milling conditions (Peri, 2014). VOO producers should not try to beat their main international competitors with low prices and poor quality. On the contrary, all players in the supply chain should combine their efforts to increase the supply of the highest quality products with the greatest health value (Roselli et al., 2017).

Excellence is a very demanding objective in which the company pursues standards that are well beyond those required for extra virgin olive oil. For instance, excellence requires values of free acidity, peroxide number and spectrophotometric values much lower than those required for common extra–virgin olive oil. Not only should sensory defects be absent, but the sensory profile should correspond to the sensory style of the brand. Finally, the concept of excellence should apply not only to production of the oil, but also and especially to consumption of the oil (Peri, 2014).

EVOO is central foods in the Mediterranean diet Scientific advances on their health benefits suggest to increase their use to prevent chronic diseases and marketing strategies are searched for orienting the choice towards quality products (Salazar–Ordóñez et al., 2018; Pintó et al., 2019). The precise detection of EVOO hydroxytyrosol and its derivatives remains the breakthrough for nutritional and health quality certification. The analysis of the tocopherols, is another important issue in the quality detection of EVOO (Psomiadou et al., 2000). Excellence may be defined as a level of high quality within the category of extra virgin olive oil. Good and excellent oils as well as common and anonymous oils are all included in this category. It is therefore of no surprise that so many proposals and attempts are being made to foster niches of excellence in local or global olive oil markets (Peri, 2014).

The experiment, planned and implemented by the nonprofit association 3E (Ethics–Excellence–Economics) received support and approval from several organizations including the Georgofli Academy of Florence, the Olive Center of the University of California Davis, the Culinary Institute of America at Greystone (California), and the Spanish Interprofesional del Aceite de Oliva. The theme of extra–virgin olive oil excellence was presented and debated in five annual meetings of the International Conference 'Beyond Extra–Virgin' (Association 3–E 2008).

The 3E model of olive oil excellence can be described as a three–step procedure concerning product and process requirements (Peri et al., 2010). First step: basic product requirements Table 1. presents the five basic requirements for excellence in extra–virgin olive oils according to the 3E model. The above requirements should be considered as common to all excellent extra virgin olive oils, independent of origin or cultivar or processing technology.

The five basic requirements have different meanings:

- •Documented chain traceability from the field to the consumer's table is the most important proof of the authenticity of the oil and its correspondence with claims
- •Three analytical values of free acidity, peroxide number and K_{232} absorption are proof of the excellent quality of the olives and good processing conditions
- •Absence of sensory defects is proof of the hygienic design and proper operating conditions of the mill.

Table 1. The five basic requirements for excellence in extra–virgin olive oil according to the 3E model (Peri, 2014)

1.	Chain traceability	Documented material balances from the field to the consumer's table
2.	Free acidity	Less than or equal to 0.3 (±0.02)
3.	Peroxide number	Less than or equal to 7.5 (±0.2)
4.	K_{232} absorption value	Less than or equal to 1.85 (±0.02)
5.	Sensory defects	Absent according to the International Olive Council panel test

Oxygen radical absorbance capacity (ORAC) method, which quotes the efficiency of the antioxidants to reduce the peroxyl radicals generated in the reaction mixture, in comparison with an analogue of the vitamin E, called Trolox (Ninfali et al., 2002). Figure 7 shows an example of the

ORAC value obtained on 25 Italian EVOOs analyzed in a seasonal production. By the ORAC method, several EVOO samples were ranked in micromoles of Trolox equivalents/g (i.e., ORAC units) and suggested four categories of ORAC quality. The ranges were the following: 1–4, low–quality EVOO; 4–8, intermediate; 8–12, high; >12, top–quality (Antonini et al., 2015). The ORAC values strictly correlated with the phenolic content (Ninfali et al., 2002).

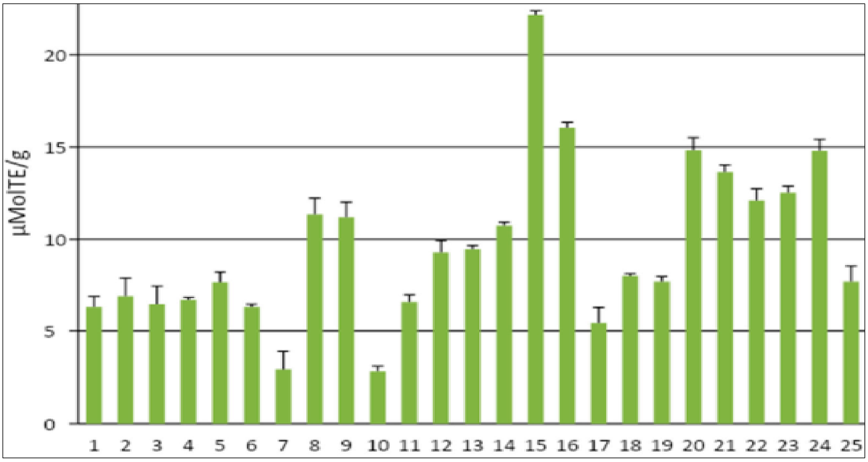


Figure 7. Heterogeneity of EVOO antioxidant capacity measured with the ORAC method (Antonini et al., 2015)

Regulation 432/2012 listed authorized health claim and relates the level of olive phenolic compounds and the impact on the protection of blood lipids from oxidative stress. The claim “olive oil polyphenols” can be used only for a natural olive oil that contains at least “5 mg of hydroxytyrosol and its derivatives (e.g., oleuropein complex and tyrosol) per 20 g of olive oil” (Tsimidou & Boskou, 2015). This properties also can be used as important quality criteria for excellent EVOO beside health claim.

Unfortunately approximately 70% of commercially available olive oil is detective due to rancidity or adulteration but is labelled as fresh–a possible ethical violation of consumer rights (Staley et al., 2014). So that not only final control at market places, but also whole production chain of EVOO should be controlled by both government and self–control of the company (Figure 8). This is essential to produce and preserve excellence quality of EVOO.

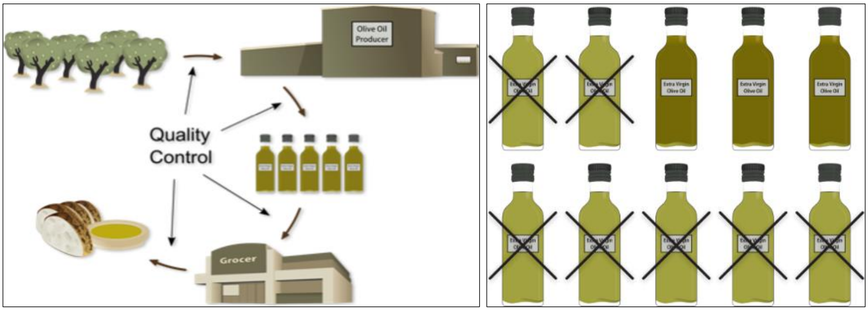


Figure 8. Total quality control places of EVOO and schematic view of real EVOO ratio (Staley et al., 2014)

To Do List:

- Be aware that each EVOO has not same quality
- Control cultivation, process and storage as an excellence chain
- Consume health claim and/or excellent quality olive oils for disease prevention

HEALTH BENEFITS OF OLIVE OIL

Collecting and circulating scientific research findings on the health–related properties of olive oil provides key support for the campaigns to promote and expand worldwide consumption of olive oil (Paricio and Harwood, 2013). Olive oil is nowadays highlighted and marketed as a superfood for human health not only due to its lipid profile (e.g., high oleic acid and low saturates), but also due to its high content in micronutrients such as squalene and polyphenols (Galanakis, 2017). The latter powerful antioxidants are in many cases advertised almost as an elixir that promises to relieve us against multiple diseases and health problems (Secmeler and Galanakis, 2019).

Consumption of olive oil has anti–inflammatory effects by lowering plasma levels of cytokines and adhesion molecules and by reducing the induction of monocyte adhesion to the endothelium. In addition to its anti–inflammatory properties, it helps to protect against cardiovascular disease by reducing plasma cholesterol levels, protecting against the oxidation of LDL, lowering blood pressure, and attenuating platelet aggregation. In addition, there is increasing evidence showing that in Mediterranean countries, diets relatively high in fat from olive oil may be effective alternatives to the traditional low–fat diet for initial weight loss in obese persons. It is attributed to a satiating effect of olive oil intake (Aparicio & Harwood, 2013).

EVOO is reported as a key bioactive food with multiple beneficial properties and it may be effective in the management of some immune inflammatory diseases (Figure 9) (Aparicio–Soto et al., 2016). A population based prospective investigation involving more than 22,000 Greek adults found no significant correlation between consumption of olive oil or other individual food group from the Mediterranean diet, although a higher degree of adherence to the diet was associated with a reduction in overall total mortality (Covas, 2007). Despite this, there is a wealth of evidence to indicate that dietary olive oil has a beneficial effect on a number of contributory causes of myocardial infarction, including atherosclerosis development, hypertension, and hemostasis and that these benefits are due not only to the high mono content but also to the many micronutrients present in the oil (Covas, 2007; Bester et al., 2010; Aparicio & Harwood, 2013).

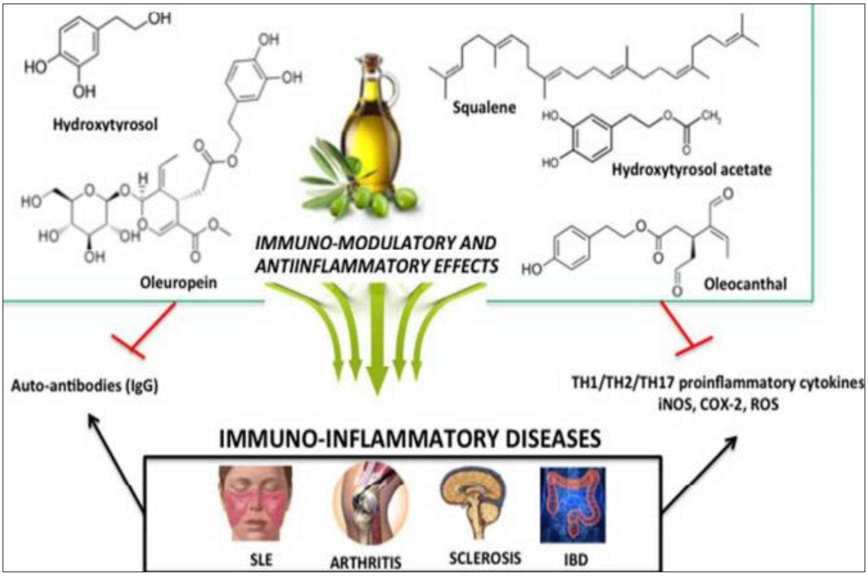


Figure 9. The beneficial effects of EVOO and its minor components on immune–inflammatory diseases like rheumatoid arthritis, systemic lupus erythematous (SLE), sclerosis and inflammatory bowel disease (IBD) (Aparicio–Soto et al., 2016)

Over the last two decades, olive oil has concentrated scientific attention not only in the Mediterranean area, but all around the world due to its beneficial effects in human health (Rahmanian et al., 2014). This trend is mainly driven by its content in polyphenols hydroxytyrosol, tyrosol, oleuropein, eleocanthal, oleacein and other polyphenols (Figure 10) with exotic names may not be well–known to the general public yet, but they already appear in the product labels in the shelves of supermarkets and pharmacies, promising to provide multiple benefits to consumers (Aristoil, 2020; Secmeler and Galanakis, 2019).

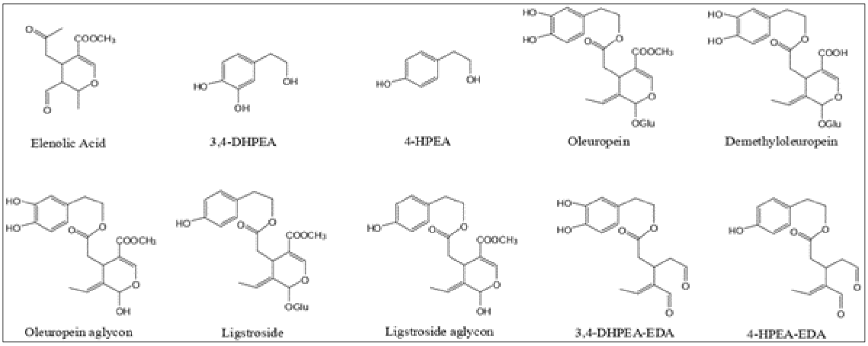


Figure 10. Molecular structures of the major phenolic compounds in olive (Jh et al., 2014)

Consumption of extra virgin olive oil has relevant health benefits, preventing cardiovascular and neurological pathologies, diabetes, and some types of cancer, and attenuating degenerative processes associated with aging, like osteoporosis, among others. Some of these healthy properties may be due to the modulation of biochemical pathways and positive effects of the constituents of this food on Mesenchymal Stem Cell (MSC) populations (Figure 11). All that may have positive consequences for other cells, tissues, organs, and the whole organism (Casado–Díaz et al., 2019).

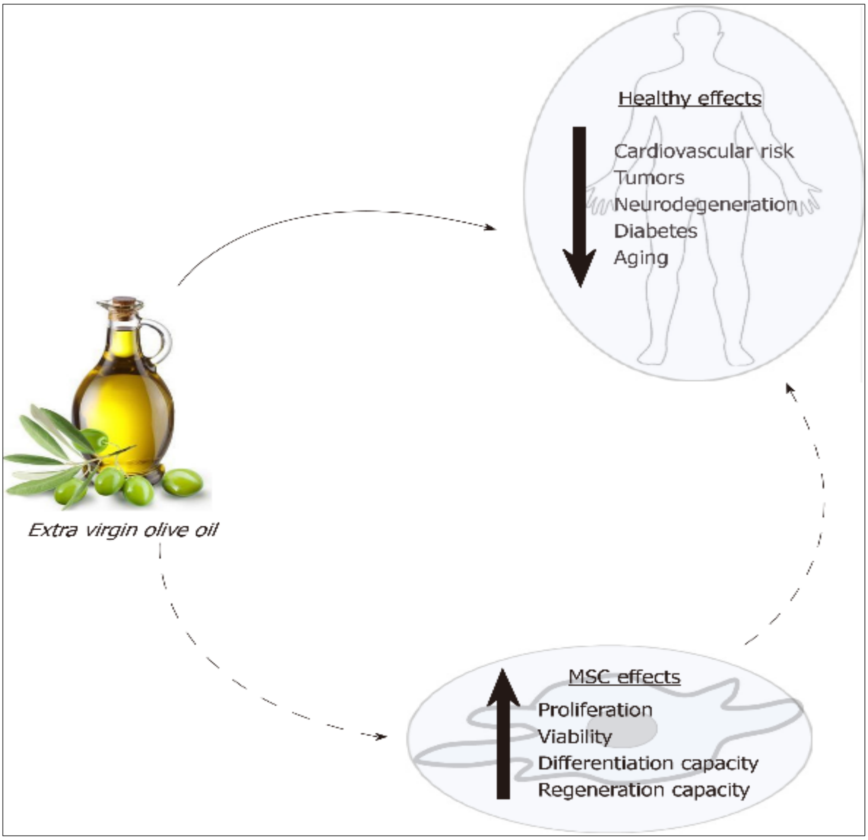


Figure 11. Effects of extra virgin olive oil on health and mesenchymal stem cells (Casado–Díaz et al., 2019)

Mono unsaturated fatty acid percentage has an impact on the health and nutritional properties of EVOO. The melting point of oleic acid is lower than the temperature of the human body, which is an essential requisite for preventing lipid accumulation in arteries and for guaranteeing cell membrane fluidity. At the same time, it is much more resistant to oxidation than the other unsaturated fatty acids. This is essential for preventing oxidative damage to critical cell structures (Ghanbari et al., 2012).

Oleic acid has a number of biological functions; for example: (i) lowering blood pressure; (ii) ensuring the free flow of blood by reducing the clogging and hardening of arteries; (iii) lowering the level of low–density lipoprotein or bad cholesterol, while increasing the levels of high-density lipoprotein or good cholesterol; (iv) strengthening cell–membrane integrity and helping to repair cells and damaged tissues; (v) fighting cancer, especially breast cancer; and (vi) relieving symptoms of asthma (Peri, 2014). On the other hand, the mechanisms by which olive oil exerts its health–promoting effects are not yet fully understood, but it is now clear that the oleic acid content alone is not sufficient and that minor components must also be considered (Aparicio & Harwood, 2013).

The 3,4–DHPEA–EDA, derived from oleuropein, is responsible for the bitter taste, whereas p–HPEA–EDA, derived from ligstroside, is responsible for the pungent taste (Trombetta et al., 2017). Bitter and pungent are therefore positive characteristics of the EVOO as linked to health benefits (Inarejos–García et al., 2010). Biological activities of the secoiridoids consist principally in: depletion of oxidized low density lipoprotein; increase of the plasmatic antioxidant capacity; protection from inflammatory reactions (Cicerale et al., 2010). Concerning the latter aspect, the oleocanthal was shown to be molecularly active within the cell, in a very similar way as ibuprofen (Beauchamp et al., 2005).

The ability of EVOO polyphenols and their metabolites to modulate cellular pathways related to reactive oxygen species and inflammation have shown significant effects in animal models and in vitro, supporting the growing in vivo evidence of their beneficial effects on aging. Antioxidant/anti–inflammatory action of EVOO polyphenols, which may impede the appearance of a pro–inflammatory phenotype in several age–related disorders and during the aging process itself (Figure 12). Thus, EVOO polyphenols–rich dietary supplements, present in a wide variety of products on today’s market, or much better, the regular consumption of EVOO as the principal dietary fat within a balanced Mediterranean–type diet, can potentially confer additional benefits that help slow aging, improving health and lifespan (Phull et al., 2018).

