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Review Article

THE BENEFICIAL EFFECTS OF OLIVE TREE (*OLEA EUROPAEA* L.) IN THE NUTRITIONAL, PHARMACEUTICAL AND INDUSTRIAL APPLICATION: A REVIEW

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Abstract: *Olea europaea* L. (olive tree / zaitoon tree / zaitoon) belong to family *Oleaceae*. This is a valuable and an economically commercial oil woody shrub or small evergreen tree plant species and especially popular in diet of people of Mediterranean region. The olive tree oil is extracted from the fruit of *O. europaea* and used for cooking, agricultural, biological, biochemistry, genetics, microbiology, immunology, pharmacology, toxicology, food technology, pharmaceutical sciences, agro-food sector and environmental sustainability. The whole parts (leaves, branches, fruit) of this plant traditionally used and cultivated for food and medicine in Europe, Mediterranean, warm temperate region, Asian, African, Kingdom of Saudi Arabia, Tunisian regions and in different parts of Pakistan. *O. europaea* also provide an excellent material of polyphenol, abundant unsaturated fatty acids and flavonoids.
O. europaea seedling also possesses different types of resistance and tolerance to biotic and abiotic stress. There are several publications available which has highlighted the influence of waste product, polluted and contaminated air, water and soil on olive tree growth. *O. europaea* also contains many bioactive compounds and oil have been reported to control many ailments. A lot of work has been published on the biological compounds derived from olive tree in recent years for the treatment of different diseases. The potential of *O. europaea* plant extract showed antidiabetic, anticancer, asthma, cholesterol, uric acid, diarrhea, inflammation, blood pressure, antiheart and antiarthritis treatment.
This review study was aimed to assess the beneficial characteristics of olive tree in terms of its nutritional, pharmaceutical properties and application in industries. The outcome will help to researchers working in the field of the nutritional, pharmaceutical and industrial sectors for examining the fruitful results. The 650 research articles were searched for review and 166 were selected using electronic search engine likewise google, google scholar, research society and development and science direct.

Keywords: Antioxidant, antidiabetic, cultivar, environmental pollution, industrial activities, oleuropein, olive tree, photosynthesis, zaitoon tree.

Introduction

Olea europaea L. (olive tree / zaitoon tree / zaitoon) belongs to family *Oleaceae* and is traditionally used as a functional food in Europe and Mediterranean countries and also to treat different types of diseases. The olive tree represent an important economic position in the Mediterranean area due to their wide distribution and representativeness such as in Tunisia with 90 million olive trees covering 1.8 million hectares of land, where it is grown traditionally in rain fed conditions, such as the case of Sfax region that was retaining 25% of national olive tree oil production [DGPA, 2018]. These oil trees, in fact, are capable of maintaining relatively high yield with symbol of longevity [JAFRI, 2021; CHIESI & al. 2022]. ESPESO & al. (2021) believed that olive tree cultivation began in Mesopotamia (4,000 B.C.), with the first records of olive tree crops dating to the Minoan civilization, at around 2,500 B.C. The olive tree is one of

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the most beloved trees in the history of mankind and considered it sacred since Ancient Greek times, throughout the Mediterranean region and now spread over the subtropical region globally, including Pakistan [EFLORA, 2023]. The global trend towards greater population will give rise to substantial increases in world demand for food animal protein (meat, milk and dairy products), vegetable oils and processed foods [PERONE & al. 2022] in developed and developing countries.

O. europaea has many ethnopharmacological [HONG & al. 2021] and nutritional relevance. The fallen herbal waste of olive tree leaves are a good source of antibacterial activity, color and in dyeing of cotton fabrics [YILMAZ & BAHTIYARI, 2020]. Olive tree is the main ingredient associated with many health benefits for treatment of Alzheimer's disease, heart health, cancer prevention, lower blood sugar, cholesterol, uric acid levels, as a laxative, mouthwash, and as a vasodilator, it has also been used to treat diabetic ketoacidosis, inflammation, diarrhea, respiratory and urinary tract infections, stomach and intestinal illnesses and asthma, and also range from fighting inflammation to reducing the growth of microorganisms [HASHMI & al. 2015; ZHAO & al. 2023]. In Mediterranean folk medicine, *O. europaea* leaf preparations are used as a common remedy for gout [FLEMMIG & al. 2011].

The use of natural bioactive molecules extracted by-products of the olive tree oil supply chain for the production of functional feeds may represent a possible source of circular economy in view of environmental sustainability [DI MEO & al. 2023]. This oil trees also helps in combating global warming, climate change, soil erosion, soil contamination, salinity, waterlogging and desertification problems. The byproducts of table olive tree oil industry are of great value but also to the environment and to the human health. Since leaves represent around 10% of the total weight of olive tree arriving at the mill, it is worth obtaining high added-value compounds from those materials for the preparation of dietary supplements, nutraceuticals, functional food ingredients or cosmeceuticals [ŞAHIN & BILGIN, 2018].

