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Original Research Article

Nutritional quality assessment of extra virgin olive oil from the Italian retail market: Do natural antioxidants satisfy EFSA health claims?

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ABSTRACT

Extra virgin olive oil (EVOO) is the top commercial grade of olive oil, and its fatty acid composition and minor compounds have many documented health benefits. The European Food Safety Authority (EFSA) has recently attributed some health claims to EVOO. Although numerous studies have been carried out on its production technology and nutritional effects, little is known about the composition and quality of EVOO from the retail market. Thus, our aim was to evaluate EVOOs from the Italian market by assessing their fatty acid composition, quality indices, polyphenols, tocopherol content and antioxidant activity (ABTS method) with a view to the possible application of EFSA health claims. High variability was found for phenolic compounds and tocopherols, the levels of which were significantly higher in 100% Italian labeled oils compared with European Union blends. Consumption of the recommended daily amount of EVOO would cover about 50% of the recommended daily allowance (RDA) of tocopherols, as well as the polyphenol intake recommended by EFSA. Only 3 of the 32 samples had a phenolic content above 250 ppm. Particularly high polyphenol indices were found in the samples of Italian oils covered by Protected Designations of Origin (PDOs). In conclusion, the food industry and consumers need to pay close attention to producing and choosing the best EVOO from the nutritional viewpoint.

1. Introduction

Extra virgin olive oil (EVOO) is the top product among olive oils and vegetable oils. It is produced from the olive fruit by mechanical (physical) methods only, and no additive is allowed in the extraction process. EVOO must comply with strict physico-chemical quality requirements and organoleptic characteristics defined by national and European laws and regulations. A distinction is made between the different grades of olive oil (extra virgin, virgin, olive oil) on the basis of the maximum values for some quality indices (acidity, peroxide value, K_{232}, K_{270}, ΔK values, alkyl esters) and the panel test score, as defined by EC Regulation 2568/91 and subsequent modifications.

The popularity of EVOO is linked to its pleasant aroma, particularly its flavor notes, bitterness and pungency, as well as to its health effects. Extensive scientific research has demonstrated that its beneficial effects on human health are related to its balanced fatty acid composition (high content of oleic acid and ratio between omega-3 and omega-6 fatty acids) and vitamin E content and the presence of phenolic compounds, also called "biophenols" or "phenolics" (Servili et al., 2009). The main classes of hydrophilic phenols found in VOO are phenolic alcohols and acids, flavonoids, lignans and secoiridoids. These compounds have been reported to possess many health-promoting functions, such as antioxidant, anti-inflammatory, chemo-preventive and anti-cancer properties (Servili et al., 2009). Some authors have highlighted specific compounds for their particularly significant impact on health, *e.g.* the deacetoxy-ligstroside aglycone, also known as oleocanthal, which has been proved to have anti-inflammatory properties similar to ibuprofen (Inajeros-García et al., 2010). Olive- and olive oil polyphenols are recognized as

Abbreviations: ABTS, 2,20-azinobis(3-ethylenbenzothiazoline-6-sulfonic acid); Ty, tyrosol; OHTy, hydroxytyrosol; OHTy-DEDA, dialdehydic form of decarboxymethyl oleuropein aglycone; TAA, total antioxidant activity; Ty-EDA, dialdehydic form of elenoic acid linked to tyrosol; OHTy-EDA, dialdehydic form of elenoic acid linked to hydroxytyrosol; Ty-EA, aldehydic form of elenoic acid linked to tyrosol; OHTy-EA, aldehydic form of elenoic acid linked to hydroxytyrosol; SPME, solid-phase microextraction; HPLC–DAD, high performance liquid chromatography–diode array detector.

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potent nutraceutical compounds, *e.g.* their high antioxidant activity has positive effects on EVOO shelf life and on the reduction of *in vivo* oxidative stress in humans and animals (Baldioli et al., 1996; Servili et al., 2009; Martín-Peláez et al., 2013).

Olive oil is widely known as the main source of fat in the so-called Mediterranean diet, which has been linked to reduced risk of overall mortality, cardiovascular mortality, cancer incidence and incidence of neurodegenerative diseases (Martín-Peláez et al., 2013). The Mediterranean diet is characterized by high consumption of vegetables, legumes, fruits and cereals and moderate intake of wine, fish, white meat and dairy products. Fat consumption is relatively high, but is mainly made up of monounsaturated fat (oleic acid), due to the extensive use of olive oil. There are notable differences among the different categories of olive oils, related not only to the intensity of their taste and aroma, but also to their processing conditions and nutritional profile.

Thus, the information on the label of this kind of product is fundamental to understand its quality and health benefits. A health claim is defined as any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents and health (Martín-Peláez et al., 2013). The European Food Safety Authority (EFSA) has approved a number of health claims for olive oil on the basis of generally accepted scientific data, *e.g.* the claim that "olive oil polyphenols contribute to the protection of blood lipids from oxidative stress". In recent years many health claims have been considered for olives and olive oil and their minor compounds, particularly phenolic compounds that occur naturally in olive oil. As consumers are very sensitive to health-related notices, it is important to understand if and when the health claims authorized by EFSA can be used on the label of a virgin olive oil. Producers or industry may add the following claim in the olive oil label: "olive oil polyphenols contribute to the protection of blood lipids from oxidative stress", when the product contains at least 5 mg of hydroxytyrosol and its derivatives per 20 g of olive oil (Martín-Peláez et al., 2013).

