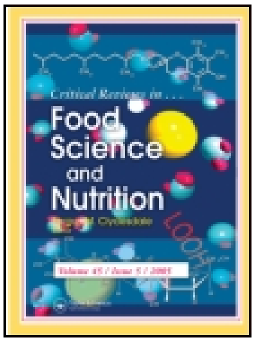

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The Historical Development and Nutritional Importance of Olive and Olive Oil Constituted an Important Part of the Mediterranean Diet

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The olive tree (Olea europaea) is widely cultivated for the production of both oil and table olives and very significant because of its economic value. Olive and olive oil, a traditional food product with thousands of years of history, are the essential components of the Mediterranean diet and are largely consumed in the world. Beside of their economical contribution to national economy, these are an important food in terms of their nutritional value. Olive and olive oil may have a role in the prevention of coronary heart disease and certain cancers because of their high levels of monosaturated fatty acids and phenolic compounds. In addition, olives (Olea europaea L.) and olive oils provide a rich source of natural antioxidants. These make them both fairly stable against auto-oxidation and suitable for human health. The aim of this paper is to define the historical development and nutritional importance of olive and olive oil constituted an important part of the Mediterranean diet.

Keywords History, olive fruit, olive oil, phenolic compounds, antioxidant activity, health and nutrition

INTRODUCTION

The olive tree, one of the oldest known cultivated trees in the world, has been a part of Mediterranean civilization since before recorded history (Zamora et al., 2001; Bartolini and Petruccelli, 2002). The edible olive seems to have coexisted with humans for approximately 5000 to 6000 years, going back to the early Bronze Age (3150 to 1200 BCE). Based on written tablets, olive pits, and wood fragments found in ancient tombs, its dispersal has been tracked throughout the civilizations that developed in the Mediterranean region in the areas now known as Southern Turkey, Syria, Lebanon, Palestine, and Israel. Some researchers have reported that the cultivated olive tree originated in Asia Minor, between present Syria, Lebanon, and Israel. Ancient documents in Syria indicate that ca. 2000 BCE, the value of olive oil was five times that of wine and two and a half times that of seed oils. The spread of the olive tree probably coincided with the breeding and cultivation and trade of superior wine grapes, date palms, and fig varieties (Harwood and Aparicio, 2000; Vossen, 2007). There is no doubt that the olive tree has played an important role in ancient civilizations; indeed, cultivated olive trees played a significant role in the early civilizations of Egypt and Greece (Galili et al., 1997).

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OLIVE (OLEA EUROPAEA L.) AND ITS DISTRIBUTION

The olive tree belongs to the family, *Oleaceae*, which includes approximately 30 genera and 600 species (Cronquist, 1981). The *Olea* L. genus consists of more than 30 species, which are distributed throughout Europe, Asia, Oceania, and Africa, with only *Olea europaea* L. as the cultivated species. Two coexisting forms have been described for this species, the wild olive or oleaster (*Olea europaea* subsp. *europaea* var. *sylvestris*) and the cultivated olive (*Olea europaea* subsp. *europaea* var. *europaea*). The relatives of the Mediterranean olive tree are clustered into the following five subspecies: (a) *laperrinei*, present in Saharan massifs; (b) *cuspidata*, present from South Africa to Southern Egypt and from Arabia to Northern India and Southwest China; (c) *guanchica*, present in the Canary Islands; (d) *maroccana*, present in Southwestern Morocco; and (e) *cerasiformis*, present in Madeira (Green, 2002).

It has been reported that two wild olive species, *Olea cuspidatae* and *Olea glandulifera*, have been found in the southern region of the Himalayas Range of Western Nepal (Burtolucci and Dhakal, 1999), and some of them are more than 15-m tall. Being in the rain-shadow of the Himalayas, this region is comparatively arid. This important discovery confirms that the early distribution of olives stretched along the dryland areas from the Mediterranean Basin to the Middle East to Central Asia to near the Himalayas. Almost all of the information available today regarding olive trees and olive oil are based on findings collected from the Mediterranean region (Hosseini-Mazinani et al., 2004; Omrani-Sabbaghi et al., 2007).

The spread of the olive tree commerce is well documented. The primary direction of movement, however, was to the west. In Greece, Egypt, and Western Turkey, there are many archaeological sites with olive-related findings, such as milling stones, decantation basins, storage vessels, frescos, and ancient writings (Vossen, 2007). These archaeological findings suggest that olive cultivation spread throughout Syria, Israel, and Crete between 5000 and 1400 BCE. Commercial networking and the application of new knowledge then brought the plant to the dry areas of Southern Turkey, Cyprus, and Egypt. Until 1500 BCE, Greece—and, in particular, Mycenae—was the area where olives were the most heavily cultivated. However, with the expansion of the Greek colonies, olive cultivation reached Southern Italy and Northern Africa in the eighth century BCE and then spread into Southern France. Olive trees were planted throughout the entire Mediterranean Basin during Roman rule (Di Giovacchino, 2000).