Olive tree leaves have recently been recognized as a valuable source in cosmetic and pharmaceutical industry as well as in preparation of health supporting beverages [PONGRAC & al. 2022]. The nutritional status of olive tree (zaitoon) orchards from the central region of the Rio Grande do Sul with fruit yield recorded. Soil, leaf, and fruit from eight orchards for the contents of N, P, K, B, pH, TOC, $Al^{+3,}$ and soil texture analyzed. The available P content in soil were found low. In leaf tissue, K and N presented high contents [FIGUEIREDO & al. 2022].

The different aspect of olive tree growth, pollen development, structural changes, mesocarp formation, alternate bearing behavior by the balance between growth of vegetative and reproductive organs growth was observed [RODRÍGUEZ-GARCÍA & al. 2003; GOMES & al. 2009; ZIENKIEWICZ & al. 2011; ZUCCHINI & al. 2023]. The leaves of olive tree can provide a greener alternative for the recovery of heavy metals from the products of waste and raw materials (mobile phone, keyboards, circuits, computer accessories). Printed circuit boards (PCBs) is becoming a source of precious metals and polyphenols rich plant extract was obtained from olive tree leaves, and its ability to contribute to reducing four metals, namely, Ag, Cu, Cr, and Sn, that are present in scrap PCBs [ALEXANDRE-FRANCO & al. 2022]. There are predictions in Tunisia about the increase of temperature to 2.7 °C on the horizon of 2050, which may contribute to the degradation of agro-ecosystems and particularly the olive tree sector. The physio-biochemical feature, oil quality and growth behavior of "Zelmati" olive tree in Kebili-Rjim Maatoug region, which is a desert oasis in southwestern Tunisia characterized by a hot desert climate was carried out [ROUINA & al. 2019]. The authors recorded the decrease in chlorophyll content, with an increase of malondialdehyde, soluble proteins, proline and soluble sugars contents in leaf tissues due to hot climate. The published result showed evidence about

the plant tolerance or resistance to biotic or abiotic stresses due to disturbances of nutritional status [HUBER & al. 2012; SANZANI & al. 2012]. Olive tree is reported a moderately salt tolerant crop. Recent studies suggestd that olive tree can be irrigated with water containing 3200 mg/l of salt (ECw of 5 dS/m) producing new growth at leaf Na levels of 0.4-0.5% dry weight, fruit weight, and moderate salinity is associated with reduction of CO_2 assimilation rate, stomatal and mesophyll conductance [CHARTZOULAKIS, 2005]. In natural environment the growth of olive tree being reported to abiotic stresses, such as water deficit [FERNÁNDEZ-ESCOBAR, 2019; TEKAYA & al. 2022]. Olive tree oil extraction processes generate significant amount of wastes likewise, olive tree mill solid waste, and olive tree mill wastewater, which are rich in precious compounds and reported toxic to the environment [MECHNOU & al. 2021].

Table 1. Botanical description of olive tree (*Olea europaea* L.)

Kingdom	Plantae
Order	Lamiales
Genus	Olea
Family	Oleaceae
Botanical name	*Olea europaea* Linn. (fruit oil)
Tree	tree grow up to 7 m high, greyish-green
Bark	grey, on branchlets whitish
Leaves	lanceolate, sometimes ovate, c. 4 cm long, 1 cm broad, coriaceous; upper surface dark green, with few scales, ventral silvery-whitish due to scaly hairs; petiole 5 mm.
Flowers	whitish, in terminal or lateral cymes. Calyx truncate or with 4 little teeth. Corolla tube short; lobes 4, 1-2 mm long. Drupe blackish-violet when ripe, ovoid, 1-2 cm in diam.; pulp oily.
Flowering period	April-May. Fruit: September-October.
Genetic variability	Olive tree cultivars represent an invaluable heritage of genetic variability selected over more than 5500 years of cultivation
Soil	well drained
Average life span	500 years, current oldest recorded for 2000 years
Origin / distribution	probably in Asia Minor. Cultivated since ancient times throughout the Mediterranean region (Algeria, Argentina, China, Cyprus, France, Greece, Israel, Italy, Jordan, Libya, Morocco, Portugal, South America, Spain, Syria, Turkey, Tunisia), Europe, now spread over the subtropical regions of the entire globe.
Nutritious value	Fat, fibre and water, calorie, olive oil is rich in monounsaturated oleic acid. Vitamin E.
Olive tree oil grade	(1) virgin, from first pressings that meet defined standards; (2) pure, or edible, a mixture of refined and virgin; (3) refined, or commercial, consisting of lampante from which acid, colour, and odour have been removed; (4) lampante, high-acid oil, named for its use as a lamp fuel, obtained from a second pressing of residual pulp with hot water (some inferior virgin oils are classed as lampante); and (5) sulfide, extracted with solvents and refined repeatedly.
Constituents	Oleic acid, Linoleic acid, Palmitic acid, Stearic acid.Phenolic compounds (oleuropein, hydroxytyrosol, tyrosol and oleocanthal).
Food industry	The extraction of olive tree oil obtained by crushing, pressing and centrifuging, generating byproducts that can be reused for recovery of compounds or generation of new products which is a new approach in the food industry.
Miscellaneous properties / uses	They have been used in the human diet as an extract, an herbal tea, and a powder, and they contain many potentially bioactive compounds that may have antioxidant, antihypertensive, antiatherogenic, anti-inflammatory, hypoglycemic, blood pressure, and hypocholesterolemic properties. Olive oil has a high content of antioxidants, which assists in the repairing of cell membrane and moisturizing the skin. Its chlorophyll content aids in the healing of skin conditions and reducing the signs of aging.