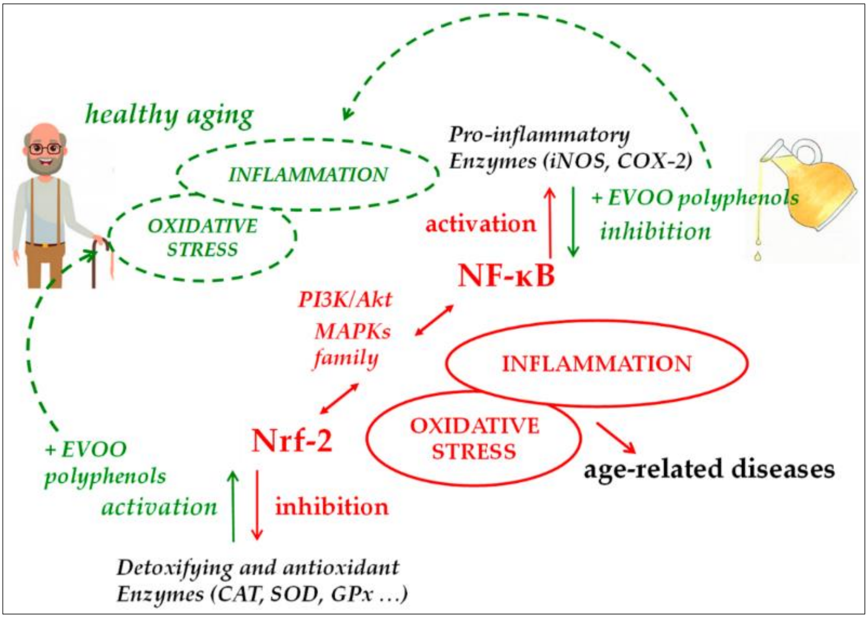


Figure 12. Main molecular pathways involved in EVOO polyphenols health effects in aging (Phull et al., 2018)

Anticancer properties of olive oil seem to correlate with the antioxidant activity of phenolic and polyphenolic compounds present there in that are capable of scavenging free radicals and reactive oxygen species. Oleuropein, tyrosol, hydroxytyrosol, verboscoside, ligustroide, demethyleuropein were all proven to protect against the coronary artery disease (Manna et al., 2002; Malik and Bradford, 2006) or cancer (Tripoli et al., 2005). They also display antimicrobial and antiviral effects. Antioxidant and anti–atherogenic effects of olive oil polyphenols, like oleuropein and hydroxytyrosol, have been vastly confirmed in the literature (Aristoil, 2020; Gorzynik–Debicka et al., 2018) Following a diet rich in olive oil leads to improvement of risk biomarkers as reported in Figure 13.

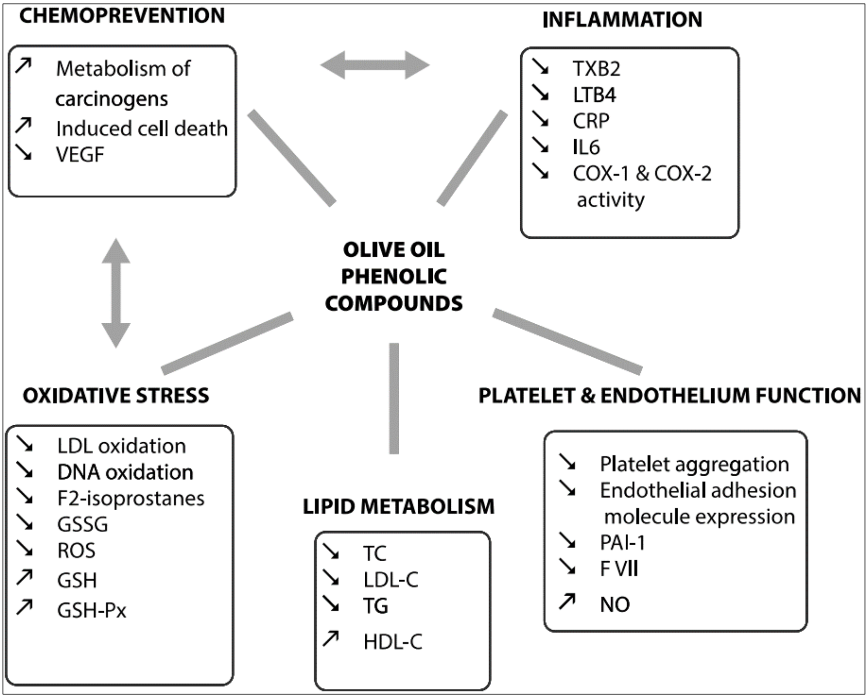


Figure 13. Different actions of olive oil phenolic compounds (Amiot, 2014)

After food industry, cosmetology is another important sector where EVOO is used. In fact, antioxidants of EVOO exploit anti–inflammatory activity and in combination with vitamin E, D and K as well as carotenoids, guarantee nutrition and protection to the skin against UV arrays and dehydration (Romani et al., 2019). Cosmetology based on EVOO has generated research and development products able to protect irritated skins, when threatened by skin pathologies, like psoriasis and eczema. Many products are actually on the marketplace based on the antioxidant properties of EVOO, but their use will require further improvement for consistent beneficial effectiveness (Lanza and Ninfali, 2020).

To Do List:

•Learn oil categories of olive of olive. They have different health beneficial potential,

•Follow the scientific results to obtain healthy beneficial EVOO,

•Be aweare health protective effect more important than curing of illness,

•Consume healthy food as a part of diet in whole life.

HEALTH CLAIM LABELLING OF OLIVE OIL AND ITS EFFECT ON CONSUMER PREFERENCES

Considering the extreme variability in the concentrations of health–promoting molecules, all EVOOs are not created equal health benefits effects and so cannot all be sold at the same price. Currently, consumer choice is characterized by a growing awareness of the importance of a healthy diet and the close relationship between nutrition and psychophysical well–being (Grunert, 2005; Bimbo et al., 2016). Consumption of EVOO only 0,8 liters per capita in USA which is one–tenth of what a typical Italian uses in a year (Figure 14). Consumption of EVOO has doubled worldwide has tripled in the USA since 1990 and is still (Robison & Vernon Silver, 2016). This increasing trends may be parallel to increasing attraction of healthy nutrition and health benefits of EVOO.

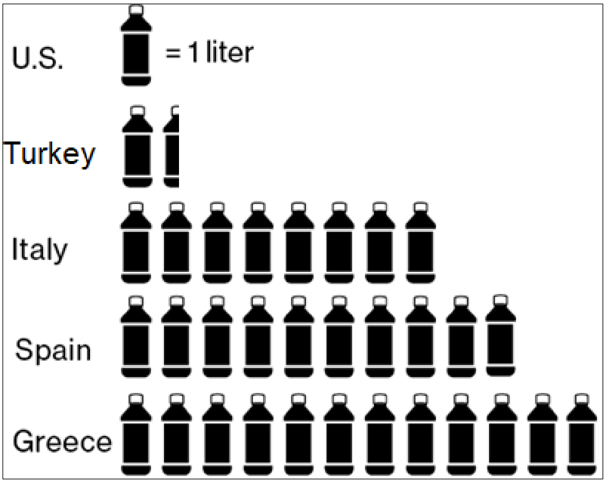


Figure 14. Consumption of EVOO per capita in a year (Robison & Vernon Silver, 2016)

In the context of Regulation (EC) No:1924/2006 a health claim is any statement about a relationship between food and health based on an opinion of the European Food Safety Authority (EFSA), which is responsible for evaluating scientific evidence provided by the interested parties. The aim of the Regulations is to "enhance the consumers' ability to make informed and meaningful choices" providing them with messages that are "clear, accurate and based on evidence accepted by the whole scientific community" through claims that appear on "labeling, presentation or marketing in the EU (Tsimidou and Boskou, 2015).

Label attracts consumer attention

(Peter, 2012)

Consumers, who are observant and check more olive oil packages to have been informed on labels indicate that olive oil contains substances that shield the human body against various health problems. Besides, since 2012, olive oil can be labeled with a health claim approved of the European Authority for Food Safety (EFSA) and is strictly defined by the EU regulation 432/2012 as follows: "Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress" (EU, No 432/2012). However, this claim can only be used for olive oils containing at least 5 mg of hydroxytyrosol and its derivatives (e.g., oleuropein complex and tyrosol) per 20 g of olive oil.

In addition, the label must provide information to the consumer that the beneficial effect is obtained with a daily intake of 20 g of olive oil (about one and a half spoon). This disclaimer should be given considering current concerns on consumption of high energy foods such as fats (Tsimidou & Boskou, 2015; Secmeler & Galanakis, 2019). This hydroxytyrosol concentration corresponds to a minimum content of total phenolic compounds in EVOO of no less than 300–350 mg/kg, corresponding to a bio–phenol concentration of at least equal to 250 mg/kg (Servili, 2014). The total concentration of phenolic compounds in oils belonging to the marketable class of EVOO varies widely, between 40 mg/kg and 1000 mg/kg (Clodoveo et al., 2015).

A health claim, and especially a proprietary health claim, seems to be more attractive than a nutrition claim in marketing and may partially justify why industry urges to speed up authorization process. However, technical gaps may cause considerable delays, from authorization to the implementation of a particular claim and can practically jeopardize benefits anticipated by the applicants (Tsimidou and Boskou, 2015).

The current product classification of olive oils, conceived in 1991, is obsolete and insufficient to adequately describe the qualitative differences of the olives' oils on the market (Figure 15). As a result, the polyphenol claim becomes a useful differentiation tool for the consumer to attribute a premium price to the best products. It is interesting to note that no more than 10% of bottled oils available on the market have a suitable phenolic content for the application of the health claim (Caporaso et al., 2015). This datum opens a reflection on the direction of which efforts should be directed to support the European olive oil supply chain, guaranteeing adequate profitability to producers and millers (Bellumori et al., 2019).

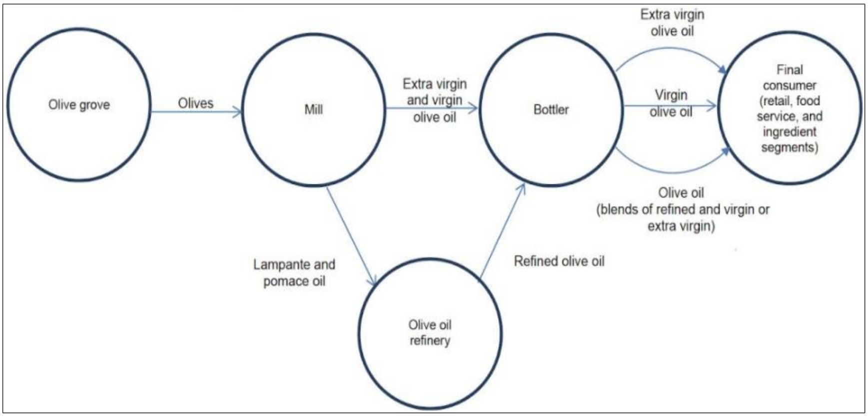


Figure 15. Production and marketing system of olives oil (Huang et al., 2018)

Authorization of the health claim aroused enthusiasm and was considered by the small and medium–sized enterprises in the producing countries as a means to convey more benefits from virgin olive oil consumption to consumers and also to gain better prices for their products. Such an interest had not been expressed by producers, industry and mass media so far for important health claims regarding virgin olive oil that are easily grasped by the consumers (Martin–Pelaez et al., 2016).

Dissemination of what is known about the healthy effects of eating olive oil has been decisively effective in increasing consumption. That is why it is so worthwhile to publicise this knowledge through information and promotional events (Paricio and Harwood, 2013). The new lifestyle habits and the relative spending patterns linked to a growing demand for well–being are shaping growing consumption trends for health foods. The tendency to exalt the health virtues of a product, and the awareness of the value attributed by the consumer to these characteristics, has enormously influenced advertising communications (Bellumori et al., 2019).

According to a survey to assess consumer (2234 consumers in US) attitudes and perceptions regarding olive oil, there was a disconnect between what people thought they knew about olive oil and what was actually correct knowledge (Figure 16). These inspired oil experts to assess the user’s current knowledge regarding olive oil (Huang et al., 2018).

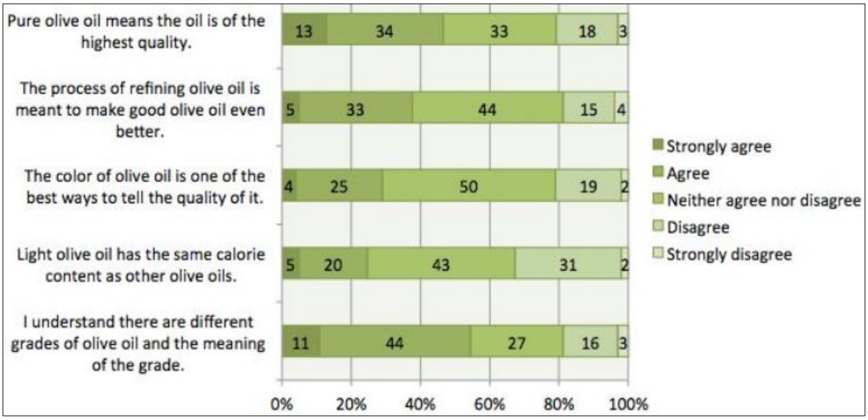


Figure 16. Assessing oil knowledge of consumers (Huang et al., 2018)

In Italy researcher reported that including a label with the health claim based on olive oil polyphenols content would be useful to effectively signal both the "highest quality" and the "healthiest" Italian extra virgin olive oils (Roselli et al., 2017). The health claims reported as more effective than protected designation of origin and organic labels on the choices of several types of consumers (Boncinelli et al., 2016). There are also opposite findings which report that general health claim doesn't seem to attract consumers probably because they are already aware of the benefits of extra–virgin olive oil within the Mediterranean diet in helping cardiovascular system.

There are a lot of evidence of consumers' willingness to pay a premium price for the health–enhancing features of food (Barbieri et al., 2015; Bimbo et al., 2016). In addition, a few studies have found that some consumers' segments are willing to buy and pay a higher price for EVOOs with health claims (Boncinelli et al., 2016; Casini et al., 2014). However, the olive oil industry has not taken advantage of this opportunity and the claims approved by the EC. In particular, in the specific case of the claim of phenolic compounds, several problems may have hindered its implementation. The main concerns involve the lack of clarity in determining the bioactive compounds and the analytical protocol to apply the claim (Romero & Brenes, 2014).

Beneficial cardioprotective effect of EVOO (contain 5 mg hydroxytyrosol/20 g) by reducing inflammation, thrombosis, were reported (Figure 17) (Romani et al., 2019). But health claims represent a rarely used legal tool (European Commission 2006) that could be helpful in designing comprehensive labelling to increase consumers' knowledge about the product quality and their willingness to pay. Researcher believe that increased use of these health claims could change a credence attribute into a search attribute, thus reducing the difference between the perceived and actual value of EVOO. From a theoretical viewpoint, reducing the uncertainty about a positive attribute, as in the case of the healthy properties of EVOO, could increase demand for the same quality level (Coppola & De Stefano, 2000).

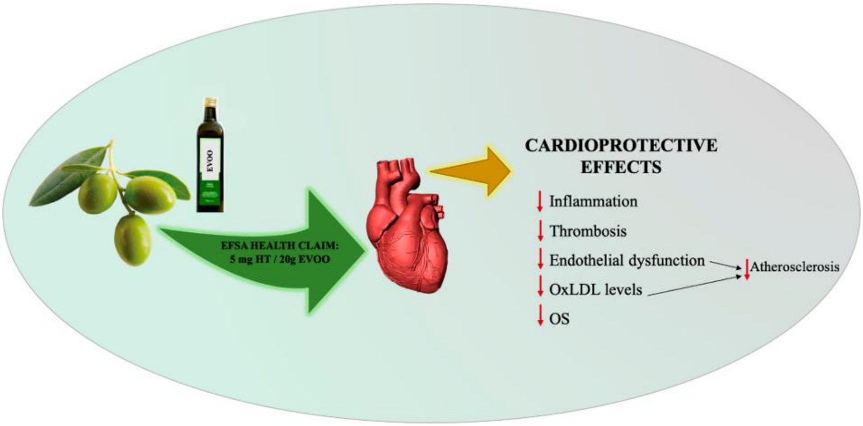


Figure 17. Cardioprotective action of EVOO which have health claim (HT: hydroxytyrosol; OxLDL, Oxidized Low Density Liprotein, OS: Oxidative Stress) (Romani et al., 2019)

Beyond the health properties of EVOO, the polyphenol content also affects the sensory properties of the product. This feature is very interesting because it can transform a credence attribute (health property) into an experience attribute (sensory property). In fact, while much of the label information refers to properties that the consumer cannot directly evaluate (e.g. origin, extraction method, organic process), the presence of polyphenols is clearly attested by the presence of a bitter and pungent taste, which varies in intensity depending on the concentration (Roselli et al., 2017).

Consumers are attracted to the increase EVOO quality as they are appreciating the health benefits of EVOO and can recognize the organoleptic properties, associated with agronomic and technological factors (Lanza & Ninfali, 2020). Health claims and the delivery of information about the origin and quality of olive oil could help to create a “culture” around olive oil product. It is important to identify the most effective way to promote and deliver such claims to consumers to make them aware of the health benefits of olive oil, increase their knowledge about its qualitative characteristics (e.g., colour, flavour, taste) and purchase it in a more conscious way (Roselli et al., 2017).