OLIVES AND OLIVE OIL IN MYTHOLOGY AND HISTORY

The olive tree has been described as a gift from God, dating to the source of many legends and inscriptions on sacred books. There, olive fruit is mentioned several times in both the Quran and the Bible. There are also many symbolic references, including the olive wand of ancient kings and, the holy oil of priests, which have indicated olive as a symbol of peace, dignity, abundance, wisdom, and health. In addition to the vitality of a white dove with an olive branch in his mouth (i.e., Noah's ark), for centuries, the olive was a sing of peace, allowing the admission of its bearer (Özkaya et al., 2009).

According to Jewish mythology, in the drylands of Israel, Kings David and Solomon placed great importance on the cultivation of olive trees. King David posted guards to watch over the olive groves and warehouses, ensuring the safety of the trees and the precious oil. Even today, in many places in Northern Israel, very old trees and olive groves are found, and some of them are thought to be more than a thousand years old. In Greek mythology, when Athena, the Goddess of wisdom and peace, struck her magic spear into the Earth, it turned into an olive tree; thus, the location where the olive tree first appeared and grew was named Athens in honor of the Goddess. Local legend indicates that the original olive tree still stands at the ancient sacred site, and the citizens claim that all of the Greek olive trees originate from rooted cuttings that were grown from that original olive tree. The great ancient Greek writer and philosopher, Homer, claimed in his writings that the ancient olive tree growing in Athens was already 10,000 years old and stated that the Greek courts sentenced people to death if they destroyed an olive tree. At the site of the ancient Olympic stadium in Olimpiya, Greece (775 BCE), the winners were triumphantly acclaimed and crowned with a wreath made of olive twigs. Ancient gold coins that were minted in Athens depicted the face of the Goddess Athena wearing an olive leaf wreath on her helmet and holding a clay vessel of olive oil (Malcolm, 2011).

At the Palace of Knossos (~1700 BCE) on the island of Crete, clay tables record the trade of olive oil. In Urla, a district of İzmir, Turkey, there is an ancient olive oil processing facility dating to 600 BCE. Many clay vessels, called amphora, which were used to store and transport olive oil, can be found in the ruins throughout this area. During this time, the olive tree continued to move westward into Sicily, Sardinia, Italy, France, Spain, Portugal, Algeria, Tunisia, and Morocco. Circa 1000 BCE, the Phoenicians took the olive to Spain and North Africa, and the Greeks brought the trees into Italy. The first recorded agronomic writings can be attributed to the Romans, and, certainly, the expansion and prosperity of the Roman Empire was instrumental in the spread of olive trees and oil processing facilities throughout the Mediterranean Basin. Spain and Portugal and the North Coast of Africa became important production areas of olive oil, which was shipped in large amphorae to England, Germany, France, and Italy (Grigg, 2001; Luchetti, 2002; Vossen, 2007). During the Middle Ages, the production and importance of olive oil continued to increase, primarily in Spain, Italy, and Greece. Galili et al. (1997) reported finding thousands of crushed olive pits with olive pulp at the Kfar Samir prehistoric settlement off the Carmel Coast south of Haifa. Observations at this site, and at other Late Neolithic to Early Chalcolithic offshore settlements in this region, record olive oil cultivation along the Carmel coastal plain as early as 6500 years ago. These findings have helped define the technology of olive oil production and refine the chronological definition of cultural units along the Southern Levant Coast during the seventh millennium BCE—a time of major transition between the end of the Neolithic age and the beginning of the Chalcolithic age (Di Giovacchino, 2000).

THE WORLDWIDE PRODUCTION OF TABLE OLIVES AND OLIVE OIL

Olive trees possess an amazing ability to survive under unfavorable conditions; however, it is a demanding crop if it is to flourish. Therefore, a suitable environment and proper cultural care are necessary for the full development of the agronomic characteristics and steady production conditions. The tree is cultivated today in many countries, including Spain, Italy, Greece, Tunisia, Turkey, Portugal, Morocco, Syria, Algeria, Egypt, Israel, Libya, Jordan, Lebanon, Cyprus, Croatia, Slovenia, Argentina, Chile, Mexico, Peru, the United States, and Australia (Boskou, 2009).

According to the report of the International Olive Oil Council (IOOC, 2011), Mediterranean countries accounted for approximately 97% of the world's olive cultivation, estimated at approximately 10,000,000 hectares. There are more than 800 million olive trees currently grown throughout the world, of which more than 90% are grown for oil production and the rest for table olives. It is estimated that more than 2,500,000 tons of olive oil are produced annually throughout the world. Approximately 81% of the total olive production comes from the European Community (EC) (Spain, Italy, Greece, Portugal, and France), with the Near East contributing, approximately 7% and North Africa supplying approximately 11%. The remaining 1% is of American origin, chiefly from Argentina, Mexico, Peru, and the United States.