References: RUGINI & FEDELI, 1990; RAINA, 2003; EL & KARAKAYA, 2009; SAAD, 2015; RALLO & al. 2018; WANG & al. 2019; DOOLY, 2020; SILVA & SCHMIELE, 2021; FERREIRA & al. 2021; BRITANNICA, 2023; EFLORA, 2023; AGMRC, 2023; PP, 2024.

This olive tree plant species was not growing well in Pakistan in the past. Recently different varieties have been planted together with some proper pollinators, and the results are quite satisfactory. There is hope now that the cultivation of the olive tree will spread all over the northern regions of Pakistan in the near future [EFLORA, 2023]. FRÖLECH & al. (2021) evaluated about basal lesion and the forms of application of indolebutyric acid (IBA) in 'Arbequina' olive (*Olea europaea* L.) minicut. It was concluded that minicutting of olive 'Arbequina' can be done with lesion at the base and without indolebutyric acid. The micropropagation of the olive tree used to obtain several healthy seedlings in less time, compared to traditional techniques, from an explant. Thus, this work was defined a protocol of contamination and oxidation for Oliveira (*Olea europaea* L.) cv. Koroneiki explants [OLIVEIRA & al. 2021]. STANNER & WEICHSELBAUM (2013) studied antioxidants role for human nutrition.

The fruit and oil of olive tree has many nutritional, medicinal and industrial application in many ways for living organisms. In recent years its cultivation is increasing in the agricultural area due to public demands on global scale. The aim of this review is to highlight the nutritional and pharmaceutical importance of *O. europaea* in industrial sector. The information was gathered from different research articles published in national and international scientific journals.

Table 2. Different varieties of olive tree (*Olea europaea* L.)

Name of olive oil tree varieties	Reference
Tunisian olive tree varieties, namely, Chemchali, Chemlali, Chétoui, Gerboui, Sayali, Zalmati and Zarrazi.	ABAZA & al. 2007.
Jordan cultivars (Nabali, Improved Nabali and Abo-shoka)	AL-MAAITAH & al. 2009
Greek cultivars *koroneiki*, *megaritiki* and *kalamon*	KIRITSAKIS & al. 2010
Olea europaea var. *mastoidis* and *O. europaea* var. *Koroneiki*	KAVROULAKIS & NTOUGIAS, 2011
Konservolea and Kalamata	ABUSAFIEH & al. 2011
Corregiola and Frantoio	GOLDSMITH & al. 2015
Kalamata	BASAHI & al. 2016
IFAPA Centro 'Alameda de Obispo', Cordoba, Spain	KYÇYK & al. 2016
Zelmati	ROUINA & al. 2019
O. europaea var. *sylvestris*	HAROUAK & al. 2021
Olive tree cultivars (Chemlali, Manzanilla, Picaul and Toffahi)	RASHED & al. 2022
Italian cultivars ('Biancolilla', 'Nocellara Etnea', 'Nocellara Messinese', 'Nocellara Siracusana', 'Zaituna')	PALMERI & al. 2022
Leccino	SODINI & al. 2023

Material and methods

The information was sighted from the national and internationally published research work using different online electronic search engine tools such as ACS Publications, BioOne, EGU (European Geosciences Union), Europe PMC, Google Scholar, Google, Hindawi, IDEAS/RePEc, PebMed, Plos One, Science Direct, Springer Link, Taylor & Francis Online, and with different keywords which includes: antioxidant, anticancer, cultivar, ecology, environmental pollution, germination, growth, oils, oleuropein, olive tree, pollution, polyphenol, virgin olive oil and explained in Tables 1-4.

Discussions

Phytomedicine - therapeutical or pharmaceutical benefits

Olive tree leaves in traditional remedies for different types of ailments in European and Mediterranean countries such as Greece, Spain, Italy, France, Turkey, Israel, Morocco, and Tunisia were used. There are many publications available on the use of olive tree that showed health benefits for the treatment of hypertensive, inflammatory, diabetic, cancer, heart, stroke and gout (Table 2). The phenolic compounds present in olive tree leaves confer benefits to the human health especially the oleuropein, are associated to antioxidant, antihypertensive, hypoglycemic, hypocholesterolemic, gastroesophageal reflux, aommon disorder disease, cardioprotective activity and as a support in the treatment of obesity [VAKIL, 2004; PICHE & GALMICHE, 2005; TACK, 2005; KARAMANOLIS & al. 2006; CORON & al. 2007; VOGEL & al. 2014; MONE & al. 2016]. The oldest and traditional methods of prevention and cure of known diseases in Greek, Arab, Islamic health systems based on method diet therapy (Plants and animal product) and early Muslims utilized many plants and animal products mentioned in the Holy Quran and in the Hadith of the Prophet Muhammad (peace be upon him) for health promotion, for example, dates, black seeds, olive tree leaf and olive oil, honey, and camel milk, respectively [SAAD, 2015]. The positive effects of olive tree leaf extract and its key phytochemical constituents have been reported on blood pressure, cancer, respiratory infections, inflammation, insulin resistance and incidences of cardiovascular disease [SOMOVA & al. 2003; AL-AZZAWIE & ALHAMDANI, 2006; POUDYAL & al. 2010; BOSS & al. 2016; BREAKSPEAR & GUILLAUME, 2020; ANTONIOU & HULL, 2021; USMANI & ALMOSELHY, 2023].