EVOO has importance role in the Mediterranean diet which preventing from heart diseases. But it is not matched with consumer’s willingness to pay for EVOO. This general health claim doesn’t seem to attract consumers probably because they are already aware of the benefits of EVOO within the Mediterranean diet in helping cardiovascular system. On the other hand, the acidity level, even if interesting, seems to be judged not equally among consumers (Finardi et al., 2009).

Other minor barriers for the use of health claims by olive oil small and medium–sized enterprises can be related to the lack of competencies, including a lack of legal knowledge, on the use of claims on the label and communication campaigns (Roselli et al., 2017). Many studies have demonstrated that overall acceptability is influenced by extrinsic properties such as health claims, price, the appearance of the label, the brand and the colour of the product. Moreover, the hedonic response is affected by consumers' expectations for the product, which are based on factors such as previous experience, peer pressure, expert recommendations and brand familiarity (Saba et al., 1998).

To Do List:

For producer;

•Follow legal and scientific based tools for consumer communication,

•Write your label as clear and informative as possible,

•Cultivate, process and store according to scientific results and legal rules,

•Organize courses or activities to increase awareness of EVOO,

For consumer;

•Join courses or activities about EVOO,

•Bleave only scientific based informations,

•Read labels carefully.

CHEMICAL AND SENSORIAL CHARACTERS OF OLIVE OILS

EVOO is one of the main ingredients of the Mediterranean diet, also support the unquestionable healthy food claim as a consequence of the balance between mono and polyunsaturated fatty acids and the bioactivity of minor compounds such as phenols, squalene and triterpenic alcohols (Aparicio & Harwood, 2013). Detailed component of EVOO was given in Figure 16. Compounts of EVOO can be grouped as saponifable components (~99% of EVOO which are oil part) and unsaponifable components (~1% of EVOO which are other than oil part).

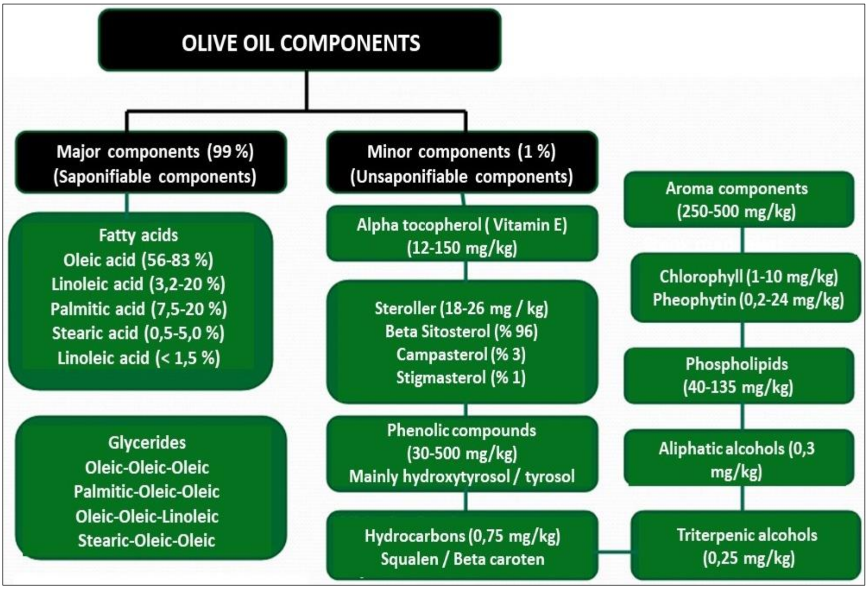


Figure 18. Olive oil components (Altinbas Ozdemir & Ozdemir, 2011)

In regard to EVOO, it is a food composed of a major saponifiable fraction, represented by oleic acid, and a minor unsaponifiable fraction, including a high number of vitamins, polyphenols, and squalene (Flori et al., 2019). EVOO's unique chemical composition is made not only of well–balanced fatty acids but also of a plethora of minor compounds, which allows chemical characterization and explains the huge variety of aromas and tastes that EVOO can offer to consumers (Aparicio & Harwood, 2013; Ozdemir et al., 2016). Color of olive oils was determined as a subjective visual rating to assure that the oil does not have unusual color uncharacteristic of the product in USDA (2010) regulation. The color of olive oil is influenced by many factors (climate, cultivation, cultivar, ripeness etc.) but the color is not a objective quality indicator.

The classification as EVOO leads to a broad range of defect–free but sensory very different qualities–simply from excellent to low or almost no taste (Oberg, 2010). In general, beneficial effects of EVOO are linked to the minor components, but recently, further studies have shed light on the health effects of the fatty fraction and the other constituents of the unsaponifiable fraction (Figure 19).

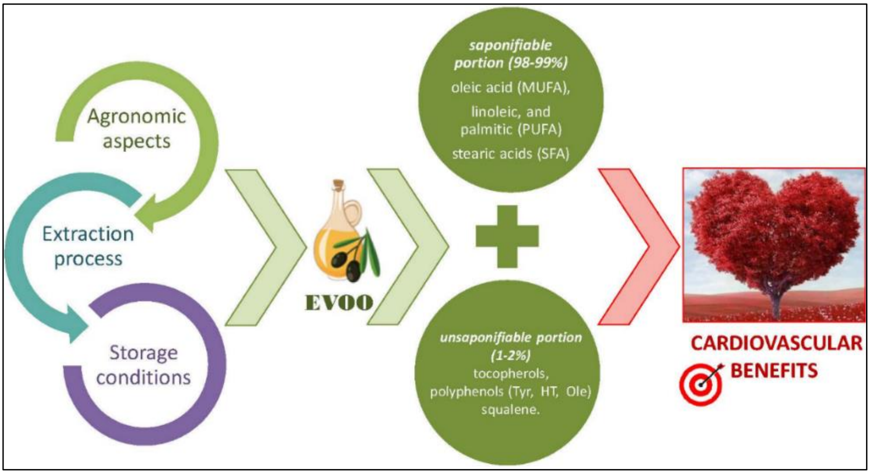


Figure 19. Components of olive oil and its bioactive constituents on the cardiovascular system (Flori et al., 2019)

The unique fatty acid composition of olive oil is distinguished from other vegetable oil with this feature Fatty acid composition is also one of the key parameters used to characterize and grouping of olive oils EVOO. (Lee et al., 1998; Ozdemir et al., 2016). Fatty acid composition determines the technological and nutritional properties (Figure 20) of EVOO. Oleic acid is the major fatty acid in the olive oil (55–83%), whereas linoleic acid accounts for 3.5–21% and linolenic acid for < 1% (Hernández et al., 2018). Besides that, EVOOs contain a relevant concentration of efficient chemopreventive molecules, including tocopherols (vitamin E), β–carotene, and phenolic compounds (Lanza & Ninfali, 2020). The presence in olive oil of minor components with antioxidant potential, as well as its high content in monounsaturated fatty acids appear to be essential for the beneficial effect of this food (Trichopoulou & Dilis, 2007).

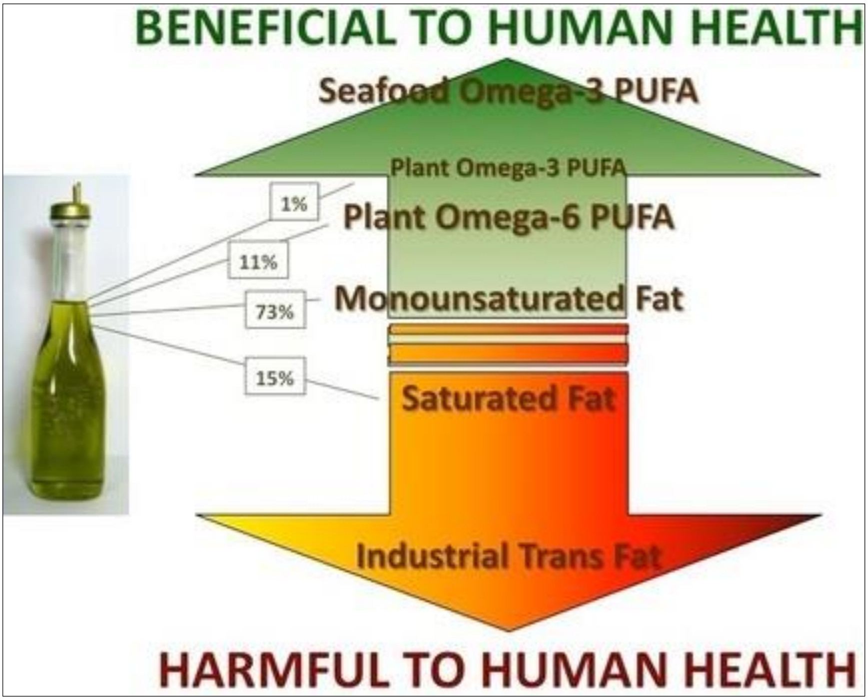


Figure 20. Miller's diagram depicts the fatty acid content of olive oil (White, 2010)

General perception of the consumers that EVOO category is the best one in terms of health benefits. Also, its sensory properties reflect the sensory character of each monocultivar or blend of cultivars of olives of origin (Trichopoulou & Dilis, 2007). Thus, sensory properties (Figure 21) and health characteristics of olive oil are linked to its chemical characteristics, in particular to the presence of several minor components, which are strongly influenced by the operational conditions in the technological extraction process. Therefore, they may be considered as analytical markers of the quality of olive oil processing (Peres et al., 2017).

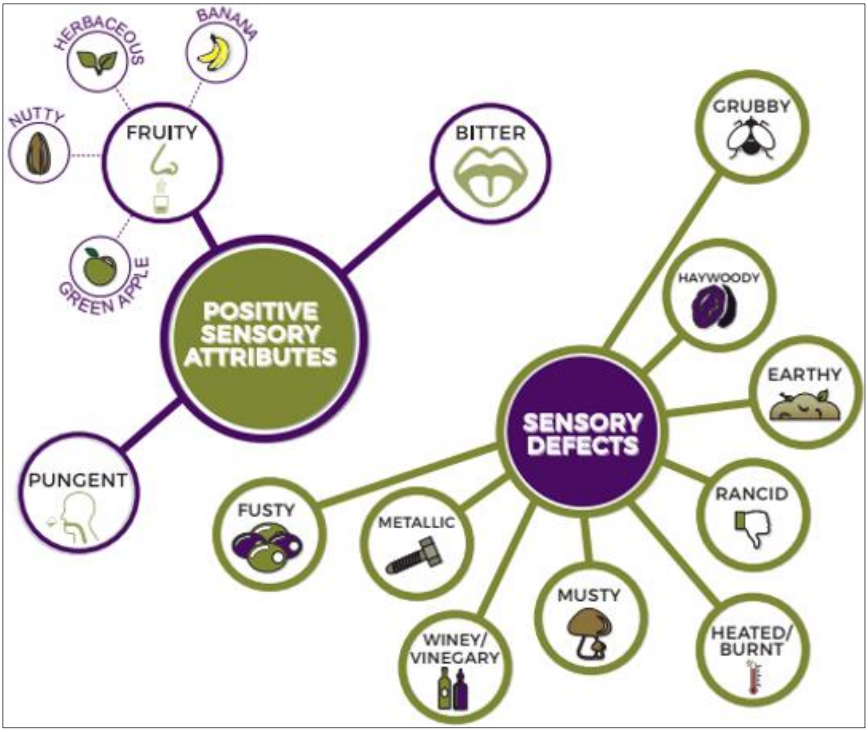


Figure 21. Positive and negatıve attributes of EVOO (Anonym, 2020)

A bitter and pungent oil is ideal in a weight loss diet because only a small amount, containing fewer calories, is needed to add taste to food (Roselli et al., 2017). Increasing the content of bitter polyphenols for health may be wholly incompatible with consumer acceptance (Barbieri et al., 2015). Phenolic compounds with important health benefits are characterized by bitterness, which is often perceived as aversive. The intensity of these sensations can be modified by learning to combine other ingredients in culinary preparation and moderating the quantities used. Learning to like bitter EVOO may require repeated exposure and is enhanced by peer pressure and consumption under positive conditions (Blatchly et al., 2014; Roselli et al., 2017). Attenuating the sensory properties by using a lower quantity of bitter EVOO may not be the only solution, because consumers very often learn to like foods or beverages that are initially perceived as unpalatable (Roselli et al., 2017).

Many consumers new to olive oil tend to favor light flavored oils without a lot of bitterness or pungency that have nutty, floral, and buttery characteristics. As olive oil consumers become more familiar with olive oil, they tend to prefer stronger, more herbaceous, or green fruity oils that are quite bitter and pungent. When they find out that those oil styles also contain more of the healthy minor components, then demand for those oil types will increase significantly (Aparicio & Harwood, 2013).

The task of the taste panel is to determine positive and negative sensory attributes whose short descriptions were given in Figure 22. The positive notes, are mainly attributable to fruity (green or ripe), bitter and pungent sensations. Reminiscent sensation of freshly cut grass (grassy), green fruits (green odor), sweet and astringent notes can be also considered as positive characteristics of good quality olive oils. On the contrary, winey–vinegary, fusty–muddy, musty–humidity, rancid and metallic are the most frequent off–flavours (Morales & Alonso, 1995; De Santis & Frangipane, 2015). Positive and negative scores is decisive for categorizing commercial classification and price determination of olive oils.

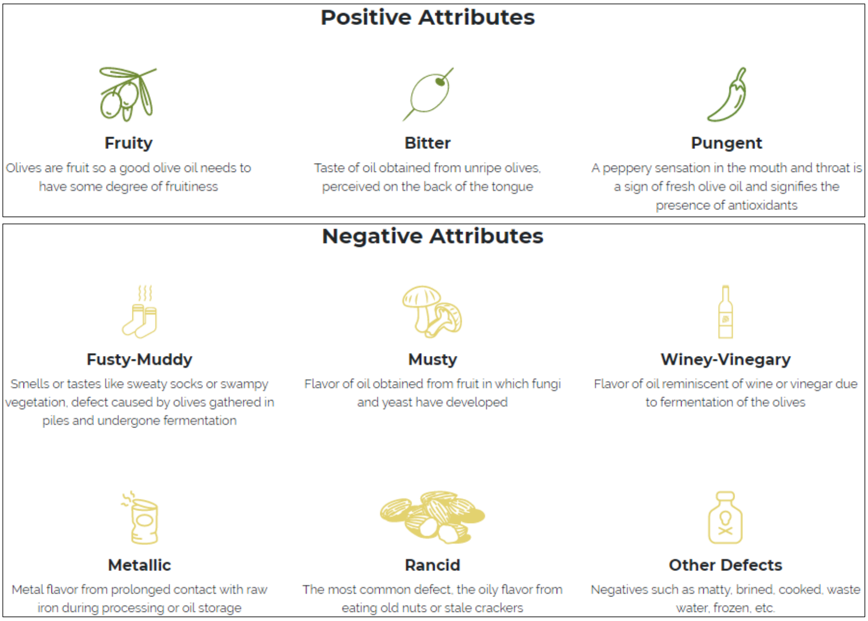


Figure 22. Positive and negative sensory attributes of EVOO (Huang et al., 2018)

Polyphenols in olive oil are the most likely source of this bitter taste. The concentration of these bitter compounds is highest in green olives, and diminishes as the olives mature. Pungency, an irritation in the back of the throat that often causes a cough, is poorly understood at a mechanistic level (Blatchly et al., 2014).

The variability in the concentrations of substances phenolic compounds, oleic acid and vitamin E makes the related functional health claims optimal tools to differentiate within the broad category of EVOO. This is true, in particular, for the claim relative to the minor compounds e polyphenols and vitamin E. It is important to underline that the presence of minor compounds, mainly phenols, can be modulated by the application of the best agronomic and technological practices. The phenolic profile (the quantity and types of phenol compounds) also depends on the olive's genetic makeup because it is related to the cultivar (Hajimahmoodi et al., 2008; Morello et al., 2005).

The high quality EVOO is considered as a true pharm–food. When this property is associated with oil composition, it is reported that high oleic acid concentration which ranges from 56% to 84%; the essential polyunsaturated fatty acids (mainly linoleic acid) ranging from 3.5% to 21% and linolenic acid <1.5% are effective (Lanza & Ninfali, 2020).

To Do List:

For producer;

•Write clearly the allowed product components on your label,

•Plan aquaculture and processing to increase the useful ingredients,

•Do the storage to protect useful components,

•Periodically analyze the components of product,

For consumer;

•Carefully read the ingredients on the label,

•Select light protective packages,

•Join sensory evaluation course of EVOO,

•Store cold and dark place,

•Do not store long time (especially after opening).

ORGANIC CULTIVATION OF OLIVE

In many countries around the world, organic agriculture, which is a human and environment friendly production system, has been started in order to restore the natural balance lost as a result of faulty agricultural practices. Today, controlled and certified organic production is carried out with 2.8 million producers on an area of approximately 71.5 million hectares in 186 countries around the world.

Organic olive cultivation; It is a controlled and certified production method, from production to consumption, using only the inputs permitted in the organic agriculture regulation, without using pesticides and synthetic fertilizers harmful to human health. There is a great demand for natural extra virgin olive oil and table olives obtained from olives grown organically in the world in recent years. The most important reason for this is that these products are grown by natural methods.