The worldwide production of table olives for the 2010–2011 season amounted to 2,266,500 tons, the majority of which (~34.1%) was located in the European Union (Spain, France, Greece, Italy, Portugal, and Slovenia). Other significant non-EU producing countries include Egypt (16.4% of the world production), Turkey (13.6%), Syria (7.2%), Argentina (5.2%), Morocco (4.6%), and the United States (3.3%) (Fig. 1). The worldwide production of olive oil has been estimated to be 2,948,000 tons in the 2010–2011 season (Fig. 2) (IOOC, 2011).

The olive tree has been grown for its oil-rich fruit since late prehistoric times. The cultivated variety, *O. europaea* L. var. *europaea*, has become more adaptable to a wider range of climatic and environmental conditions (Carrion et al., 2010). Many cultures have used olive oil primarily as a lamp fuel; however, in the late 19th and 20th centuries, the demand for olive oil decreased after the development of low-cost solvent extraction techniques for seed oils and the use of other sources of light (gas and electricity). Today, the olive fruit and oil provide valuable nutrients for humans, and they play important roles in the diets of the people in the areas of cultivation, in addition to the role in their economy and culture (Blazquez Martınez, 1996; Civantos López-Villalta, 1998; Vossen, 2007; Uylaser et al., 2008).

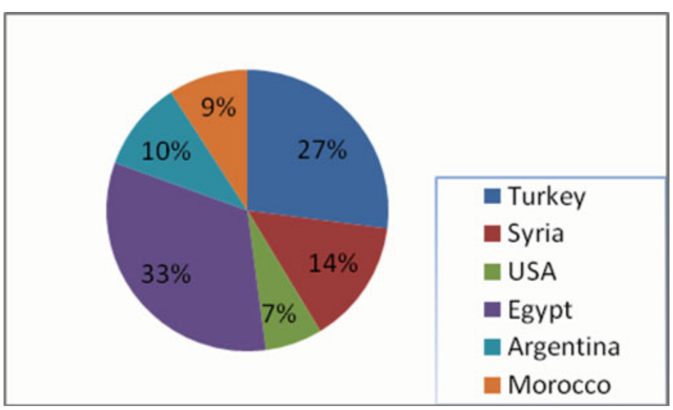

Figure 1 Countries with significant interests in table olive production in 2010–2011 (IOOC, 2011). (color figure available online.)

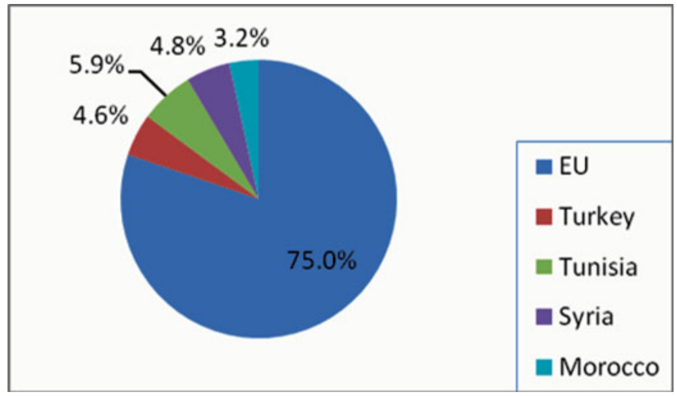

Figure 2 The worldwide production of olive oil for 2010–2011 seasons (IOOC, 2011). (color figure available online.)

NUTRITIONAL BENEFITS OF OLIVES AND OLIVE OIL

Olives

Processing Methods

The olive fruit (*Olea europaea* L.) is a drupe, a single-seeded indehiscent fruit with a fleshy outer layer. The unripe fruit is pale green; as the fruit ripens, the color changes from purple to black. A few varieties are green when ripe, and some turn a shade of copper brown. Olive cultivars vary considerably in size, shape, oil content, and flavor. The shapes range from almost round to oval or elongated with pointed ends (Hashim, et al., 2005; Morello et al., 2006; Casa Do Azeite, 2011). The ripe olive fruit exhibits a typical drupe structure, with a thin protective exocarp, a fleshy mesocarp and a stony endocarp that surrounds the seed. Most table olives are harvested in mid-autumn when they are firm and the color changes from green to yellowish green. In contrast, oil olives are harvested in the late autumn or winter after they have turned black, with a reduction in the chlorophyll content and an increase in the anthocyanin content, and have attained their maximum oil content (Fedeli and Cortesi, 1993; Haralampidis et al., 1998). The olive fruit has a bitter component, oleuropein, an alkaloid that makes the fruit bitter and unpalatable; a low sugar content (2.6–6%) compared with other drupes (12% or more) and a high oil content (12–30%) depending on the time of year and variety. Because of the oleuropein, the olive fruit cannot be consumed directly from the tree and requires processing. The most commonly used industrial methods to process olives are as follows: the black oxidizing or the Californian processing methods; the Spanish processing method for green olives; naturally fermented black olives in brine; Gemlik or Greek processing and naturally fermented black olives in dry salt. These methods differ considerably from region to region, and their use also depends on the variety. The Spanish processing method includes a treatment with a sodium hydroxide solution, for the total removal of the bitter compound, oleuropein, washing, brining and fermentation, sorting, and size grading and packaging (Romero et al., 2004; Uylaser et al., 2008). The Californian method of treatment includes a lye treatment, washing, iron-salt treatment and air-oxidation, washing, sizing, canning, sterilization, and packaging (Marsilio et al., 2001). The Gemlik or Greek-style method of treatment is milder and includes washing, natural fermentation in brine, air-oxidation (for color improvement), size grading, and packaging (Piga et al., 2001; Uylaser et al., 2008). Some olives, however, do not require extensive processing, because they sweeten as they ripen on the tree, and, in most cases, the sweetening is due to fermentation; one example is the Greek Thrubolea variety (Garrido Fernandez et al., 1997; Uylaser et al., 2008).