Table 3. Therapeutic treatment from different parts of *Olea europaea*

Plant part/product	Treatment	Reference
Olive extract	Inhibited the activities of amylases from human saliva and pancreas	KOMAKI & al. 2003
Leaf	Human leukemia HL-60 cells	ABAZA & al. 2007
Plant	Anticancer	DAI & MUMPER, 2010
Leaves	Antihypertensive, hypoglycemic, hypocholesterolemic, cardioprotective activity and support treatment of obesity	VOGEL & al. 2014
Extra virgin olive oil	Anti-osteoporosis, anti-inflammatory properties, anticancer properties in patients	LIU & al. 2014
Oleuropein	Anti-proliferative activity against a number of cancer types (pancreatic cancer cells)	GOLDSMITH & al. 2015
Leaf	Infectious diseases	EFENTAKIS & al. 2015
Olive oil	Affected bone and uterus in ovariectomized rats	ZHENG & al. 2016
Leaf	blood pressure and inflammatory markers	LOCKYER & al. 2017
Olive oil	Cardiovascular disease, cancer, neurodegenerative disease, osteoporosis, anti-proliferative, pro-apoptotic, and anti-inflammatory activities	GARCIA-MARTINEZ & al. 2018
Extra virgin olive oil	Lowering the incidence of cardiovascular events, including myocardial infarction and stroke	NOCELLA & al. 2018
Extra virgin olive oil	Linked to ageing and age related diseases related to a common chronic low grade inflammation	GAMBINO & al. 2018
Olive oil	Positively associated with a better volumetric bone mineral density treatment in Spanish women	RONCERO-MARTÍN & al. 2018
Olive oil	Fatty liver disease	ABENAVOLI & al. 2019

Olive oil, fruit	Seem to be beneficial for preventing osteoporosis disease and its progression	CHISARI & al. 2019
Leaf extract	Cardiovascular, metabolic disease, blood pressure, respiratory infections, inflammation, and insulin resistance	BREAKSPEAR & GUILLAUME 2020
Olive oil	Beneficial effect on some bone characteristics	DÍAZ-CURIEL & al. 2020
Olive product	Reduced incidences of cardiovascular disease	ANTONIOU & HULL, 2021
Leaves	Cancer cell	ALBOGAMI & HASSAN, 2021
Olive product	Antitumor, tumor genesis, tumor suppression and chronic inflammation, delaying the development, progression or recurrence of various types of tumors	FERREIRA & al. 2021
Leaves	prostate cancer cell lines (HT29 and PC3, resp.)	ALBOGAMI & HASSAN, 2021
Olive oil	Prevent bone mineral density loss	RONDANELLI & al. 2021
Product	Cure the symptoms of Gastroesophageal reflux disease	DA SILVA & al. 2022
Leaves	phenols, secoiridoids, hydroxycinnamic acids, flavonoids	PALMERI & al. 2022
Plant	Human lung cancer cell lines (A549)	NAJIBULLAH & al. 2023
Fruit	Cancer therapy	ALHARBI & FELIMBAN, 2023
Leaves	Exhibiting anti-photoaging activity	XU & al. 2023
Olive oil	Hepatic steatosis and liver enzymes	MA & al. 2023
Olive oil	Cardiovascular	TARABANIS & al. 2023

Anticancer properties

Olive tree leaves have a long history of medicinal and therapeutic use [ALBOGAMI & HASSAN, 2021]. Cancer is one of the most serious public health issues worldwide and might be an important cause of death. A nontoxic strategy for producing silver nanoparticles (AgNPs) for cancer therapy was established in green synthesis method using (OFE) *Olea europaea* fruit extract [ALHARBI & FELIMBAN, 2023]. The AgNPs-OFE was reported highly cytotoxic against the T47D cancer cell line with a 50% inhibitory concentration (IC50) of 77 µg/mL. The leaf extracts of the four olive tree cultivars (Chemlali, Manzanilla, Picaul and Toffahi) as a source for some anticancer agents was examined. The olive tree leaf extract has anti myeloma activity and *in vitro* cytotoxic activity of olive tree leaf extract against mouse metastatic melanoma B16F10 cell lines [MAJUMDER & al. 2019]. In another study, NAJIBULLAH & al. (2023) examined the anticancer potential of chemically characterized *O. europaea* extract in MTT assay and EB/AO double staining method using Human lung cancer cell lines (A549). The study outcome showed that *O. europaea* extract significantly inhibited cell proliferation and apoptosis in human lung cancer (A549) cell lines, and it also explores the chemical composition of *O. europaea* leaves extract. ALBOGAMI & HASSAN (2021) investigated the anticancer properties of an olive tree leaf extract *in vitro* using colorectal and prostate cancer cell lines (HT29 and PC3, resp.)