Producers who want to cultivate organic olives are required to apply with a petition to any control and certification organization that has been granted a work permit by the relevant Ministry. The Control and Certification body decides whether the application is suitable for organic production with the help of the documents and information requested from the producer and informs the Organic Agriculture Committee. The control body takes the producer to the transition process, which it agrees to do organic production and contracts with. The transition period to organic agriculture is accepted as two years for annual plants and three years for perennial plants containing olives.

For organic olive cultivation, first of all, olive producers should be trained on the principles and objectives of organic agriculture, and have sufficient awareness and knowledge about the environment and cultivation. Organic farming olive groves should be away from the impact of conventional farming areas. Organic olive cultivation should not be done in areas close to highways with industrial pollution or heavy vehicle traffic.

The products obtained by organic production method cost more than those produced in conventional farming conditions. For this reason, the organic olive producer has to take measures to minimize the production difficulties and obtain more products while establishing the Olive Garden. Olive grove selection and preparation for planting, planting spacing and distances, train up method, irrigation and feeding practices and disease and pest control methods are very important. Making all these choices right from the beginning will make organic farming more profitable.

Planting Distances and Production Systems

Today, in order to get more products from olive trees, the necessary cultural practices (drip irrigation, pruning, fertilization, fighting etc.) planting can be done at more frequent distances if it is done. High density and super high density systems applied in some countries in recent years are not recommended for organic farming. In organic farming, it is aimed to ensure that more light and air enter the canopy for the natural control of potential diseases and pests. Therefore, the distances between the trees should be kept wide.

Planting distances of 6×8 m–7×7 m are recommended for varieties with large canopy, 5×5 m–4×6 m for varieties with small canopy, 5×7 m–6×6 m for varieties with medium canopy. Determining the proper spacing and distances and the method of training in trees depends on various environmental and cultural factors. In organic farming, central open systems in trees are more suitable than the central leading system applied in more intensive cultivation. In order to reduce the alternate bearing tendency seen in olive trees, it is suggested that the tree should be pruned vigorously in order to reduce its load when entering the yield year. For this purpose, crop pruning should be done every two years, when entering the crop year. In addition, alternate bearing in trees can be reduced by encouraging the growth of shoots that will give the product of the next year with adequate irrigation and feeding practice. Early harvesting of trees and not using poles during harvest also reduce the severity of alternate bearing.

Cultivation Techniques Feeding of Olive Trees

In organic olive cultivation, the soil creates a unique ecosystem with its organic structure and inorganic nutrients, fauna and flora structure that must be protected. The nutritional status of olive trees is controlled by applying leaf and soil analysis. Since the use of chemical and synthetic fertilizers in organic olive cultivation is prohibited, only fertilizers permitted by the relevant legislation can be used according to soil analysis results. In addition, in case the macro and micro element deficiencies cannot be eliminated, the use of specific products approved by the control and certification organizations is also allowed. Organic fertilizers permitted to be used in organic agriculture; farm manure, green manure and compost. Farm manure is a very important fertilizer for organic farming.

Green fertilization can be done with nitrogen fixing legumes (beans, vetch, peas, etc.) or a mixture of grain and legumes (8 kg vetch, 3 kg barley per decare). Green manure crops; It is planted in the soil in autumn, it is plowed and mixed into the soil at the beginning of flowering (Figure 23). The amount of nitrogen to be given to the soil is determined according to the nitrogen content of the green manure plant. Another alternative to organic farm manure is compost. Compost can be obtained from pruning residues or by composting olive oil mill waste water and olive pomace. In addition, wastes obtained from 2–phase olive oil production systems can be composted and used as fertilizers.

Figure 23. Mixing barley/vetch mixture into the soil

Figure 24. Preparation and maturation of compost piles

Figure 25. Application of compost to olive trees

Figure 26. Organic olive saplings grown in compost

Weed Control

With irrigation and nutritional practices in organic olive groves, weeds proliferate rapidly and cause a decrease in the yield in common with the water and nutrients of the trees. They also host diseases and pests, making harvesting difficult, hence increasing labor costs. In the fight against weeds in organic olive groves; It is the superficial tillage in a way that does not damage the root parts of the trees, and the weeds are mowed at certain intervals before they bloom in sloping areas where plowing is not possible. Thus, seed binding of weeds is prevented. With the application of cover crops in olive groves, both weeds are suppressed and the water in the soil is preserved (Figure 27). In addition, weeds are controlled by mulching. It can be used in mulching plant materials such as straw as well as plastic covers (Figure 28). In addition, weed control is carried out by tillage and animal grazing.

Figure 27. Cover plant

Figure 28. Mulching

Protection from Disease and Pests

Diseases and pests cause significant crop losses in organic agriculture. Cultural measures and biological control methods are accepted in pest management in the organic production system. It is necessary to know very well the regional conditions in the production areas and to know which product and which varieties will be grown in order to avoid pest problems that cause significant production losses. In addition, good records of pest problems will be effective in developing more effective pest control strategies in the next year. It is important to correctly identify the pests in the product and the beneficial species that suppress these pests in terms of preventing product losses. In addition, it is necessary to determine the economic damage thresholds of the pest and to apply appropriate combat methods in order to decide on the fight. Traps are used to determine the adult outflows of harmful insects and directly control pests. McPhail traps (Figure 29) and yellow sticky traps (Figure 30) are used to determine the adult growths of the olive fly (Figure 31). Eco–trap (Figure 32) and Olipe trap (Figure 33) are used for mass trapping against olive fly. Delta–type pheromone traps are used for olive moth adult population control and mass trapping (Figure 34).

Figure 29. Olive fly adult and larvae

Figure 30. McPhail trap

Figure 31. Yellow sticky trap

Figure 32. Eco–trap

Figure 33. Olipe–trap

Figure 34. Delta type pheromone trap

Cultural measures are also very important in the fight against soil–borne fungal diseases. For *Verticyllium dahliae* (Figure 35), which has been a major problem in olive groves in recent years, olive groves should be avoided in areas where cotton and vegetables are grown for many years in the base lands. If Olive groves are to be established in these areas, it should be done after growing cereals such as barley, oat, wheat that are not host to *V. dahliae* for at least 2 years on these lands. Since it is a disease transmitted to trees from the root, soil tillage should be done superficially and without entering the canopy projection of the tree, so as not to damage the roots. Solarization (Figure 36) is applied in summer to reduce the intensity of the disease in the soil.

Figure 35. *Verticyllium dahliae* in olive

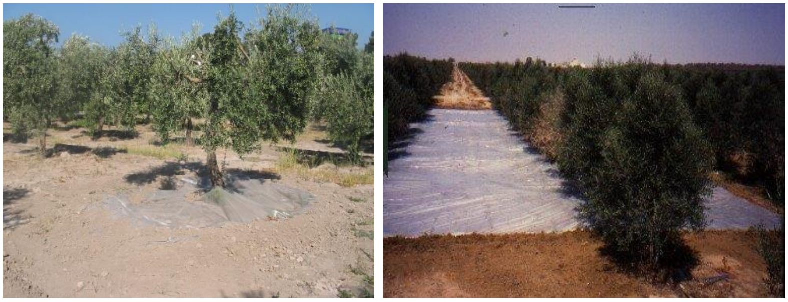


Figure 36. Solarization application

INFLUENCE OF ORGANIC AND CONVENTIONAL AGRICULTURE ON OLIVE OIL QUALITY

High quality EVOO can be produced only from healthy, fresh fruit at the right ripening grade (Frankel 2010). The quality of the oil present in the fruit cells can only be preserved during the elaboration process, but no technological solution is available that can create a quality product from poor–quality olives. The final quality of EVOO and the level of bioactive compounds arises, first of all, inside the orchard (Clodoveo et al., 2015). The farmer must have the right climate then manipulate the choice of cultivars, tree spacing, pruning, fruit thinning, irrigation, fertilizing, pest control, harvest timing, and harvest method in order to maximize quality and keep costs low. When making these decisions, having a good knowledge of the production and quality characteristics of each cultivar is important (Figure 37). To a large extent the cultivar will effect fruit and oil yield and the fatty acid profile and sensory characteristics of EVOO which based on the profile and concentration of pigments, phenols, volatiles, and other phytochemicals present (Aparicio & Harwood, 2013).

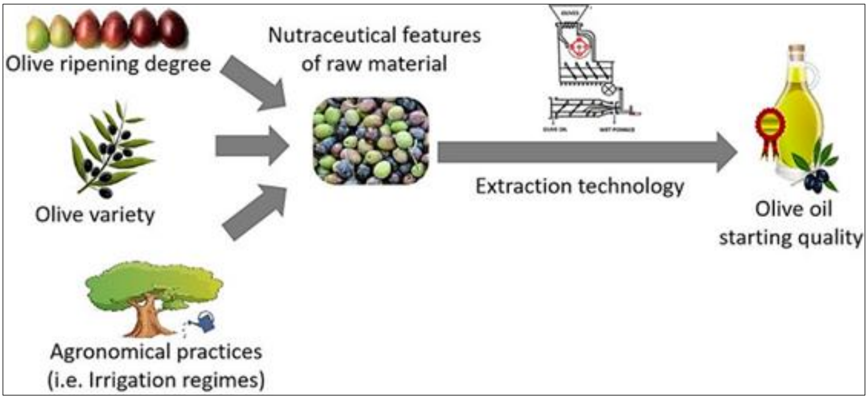


Figure 37. Variety, agronomical practices, harvest ripening degree and oil production technology are effective factors for EVOO quality (Flori et al., 2019)

Environmental factors and agronomic practices, such as fertilization and irrigation, have also been shown to affect the phenolic composition of virgin olive oil (Morales–Sillero et al., 2007; Clodoveo et al., 2015). Limiting nutrients (nitrogen, phosphorous, potassium), but especially nitrogen, can have a negative effect on olive tree vigor. Interestingly, little to no negative growth response is seen if these nutrients is adequate, which is relatively easy and inexpensive to achieve with the use of modern fertilizers. Excess nitrogen fertilization has also been show to lower total polyphenols in olive oil (Uceda, 2006). EVOO quality decreases were also reported with nitrogen overfertilization. Excess nitrogen was accumulated in fruit and consequently phenol content significantly decreased in EVOO (Fernandez–Escobar et al., 2006).

α–tocopherol content, on the contrary, increased with nitrogen application. Polar phenol content, K_{225} (bitterness index), and oxidative stability were reported lower in the oils from trees receiving greater fertilizer doses (Morales–Sillero et al., 2007). Phenolic compounds of EVOO are also influenced by irrigation management (Berenguer et al., 2006; Gómez–Rico et al., 2007) during the growing season: thrifty watering increases the phenol level due to their involvement in defense against oxidative stress. The phenolic compound levels show an inverse relationship with the amount of water applied to the olive trees; bitterness and oxidative stability have been observed to decrease with the increase in applied water (Berenguer et al., 2006).

Soil type has no clear effect on olive oil composition other than an inherent ability to hold more or less water available to the trees based on rooting depth. Plant nutrition, applied through conventional fertilizers, especially nitrogen and phosphorous, has been shown to affect the fatty acids in olive oil. It has been demonstrated that when the levels of phosphorous in the fruit are increased to optimum levels, oleic and α–linolenic fatty acids increase. But when nitrogen level is increased, oleic acid content is decreased. Excess levels of nitrogen increases linoleic acid content which lowers oil stability and the ratio of mono–to polyunsaturated fatty acids (Dag et al. 2009, Fernández–Escobar et al., 2009).

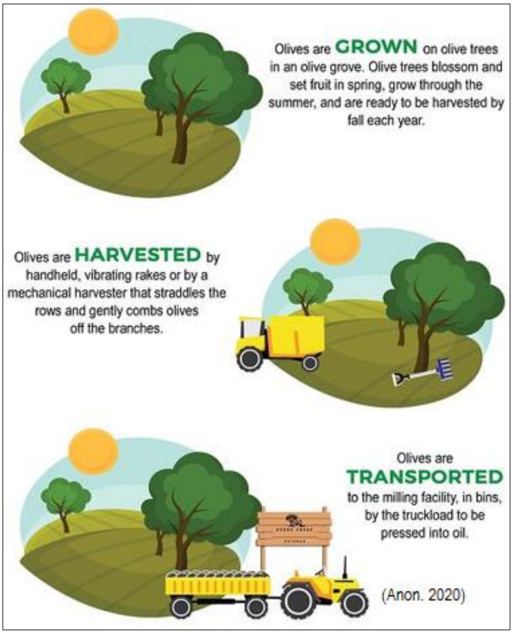
Growing region and olive cultivar have effective role on EVVO's different types of antioxidant compounds (Ripa et al., 2008, Tura et al., 2008). Differences in total phenol content can be due to temperature (degree day accumulation) the warmer the temperature and the higher the altitude of the orchard, the lower the phenolic content of the oil (Mousa & Gerasopoulos, 1996).

The main effect on oil quality from giving trees more irrigation water is on the concentration of phytochemicals in the oil. Both, the synthesis of polyphenols and other compounds decreases, plus concentration levels are also diluted out in fruit with higher–than–normal moisture content. An experiment in California provides an example of how irrigation level can influence both the total polyphenol content and oxidative stability (Berenguer et al., 2006). This experiment demonstrated that there can be three to four times more or less total polyphenols or bitterness in a single cultivar (Arbequina) based on the amount of irrigation water the trees received. The heavily irrigated trees produced oils that were almost bland with lower fruity, herbaceous, and floral flavors. Very similar results were obtained in Spain with the Cornicabra variety, where drought–stressed trees and deficit irrigated trees produced oils with sensory attributes that were almost always greater than more heavily irrigated trees (Gomez–Rico et al., 2007).

Fruit damage from pests can have a huge negative impact on olive oil quality, especially flavor. Oil obtained from olives damaged by anthracnose (*Gleosporium olivarum* Alm.) show significant increases in aldehydes such as heptanal, octanal and nonanal, which are off–flavors that can be attributed to oxidation and decomposition reactions (Runcio et al., 2008; Aparicio & Harwood, 2013). Olive fruit fly (OLF) (*Bacrocera oleae*) is a pest that must be controlled in order to prevent fruit damage and obtain high–quality oil. In the case of OLF damaged fruit, volatiles such as carbonyl compounds and alcohols intensify, but in addition phenolics decrease, lowering oxidative stability, plus as the fruit ripens, free fatty acids and peroxide values increase (Gómez–Caravaca et al., 2008; Mraicha et al., 2010). One of the methods to reduce the negative effects of OLF on oil quality is to harvest early before fruit softens and rots from fungal and bacterial contamination. Fruit deterioration is also less in cultivars that have a high polyphenol content that resists oxidation and microorganism attack. OLF seems to have no significant effect on oil fatty acid profile. Varietal differences are important in that OLF damage is lower in small fruited varieties with a small flesh–to–pit ratio (Koprivnjak et al., 2010). Freeze injury to olives prior to harvest can also reduce oil quality by lowering chlorophyll and carotenoid contents, reducing oil stability, bitterness, and pungency and increasing the levels of vanillin and vanilic acid causing the oil to taste sweet, woody, and bland (Morelló et al., 2003; Aparicio & Harwood, 2013)

Training system and pruning appear to have no effect on oil quality (Gucci et al., 2007). Sugars produced in olive leaves are transported to the fruit and converted into oil. Therefore, the ratio of leaves to fruit can dramatically affect fruit oil content. In years with heavy crop loads, total oil ratio is higher, but compressively lower oil ratio was reported in light crop years (Aparicio & Harwood, 2013).

Cultivar, ripening level, climatic conditions and irrigation management are some of the factors that can influence the behavior of the enzymes present in olive pulp and seeds (Berenguer et al., 2006; Perez et al., 2014). Under adequate extraction conditions, extra virgin olive oils are always produced when healthy olives are used, whichever the olive cultivar processed. Only olives attacked by pests and diseases, or fallen to the ground before harvesting, produce olive oils with off–flavors. Other defective sensory notes in EVOO are due to inadequate harvesting, post-harvesting, processing or oil storage (Alba et al., 2008). Moreover, the production of high–quality EVOO at the highest yield and minimum cost, as well as using an environmentally friendly olive oil production, is more and more requested. Consequently, the use of "ecological" agriculture practice and technologies had the greatest impact in the characteristics of EVOO, in the last 25 years (Garcia–Gonzalez & Aparicio, 2010; Peres et al., 2017).



Awareness–raising campaigns are crucial to enrich the knowledge of consumers concerning organic olive oil and differentiating it clearly from the conventional, emphasizing its differences (Pleguezuelo et al., 2018). In terms of minor polar phenols, there is disagreement on which between the organic or conventional EVOOs show higher concentration values (Lanza & Ninfali, 2020). Most studies comparing organic (ecological) versus nonorganic (nonecological) cultivation methods have shown no significant differences in oil composition and properties probably because of the high degree of variability due to fruit maturation, pest damage, water status, genetics, etc. (Ninfali et al., 2008).

The consideration of organic olives and organic olive oil as a "strategic sector" in some cities is due to its potential to spur the economy and generate employment, and also because of its social, environmental, and cultural value. Besides considering this sector as an income and job promoter, it must also be interpreted as a sector which satisfies an environmental necessity, of land management, social equilibrium, and promotion of familiar enterprises, thereby promoting the new functions that society demands from the rural environment and fostering the sustainable agriculture in olive–growing areas (Pleguezuelo et al., 2018).

Researchers agree on the need to set up experiments to eliminate the effect of the seasonality as well as to fix the parameters, which clearly distinguish the organic and the conventional practices. This difficulty lies probably in the fact that the definition of organic and conventional practices is too broad and different techniques are enclosed in the same system (Rosati et al., 2014). Furthermore, the different location of the olive orchards introduces differences in the olive exposition to light, which is an important determinant for affecting the phenols content (Proietti et al., 2012). Therefore, a wide number of parameters must be controlled to detect whether the nutritional quality of organic olive is higher than the conventional ones (Lanza & Ninfali, 2020).