Olives in the Diet and Health

Table olives and olive oil form a significant part of the Mediterranean diet, and both are extensively consumed throughout the world. It is well known that the decreased occurrence of cardiovascular disease in the Mediterranean area is partly attributed to the consumption of olive products. The nutritional and medicinal qualities of olive derivatives could be related to their high content of phenolic compounds, which are considered to be responsible for conferring specific organoleptic and antioxidant properties. Olive polyphenols may play an important role in human diet and health, as these compounds act mainly as antioxidants and free radical scavengers and could be used as sources of potentially safe natural antioxidants for the food industry. The shelf life and nutritional quality of olive oil increases as the phenolic content increases (Visioli et al., 2002; Morello et al., 2005; Uylaser and Karaman, 2005; Ben Othman et al., 2008; Uylaser et al., 2008; Uylaser et al., 2009; Frankel, 2011).

The olive is an important food due to its nutritional value in addition to the beneficial fatty acids, especially monounsaturated fats, the benefits of table olives are also associated with minor constituents, such as phenolic compounds, and tocopherol (Uylaser et al., 2009). The phenolic fraction of table olives is very complex and can vary both in the quality and quantity of phenolics, depending upon the processing method, the cultivar, the irrigation practices, and the degree of maturation. Phenolic compounds of the *Oleaceae* family can be characterized by the presence of a number of coumarin-like compounds known as secoiridoids. The major phenolic compounds present in table olives are tyrosol, hydroxytyrosol, oleanolic acid, and oleuropein. The most important changes in the phenolic fraction are due to the depletion of oleuropein during the growth of the olive fruit and the increase in the tyrosol and hydroxytyrosol concentrations (Blekas et al., 2002; Romero et al., 2002; Bianchi, 2003; Owen et al., 2003; Romero et al., 2004; Morello et al., 2005; Ben Othman et al., 2008; Menz and Vriesekoop, 2010; Ziogas et al., 2010). According to some authors, oleuropein is the most prominent phenolic compound in olives and may reach concentrations of up to 140 mg/g on a dry matter basis in unripe olives (Morello et al., 2005).

Phenolic Compounds

Menz and Vriesekoop (2010) indicated that the levels of total phenolics of olives slightly decrease over the maturation period; however, these compounds were continually being synthesized until maturity (fully black in color). These researchers determined that the total phenolic content of the olives decreased rapidly to 1560 ppm gallic acid equivalents (GAE), less than 50% of the original value (3900 ppm GAE), over the first 40 days, yet was relatively stable from 40 to 171 days, with a slight increase to 2200 ppm GAE.

Boskou et al. (2006) determined the phenolic profile of table olives (Kalamon, Tsakistes, Crete, Amfissas, and Thrubes Crete) from a Greek market. According to the study, the gas chromatography–mass spectrometry (GC/MS) qualitative analysis revealed the following 13 different polyphenols, ranging from 10 to 13 per species; cinnamic acid, tyrosol, *p*-hydroxybenzoic acid, *p*-hydroxy-phenyl-acetic acid, *p*-hydroxy-phenylpropanoic acid, vanillic acid, hydroxy-tyrosol, protocatechuic acid, 3,4-dihydroxy-phenyl-acetic acid, *p*-coumaric acid, ferulic acid, caffeic acid, and oleanolic acid. These authors reported that approximately 5–10 table olives might provide the recommended daily intake of polyphenols.

In a similar study, the analysis of the phenolic compounds of table olives from Portugal was performed by reversed-phase high performance liquid chromatography with diode array detector (HPLC/DAD), and the following seven compounds were identified and quantified: hydroxytyrosol, tyrosol, 5-O-caffeoylquinic acid, verbascoside, luteolin 7-O-glucoside, rutin, and luteolin (Pereira et al., 2006).

He et al. (2009) described that one new phenolic compound was isolated and purified using a polyamide column and Toyopearl HW-40 (S) column chromatography from an acetone extract of Chinese olive fruits. This compound was identified as 3-*O*-galloyl quinic acid butyl ester by electrospray ionisation mass spectrometry (ESI-MS), 1D- and 2D-nuclear magnetic resonance (distortionless enhancement by polarisation transfer (DEPT), correlation spectroscopy (COSY), heteronuclear multiple bond coherence (HMBC), heteronuclear multiple quantum correlation (HMQC)), and ultraviolet–vis techniques.