The phenolic compounds from olive tree products have antitumor potential through their effects in the prevention of tumor genesis and tumor suppression in different cancer models. The phenolic compounds from olive tree products (oleuropein, hydroxytyrosol, tyrosol and oleocanthal) may exert tumor genesis inhibiting effects, such as repair and protection against damage from oxidative stress and chronic inflammation, and thus could help in reducing the risk of cancer and delaying the development, progression or recurrence of various types of tumors [FERREIRA & al. 2021]. Oleuropein has been shown to exhibit anti-proliferative activity against a number of cancer types. The treatment of water, 50% ethanol and 50% methanol extracts of Corregiola and Frantoio variety *O. europaea* leaves showed slight differences in their phytochemical properties, and at 100

and 200 µg/mL, all decreased the viability of the pancreatic cancer cells relative to controls [GOLDSMITH & al. 2015].

Anti-heart disease

Extra virgin olive oil is the most representative component of this diet and seems to be relevant in lowering the incidence of cardiovascular events and stroke [NOCELLA & al. 2018]. Atherosclerosis is characterized by a chronic low grade inflammatory process which can result in atherothrombosis and a number of cardiovascular diseases. The consumption of extra-virgin olive oil is associated with a reduction in inflammatory biomarkers and molecules implicated in atherosclerosis as well as cardiovascular diseases incidence and mortality as well as other complications such as heart failure and atrial fibrillation [WONGWARAWIPAT & al. 2018]. The presence of monounsaturated fats in olive oils favor the heart health. BREAKSPEAR & GUILLAUME (2020) identified the olive tree leaf extract, prepared from the fresh or dried leaves of *O. europaea* is generating interest as a cardiovascular and metabolic disease risk modifier. Positive effects for the olive tree leaf extract and its key phytochemical constituents have been reported on blood pressure, respiratory infections, inflammation, and insulin resistance. The olive tree which is rich in olive products has positive effects on health, associated with reduced incidences of cardiovascular disease [MARTÍNEZ-GONZÁLEZ & al. 2019; ANTONIOU & HULL, 2021].

Infectious – inflammation, liver function and bone health

Olive oil has been associated with bone health and overall data suggested a protective impact of virgin olive oil as a source of polyphenols in addition to vitamin D3 on bone metabolism through improvement of oxidative stress and inflammation was recorded [TAGLIAFERRI & al. 2014]. Olive tree can help with reduction in inflammation which is a root cause of many diseases. The olive tree leaf is considered an important traditional herbal medicine utilized against infectious diseases [EFENTAKIS & al. 2015]. The presence of polyphenols found in olive tree can help reduce the risk of chronic inflammation. The liver is an organ susceptible to a multitude of injuries that causes liver damage, like steatosis, non-alcoholic steatohepatitis, cirrhosis, hepatocellular carcinoma, ischemia-reperfusion injury and extra virgin olive oil presented several protective effects on the liver, reducing hepatic steatosis, hepatocyte ballooning, fibrogenesis, preventing lipid peroxidation, among other effects [SOTO-ALARCON & al. 2018]. Osteoporosis is a metabolic disease affecting the bone mineral density thus compromise the strength of the bones and suggested that the intake of phenols seems to influence bone mineral density by acting as free radical scavengers, preventing oxidation-induced damage to bone cells [CHISARI & al. 2019].

Anti-diabetic potential

Diabetes is a lethal disease in both developed and developing countries and fourth leading cause of death in the most develop countries and diabetic foot ulcer [RAO & al. 2010; WAINSTEIN & al. 2011; ARUMUGAM & al. 2013; BUOWARI, 2013; MOGHADDAM & al. 2013; SALAH & al. 2017]. This developed due to inadequate regulation of the blood sugar which imposes a serious health issue [SALEHI & al. 2019] and affect almost every part of the body and often leads to blindness, heart and blood vessel disease, stroke, kidney failure, amputations, insulin and nerve damage [SOUMYA & SRILATHA, 2011; SHARMA & ARYA, 2011; SINGAB & al. 2014; WANG & al. 2014].

The regular consumption of extra virgin olive oil as a main source of fat altered the inflammatory response characterizes chronic immunemediated inflammatory diseases (IMID) such as rheumatoid arthritis, inflammatory bowel disease, multiple sclerosis, systemic lupus

erythematosus, and psoriasis. It is also associated with a reduced risk of developing chronic degenerative disorders such as cardiovascular diseases, type 2 diabetes and cancer [SANTANGELO & al. 2018].

***Gastroesophageal reflux disease* (*GERD*)**

Gastroesophageal reflux disease (GERD) is a common clinical problem that affects millions of people worldwide [CLARRETT & HACHEM, 2018; GYAWALI & FASS, 2018; KATZKA & KAHRILAS, 2020; CHAPELLE & al. 2021; DE SANTIAGO & al. 2021; SHARMA & YADLAPATI 2021; MALFA & al. 2021]. It was found that the use of *O. europaea* in traditional chinese medicine in the main symptoms of GERD [SILVA & al. 2022].