Olives are a crop that lends itself well to organic production methods with comparably few insect and disease problems. Olives can also survive and even thrive on lower water and nutrient inputs than many other tree crops, so they will be popular to grow. With existing problems, growers must reduce the use of conventional pesticides and evaluate the effectiveness of more natural products or methods to control olive fly, anthracnose, foliar diseases, weeds, and other olive orchard pests (Aparicio and Harwood, 2013).

Production of organically grown foods is part of a broad movement consisting of a spectrum of attitudes and practices with social, philosophical, and agronomic implications (Sinha et al., 2011). Organic products such as olive oil have attracted many types of consumers in recent years. In this context, the Mediterranean basin represents 5 Mha of the 10 Mha of olive farming worldwide, with Spain being the leading producer (Figure 38). Also, during the recent decades, olive farmers met the challenges of sustainability by implementing principles of agroecological production (Pleguezuelo et al., 2018).

Figure 38. Organic olive groves in Andalusia (Spain) (Pleguezuelo et al., 2018)

A farm survey which compared productivity and olive oil quality parameters in organic and conventional production systems, showed similar results. Yield reduction was also not reported in agronomic and economic studies between organic and conventional systems (Volakakis, 2009; Gkisakis et al., 2015, 2016). In contrast, some studies reported lower yields for organic agriculture practices (Parra et al., 2005).

Organic olive oil production has considerably increased worldwide (Anonym, 2016), but everything is not advantageous, as organic agriculture also has several drawbacks that should be taken into account, such as expensive certification systems or few organic inputs available in some places, making the final price of the organic products generally higher. Nevertheless, this price increase is often justified, due to the higher production costs for organic foods because of greater labour inputs per unit of output and the expensive control systems to avoid fraud. Also, the production can be uneven, and therefore the harvest and distribution costs are greater than those for conventional foods (Pleguezuelo et al., 2018).

Prices for organic olive oil is currently between 50% and 100% higher than those of equivalent products from conventional production. This is mainly attributed to higher costs of inputs (e.g., manure, legume seed, and mass–trapping systems), quality assurance, and certification in organic production systems. However, there are still relatively few studies comparing the yields and cost structures in organic and conventional production systems (Volakakis et al., 2017). In some biggest olive producer cities organic olive orchards percentages n the total organic surface area has been reduced in the last few years, due to a lack of adequate organic olive mills (Bosa 2011). In fact, some olive mills do not differentiate between organic and conventional olives, so the final product has the same label regardless of the origin, and the work of farmers is not properly recognized (Pleguezuelo et al., 2018).

The available evidence suggests that organic olive oil agriculture result in (a) lower environmental impact (especially with respect to nitrate leaching, phosphorus runoff, and pesticide contamination) and (b) lower environmental and food–based exposure of consumers to potentially harmful OP and other pesticides. In contrast, there is currently no evidence for substantial differences in other olive quality parameters such as acidity and fatty acid composition (Volakakis et al., 2017).

OLIVE HARVEST TIME AND METHODS

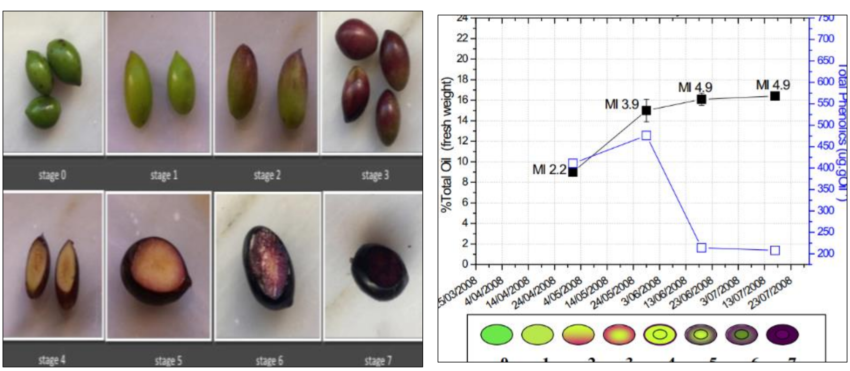
The olive harvesting time and operation critically influences oil yield and quality as well as the cost of oil production. Optimizing olive harvesting entails obtaining the highest amount of oil of predefined level of quality. In quality–oriented companies, oil yield is a dependent variable of oil quality. In fact, the harvesting decision is determined by the need to meet suitable sensory and analytical requirements and the yield of olives per tree and per hectare follows as a consequence (Peri, 2014).

Harvest time is very important for produce high quality oil

Early harvested olive is better for higher quality

Phenol levels naturally change as the olive fruit ripens, the timing of the harvest is very important. Early harvesting results in oils with higher polyphenol values. Because phenol levels naturally change as the olive fruit ripens (Dag et al., 2011), harvest time becomes very important. After choosing the best harvesting time for each cultivar in each particular geographical area (Caruso et al., 2014), the other two main factors that are crucial for establishing the final quality of virgin olive oil in terms of phenolic concentration should be considered: the harvesting methods and the post-harvesting storage (Servili et al., 2012).

According to the International Olive Council, olives are divided into eight groups from 0 to 7 according to their shell and flesh colors. The maturity groups of olives are given in Figure 39 (a) and the change in oil and phenol content according to this maturity status is given in Figure 39 (b).



(a) (b)

Figure 39. (a): Maturity groups of olives (Milionis et al., 2016), (b): Oil and phenol content of olives during ripening (Wong et al., 2009)

It has been reported that, different content changes during their maturation especially phenol and oil contents depending on the olive cultivar. For this reason, farmers need to know the characteristics of the cultivars they grow, know what changes in their content depending on the level of maturity and give decision on harvesting time accordingly. In this way, optimum values can be achieved in terms of both high oil yield and oil content.

Studies related to the changes in fruit and their influence on the properties of extracted oils have indicated that during olive ripening, the concentration of phenols progressively increases to a maximum level at the "half pigmentation" stage (3. maturation stages), decreasing sharply as ripening progresses (Rotondi et al., 2004; Ozdemir et al., 2016).

Quality parameters tended to increase and the highest values were found in EVOOs from late harvest dates. In addition, the harvest date had a significant effect on the oxidative–stability, chlorophyll and phenolic composition of oil. However, olive–oil yield, carotenoids, and tocopherol content showed no significant variation. According to the results based in the ripening process, the maturation index 2.4 appears to be the most appropriate harvest moment to collect olives in order to obtain high chemical quality EVOO of from Chemlal cultivar (Bengana et al., 2013). It is worth noting that there is a significant difference between the time of phenolic maturation and the time of industrial maturation, i.e., the period where the oil yield reaches the maximum (Trombetta et al., 2017).

There are two main techniques for harvesting olives: the traditional harvest by hand picking or the newest mechanical methods. Mechanical harvesting systems can be categorized in two groups: systems based on vibration (manual aid branch shakers or trunk shakers) or contact canopy shakers (individual comb shakers and canopy shakers) (Ferguson et al., 2010). Harvesting by hand, although slow, guarantees the best quality of the olive fruit, creating better quality of the final product but also a higher price tag due to extra manual labor.

The influence of olive harvesting on production cost is very important. Mechanization plays a strategic role in the planning of olive groves and in choosing the cultivars and the tree training system. Developments towards a high degree of harvest mechanization consist in choosing the right machinery but also adapting the trees to machinery use (Bengana et al., 2013; Peri, 2014). Mechanical harvesting allows a higher working capacity (Famiani et al., 2014). As an example, using continuous harvesters, one hectare of a high–density olive orchard is harvested within just 2–3 hours; this allows for harvest of a cultivar in a very short period with low costs. On the other hand, mechanical harvesting systems may sometimes reduce fruit quality due to damage and bruises, resulting in a bad quality of the final product (Godini et al., 2011).

To Do List:

- Avoid all damages to olives,
- Use appropriate harvesting machines and mechanical facilitators to reduce damages to olives,
- Separate all foreign material (stem, leaf etc.),
- Separate injured and unhealthly olives from healthy olives as soon as possible (Peri, 2014).

EFFECT OF PROCESSING ON EXTRA VIRGIN OLIVE OIL QUALITY

Olive oil is a sector challenged by many directions: cultivation, production, environmental footprint, and market needs. The latest reflects consumers demand for EVOO of the highest quality. Cultivation and production line dominates the quality of the product, however its price at the end of the day is affected by market rules. This fact results in price variations from time to time that pressure the small traditional producers. On the other hand, local authorities pressure olive oil industries to reduce their environmental impact (Galanakis, 2017). Scheme of olive oil extraction line was given in Figure 40.

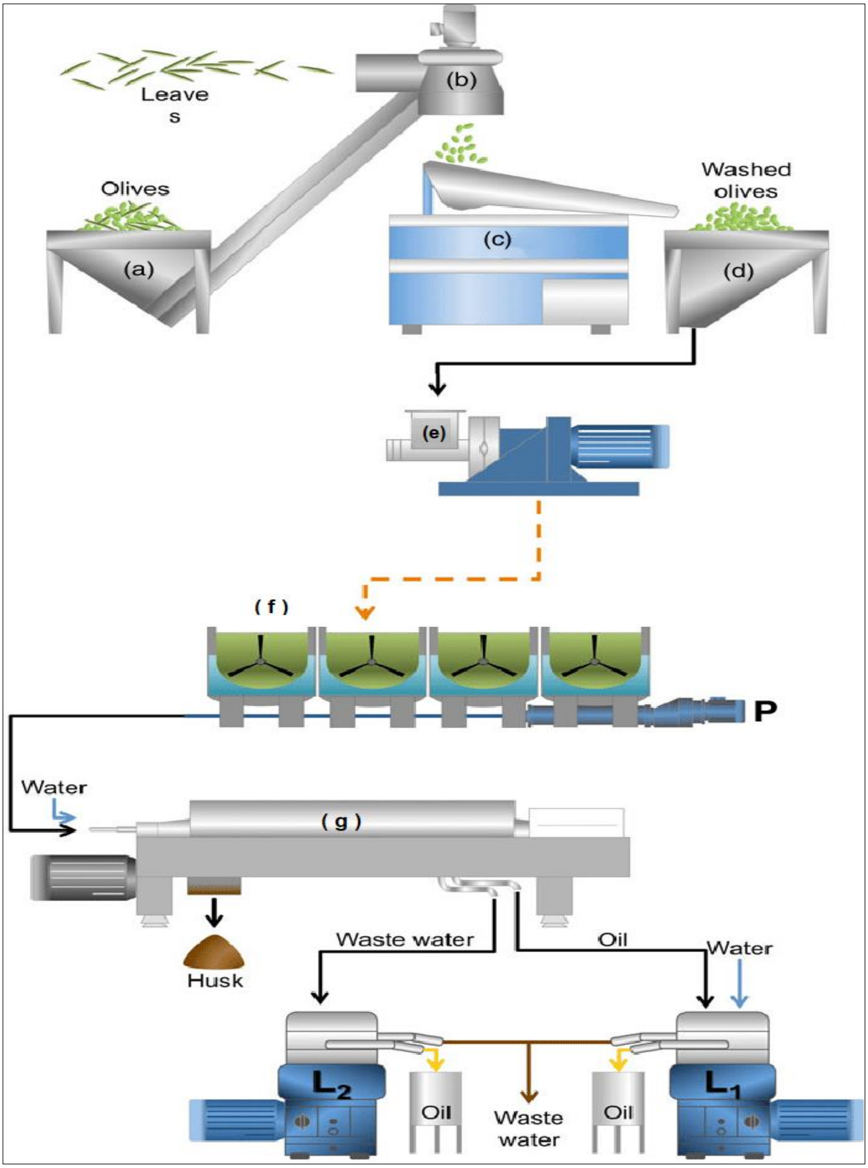


Figure 40. Layout of EVOO process: (a) loading hopper; (b) defoliator; (c) washing machine; (d) hopper; (e) hammer crusher; (f) malaxer machines; (g) solid/liquid horizontal centrifugal decanter; (L) liquid–liquid vertical centrifuges; (P) Cavity Pump (modified from Romaniello et al., 2017)

Due to multiple technological processes, the content of polyphenols may vary in olive–oil. Figure 41 represents the level of polyphenols in oil dependent on the technological process of oil production (Gorzynik–Debicka et al., 2018). If process is not conducted properly, it can lead to a dramatic reduction in antioxidants, particularly phenols, as these molecules are susceptible to chemical and biochemical oxidation reactions (Frankel, 2010).

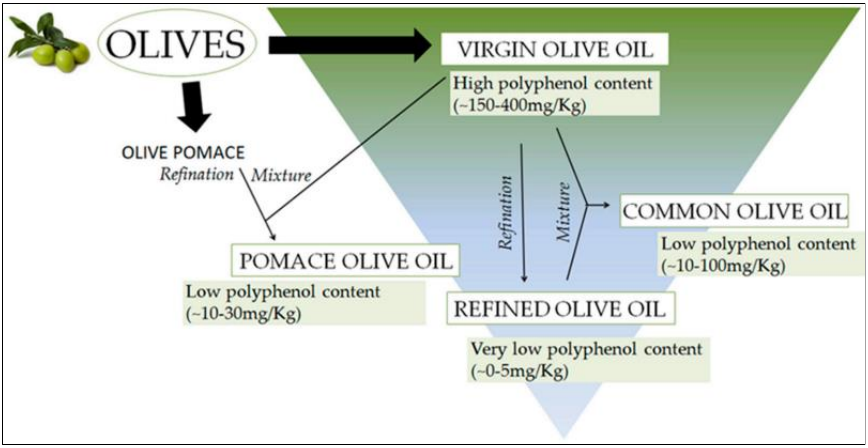


Figure 41. The concentration of polyphenols in different kinds of olive oil depending on technological process of the oil extraction (Gorzynik–Debicka et al., 2018).

In these section influence of processing on EVOO quality was described by step and step. These are post-harvest practice, leaf removal and olive washing, crushing, malaxation, separation of phases, filtration, packaging and storage. This process is aims to obtain EVOO at highest yield with highest quality as possible as. Both process systems and parameters have decisive effect on yield and quality of EVOO. After production packaging and storage also has remarkable effect on prevention of quality losses.

Post-Harvest Practice

Olive processing is often not well synchronized with crop harvests. So, the fruits are often piled into large heaps and stored at ambient temperature for up to several days prior to processing for oil extraction. If this happens, the greatest deterioration takes place. Pressure within the olive pile during storage may cause secretion of fluid from the olives, thereby providing an optimum medium for the growth of fungi and bacteria (Servili et al., 2012). Strictly avoid putting the olives on the floor or in sacks. Plastic and ventilated boxes or containers for olive handling, storage and transportation until the time of processing (Peri, 2014). Pseudomonas and other soil bacteria are able to metabolize a wide variety of organic compounds, such as phenol and its derivatives. Moreover, breakdown of the cells may favor contact of the phenolic substances with the oxidative enzymes. Olives contain oxidoreductases, such as polyphenoloxidase and peroxidase, that may oxidize phenols and impair the health–related qualities and sensory characteristics of olive–oil (Servili et al., 2012).

Avoiding mechanical damage and controlling time–temperature relationships are key factors for satisfactorily handling and storing olives during the period from harvesting to milling (Peri, 2014). Furthermore, heat production from respiratory activity may accelerate the deterioration of the fruit and eventually cause the breakdown of cell structure. The oil extracted from these damaged olives can be high in acidity, low in stability (Amodio et al., 2005; Clodoveo et al., 2007), and poor in phenols and might develop off–flavors. When the amount of damaged fruit is high, the extraction of oil should be made promptly, avoiding fruit storage at ambient temperatures (Clodoveo et al., 2014).

With the availability of many milling plants, both small and large farms can process their olives within 4–48 h, thereby increasing the organoleptic and nutritional quality of olive oil (Peri, 2014; Clodoveo et al., 2015). It is often recommended that olives be milled ‘in the shortest time possible’ after harvesting. But when if it is not possible time–temperature relationship should be used to avoid quality losses, as presented in Figure 42 (Peri, 2014).

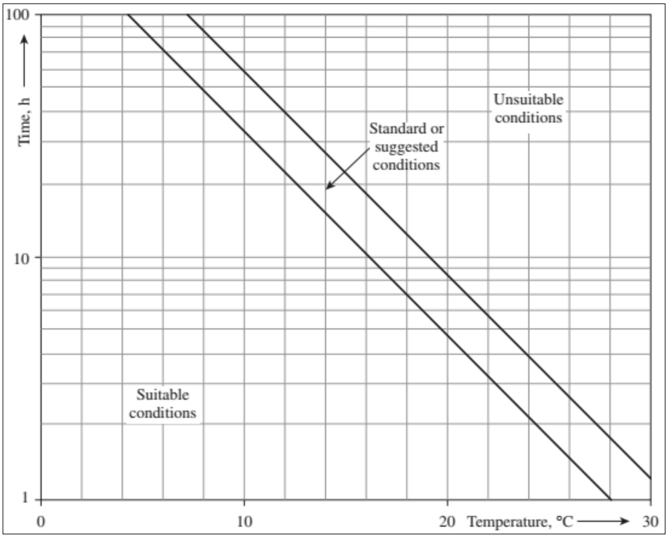


Figure 42. Time–temperature relationship of olive storage before oil processing (Peri, 2014)

The fruit deterioration can be reduced by controlling the storage temperature. It is known that low temperatures are able to reduce both microbial and endogenous enzyme activity. Several studies tested the combined use of controlled atmosphere and cold storage of olive fruits with the aim to control microbial development (Amodio et al., 2005; Clodoveo et al., 2007). Despite some promising results, this technology has not been widespread due to its high cost, which is not supported by the commercial value of the product (Amirante and Catalano, 2000). A rational approach requires coordination of the harvesting and milling operations to avoid fruit storage (Amirante & Catalano 2000; Clodoveo et al., 2015).