In a study investigating the changes in simple phenolic compounds during olive processing, the authors indicated that both spontaneous and controlled fermentations led to an important loss of total phenolic compounds, with a reduction rate of 32–58%. According to the results after fermentation, the hydroxytyrosol and caffeic acid concentrations increased, whereas the protocatechuic acid, ferulic acid, and oleuropein concentrations decreased. The hydroxytyrosol concentration in black olives increased from 165 mg/100 g dry weight to 312 and 380 mg/100 g dry weight after spontaneous and controlled fermentations, respectively, and the oleuropein concentration in green olives decreased from 266 mg/100 g dry weight to 30.7

and 16.1 mg/100 g dry weight after spontaneous and controlled fermentation, respectively. During olive fermentation, phenolic loss is essentially due to the diffusion of these compounds into the brine; the main phenolic compound identified and quantified in the different brines was hydroxytyrosol. To preserve the antioxidant quality of table olives, it is necessary to use a controlled process to minimize the loss of phenolic compounds (Ben Othman et al., 2009).

Antioxidant Activity

As stated by many researchers, phenolic compounds are the most abundant natural antioxidants in our diet. As natural preventive agents against several diseases, they protect body tissues against oxidative stress; the antioxidant activity of phenolics has been associated with a lower risk of coronary heart disease, lower risks of some types of cancer, lower inflammation, and the inhibition of platelet-activating factor. Many studies indicate an antioxidant capacity of these polyphenols with respect to the oxidation of low-density lipoproteins (LDLs) and oxidative alterations due to free radicals and other reactive species (Boskou et al., 2006; Gilani et al., 2006; Pereira et al., 2006; Kountouri et al., 2007). According to comparisons made by researchers, hydroxytyrosol has a much better radical-scavenging capacity than tyrosol. Similar results were obtained when comparing these compounds as antioxidants in a refined olive oil matrix, where hydroxytyrosol showed an induction time that was up to five times higher than tyrosol in the Rancimat test (Mateos et al., 2003; Artajo et al., 2006).

The antiradical and antioxidant activities of olive and olive oil phenolic compounds are due mainly to the presence of a 3,4-dihydroxy moiety linked to an aromatic ring, and it was found that the effect depended on the polarity of the phenolic compound (Morello et al., 2005). The antioxidant quality of phenolic compounds is mainly due to their redox properties, which allow them to act as reducing agents, hydrogen donors, and singlet oxygen quenchers (Ben Othman et al., 2008).

Boskou et al. (2006) reported that black olives, which contain higher concentrations of phenolics compounds, present a higher antioxidant activity compared with green olives.

In a study conducted by Malheiro et al. (2011) regarding antioxidant activity, the Santulhana and Cobrançosa varieties cultivated in the Tras-os-Montes region of Portugal showed high EC_{50} values, lower than 1.40 and 0.48 mg/mL for reducing power and 2,2-diphenyl-1-picrylhydrazyl (DPPH) methods, respectively. Significant negative correlations were obtained between the olive phenolics and EC_{50} values of the antioxidant activity.

According to another study, autumn olives had high contents of carotenoids, total phenolics, and high antioxidant capacities against DPPH, 2,2′-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid (ABTS+·), ROO·, O_2–·, ·OH, and O_2 radicals. Autumn olives also have high levels of antioxidant enzyme activities and nonenzyme components (e.g., ascorbic acid and glutathione). These activities were different among the autumn olive genotypes, and it has been proposed that dietary supplementation with various fruits and vegetables, including the autumn olive, could have benefits to human health (Wang and Fordham, 2007).

Ocakoglu et al. (2009) described the following major phenolic compounds in Turkish extra virgin olive oils from six important olive cultivars (Memecik, Erkence, Domat, Nizipyaglik, Gemlik, and Ayvalık): hydroxytyrosol, tyrosol, vanillic acid, *p*-coumaric acid, cinnamic acid, luteolin, and apigenin. It was observed that the phenolic profiles of olive oils depended highly on the season of harvest; in addition, the oils of different olive cultivars have different distribution of phenols. No significant correlation was observed between the oxidative stability and phenolic compounds.

Medicinal Use of Olives

Olives have multiple medicinal uses, including disorders of the gastrointestinal and cardiovascular systems. The olive fruits and leaves are indicated in arrhythmia, atherosclerosis, cardiopathy, colic (spasm), diarrhea, fever, gout, headache, hepatosis, hypercholesterolemia, hyperglycemia, and hypertension. Olive oil is used in traditional medicine as a cardioprotective, gastroprotective, and enteroprotective; it is effective in the treatment of cancer, constipation, diabetes, and rheumatism. Phytochemical studies revealed that olives contain multiple compounds that have been indicated as therapeutics, including aescultin, alpha-tocopherol, apigenin, arabinose, beta-carotene, caffeic acid, catechin, choline, cinchonidine, cinchonine, elenolide, erythrodiol, esculin, estrone, fat, fiber, glucoside, iron, linoleic acid, luteolin, mannitol, myristic acid, oleanolic acid, oleoside, olivine, oleuropeic acid, oleuropein, pectin, palmitic acid, quercetin, quinone, rhamnose, rutin, squalene, tyrosol, verbascoside, tannins, saponins, and secoiridoids (Gilani et al., 2006).

