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NUTRITIONAL PROPERTIES OF VIRGIN OLIVE OIL WITH EMPHASIS ON PHENOLIC COMPOUNDS

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Review

Summary
Foods have been used historically, across cultures and for centuries, in treating disease and curing illness, owing to the role of antioxidants found naturally in foods. Also, it is known that in the process of historical development, virgin olive oil with a high content of antioxidants was consumed not only as food but also was used as a therapeutic agent in the treatment of various diseases, applied by rubbing onto the skin. Olives and the oil extracted from them by physical means are key nutrients in the Mediterranean diet pattern. They contain high amounts of bioactive compounds (polyphenols, tocopherols, phospholipids, carotenoids, chlorophylls, sterols and squalene) and possess high antioxidant potential. The supplementation of diets with virgin olive oil positively affects human health. The main objective of this review is to describe the physicochemical and nutritional characteristics of virgin olive oil and the influence of its physiologically active compounds, with special emphasis on the effect of phenolic compounds on human health.

Keywords: bioactive compounds, public health, promoting the consumption of virgin olive oil

Introduction

Across centuries and civilisations, many fruits and vegetables and other plant foods have been used, recommended and/or avoided for their supposed medicinal properties. These types of foods, which have their own antioxidant properties, are essential for health and wellbeing and play an important role in treating/preventing disease. Olives and virgin olive oil (VOO) are chief components of the Mediterranean diet and they contain many compounds useful for human health. Olive fruit, which is particularly interesting, contains over 230 antioxidant compounds. As olive oil is made from olive fruit, it also contains a lot of these compounds. The best olive oil is extra virgin olive oil (EVOO), which is produced by the first pressing or by other physical processes under conditions that do not lead to changes in the oil, which has not undergone any process other than washing, decantation, centrifugation or filtration. It is considered to be high-quality oil for health and nutrition. Depending on its chemical and organoleptic properties, olive oil is classified into different grades that also serve as guidelines for the consumer in the choice of the preferred kind of oil. Based on Trade Standard applying to Olive Oils and Olive -Pomace Oils (International Olive Council, 2016), virgin olive oils are the oils obtained from the fruit of the olive tree (*Olea europaea* L.) solely by mechanical or other physical means under conditions, particularly thermal conditions, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decanting, centrifuging and filtration. The aim of this review is to reveal the multiple nutritional properties of VOO, and the correlation between polyphenols and other bioactive compounds, and their antioxidant activities.

Nutritional properties of virgin olive oil

The olive flesh components are passed on to the oil, which mainly consists of two components, namely saponifiables and unsaponifiables. The former, comprising triacylglycerols, partial glycerides, esters of fatty acids or free fatty acids and phosphatides, represent nearly 98% of the oil's chemical composition, while the latter, consisting of mainly minor components, account

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for 1%-2% of the oil composition (Viola and Viola, 2009). In particular, oleic acid (18:1 n-9) ranges from 56% to 84% of total fatty acids, while linoleic acid (18:2 n-6), the major essential fatty acid and the most abundant polyunsaturate in our diet, is present in concentrations between 3% and 21% (Tiscornia et al., 1982). The nutritional value and health functions of VOO are ascribed to the presence of large amounts of monounsaturated fatty acids (MUFAs) such as oleic acid and valuable minor components, including aliphatic and triterpenic alcohols, sterols (mainly β-sitosterol), hydrocarbons (squalene), volatile compounds, tocopherols (chiefly α-tocopherol), pigments such as chlorophylls, carotenoids (β-carotene and lutein) and antioxidants (Ghanbari et al., 2012).

In addition to triglycerols and free fatty acids, olive oil contains a variety of nonsaponifiable nonglyceridic compounds that add up to 0.5%-2% of the oil and are important for its oxidative stability and unique flavour and taste (Lee et al., 2006; Pellegrini et al., 2001). Also, the composition of the bioactive compounds is affected by many agronomical and technological factors. Factors affecting the bioactive compounds content of olive oil are cultivar, climate, ripeness of the olives at harvesting and the processing system for the type of olive oil (Cimato et al., 1992).

There is an increasing interest in the phenolic compounds in olive oil due to their biological properties (Ross and Kasum, 2012). Polyphenols are plant secondary metabolites present in all plant tissues and their primary role is to protect plants from insects, ultraviolet radiation and microbial infections, and to attract pollinators (Del Rio et al, 2013). At least 30 phenolic compounds belonging to the hydrophilic group have been detected in olive oil (Tuck and Hayyball, 2002).

Low phenolic content of common olive oil ranges from 10 to 70 mg/kg, while high phenolic content of VOO ranges from 150 to 400 mg/kg. Phenolic compounds are at the top of antioxidant substances naturally present in VOO (Boskou, 2009a). Phenolic compounds of VOO belong to different classes: phenolic acids, phenyl ethyl alcohols, hydroxy-isochromans, flavonoids, lignans and secoiridoids, which are the main compounds of the phenolic fraction of *Oleaceae* plants (Boskou, 2009b).