To Do List:

- Closely control temperature and time,
- Avoid contact between olives and soil,
- Avoid mixing good and healthy olives with broken or mouldy ones.
- For olive transportation and storage use rigid plastic containers with ventilation holes and layers of olives not thicker than 30 cm.
- Avoid exposure of harvested olives to the sun or rain.
- Storage should not be in open air but in a covered well–ventilated space.
- Relative humidity in the storage environment should not exceed 80%.
- The olive storage area should be clean and free of smoke, exhaust, fusty smell, etc. (Peri, 2014).

Leaf Removal and Olive Washing

It is necessary to clean the olives and to remove stems, leaves, twigs, and other residues that can affect the quality of the resulting olive–oil regarding sensory quality and storage stability. It is also necessary to wash the olives to remove pesticides and other contaminants (Gupta, 2012). Most millers choose to pass the olives over a vibrating screen with a blower that removes leaves and other debris to protect the extraction plant from damages caused by Stones and to avoid off–flavors deriving from the presence of leaves or other foreign bodies Olive leaves are considered an excellent source of compounds with biological properties, but the resulting oils showed higher free fatty acids, peroxide value, and K_{232}. The authors assumed that the negative effect of addition of olive leaves on legally established parameters could be due to the presence of lipolytic enzymes in the olive leaves. (Clodoveo et al., 2015). High risk of fruit cross–contamination due to the poor hygiene of the water used in olives mills to wash olives, and point out the effect on EVOO quality (Vichi et al., 2015).

Olive cleaning is carried out in two steps. In the first ‘separation’ step, particulate foreign materials are removed by sifting, vibrating screens and air blowing of leaves. In the second 'washing' step olives are shaken into a washing basin and finally rinsed with clean water (Peri, 2014).

To Do List:

•Take sample after leaf removal and olive washing and take precaution if needed,

•Control washing water cleanless and replace it frequently,

•Frequently clean the plant (at least daily).

Crushing

The main purpose of crushing is the size reduction of olive fruit tissues and the breakdown of cells in order to facilitate the releasing of oil (Clodoveo et al., 2015). The intensity of the milling action should be considered as an important control parameter of the EVOO process. In modern olive oil factories, crushing intensity is controlled through variable rotating speed. Sometimes different types of crushing mills (as, for example, hammer and disc mills) were used depending on cultivar and ripeness of the olives (Peri, 2014). An intense milling action causes a significant size reduction of the tissues and disruption of cellular material. Phenolic compounds are released to a greater extent and enzyme activities are triggered with formation of oleuropein aglycones that are partially soluble in oil. As a consequence, a more intense milling action results in an oil with greater bitterness and pungent characteristics and a higher content of antioxidants (Inarejos–Garcia et al., 2011).

The used method for grinding influences the flavor of the resulting oil. Especially the use of metal tooth grinders or metallic disks increases the presence of polyphenols which are responsible for a bitter and pungent taste. Normally, olives are not destoned, because on the one hand the oil yield decreases and on the other hand the presence of stones seems to have no adverse effect on the flavor of the oil (Gupta, 2012). It is evident that an intense milling action should be applied to cultivars with a low phenolic content, whereas a milder milling action is suitable for cultivars that have a high phenolic content. Doing the opposite may result in an oil with a flat sensory profile in the first case and an oil with excessive bitterness and pungency in the second (Peri, 2014).

To Do List:

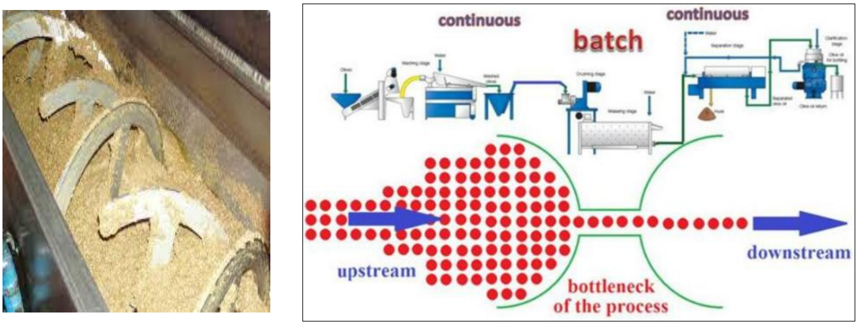
•Take sample after crushing, determine particle size and re–adjust crushing level if needed

•Control temperature crushed olives

•Frequently control crushing machine to avoid metal contamination to olive paste

Malaxation

Malaxation is one of the effective step of EVOO process layout (Figure 43). So that this step is need attention to obtain higher quality EVOO. Malaxation prepares the olive paste for the subsequent separation of the oil. It is a slow mixing of the paste at a carefully monitored temperature (20–35°C) for a period between 20 and 60 minutes, depending on the features of the raw material. Malaxation promotes the coalescence of the tiny oil drops into drops of greater sizes; these can be more easily separated in a centrifugal field and this reduces the olive paste viscosity to optimize the phase separation inside the decanter (Gupta, 2012; Peri, 2013; Clodoveo et al., 2015).



(a) (b)

Figure 43. (a): Inside photo of malaxation, (b): Illustration of bottleneck caused by malaxation in EVOO process (Clodoveo, 2015)

The effect of malaxation is not only coalescence of the oil but profound physical and chemical changes that are responsible for giving the oil its main nutritional and sensory characteristics (Stefanoudaki et al., 2011; Taticchi et al., 2013). During this process, also called as malaxing, enzymatic processes take place resulting in the formation of the typical flavor of olive oil. The longer the mixing time, the higher the chance of the oil taking up minor components that can improve the flavor. On the other hand, it has to be taken into consideration that oxidation processes occur which impair the oxidative stability of the oil and decrease the shelf life (Gupta, 2012).

Two main effects of the malaxation time on the phenol content of virgin olive oil should be taken into account:

1. The mechanisms that are involved in the dissolution of phenol classes in the oily phase,

2. The activity of enzymes and the rate of phenol oxidation over time in the presence of oxygen and high water content.

Ideally, it should be controlled by a thermostated system. The malaxation temperature must be sufficiently low to minimize the enzymatic biotransformation of the polyphenols by the action of peroxidases and phenoloxidases. This biotransformation is minimized if the temperature of the process does not exceed 28°C. On the other hand, the enzymatic activity of glucosidases and esterases, the main enzymes involved in the biotransformation of oleuropein and ligustroside, does not trigger below 24°C. Therefore, the temperature ranges to be controlled (for the entire extraction process) is very narrow (Aristoil Guide, 2019). It is possible to heat the paste or to add water to the paste, thus increasing the oil yield but lowering the oil quality (Gupta, 2012). A malaxation time of less than 30 minutes is recommended for the production of olive oil with high phenol content (Aristoil Guide, 2019). The change in the total phenol content of olive oils depending on the use of different malaxation time in olive oil production from olives harvested at four different times is given in Figure 44.

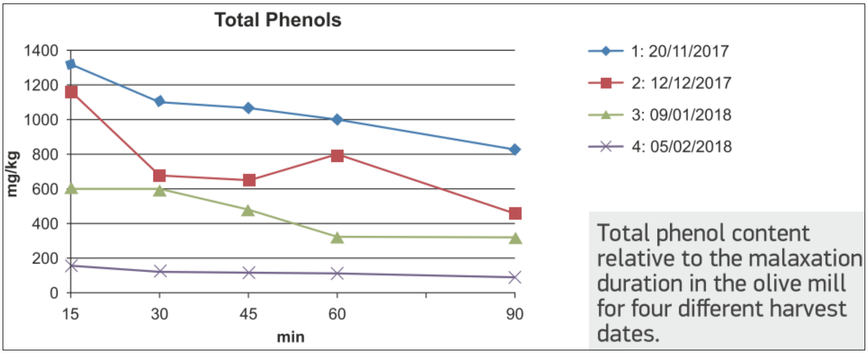


Figure 44. Changes in phenol content of olive oil depending on malaxation time (Aristoil Guide, 2019)

Usually, a long malaxing time in nonhermetic malaxers produces a decrease in oil phenol content and related parameters, such as oxidative stability and bitterness (Clodoveo et al., 2015). Based on literature information and practical experience, Figure 45 shows the range of time–temperature conditions that are suitable for optimal malaxation. The temperature interval on the abscissa is between 20 and 35°C, whereas the times on the ordinate in logarithmic scale vary from 10 to 100 minutes. The two oblique lines indicate the conditions within which coalescence takes place at a suitable rate. The rectangular area traced in the center of the diagram, between 25 and 30°C and between 20 and 50 minutes, is the area in which the best compromise between yield and quality can be found (Peri, 2013).

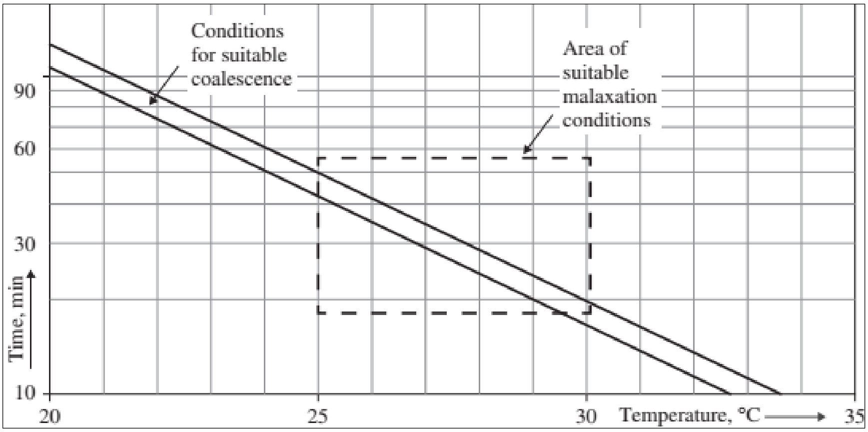


Figure 45. Time–temperature conditions for optimal malaxation (Peri, 2013)

The term 'cold extraction' on label of EVOO can be used when its malaxing temperature does not exceed 27°C (the Commission Regulation (EC) No 1019/2002), but there should be indications about malaxing time (maybe equipment working parameter and type) with mentioned temperature.

Heating results in lowering of the viscosity of the oil droplets, but accelerates oxidation processes and enzymatic breakdown of the paste. During this process, also called as malaxing, enzymatic processes take place resulting in the formation of the typical flavor of olive oil. The longer the mixing time, the higher the chance of the oil taking up minor components that can improve the flavor. On the other hand, it has to be taken into consideration that oxidation processes occur which impair the oxidative stability of the oil and decrease the shelf life. With increasing mixing temperature and constant mixing time, the content of polyphenols increases while longer mixing time with constant mixing temperature results in a decrease of the total polyphenol content in the oil (Gupta, 2012).

To Do List:

- Choose time and temperature to maximize oil content with maximize desired and minimize undesired characteristics of oil,
- Set a maximum temperature for heating water to prevent unwanted temperature increases in malaxer,

•Set a flow rate for heating water to obtain suitable average temperature in malaxer,

•Avoid mixing previous and next batches in malaxer,

•Completely discharge olive paste for malaxing of new batch,

•If it is possible wash the malaxer after each malaxing batch,

•Do detailed cleaning and control after each working day.

Separation of Phases

The separation of oil from solid and liquid phases of olive paste is obtained by applying three different systems: pressing, percolation and decantor (Baccioni and Peri, 2014). All of them work based on different physical separation techniques. Pressing is oldest method based on filtration with under gravity or press. Percolation depends on surface tension used by very low number of producer. Decantor is a horizontal centrifuge spear oil with density difference.

Centrifugation is an essential part of a modern EVOO process. Old methods based on pressing or selective percolation cannot be considered as suitable in terms of effectiveness for oil recovery, hourly capacity, flexibility and cost (Peri, 2014).

Pressing

For the separation of the oil from the solid material, different techniques are in use. The oldest ones are the separation by means of gravity or pressing with either lever or screw presses. In that case, the paste was put on mats or in bags that were squeezed by pressing (Figure 46). Disadvantages are low oil yields resulting from low pressure and time–consuming labor due to the discontinuous process (Gupta, 2012; Clodoveo et al., 2015). Some producers write on label of EVOO “cold press” as a higher quality indicator for consumer attraction but oil production with pressing is not a quality indicator.

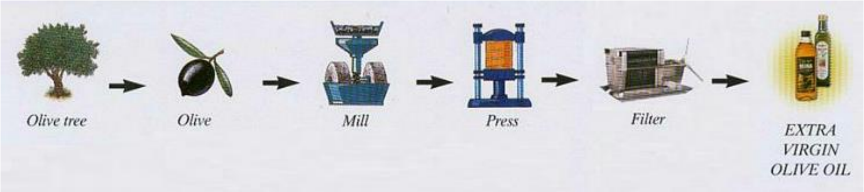


Figure 46. EVOO production process with pressing method (modified from Depastas, 2015)

Percolation

In percolation system oil is extracted from the paste by using the Sinolea equipment. Due to the different surface tension of oil and water, the olive oil is separated from the paste by steel blades which deliver the oil. The plates are coated with the oil and when withdrawn from the paste olive oil drips off in a continuous process (Gupta, 2012). Advantages of the process are higher polyphenol contents of the oil because of no use of water, low temperature load of oil during processing, oil has good aroma and flavour continuous, automated cycle which require low labour, no use of additional water and lower operating costs. It is unfavorable that the oil yield is lower (only 70–75% of the oil contained in olives is extracted) so that the process has to be combined with one of the other processes and the use of plates results in a large surface with a risk to accelerate oxidation (Gupta, 2012; Khdair et al., 2015).

Decanter

Centrifugation technology was introduced at the end of the 1980s and currently is the most applied extraction process. It is based on the differences in the density of the olive paste constituents (olive oil, water, and insoluble solids). Today, two different decanter systems are mainly used for olive oil production, depending on the products produced at the end of processing: the three–phase and the two–phase centrifugation techniques (Amirante et al., 2010b). Mass balances of there and two types decanter systems were given in Figure 47. Significant difference in olive oil quality obtained from different pressing systems in terms of free acidity, ultraviolet absorption, peroxide value, polyphenol content, organoleptic assessment and overall quality index (Khdair et al., 2015). Three–phase decanter separate oil, water, and solids individually, whereas the two–phase decanter separates the oil from the wet paste. Both methods have low operating costs and the pomace only contains low amounts of residual olive oil; however, the investment is high, the pomace is wetter than for the production by pressing, and a high volume of wastewater is produced (Gupta, 2012).

The paste is pumped together with lukewarm water through the three–phase decanter which increases the fluidity of the mixture and improves the separation of oily and solid material, but produces high amounts of wastewater. This results lower amounts of polyphenols in the oil because of the use of water. Also there is a reduction in bitterness value of and oxidative stability of oil (Gupta, 2012).

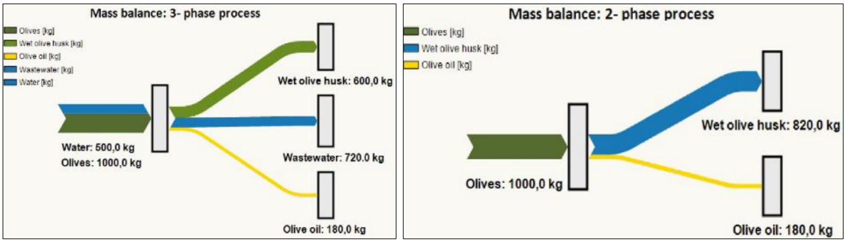


Figure 47. Mass balance of three–phase (a) and two–phase (b) centrifugation oil extraction method (Alburquerque et al., 2004; Vlyssides et al., 2004)

The two–phase decanter requires no dilution or only a little dilution during the malaxation phase. So, the main difference between the two types of machines is the amount of water added to dilute the olive paste: The two–phase decanter has low water consumption and low waste water production (Clodoveo et al., 2014) It is strongly recommended to use the two–phase decanter system. Changing from 3–phase system to the 2–phase decanter will bring several advantages such as prevent water consumption, decrease in wastewater production, increase in sensory scores and the quality of the EVOO, improves with 30% higher total phenol content of EVOO (Khdair et al., 2015; Antonini et al., 2016).

After decanter the extracted oily phase can be further clarified in an automated discharge vertical centrifuge (disk centrifuge) with lukewarm tap water added. This can be thought as second step in centrifugation is carried out to make the oil as clear and stable as possible. Vertical centrifugation separates the residual water and the solid impurities in order to obtain a clear oil, reducing the virgin olive oil humidity concentration to a mean value about 0.18% (Masella et al., 2009). However, the addition of water reduces the hydrophilic phenol content. As recently reported (Masella et al., 2012), vertical centrifugation causes a strong oxygenation of the virgin olive oil, resulting in a marked increase of dissolved oxygen concentrations. This condition can lead to a noticeable shortening of the oil shelf life as a consequence of accelerated oxidation (Clodoveo et al., 2015)

After decantor oil is put through the vertical separator, which mixes the oil and water to separate any impurities left in the oil. It is also named as finishing centrifuges and reduce as much as possible the suspended material in the oil by using effective finishing centrifuges.