In addition, some researchers have also demonstrated that the phenolic compounds present in olive products, such as oleuropein and hydroxytyrosol and aliphatic aldehydes, inhibit or delay the rate of growth of a range of bacteria and microfungi, so that they might be used as alternative food additives or in integrative pest management programs. The increasing resistance of bacteria to antibiotics represents the main factor justifying the need to find and/or develop new antimicrobial agents. Thus, many studies have been focused on antimicrobial agents and on the antimicrobial properties of plant-derived compounds, such as spices and essential oils, which have long been used in traditional medicine to treat infections (Pereira et al., 2006).

OLIVE OIL

Through the centuries, olive oil has become one of the most widely accepted and used oils in culinary applications (Visioli and Galli, 1998; Boskou, 2009). Olive oil is a staple food for the people of the countries surrounding the Mediterranean Sea, but its use has now expanded to other parts of the world due to its unique flavor, high content of healthy monounsaturated fatty acids, and the presence of biologically important minor constituents. In the specialty food arena, olive oil is a dominant product that continues to grow in popularity. Olive oil is a favorite source of fat for some health-conscious people who have adopted the Mediterranean diet (Boskou, 2009).

Edible olive oils are graded into six categories: extra virgin olive oil, virgin olive oil, refined olive oil, olive oil, refined residue oil, and olive residue oil. Extra virgin olive oil (acidity up to 0.8%, as oleic acid), virgin olive oil (acidity up to 2.0%), olive oil (a mixture of refined and virgin olive oil), and olive residue oil (a blend of refined residue oil and virgin olive oil) contain biologically important polar compounds, such as phenols, alpha-tocopherol, and squalene. Refined olive oil has the same glyceridic composition as virgin olive oil but contains less alpha-tocopherol and squalene. Refined olive residue oil is obtained by the extraction of olive pomace with a solvent and refining. It has the same triglyceride composition as virgin olive oil; it contains no polar antioxidant phenols but is richer in biologically active pentacyclic triterpenes such as oleanolic acid and erythrodiol (Boskou, 2009). Virgin olive oil can be classified into two fractions from a quantitative point of view. The major fraction constitutes 98–99% of the oil, and it is mainly composed of saponifiable glyceridic compounds, largely triacylglycerols. The main fatty acid in this fraction is oleic acid (18:1, *n*-9), ranging from 60–84% of the total fatty acids, whereas linoleic acid (18:2, *n*-6), is present in concentrations between 3–21%. The minor components account for the remaining 1–2% of the oil, and, despite being a small proportion, they confer important biologic activities. The minor components of virgin olive oil are hydrocarbons, tocopherols, fatty alcohols, 4-methylesterols, sterols, triterpenic dialcohols, polar-colored pigments, and phenolic compounds (Ruiz-Gutierrez et al., 2000).

Phenolic Compounds and Antioxidant Activity

The various phenolic compounds present in olives are believed to protect the plant from environmental stress, and they contribute to the organoleptic profile of raw olives and, consequently, to that of virgin olive oil. Their concentration in the oil depends on various factors, including the cultivar, maturity, climate, rootstock, agricultural practices (Ryan and Robards, 1998), and the choice of the extraction, separation, and quantification techniques (Visioli et al., 2002; Carrasco-Pancorbo et al., 2005). The major phenolic compounds in olive oil are as follows: (1) simple phenols (e.g., hydroxytyrosol, tyrosol, vanillic acid); (2) secoiridoids; oleuropein glucoside, and SIDs, which are the dialdehydic form of oleuropein (SID-1) and ligstroside (SID-2), lacking a carboxymethyl group, and the aglycone form of oleuropein glucoside (SID-3) and ligstroside (SID-4); and (3) polyphenols; lignans (e.g., [+]-pinoresinol and [1]-acetoxypinoresinol) and flavonols. Tyrosol, hydroxytyrosol, and their secoiridoid derivatives make up approximately 90% of the total phenolic content of virgin olive oil (Owen et al, 2000a; Covas et al., 2006b). The hydroxytyrosol can be found in a higher concentration in extra virgin olive oil (14.42 ± 3.01 mg/kg) than in refined virgin oil (1.74 ± 0.84 mg/kg) (Owen et al., 2000a). Moreover, the consumption of table olives cannot be underestimated. The presence of hydroxytyrosol in the fruit depends on several factors, such as the altitude where the olive trees are grown, the harvesting time and the processing conditions. Therefore, levels of this phenol have been found to vary from 100–340 mg/kg in Greek-style naturally black olives, 170–510 mg/kg in Spanish-style green olives, and 250–760 mg/kg in Kalamata olives (Blekas et al., 2002). The total phenolic content has been reported to be in the range of 196–500 mg/kg (Owen et al. 2000a). These phenolic compounds contribute to the stability of the oil and may have anti-inflammatory and antiatherosclerotic properties (Carluccio et al., 2003; Gonzalez-Santiago et al., 2006; Kaliora et al., 2006), which are possibly mediated by their antioxidant properties (Tripoli et al., 2005).