Beside polyphenols, other bioactive compounds in olive oil are oleuropein, squalene, tyrosol, lignanes, hydroxytyrosol (3,4-dihydroxyphenylethanol), caffeic acid, phytosterols, vanillic acid, flavonoids, syringic acid, rutin, protocatechuic acid, leuteolin and p-hydroxyphenylacetic acid (Ghanabari et al., 2012). Such components also contribute to the unique flavour and taste of olive oil.

Health benefits of virgin olive oil consumption

The benefits of consuming olive oil have been known since antiquity. Olive oil was used not only for cooking/lighting but also as medicine, mainly as the basic ingredient for ointments (Efe et al., 2011). It has been the subject of several studies around the world, especially with regard to reporting its role in human nutrition, given its strong physiological effects on human health. However, it is now well established that health benefits are not attributed just to oleic acid but also to the phenolic fraction of olive oil with its anti-oxidant, anti-inflammatory and anti-microbial activities (Martín-Peláez et al., 2013).

The role of antioxidants, naturally occurring in foods and taken into the human body through diet, in the treatment of diseases and in disease prevention is one of the subjects of research (Howard and Kritchevsky, 1999; Visioli et al., 2000). Bioactive compounds which have antioxidant characteristics are put forward as the main reasons for a lower incidence rate of cholesterol and cardiovascular disease, atherosclerosis, neurodegenerative diseases, certain types of cancer, blood pressure in hypertensive patients, rheumatoid arthritis and improved cerebral and visual function among populations which have the habit of regular virgin olive oil consumption (Kiortsis and Simos, 2014; Khalatbary, 2013; Martín-Peláez et al., 2013; Bach-Faig et al., 2011; Cicerale et al., 2009).

In their studies, Owen and co-workers (2000a, 2000b, 2000c) stated that at high rates squalene and oleic acid as well as other phenolic compounds in olive oil have protective effects against bowel, breast and skin cancers, coronary

heart disease, oxidative stress and aging and they highly recommended the consumption of VOO.

Health-related properties of phenolic compounds in virgin olive oil

It has been found that a linear relationship exists between the phenolic content and oxidative stability of olive oil. Polar phenolic compounds, found in small amounts in olive oil, are important ingredients because they affect both the stability and the biological properties of the oil (Visioli et al., 2004).

The major phenolic compounds in olive oil are: (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 (Owen, 2000a; Covas et al., 2006). Tyrosol and hydroxytyrosol are the most representative phenolics of olives and olive oil where they occur as such or in the form of esters of the secoiridoid elenolic acid. Tyrosol, hydroxytyrosol, and their secoiridoid derivatives make up around 90% of the total phenolic content of a VOO.

The phenolic compounds have been widely studied for their effects on coronary heart disease, specifically for their ability to reduce blood pressure and LDL cholesterol. Also, the Mediterranean Diet with extra-VOO significantly reduced the risk of atrial fibrillation, and related morbidity and mortality (Lou-Bonifante et al.;2012, Martínez-González et al., 2014)

Polyphenols isolated from olive oil include oleuropein and hydroxytyrosol which have displayed antioxidant activity in *in vitro* models of LDL oxidation. In addition, α-tocopherol has antioxidant activity that protects against LDL oxidation. Consumption of phenols-rich olive oil as a source of fat provides additional benefits not just against the cardiovascular risk profile but also against oxidative DNA damage (Martín-Peláez et al., 2013).

New evidence suggests that phenolic compounds found in extra-VOO have a role in cancer prevention. So, olive oil consumption has benefits for colon and breast cancer prevention. Antioxidant phenolic compounds present in olive oil are potent inhibitors that act directly in the colon to reduce oxidative damage (Martín-Peláez et al., 2013; Waterman and Lockwood, 2007).

Phenolic compounds have been also demonstrated to inhibit or delay the rate of growth bacteria because oleuropein, hydroxytyrosol and tyrosol have antimicrobial effects against several bacterial strains which are causal agents of intestinal or respiratory tract infections in humans (such as *Salmonella typhi, Vibrio parahaemolyticus, Vibrio cholerae, Staphylococcus aureus and Moraxella catarrhalis*) (Waterman and Lockwood, 2007).

Studies (human, animal, *in vivo* and *in vitro*) have demonstrated that olive oil phenolic compounds have positive effects on certain physiological parameters (Cicerale et al., 2010).

Conclusions

After summarizing the current knowledge on the phenolic compounds of virgin olive oils, this paper gives an overview of scientific literature available on multiple nutritional and pharmacological properties of virgin olive oil. The consumption of virgin olive oil may deliver greater health benefits through the supply of natural antioxidants for its high antioxidant potential, so the supplementation of diets with virgin olive oil is important.

In sum, biologically active metabolites, in particular those derived from virgin olive oil, possess high antioxidant potential. Therefore, continuous efforts should be made to promote the consumption of virgin olive oil and raise awareness of its public health benefits. This was the purpose of this review. Knowing that olive oil contains high amounts of bioactive components will also be useful to consumers in planning rich antioxidant diets, and to nutritionists in estimating the daily intakes of phenolic antioxidants and their impact on health.

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