The nutritional profile of EVOO is widely known to be dependent upon the conditions of olive growing, harvesting and processing as well as on the length and conditions of storage. This last aspect is particularly important because olive oil is susceptible to lipid oxidation and is usually bottled in transparent glass or polyethylene terephthalate (PET) containers, which are exposed to light throughout storage. As olive oil contains a significant amount of unsaturated fatty acids, it is susceptible to lipid oxidation from the time it is produced until it is cooked and consumed. The chemical aspects of olive oil oxidative stability have been widely studied within the scientific community during the past decades; however more work is needed to find other ways of minimizing lipid oxidation. As previously reported by a recent review on this matter, there has been little testing of shelf life in the retail market, probably due to the higher oxidative stability of VOO compared with other vegetable oils (Frankel, 2010). Much research has focused on analyzing olive oil under accelerated oxidative conditions, *e.g.* using the questionable Rancimat test, while other studies have proposed simple but ineffective or inaccurate models to predict the future stability of EVOO (Frankel, 2010).

Some compounds found at low concentrations, particularly polyphenols and tocopherols, have dramatic effects on the stability and nutritional value of EVOO. Tocopherols and other natural antioxidants have been widely correlated with the oxidative stability of VOO. They act as lipophilic "chain-breaking" antioxidants, and possess free-radical scavenging effects (Servili et al., 2009; Martín-Peláez et al., 2013). Among tocopherols, α-tocopherol is the most abundant compound, representing about 95% of the total content (Tasioula-Margar and Okogeri, 2001). Rivera del Álamo et al. (2004) reported the characterization of a large number of EVOO samples obtained exclusively from the cultivar 'Cornicabra', and EVOOs were taken directly from the mill and stored at 4 °C, which did not provide information about the quality changes at room temperatures.

In previous studies, our research group focused on the shelf life and stability of EVOOs bottled in different types of plastic containers (PET) to determine the effects of container material on compositional changes during 12 months storage at room temperature (Savarese et al., 2013). The results of this research, like other findings reported in the literature, showed that EVOO undergoes rapid and dramatic changes during storage. It is therefore of great importance to assess the characteristics of this food product at retail, due to the major implications for consumer health and satisfaction.

Thus, the aim of this work was to evaluate the most important nutritional parameters for defining EVOO quality (fatty acid composition, natural antioxidant concentration and antioxidant activity) in samples from the Italian retail market. The second goal was to assess the actual possibility for producers to declare EFSA health claims on EVOOs based on their composition, particularly their antioxidant concentration.

2. Materials and methods

2.1. Samples

Thirty samples of EVOO were bought from different retailers and supermarkets located in Nola (NA), Benevento and Montesarchio (BN), Southern Italy. The most widely distributed olive oil brands in Italy were represented (Cirio, Farchioni, Bertolli, Desantis, De Cecco, Dante, Costa D'oro, Monini, Carapelli, Pietro Coricelli, Sagra). Also, samples of two EVOOs from the Cilento PDO – Salella and Pisciottana Pietrabianca (Salerno, Italy) – were collected directly from producers. The EVOOs were stored in a cool, dark place until the chemical analyses were carried out.

2.2. Chemical analyses

2.2.1. Legal quality parameters

Olive oil acidity (% oleic acid per 100 g olive oil), peroxide value (meq O_2 kg^{-1} oil) and UV determinations (K_{232}, K_{270} and ΔK) were carried out according to the EC Reg. 2568/1991 and International Olive Council (IOC) standard methods. The parameters K_{232} and K_{270} are the oil absorbance at 232 and 270 nm, respectively, and ΔK was calculated from the absorbances at 262, 268 and 274 nm. Spectrophotometric determinations, K_{232}, K_{232} and ΔK analyses were carried out using a Shimadzu UV-1601 spectrophotometer (Shimadzu, Kyoto, Japan). Sensory analysis was carried out by eight assessors who were fully trained in the evaluation of VOO according to the official methods of the IOC (1996) and EC Reg. 2568/1991.

2.2.2. Fatty acid composition

GC analysis of the fatty acid methyl esters was performed as described by Christie (1982) with some modifications. The olive oil was diluted in hexane (1% oil) and 0.4 mL solution was added to 0.2 mL methanol solution with 2 N KOH. The mixture was shaken vigorously for 1 min and 1 μL of the hexane organic phase was collected for GC injection. A Shimadzu model GC-17A equipped with flame ionization detector (FID) (Shimadzu Italia, Milan, Italy) was used for the analysis. The acquisition software was Class-VP Chromatography data system version 4.6. (Shimadzu Italia, Milano, Italy). A FAME capillary column, 60 m, 0.25 mm i.d. with 0.25 mm 50% cyanopropyl-methyl phenyl silicone was used (Quadrex Corporation, New Heaven, CT, USA). The oven temperature was held at 170 °C for 20 min and then it increased at a rate of 10 °C min^{-1} until 220 °C, held for 5 min. Injector temperature and

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