Phenolic compounds exert their antioxidant activity by donating a hydrogen atom to the chain-propagating radicals formed during lipid peroxidation; however, their role in photooxidation is rather limited (Psomiadou and Tsimidou, 2002). As a result of using hydroxyl radical scavenging as a measure of antioxidant capacity, olive oil has a higher antioxidant capacity than seed oils, and extra virgin olive oil is more potent than refined virgin olive oil due to its higher concentration of antioxidants (Owen et al., 2000b). Most studies on the phenolic antioxidant properties of olive oil in humans concentrate on their effect on LDL and DNA oxidation, as these are believed to be key processes implicated in the development of atherosclerosis and cancer, respectively. In a study investigating the anti-inflammatory properties of certain phenolic compounds of olive oil, it was reported that the hydroxytyrosol recovery in the plasma and urine after the ingestion of 25-mL virgin olive oil was approximately 98% (Miró-Casas et al., 2003). According to some researchers, the intake of the phenolic compounds in olive oil is associated with a reduction in the levels of LDL oxidation in healthy males and patients with stable coronary heart disease (CHD) (Covas et al., 2006a; Fitó et al., 2007; Frankel, 2011). Lastly, studies have shown that the phenolic compounds in virgin olive oil significantly reduce the production of certain markers of inflammation that are involved in the atherosclerotic process (Leger et al., 2005; Visioli et al., 2005; Bogani et al., 2007). Human studies on the effect of the phenolic compounds in olive oil on DNA oxidation have produced conflicting results. The daily intake of 25 mL of olive oil has been reported to result in the following: (1) no effect on the excretion of etheno-DNA adducts, markers of lipid peroxidation, and oxidative stress (Hillestrom et al., 2006); (2) the reduction in DNA oxidation, irrespective of the phenolic content of the olive oil (Machowetz et al., 2006); and (3) the reduction in mitochondrial DNA oxidation, as associated with an increasing phenol content of the olive oil administered (Weinbrenner et al., 2004). Moreover, the intake of a daily amount of 50 g of olive oil with high phenolic content resulted in approximately 30% less DNA damage in postmenopausal women (Salvini et al., 2006).

Fatty Acids

The oil content and fatty acid composition are the most important quality criteria of olives and olive oil. Indeed, the benefits of table olives in nutrition are associated with the fatty acid content, especially monounsaturated fats and the high content of antioxidative compounds (Stark and Madar, 2002; Uylaser et al., 2009), and the beneficial effects of olive oil on cardiovascular risk factors are often only attributed to its high levels of monounsaturated fatty acids (MUFAs). On November 2004, the Federal Drug Administration of the USA permitted a claim on olive oil labels concerning: "the benefits on the risk of coronary heart disease of eating about two tablespoons (23 grams) of olive oil daily, due to the MUFA in olive oil." However, it was also expressed that if the effect of olive oil can be attributed solely to its monounsaturated fatty acid content, then any type of olive oil, rapeseed oil, canola oil, or monounsaturated fatty acid-enriched fat would provide similar health benefits (Covas et al., 2006a). However, many consider that the benefits of olive oil may be due to the synergistic combination of phytochemicals and fatty acids (Fortes, 2005). For instance, Tripoli et al. (2005) reported that the bioactivity of the phenolic compounds of olive oil are due to both their antioxidant properties and also to their interaction with important enzymatic systems.

Olives and olive oil are a rich source of essential fatty acids, and this fatty acid composition is affected by both environmental factors and the variety. Uylaser et al. (2009) found that the basic fatty acids in the Gemlik variety were oleic, palmitic, stearic, linoleic, and palmitoleic acids. According to the research results, all of the samples contained slight amounts of linolenic, arachidic, and behenic acids; other fatty acids were found in lower quantities or could not be determined. All of the samples were similar to each other, except for the olives that were taken from the Gemlik and Orhangazi districts, which generally contained higher levels of oleic acid.

Tamer et al. (2009) stated that the highest content of fatty acids in Gemlik variety table olives were found oleic acid (68.63–74.36%), palmitic acid (12.81–16.91%), linoleic acid (0.61–9.09%), stearic acid (2.89–3.99%), and palmitoleic acid (1.10–1.32%), respectively. Researchers mentioned that the fatty acid values in table olive have varied according to region and years.