Antibacterial and fungal potential

Seven aerobic bacterial strains capable of degrading several of the monocyclic aromatic compounds occurring in the phenolic fraction of olive mill wastewaters (OMWs) were isolated from an Italian OMW [DI GIOIA & al. 2002]. *Colletotrichum acutatum* is a cosmopolitan and damaging plant pathogen of temperate, subtropical, and tropical fruits and causes anthracnose on *O. europaea*. The antifungal activity of residues from the olive industry (bagasse) in the Picual variety and of vegetative parts of olive tree cultivars of the Arbequina and Picual varieties, against *Candida* spp., *Microsporum gypseum* and *Sporothrix brasiliensis* was evaluated [MARTINS & al. 2022]. The hydroalcoholic extracts of the bagasse of the Picual variety and the leaves of the Picual and Arbequina varieties showed promising fungistatic activity against the isolates of *Microsporum gypseum*, with CIM ranging from 100 mg/ml to 200 mg/ml.

Bioactive – nutritional compounds composition

Olive oil is composed of TGs, esters of oleic, linoleic, palmitic, fatty acids, along with rich in polyphenols, phenolic compounds, amongst which elenolic acid, alpha tocopherol, flavonoids, pinoresinol and lignans are the main constituents of its oil [OWEN & al. 2000; TAAMALLI & al. 2012; DE BOCK & al. 2013; HASSEN & al. 2015; SASAKI & ISODA, 2022]. Phenolic compounds playing a potential role in public health and reducing risk of chronic diseases [ABAZA & al. 2015].

The inhibitory action of an ethanol extract of *O. europaea* inhibited the activities of amylases from human saliva and pancreas with IC50 values of 4.0 and 0.02 mg/ml, respectively recorded [KOMAKI & al. 2003]. Olive tree leaves are well known for their high polyphenol content and two main phenolic compounds oleuropein and 3-hydroxytyrosol were investigated [GUGLIELMOTTI & al. 2020]. Olive tree fruits, leaves and oils are consider a sources of nutritional and other antioxidants compounds and gaining increasing interest in recent years. It has several pharmacological properties, including antioxidant, cardioprotective, anti-heterogeneous, neuropathic, obesity, anti-cancer, heart, liver, brain, kidney and other effects. The information about the use oleuropein obtained from olive tree leaves in the treatment and prevention of diseases was reviewed [OTERO & al. 2021].

O. europaea constitutes a source of many bioactive compounds and showed many benefits for human health and used in technological, pharmaceutical and industrial purposes (Table 3). RASHED & al. (2022) evaluated the biological activity of oleuropein (an ester of 2-(3, 4-dihydroxyphenyl) ethanol (hydroxytyrosol) which has the oleosidic skeleton that is common to the secoiridoid glucosides of *Oleaceae*.

Table 4. Bioactive compound derived from different parts of *Olea europaea* L.

Plant part	Bioactive compound	Reference
Leaves	Secoiridoids	GARIBOLDI & al. 1986
Olive oil	TGs, esters of oleic, linoleic, palmitic, fatty acids, along with rich in phenolic compounds, amongst which elenolic acid, alpha tocopherol, flavonoids, pinoresinol and lignans are the main constituents of its oil	OWEN & al. 2000
Leaves	secoiridoids, flavonoids, and triterpenes	EL & KARAKAYA, 2009
Leaves	secologanoside, dimethyloleuropein, oleuropein diglucoside, luteolin-7-*O*-glucoside, rutin, oleuropein, oleuroside, quercetin, ligstroside and verbascoside	KIRITSAKIS & al. 2010
Olive tree waste water	hydroxytyrosol, tyrosol, caffeic acid, p-coumaric acid, vanillic acid, syringic acid, gallic acid, luteolin, quercetin, cyanidin, verbascoside and some polymeric compounds	D'ANTUONO & al. 2014
Leaves	phenolic compounds – oleuropein	VOGEL & al. 2014
Leaves	oleuropein, total phenolic compounds, total flavonoids and oleuropein	GOLDSMITH & al. 2015
Olive oil	The main sterols found in olive oil were β-sitosterol, Δ(5) -avenasterol, campesterol and stigmasterol, Over the group of cultivars, total sterol contents ranged from 855 to 2185 mg $kg^{(-1)}$	KYÇYK & al. 2016
Leaves	Phenolic	LOCKYER & al. 2017
Fruit	Fatty acid (98-99%)	ROMANI & al. 2019
Fruit	Phenolics, phytosterols, tocopherols, and squalene (11-2%)	ROMANI & al. 2019
Leave	High polyphenol content and two main phenolic compounds oleuropein and 3-hydroxytyrosol	GUGLIELMOTTI & al. 2020
Leaves	Phenolic compounds from olive products (oleuropein, hydroxy tyrosol, tyrosol and oleocanthal)	FERREIRA & al. 2021
Oils	Primary source of mono- and poly-unsaturated fats	SALAH & al. 2021
Seed extract	The antioxidant and antidiabetic potential of Indian olive seed extracts. Treatment with MEOE and AEOE reduced the aggravated liver and kidney function biomarkers.	AKHTAR & al. 2022
Olive	The biological activity of oleuropein (an ester of 2-(3,4-dihydroxy phenyl) ethanol (hydroxytyrosol) which has the oleosidic skeleton that is common to the secoiridoid glucosides	RASHED & al. 2022
Leaves	Bioactive compounds, including 9,12-octadecadienoic acid (Z,Z)-, n-hexadecanoic acid, 9-octadecenamide, (Z)-, hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester, squalene, 2-(2-Hydroxy-2-phenylethyl)-3, 5,6-trimethylpyrazine, Benzoic acid, 4-formyl-, methyl ester, 2-Methoxy-4-vinylphenol, Vitamin E	SYED & al. 2022
Olive	Identified 37 fatty acid and 35 flavonoid compounds	NIU & al. 2022
Extra virgin oil	May exert beneficial effects on bone by modulating marrow adiposity, which would support their protective effect against bone pathologies	LIU & al. 2022
Leaves	Oleuropein and luteoloside	XU & al. 2023
Fruit	Fatty acids, sterols, erythrodiol, uvaol, and chlorophylls	GAGOUR & al. 2024