To Do List:

•Check the rotation speed and temperature for optimum oil yield and quality,

•Regularly analyze the amount of residue oil in the pomace,

•Use as little water as possible for decanter and centrifuge,

•If water will be used for decanter or centrifuge operation, check the temperature and flow rate,

•Wash decanter and centrifuge after each batch, if possible,

•Do detailed cleaning and maintenance after every working day.

Filtration

Some producers maintain that EVOO do not need filtration but also that filtration is detrimental to oil quality. This point of view should be considered as erroneous and probably the result of improper implementation of this operation (Peri, 2014).

Producers prefer filtering the oil using diatomaceous earth or cellulose fibers to achieve a more brilliant oil, avoiding the risk of developing some sediment in the bottom of the bottle. Really, a high–quality EVOO does not need to be filtered if deposition of a residue is complete. Filtration may affect the phenolic content and positive flavor attributes. To overcome such problems, Italian and Spanish researchers (Lozano–Sánchez et al., 2012) proposed inert polypropylene filter bags and inert gas flows as filter aids (Clodoveo et al., 2015). Similar results for volatile compounds of filtered and unfiltered EVOO were reported (Figure 48) (Sacchi et al., 2015).

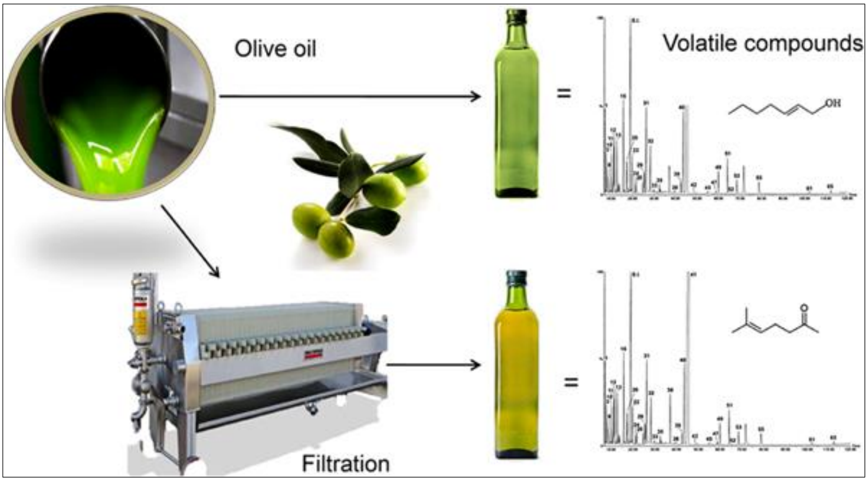


Figure 48. Similar volatile components were reported for filtered and unfiltered EVOO (Sacchi et al., 2015)

In fact, fine particles that are suspended in a virgin olive oil, even after the most effective centrifugal finishing, contain water and enzymes that may impair oil stability and ruin its sensory profile. Filtered oil has a better appearance and colour and does not form deposits in the bottles, which are not appreciated by the consumer. Filtration makes an EVOO more stable and also more attractive. If the suspended particles are not removed they slowly agglomerate and flocculate, forming a deposit on the bottom of the storage containers. Carrying out a filtration process after a period of rest in the storage tanks obviously makes filtration easier because most of the coarse particles have decanted but this fails to prevent enzymatic spoilage. It is therefore recommended that filtration be carried out as soon as possible after centrifugal separation (Peri, 2014). Although filtration can make EVOO brilliant and can increase its shelf life by reducing its moisture content, filtration sacrifices certain phenolic compounds which could affect EVOO oxidative stability and its nutritional quality. Consequently, to maintain EVOO quality, producers need to take into account both moisture loss as well as the antioxidant content during EVOO filtration (Clodoveo et al., 2015).

To Do List:

•Filtrate oil as soon as possible,

•Control temperature of EVOO (20–25°C is optimal),

•Use only appropriate filter sheets (10–30 μm porosity is preferred).

•Use only positive displacement pumps,

•Set pump at appropriate low flow rate,

•Clean and control maintenance the filter system after each use,

•Do visual control of EVOO for each batch.

Packaging

Packaging is the last marketing communication tool a company can use before the purchase decision is made. It creates positive or negative brand associations and informs consumers about the product category, personality, and quality. A central stream within the marketing research concerns the impact of visual and verbal elements of packaging in the product selection process (Luceri et al., 2020). Packages of olive oil should have both protective effect from outside conditions and marketing functions. So that size, shape or color selection of olive oil package should be considered for these two aims. Olive oil should be stored below 18°C. If the air space in the package is as small as possible, the deterioration that may occur in the presence of oxygen will be prevented. Other protection expected from the packaging is to provide protection from light, moisture and odors (Aristoil Guide, 2019).

Visual elements of food products can play an important role in determining food choice through shaping the attributes perception of consumers. Symbols and logos have the role of conveying information, but they can be interpreted in different ways (Cavallo & Piqueras-Fiszman, 2017). Visual elements include colour, shape, material, size and graphics, while verbal elements include information like ingredients, nutritional value, and country of origin. Both visual and verbal elements were reported as a powerful effect on consumers' responses to a product and can influence the purchasing decision (Luceri et al., 2020). Some required package and label informations and optimal storage and packaging conditions were given in Figure 49.

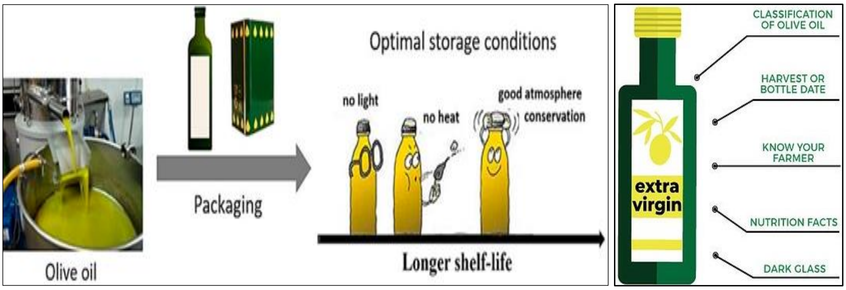
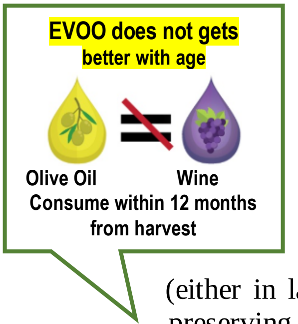


Figure 49. a: optimal storage and packaging conditions (Flori et al., 2019), b: required package and label informations (Annonymous, 2020)

The characteristics and performance of glass, metal and plastic containers in the packaging of EVOO are presented and compared in terms of cost, protection from light and oxygen, possibility of recycling and reuse, mechanical resistance and inertness. Edible oils in general, and EVOO in particular, need containers with specific protection properties at every step of the chain from production through storage, transportation, distribution, and final selling and use (Peri, 2014). The shape of the package can also have important effects on virgin olive oil stability. The best packaging is characterized by lower headspace, which minimizes the amount of oxygen in contact with the product (Clodoveo et al., 2015). Consumer perceived quality better and similarly willingness to buy and pay was higher for glass package of EVOO (Luceri et al., 2020).

Storage

Storage is critical for maintaining the quality of extra–virgin olive oil. Spoilage of oil should be minimized by carefully avoiding temperature abuse, exposure to air (oxygen), exposure to light, the presence of water and organic residues in the oil (cloudiness and deposit), lack of hygiene in the oil environment, exposure to a contaminated atmosphere, and mechanical stress during transfer, pumping or transportation (Peri, 2014).



Storage under conditions protected by the light and oxygen, possibly by steel tanks with an N_2 head–space at pressure (0.02 ATM) are necessary. The quality level is maintained if the storage conditions aim to minimize the oxidative processes that occur due to oxygen and light (Lanza and Ninfali, 2020).

The conditions of virgin olive oil storage (either in large tanks or in small packages) are critical for preserving quality and health properties (Boskou, 1996). All the strategies applied in the orchard and in the olive mill to produce virgin olive rich in phenols can be undermined by improper storage conditions (Figure 50). To slow down the oxidation rate during storage, certain factors such as the presence of oxygen and traces of metals, exposure to light, and the binomial storage time/temperature must be kept under control (Bendini et al., 2010). Headspace oxygen is a major factor in controlling the quality of olive oils during storage. Although the higher temperatures increased the rate of oil deterioration (Stefanoudaki et al., 2010).

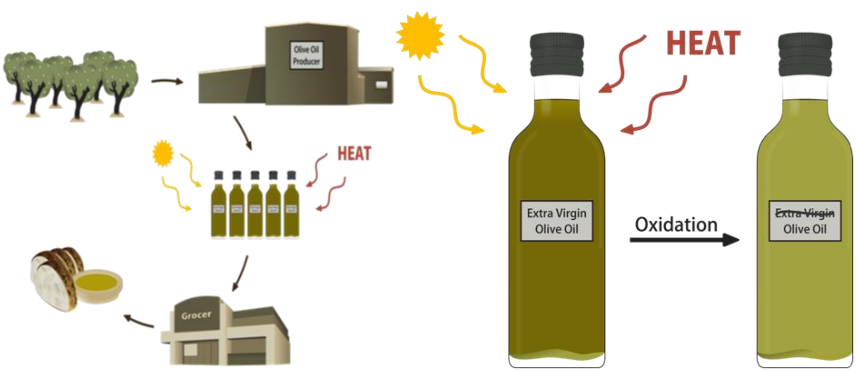


Figure 50. Illustration for heat and light protection of EVOO from production to consumption stages (Staley et al., 2014)

The main reason for the frequent spoilage of olive oil during storage, transportation and distribution, as well as during its storage and use at home, is the underestimation of the perishability of EVOO on the part of consumers and experts alike. The fact that microbial degradation is rare in EVOO has contributed to spreading the erroneous belief that EVOO is a stable product and that it can be submitted to mechanical or thermal abuse without penalty (Peri, 2014). As a final step, the residual water and solids have to be removed by a second centrifugation with faster centrifuges and then the oil is stored in tanks, where a further purification takes place by sedimentation due to differences between oil and solids in gravity (Gupta, 2012). This sediment can be removed periodically by a tap at the bottom side of tank. EVOO can be filtered before bottling.

The term EVOO spoilage does not mean that it will cause food poisoning. The occurrence of defects in the sensory properties (bad or unwanted taste and/or smell), decrease in quality, losts of its beneficial effects and losts of positive properties in taste and smell occur during EVOO spoilage. As a result, after production of high quality EVOO, all of the negative situations in EVOO can be caused by improper storage.

In restaurants, olive oils are normally served in bottles where the oil remains for days or weeks at the wrong temperature and in contact with the air. In these conditions, finding sensory defects happens frequently and the most common fate of an extra–virgin olive oil in a restaurant is the loss of its most interesting sensory notes and health–promoting properties (Peri, 2014).

INNOVATIVE TECHNOLOGIES FOR OLIVE OIL PRODUCTION

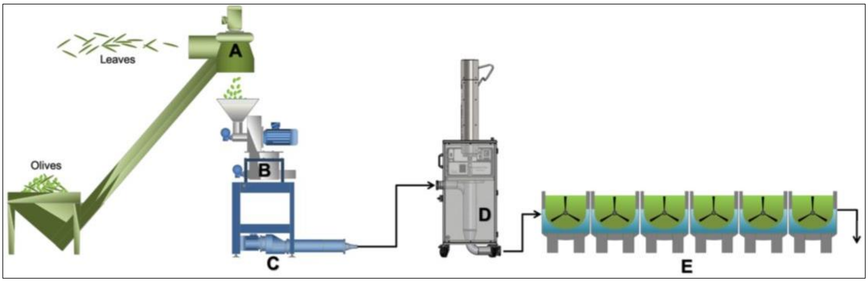
The main advantages of the innovative method compared to the conventional one are: more effective and selective heating, process time reduction, yield increase and reduction of oil losses in byproducts, faster and safer heating control, less space requirements of apparatus and applicability even for biological productions with a smaller environmental impact. In order to increase EVOO yields, reduce the process time and increase process efficiency, it is important to apply new technologies as a result (Clodoveo, 2013).

Every improvement of the olive oil technology aimed to increase yield and/or quality level which be beneficiary to increase income of olive oil processor. But this sector challenged by many directions: cultivation, production, environmental footprint, and market needs. Price of olive oil is affected by market rules. On the other hand, waste removal may cause considerable cost for oil producer. Under these conditions, even cheap solutions that promise the total treatment of olive mill processing by–products may collapse financially small olive oil units. As a result, most treatment technologies have been rejected in practice due to industries in denial that claim to close down production, and society's tolerance that delays the enforcement of environmental legislations implementation (Galanakis 2017). These reasons show that new research and development studies are needed in olive oil production but if applicable results of this studies bring high costs it would be difficult to apply in this industry.

Calcium carbonate uses, as a technological coadjuvant, can bring towards a reduction of the malaxation time. This can have an advantage in terms of the increasing of work capacity of the plant and the reduction of the total energy employed for the extraction process. But no differences were reported in terms of extraction yields (Tamborrino et al., 2017).

Pulsed electric field application in the EVOO process proposed to the increase of oil yield without malaxing. They found that the application of a pulsed electric field treatment to the olive paste significantly increased the extraction yield by 13.3%, with respect to a control in studied at pilot scale in an industrial oil mill the impact of the use of pulsed electric field technology (Puértolas et al., 2015). Furthermore, olive oil obtained by this treatment showed total phenolic content, total phytosterols and total tocopherols significantly higher than the control (11.5%, 9.9% and 15.0%, respectively). In an another research the application of a PEF treatment could permit reduction of the malaxation temperature from 26°C to 15°C without impairing the extraction yield. Parameters legally established (acidity, peroxide value, K_{232} and K_{270}) to measure the level of quality of the virgin olive oil were not affected by the PEF treatments. A sensory analysis revealed that the application of a PEF treatment did not generate any bad flavor or taste in the oil (Abenoza et al., 2012). The use of PEF technology had no negative effects on general chemical and sensory characteristics of the olive oil, maintaining the highest quality according to EU legal standards. Therefore, PEF could be an appropriate technology to improve olive oil yield and produce EVOO enriched in health–promoting compounds, such as phenols, phytosterols, and tocopherols (Clodoveo et al., 2015).

Researchers tested the employment of ultrasounds and microwaves, other emerging technologies that have already found application in the food industry, in order to obtain technological advantages in EVOO extraction (Figure 51). Both these technologies showed mechanical and thermal advantages at a pilot scale (Clodoveo and Hachicha Hbaieb, 2013; Clodoveo, 2013).



(A: cleaning section, B: crusher, C: cavity pump, D: ultrasound E: malaxer section) (Servili et al., 2019)
Figure 51. Scheme of ultrasound application in EVOO processing

A study evaluated the ability of microwave heating to substitute the malaxation process without and with megasonic treatment of the paste. An industrial microwave and megasonic prototype was installed in a commercial olive oil plant. Yields showed increased extractability after exposing the microwave–treated and malaxed paste to a megasonic field by 1,98% and 2,25%, respectively. The oil content in the pomace verified the yield trends observed. Both microwave and megasonic treatments reduced the consistency of the paste. This study reported that it is possible to insert microwave and megasonic prototypes in an industrial line to overcome the batch nature of the malaxation process, thereby producing a continuous process. The combination of microwave and megasonic equipment into a modular unit could represent a new frontier for olive paste conditioning in olive oil extraction plants (Leone et al., 2017). Promising results were also reported in a recent patent relative to a method for microwave dielectric heating in the extraction of EVOO (Clodoveo, 2014).

Ultrasound treatment was applied to olive paste before malaxation in order to increase the process efficiency by reducing the malaxation time. Further, this strategy makes it possible to reduce the number of kneaders, thus reducing the plant costs. The resulting EVOO after the ultrasound treatment presents a more harmonic taste and an appealing when applied to a variety notoriously characterized by strong bitter and pungent notes, making the oil more attractive for consumers with respect to the traditional ones (Clodoveo et al., 2013).

A traditional practice in Mediterranean gastronomy is the aromatization of olive oil with aromatic plants and spices, such as oregano, basil, rosemary, lemon, thyme, chilli or garlic. Different methods are used to flavour olive oils: (i) infusion of spices into the oil; (ii) ultrasound–assisted maceration; (iii) combined malaxation of olives paste and spices during the oil–productive process (Caponio et al., 2016).

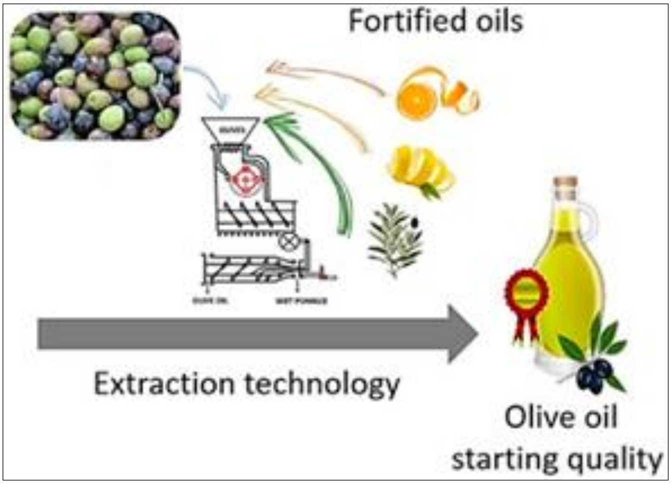


Figure 52. Malaxation of the olive paste with spices or aromatic ingredients (Flori et al., 2019)

In literature, the majority of the authors considered the infusion method (Caporaso et al., 2013; Caponio et al., 2016). Some of them evaluated the ultrasound–assisted maceration and observed that flavouring was achieved in few minutes, whereas conventional maceration required several days (Veillet et al., 2010). Some researchers reported direct malaxation of the olive paste with spices or aromatic ingredients which is easy to carry out and is faster than infusion (Figure 52) (Caponio et al., 2016; Flori et al., 2019).