Baccouri et al. (2007) investigated six wild olive populations originating from different regions of Tunisia (Mateur, Ichkeul, Enfidha, Grombalia, Sers, and Neber) and reported that oleic acid is the main monounsaturated fatty acid, representing high concentrations (70.8–73.9%), according to the variety. Palmitic acid, the major saturated fatty acid, ranged between 9.14 and 15.4%, whereas linoleic acid, the dominant polyunsaturated fatty acid, ranging from 6.4 to 14.9%.

There are only a few types of fatty acids in olive oil, but the proportions of each strongly influence the characteristics and nutritive value of the oil. The main fatty acids in olive oil comprise a range of carbon chains between myristic (14 carbon atoms) and lignoceric (24 carbon atoms) acids. The most prominent are the monounsaturated oleic and palmitoleic acids and the polyunsaturated linoleic and linolenic acids. Oleic acid, as the characteristic monounsaturated fatty acid of olive oil, constitutes 55–83% of the total fatty acids. From a human health aspect, a high intake of oleic acid in the Mediterranean region was reported to be the reason for the decreases in the rates of coronary artery disease. Furthermore, olive oil improves the lipid profile of those with cardiovascular risk by decreasing the ratio of LDL/ high-density lipoprotein (HDL) (Martinez-Gonzalez and Sanchez-Villegas, 2004).

A number of epidemiological studies performed in different countries have shown that the beneficial effects of the Mediterranean diet, which is rich in olive oil, may extend beyond the improvement in cholesterol levels and have a great potential in preventing cardiovascular disorders (Roche and Gibney, 1997; Roche et al., 1998; Zampelas et al., 1998; Williams et al., 1999).

The fatty acid composition in oils is affected by the species, genetics, variety, growing conditions, locality, climatic conditions, and postharvest treatment. Tanılgan et al. (2007) determined the fatty acid composition of five different olive varieties (Gemlik, Kilis, Uslu, Tirilye, and Ayvalık). The oils, from Turkey, were obtained using traditional methods, and the authors reported that oleic acid (65.7–83.6%) was present in the highest concentration, followed by palmitic (8.1–15.2%), linoleic (3.5–15.5%), stearic (2.0–5.6%), and linolenic (0.1–3.0%) acids.

Hashempour et al. (2010) investigated the fatty acids components of five olive oil cultivars (*Olea europea* L.), namely, "Zard," "Arbequina," "Coratina," "Frangivento," and "Beledy," and the results indicated that palmitic and oleic acids were the major fatty acids, whereas the contents of palmitoleic, stearic, linolenic, and linoleic acids were low. In addition Hashempour et al. (2010) noted that several agronomic parameters could change the fatty acid composition of the olive oil. The most studied aspects included the cultivar and origin, fruit ripening, and the pedoclimatic conditions.

The determination of the fatty acid composition of olive oil is used as a quality indicator and is also used for the classification and characterization of the oils. Some studies have been carried out with the aim of characterizing a particular type of production, and these studies have given great importance to the fatty acid profile. Kotti et al. (2008) characterized two varieties, Chetoui and Chemlali, from Tunisia, Poiana and Mincione (2004) evaluated the fatty acid compositions of olive oils extracted from different olive cultivars grown in the Calabria area. Ollivier et al. (2006) differentiated a French virgin olive oil by fatty acid composition, triacylglycerol, and the sensory characteristics. In addition, Spugnoli et al. (1998) characterized the fatty acid profile of some monovariety olive oils from Tuscany. Stefanoudaki et al. (1999) classified the virgin olive oils of the two major Cretan cultivars based on their fatty acid composition. Gurdeniz et al. (2008) classified Turkish olive oils with respect to the cultivar, geographic origin, and harvest year, using the fatty acid profile and mid-IR spectroscopy.

CONCLUSIONS

Olive oil is a natural extract of the olive fruit, and it is a major source of fat in the Mediterranean diet. Olive oil contributes protection against heart disease by controlling the LDL cholesterol levels while raising the HDL cholesterol levels. Olive oil is a natural product that contributes to the taste and aroma of certain cuisines. Some of the beneficial components, including vitamin E (alpha-tocopherol), carotenoids, and phenolic compounds, such as hydroxytyrosol and oleuropein, are all antioxidants that demonstrate health benefits in the prevention of certain diseases and ageing. In addition, olive oil decreases the risk of breast cancer and certain malignant tumors (e.g., prostate, endometrium, and digestive tract). It was reported that the consumption of olive oil as a part of the Mediterranean diet decreases both the systolic and diastolic blood pressure. It has also been demonstrated that a diet that is rich in olive oil, low in saturated fats, and moderately rich in carbohydrates and soluble fiber from fruit, vegetables, pulses, and grains is the most effective approach for controlling diabetics. Olive oil also inhibits gastric motility; as a result, the contents of the stomach are released more slowly. Furthermore, olive oil partially prevents cholesterol absorption by the small intestine due to the presence of sitosterol (Owen et al., 2000b; Visioli et al. 2002).

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