KIRITSAKIS & al. (2010) determined the olive tree leaf phenolic composition of the Greek cultivars *koroneiki*, *megaritiki* and *kalamon* using LC/MS and the ability of phenolic compounds to inhibit the lipoxygenase (LOX) activity was investigated. The ten main components in the olive tree leaf extracts for the cultivars *koroneiki* and *kalamon* were: secologanoside, dimethyloleuropein, oleuropein diglucoside, luteolin-7-*O*-glucoside, rutin, oleuropein, oleuroside, quercetin, ligstroside

and verbascoside reported. Olive tree leaves contain several potentially bioactive compounds that may have hypoglycemic and hypolipidemic properties [ACAR-TEK & AĞAGÜNDÜZ, 2020]. HAROUAK & al. (2021) tested *O. europaea* var. *sylvestris* against oral diseases and for phytochemical screening. The total flavonoides (195.80 ± 2.91 mg CE/g decocated extract) significantly ($p<0.0001$) obtained from decocted extract of *Olea europaea* L. subsp. *europaea* var. *sylvestris*, total phenolic (167.71 ± 12.52 mg GAE/g d.e.) and total condensed tannins (250.44 ± 10.18 mg CE/g d.e.) from soxhlet extract and infused extract of *Tetraclinis articulata* L. whereas; The correlation analysis using Principal Component Analysis (PCA) was found positively between infusion and decoction, between total flavonoids and total phenols. The bioactive constituents activity of a cold methanolic extract of *Olea europaea* leaves was identified [SYED & al. 2022]. Several unique bioactive compounds, including 9,12-octadecadienoic acid (Z,Z)-, n-hexadecanoic acid, 9-octadecenamide, (Z)-, hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester, squalene, 2-(2-Hydroxy-2-phenylethyl)-3, 5,6-trimethylpyrazine, Benzoic acid, 4-formyl-, methyl ester, 2-Methoxy-4-vinylphenol, Vitamin E reported.

The bioactive components of *Olea europaea* leaves extract (OLE), was determined by high Performance Liquid Chromatography (HPLC). The results showed that oleuropein and luteoloside inhibited their activity by directly interacting with MMP-1, MMP-3, and MMP-9, thereby exhibiting anti-photoaging activity [XU & al. 2023].

The published documented data reported in this review demonstrated that the main product of *O. europaea* fruits, leaves and byproducts having bioactive compounds also can be used for food, nutritional and pharmaceutical applications according to the requirement of economic strategy. *O. europaea* fruit is a peculiar vegetal matrix contain high levels of fatty acids (98-99% of the total weight of extra virgin olive oil, EVOO) and low quantities (1-2%) of phenolics, phytosterols, tocopherols, and squalene. Among these minor components, phenolics are relevant molecules for human health [ROMANI & al. 2019].

Industrial application

Olive oil industry playing an important role in the economic activities of some countries, especially in Mediterranean basin sector due to the publications of positive evidences from scientific literature related to public health. An estimated 3.2 million metric tons of olive oil was produced worldwide in 2020 [CHRAIBI & al. 2022]. Eight different categories of olive oils and olive-pomace oils exist namely, extra virgin olive oil, virgin olive oil, virgin lampante olive oil, refined olive oil, olive oil composed of refined olive oil and virgin olive oils, olive pomace oil, crude olive-pomace oil, refined olive pomace oil and only extra virgin olive oil, virgin olive oil, olive oil composed of refined olive oil [EC, 2024]. The demand for the olive oil production is increasing rapidly in recent years. Olive products is fulfilling many promising roles in olive oil and pharmaceutical industry. Olive fruits are significant source of phenolic compounds. In addition to eating of this delicious fruit, it is used for oil industry and in the ancient time Kingdom's wealth was determined among other things, was their olive oil industry [RIVULIS, 2024]. Olive is an evergreen xerophytic tree grown for its drupes, which yield oil and has been closely associated with human religious, sociocultural, medicinal, important part of nutritional needs and agroindustry and olive oil industry [SHETTY & WATERLOW, 2003; RAINA, 2003; BALASUNDRAM & al. 2005; PALMERI & al. 2007; PERALBO-MOLINA & al. 2013; ORTEGA & al. 2016; ŞAHIN & BILGIN, 2018; WANG & al. 2019; SILVA & al. 2021; JURADO-CONTRERAS & al. 2022].