EFFECT OF COOKING ON EVOO QUALITY AND BENEFICIAL COMPONENTS

EVOO is the most prized olive oil grades, being consensual that their quality attributes are maximized when consumed without being previously subjected to any thermal treatment. Thus EVOO should be preferably added as final seasoning in fresh salads, soups, or more elaborated dishes. Still, when olive oil is used as the cooking base, as in roasting, sautéing (pan–frying), stir–frying, or even deep–frying, thermal effects occurred. Besides, in opposition to other refined vegetable oils, these effects will also disturb the minor olive compounds (Waterman & Lockwood 2007, Boskou, 2009).

In gastronomy, the EVOOs are preferable to seed oils, particularly during frying vegetable. The EVOOs show higher heat stability, linked both to the fatty acid composition and the phenol content, that is important for preventing fatty acids oxidation (Lanza and Ninfali, 2020).

The use of EVOO in the coking practices may have positive or negative effects on the nutritional content. The thermal treatment oxidizes phytochemicals and fatty acids, thus reducing EVOO health benefits. So that the best option is to use EVOO on the vegetables after cooking or at the end of the cooking (Daskalaki et al., 2009). Few studies on the health benefits of EVOO have distinguished between raw oil and cooking oil. The common domestic EVOO use include: frying, soups and stews in oven. In frying, the polyphenols stability is influenced by the composition of the oil, cooking temperature, time and type of food present. Studies showed about 60% decrease in secoiridoids of VOO after 30 min at 180°C of the oil alone and about 90% after 60 min. On the other hand, thermal oxidation of VOO at 100°C (boiling) for 2 h caused a decrease by less than 20% in all classes of phenolic compounds. (Carrasco–Pancorbo et al., 2005; Daskalaki et al., 2009). Less marked depletion of phenols was reported in EVOO used for frying (Silva et al., 2010). Oleocanthal was the most stable secoiridoid but hydroxytyrosol was completely depleted by the heating process and lignans were relatively heat stable (Gómez–Alonso et al., 2003).

According to the most recent legislation, oil degradation is usually evaluated by the total polar compounds and triacylglycerols oligomer fractions. In comparison with other vegetable oils, EVOO has a lower formation rate of these compounds. Nevertheless, based on the detailed analysis of EVOO components, the phenolic compounds and tocopherols are almost depleted after a short heating period (Santos et al., 2013).

An EVOO heated 15 min at 180°C, showed a 45% depletion of polyphenols, whereas the peroxide number increased from 5 to 22 meq O_2/kg. In the presence of the vegetable mixture (onion, celery, carrot and garlic), the polyphenols of the same EVOO decreased about 30% with the peroxide number reaching 10 meq O_2/kg. In the same study, data were compared with sunflower oil, where the peroxide values increased from 1 to 38 meq O_2/kg in the oil alone and to 27 meq O_2/kg in the presence of the vegetables. Results indicated that the EVOO when mixed to the vegetables, maintained most of the phenolic compounds and extracted those of the vegetables by forming an antioxidant mixture able to increase the EVOO stability to heat (Ricci et al., 2018).

Figure 53. Sous vide cooking for prevention the loss of heat sensitive components of EVOO (Holland, 2020)

If the purpose is to accomplish a high cost–effectiveness, namely in the food industry, two strategies can be implemented: the use of mixtures of refined and EVOO, the "olive oil" grade, and periodic refreshment with fresh oil to rebalance the antioxidant pool and reduce oil degradation. The same approach should be applied under domestic cooking, with no advantages proven from the use of EVOO for thermal processing, in opposition to olive oil, as their attributes are rapidly lost (Santos et al., 2013).

The cooking practices must be performed with minimum heat stress and studies for demonstrating the best condition to minimize the phenol losses should still be carried out. For instance, the sous vide cooking method (Figure 53) must be tested for the EVOO antioxidants maintenance, at low temperatures for long exposure times (Lanza and Ninfali, 2020).

LEGISLATION ON OLIVE OIL AND ITS HEALTH CLAIM

The European Union regulation for olive oil characteristics are focused on authenticity and quality issues, including sensory attributes. The same applies for the methods recommended by the International Olive Council, Codex Alimentarius Committee, the United States Department of Agriculture and other relevant scientific bodies and food authorities (Tsimidou et al., 2019).

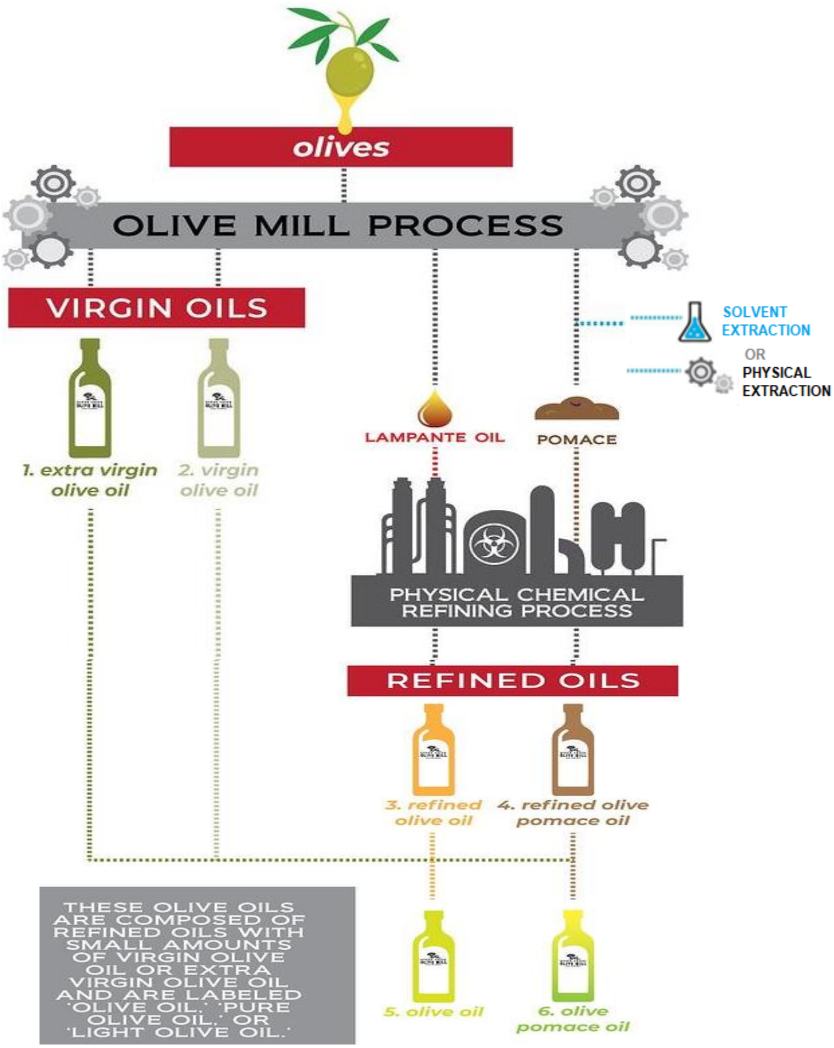


Figure 54. Categories of olives' oil (Anon, 2020)

It is generally acknowledged that the regulatory requirements for this edible oil that is traded in different commercial categories (Tsimidou et al., 2019). These categories are EVOO, VOO, refined olive oil, refined olive pomace oil, olive oil and olive pomace oil and their production information is given in Figure 54.

Acidity, oxidation, and sensory characteristics are the basic criteria to be considered when evaluating the quality of olive oil. The determination of polyphenols is also useful for characterizing olive oils (Ingele, 1994; Kiritsakis, 2007). Acidity has traditionally been used as a basic commercial criterion for grading olive oil. For VOO, the acidity must be $\leq$2.0% expressed in oleic acid. Determination of oxidation is also a main criterion for evaluating the quality of olive oil. Oxidation is evaluated by peroxide value and ultraviolet absorbance. For VOO, PV must be $\leq$20 (meq O_2/kg oil) (Sinha et al., 2011). Benefits and characteristics of each category of olives oil is given shortly in Table 2.

Table 2. Benefits and characteristics of each category (Broaddus, 2017)

Extra Virgin Olive Oil	**Virgin Olive Oil**	**Olive Oil Blend**
•High quality •Unrefined •Full flavor	•Slightly less flavor than extra virgin •Unrefined •Ideal for products that require slightly less flavor and quality but still want a natural	•Light flavor •Cheaper than virgin and extra virgin •Mix with refined oil with virgin and/or extra virgin

Refined Olive Oil	**Olive Pomace Oil**
•Very little color and flavor •Ideal for products that need olive oil to not impart its own flavor and color into the final product	•Cheapest oil grade •Little color and flavor

In the very last years the labelling issue, in its capability to carry information to the consumer, gained its momentum inside the food legislation (Figure 55) (Finardi et al., 2009). The review of horizontal legislation first, with broad consultation of external public and stakeholders (EC Directive n. 496/90), called on to give advice on nutrition labelling (Finardi et al., 2009). For the best sensory evaluation of EVOO by panel techniques, experts from various countries carried out a series of studies under the direction of the International Olive Oil Council. As a result, the "organoleptic assessment of EVOO" was proposed by creating a grading system based on a descriptive analysis of positive and negative attributes of virgin olive oils (Sinha et al., 2011).

Figure 55. Adulteration and substandard of EVOO in USA markets (Anonym, 2014)

Positive sensory scores should be as high as possible for excellence quality EVOO. Negative sensory attributes (defects) must not be detected for classify olive oil as EVOO. If Negative sensory attributes detected their intensity has to be classified, being low intensities (≤3.5) allowed for VOO and high intensities (>3.5) or absence of the positive attribute for LOO (Anonym, 1991, 2013).

According to European Commission Regulation, it should be noted that use of the term 'cold extraction', a process in which the malaxing temperature does not exceed 27°C (Anonym, 2002). Some producers write on label of EVOO "cold press" as a higher quality indicator for consumer attraction but oil labeled with "cold pressing "is not guarantee the quality of EVOO. As explained in the previous sections, care must be taken for high quality in all stages of aquaculture, production and storage, from olive cultivation to olive oil storage. "Cold press" is essential for obtaining quality oil, but does not guarantee the quality of EVOO or VOO produced in this way.

EFSA follow a scientific evaluation for approval of health claim of foods (Figure 56). After the positive report of EFSA and European Commission authorization for a health claim that is approved and announced. The Regulation (EU) No. 432/2012 of the European Commission has defined a list of permitted health claims and the European Register of Nutrition and Health Claims (Anonym, 2012) has provided food reports on all the authorized health indications, conditions and restrictions of use, as well as unauthorized health claims and the reasons for their inapplicability. The permitted health claims for olives' oil are relative to olive oil polyphenols, oleic acid, vitamin E and monounsaturated and/or polyunsaturated fatty acids (Bellumori et al., 2019).

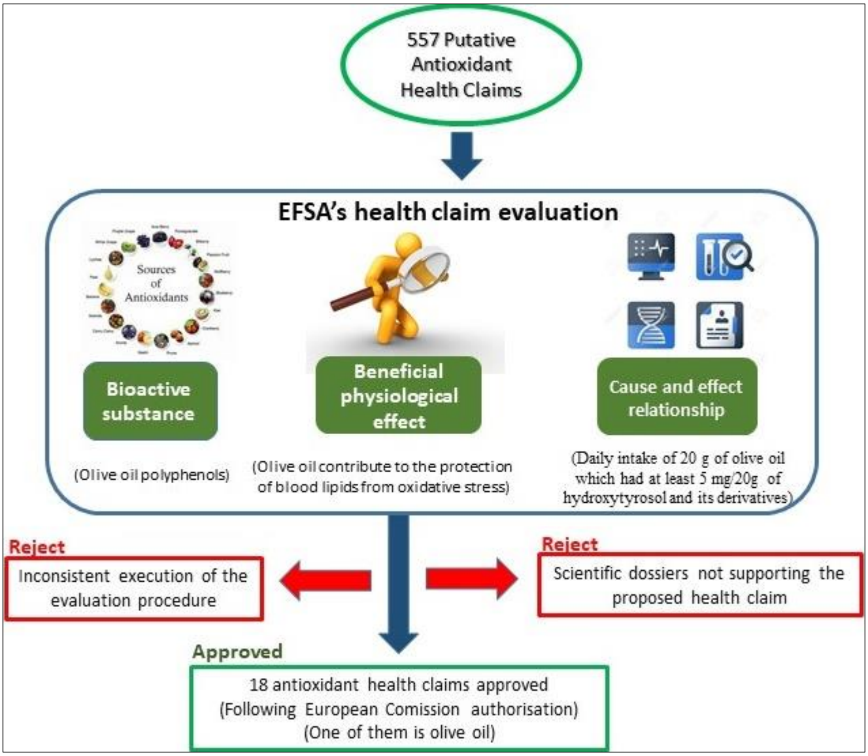


Figure 56. Health claim evaluation process (modified from Lenssen et al., 2018)

Among the list of claims approved by the EFSA, four are applicable to EVOO. Three of the four claims are authorized as functional health claims, while the other is authorized as a reduction of disease risk claim (Anonym, 2006). One of the authorized function health claims is specific to olive oil and relates to the level of olive phenolic compounds (Clodoveo et al., 2015). The claimed health function concerns the protection of blood lipids from oxidative stress. The claim "olive oil polyphenols" can be used only for an olive oil that contains at least "5 mg of hydroxytyrosol and its derivatives (e.g., oleuropein complex and tyrosol) per 20 g of olive oil".

The health claim regarding polyphenols, therefore, lends itself to being a useful legislative instrument for the segmentation of the category of EVOO. It allows the consumer to recognize the health claim approved by EFSA (European Food Safety Authority) on the label of the bottle, and the highest quality segment within the product category of EVOO (Roselli et al., 2016, 2017) Among the list of claims approved by the EFSA, four are applicable to EVOO, as reported in Table 3 (Anonym, 2012, 2014a).

Table 3. List of permitted health claims for olive oil (Roselli et al., 2017)

Claim type	Substance	Claim	Condition of use of the claim
Functional health claim (art. 13.1)	Olive oil polyphenols	Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress.	The claim may be used only for olive oil that contains at least 5 mg of hydroxytyrosol and its derivatives (e.g. oleuropein complex and tyrosol) per 20 g of olive oil. The claim information should inform the consumer that the beneficial effect is obtained with a daily intake of 20 g of olive oil
Functional health claim (art. 13.1)	Oleic acid	Replacing saturated fats in the diet with unsaturated fats contributes to the maintenance of normal blood cholesterol levels. Oleic acid is an unsaturated fat.	The claim may be used only for food that is high in unsaturated fatty acids, as referred to in the claim for high unsaturated fat in the Annex to Regulation (EC) No 1924/2006 and subsequent amendments A claim that a food is high in unsaturated fat may only be made where at least 70% of the fatty acids present in the product derive from unsaturated fat, under the condition that unsaturated fat provides more than 20% of energy of the product
Functional health claim (art. 13.1)	Vitamin E	Vitamin E contributes to the protection of cells from oxidative stress.	The claim may be used only for food that is a source of vitamin E, as referred to in the claim for vitamin E in the Annex to Regulation (EC) No 1924/2006 and subsequent amendments
Reduction of disease risk claim (art. 14)	Monounsaturated and/or polyunsaturated fatty acids	Replacing saturated fats with unsaturated fats in the diet has been shown to lower/reduce blood cholesterol. High cholesterol is a risk factor in the development of coronary heart disease.	The claim may be used only for food that is high in unsaturated fatty acids, as referred to in the claim for high unsaturated fat in the Annex to Regulation (EC) No 1924/2006 and subsequent amendments. The claim may only be used for fats and oils

The claim of "oleic acid" and "monounsaturated and/or polyunsaturated fatty acids" is usable for all foods that has rich content of unsaturated fatty acis. Whereas the claim of "olive oil polyphenols" is applicable only to EVOO or VOO because any type of refining process removes these molecules. The claim of oleic acid is also valid for the other olive oil categories, such as olive oil and pomace olive oil, as well as to other types of food (Coppola & De Stefano 2000). The other functional health claim refers to vitamin E. The claim can be used for all types of food that can be considered a "source of vitamin E", as specified in Regulation (EC) No. 1924/2006 (Inglese et al., 2011).

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This book was written within the scope of “Aristoil Capitalisation” project in order to provide useful information to farmers, industrialists, marketers and consumers beyond the known and repetitive informations by approaching olive cultivation and olive oil production/marketing/consumption with different perspectives.

Olive oil production has a history of six thousand years old. Olive cultivation and olive oil industry is an important development and culture element today as in the past. Nowadays, producers should focus on obtaining high quality products as well as yields and high production quantities. Only in this way, the labor expended for olive oil production will find its real value.

Although there are difficulties in olive cultivation and olive oil production and there are high competitive conditions, producers should not lose hope and insist on producing ordinary products. It should not be forgotten that each difficulty can be transformed into new opportunities and advantages with scientific–based solutions. In this context, production of olive oil of quality that may contain a health claim will provide new opportunities.

It is not possible to solve the problems of the olive cultivation and olive oil industry only with this book. However, the world still needs as much benefit as those who read this book can produce.

We hope this book will be useful for all readers…