Processing industries have been successfully reported for manufacturing and marketing jarred baby foods with the use of vegetable oils, including olive oil, as well as other sources of visible fat added fat in jarred infant foods supplied to the Polish market [HOZYASZ & al. 2010]. Olive

biophenols considered a valued class of natural products used for the practical application in the food, pharmaceutical, beverage, cosmetic and nutraceutical industries due to their powerful biological activity which includes antioxidant and antimicrobial properties [DELISI & al. 2016]. The processes for extracting and refining edible oils are well-established in industry at different scales [GABER & al. 2023]. The olive oil industry represents one of the fastest growing industrial sectors worldwide, such as Spain, Greece, and Italy, and becoming an important industry in countries, such as Chile, South Africa, or Argentina [ALONSO-FARIÑAS & al. 2020]. The commercial olive production generally reported to occur in two belts around the world, between 30° and 45° N latitude and between 30° and 45° S, where the climatic requirements for growth and fruitfulness available [BRITANNICA, 2023]. The most abundant agrifood residues in the Mediterranean basin derive from the traditional crop, olive trees. Olive leaves are also an abundant byproduct in the olive oil industry and characterized by high quantities of phenols [PALMERI & al. 2022]. The olive oil industry generates large amount of byproducts (leaves, branches) which negatively influenced on the economic and local environment due to incomplete processing [GULLÓN & al. 2020; ESPESO & al. 2021; GARCÍA-PASTOR & al. 2023].

The extraction of phenolic compounds through membrane technologies for their application in the food, cosmetic and/or pharmaceutical industry reported [CASSANO & al. 2011; CASSANO & al. 2013; GALANAKIS & al. 2010; PARASKEVA & al. 2007]. The olive mill wastewaters may be a suitable source of valuable compounds that could be used to transform an agro-industrial wastewater into useful and relevant ingredients [OBIED & al. 2009] and olive mill wastewater has been reported in the preparation of functional beverages [ZBAKH & EL ABBASSI, 2012]. However, the table olive industry generates large amounts of wastewater (liquid and solid form) due to the alkaline treatment, fermentation and washing steps and high content of organic matter, a high percentage of suspended solids and fats, an acidic or alkaline pH, high conductivity due to its high salt content, and colored waters due to the presence of polyphenolics compounds in wastewaters make their treatment difficult, leading to a relevant environmental problem with a complicated technological, economic, and social solution [DE LA CASA & al. 2009; BANIAS & al. 2017; FERRER-POLONIO & al. 2017; CAMPUS & al. 2018; FERNÁNDEZ-GONZÁLEZ & al. 2018; ELARIDI & al. 2020; MESSINEO & al. 2020; HADIDI & al. 2021; ARANEDA & al. 2023; GARCÍA-PASTOR & al. 2023).

The disturbances related issues in environment influences the production of olive crop yield and fruit color. Olive mill waste water (OMWW) is an acidic (pH 4-5), saline (EC ~ 5-10 mS cm^{-1}), blackish red aqueous byproduct of the three phase olive oil production process [AHARONOV-NADBORNY & al. 2017]. The effect of OMWW spreading on leaching of metal cations (Na, K, Mg, Mn, Fe, Cu, Zn) in four non-contaminated agricultural soils having different textures (sand, clay loam, clay, and loam) and chemical properties was determined. The results presented in this study demonstrate that OMWW spreading on agricultural soils, due to its organic load and the saline content, may mobilize various indigenous soil metal cations, including major elements such as Na and Mg, as well as heavy metals such as Cu and Zn and redox active metals such as Fe and Mn.

KAVROULAKIS & NTOUGIAS (2011) noted the bacterial diversity in *O. europaea* var. mastoidis generated olive mill waste waters consisted mainly of members of *Acetobacteriaceae*, *Prevotellaceae* and *Lactobacillaceae*, while the majority of β-proteo bacteria identified in *O. europaea* var. *koroneiki*-generated olive mill wastewaters were placed within the families *comamonadaceae Oxalobacteraceae*, *hydrogenophilaceae* and *rhodocyclaceae*. MARI & al. (2016) evaluated the occurrence of yeast populations during different olive oil extraction processes in three consecutive years in Tuscany (Italy), by analysing crushed pastes, kneaded pastes, oil from decanter and pomaces. The results showed yeast concentrations ranging between 10(3) and 10(5) CFU/g or

per mL. These findings suggest a phenomenon of contamination of the plant for oil extraction that selects some yeast species that could affect the quality of olive oil.

Conclusions

This review study contributes to the understanding about the ecological, pharmacological, vegetative growth potential in different environmental habitat of a woody plant species, *O. europaea* at global scale. There is a special care required for conserving and cultivating of olive tree according to current trend of climate change around the world and serious effort is required for protection of this important plant species. Phytochemical studies revealed the presence of iridoids, flavonoids, volatile oil, and other metabolites. Available scientific references revealed that this plant species has many biological properties for health benefits for the treatment of inflammation, piles, cancer, diabetic, blood pressure and diarrhea, aches, jaundice, dysentery. This review was tried to cover the comprehensive knowledge of the traditional medicinal uses, phytochemistry, pharmacology, toxicology and ecology of *O. europaea* for researchers, farm manager and agriculturist working for the increase in cultivable areas. These ideas supported the keen importance of olive tree cultivation to human kind since ancient time.

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