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Antioxidant, anticancer, antimicrobial potential of *Origanum vulgare*

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ABSTRACT

Origanum vulgar belongs to the plant family of Asteraceae , native to temperate Asia, but naturalized in many countries including scattered parts of North America (11, 12). It is an annual short-day plant. Its stem is erect brownish or violet brown. The aim of this study was to overview its Antioxidant, anticancer, antimicrobial effect. This review article was carried out by searching studies in PubMed, Medline, Web of Science, and IranMedex databases .The initial search strategy identified about 150references. In this study,65studies was accepted for further screening and met all our inclusion criteria [in English, full text, therapeutic effects of Origanum vulgare and dated mainly from the year 2009 to 2016.The search terms were "Artemisia annua", "therapeutic properties", "pharmacological effects". It is commonly used for its Antioxidant , Bio-efficacy , Antiproliferative , Radioprotective, Antibacterial and anticancer , Anti-proliferative, Colon cancer, Anti-thrombin activity , Antioxidant, Antibacterial, and Cytotoxic properties, Enterotoxin, Antibacterial, Antimicrobial , Bioactivity, The cytotoxic effect , Cell damage properties, Diabetes properties, Genotoxicity properties, Anticancer and antioxidant properties, Liver toxicity properties, Oxidative lung damage properties, Antioxidant and antiviral activities, Hepatoprotective effect, Antiurolithic activity, Antimelanogenesis properties, Low-density lipoproteins, Inhibitory activity, Antibacterial and antioxidant properties, Radical scavengers properties . It was said to be good for cancer treatment. Origanum vulgareis used for the treatment of various diseases such as diabetes, heart diseases, arthritis and eczema and possess lots of effects as antibacterial, antioxidant, Antimicrobial , Antibacterial effects. In this study, anti-cancer and Anti-inflammatory properties of this plant are presented using published articles in scientific sites. Besides, it was said to be good for cancer treatment.

Keywords: Origanum vulgare, Phytochemicals, Therapeutic effects, Pharmacognosy, Alternative and complementary medicine.

INTRODUCTION

The use of medicinal herbs and herbal medicines is an age-old tradition and the recent progress in modern therapeutics has stimulated the use of natural product worldwide for diverse ailments and diseases [1-10].

Origanum vulgar belongs to the plant family of Asteraceae , native to temperate Asia, but naturalized in many countries including scattered parts of North America [11, 12]. It is an annual short-day plant. Its stem is erect brownish or violet brown. The plant itself is hairless and naturally grows from 30 to 100 cm tall although in cultivation it is possible, that plants reach a height of 200 cm. The leaves of *A. annua* have a length of 3–5 cm and are divided by deep cuts into two or three small leaflets [13-15].

In traditional Chinese medicine, *A. annua* is traditionally used to treat fever, acanthamoebiasis, cancer, schistosomiasis, HIV, hepatitis-B and Leishmaniasis [16, 17]. Apart from the active compound Artemisinin, recent studies show that A. annua is one of the four medical plants with the highest Oxygen radical absorbance capacity (ORAC) level.

Origanum vulgar possesses the capacity to produce high phenolic compounds, which result in high antioxidant activity. Five major groups (coumarin, flavones, flavonols, phenolic acids and miscellaneous) containing over 50 different phenolic compounds were identified analyzing A. annua [21]. Flavonoids are generally known for their redox properties involved in the delay or inhibition of the initiation or propagation in oxidizing chain reactions. It has been stated that there is a negative correlation between the presence of the mentioned components and cardiovascular diseases, cancer and parasitic disease such as malaria.

The proposed mechanism of action of artemisinin involves cleavage of endoperoxide bridges by iron, producing free radicals which damage biological macromolecules causing oxidative stress in the cells of the parasite. Malaria is caused by apicomplexans, primarily Plasmodium falciparum, which largely reside in red blood cells and itself contains iron-rich heme-groups (in the form of hemozoin)[24]. Since few researches done in the synergistic effect of artemisinin and flavonoids and their biological interaction between malaria and cancer, the aim of this study was to overview anti-cancer and anti-malarial activities of Artemisia annua.

Antioxidant

The effect of extracts from known and frequently used plants as part of diet, food seasoning, and medicinal tea was investigated. Results support the promising role of the tested extracts as a source of compounds for further in vivo studies with the ability to powerfully interfere with or modify the redox state of cells according to the type of disease, which is expected to be associated with oxidative stress (11).

The comparison of the *Origanum cp* genome with the cp genomes of two other core lamiales revealed completely conserved protein-coding regions in the IR region but also in the LSC and SSC regions. The variability of the cp within the genus Origanum, studied exemplarily on 16 different chloroplast DNA regions, demonstrated that in 14 regions analyzed, the variability was extremely low (max. 0.7%), while only two regions showed a moderate variability of up to 2.3%. The cp genome of Origanum vulgare contains 27 perfect mononucleotide repeats (number of repeats>9) [12].

The antioxidant activities of vanillin and vanillic acid isolated from Origanum vulgare are investigated. Vanillin did not express inhibition of tyrosinase activity. These results supported that vanillic acid is a significantly stronger antioxidant than vanillin and exhibited stronger antimelanogenesis performance because of the structural presence of the carboxyl group[13].

The effect of an aqueous extract of oregano (Origanum vulgare. L.) on lipid peroxidation and anti-oxidant status in 1,2-dimethylhydrazine (DMH)-induced rat colon carcinogenesis was investigated. The levels of the anti-oxidants superoxide dismutase, catalase, reduced glutathione, glutathione reductase, glutathione peroxidase and glutathione-S-transferase were decreased in DMH-treated rats, but were significantly reversed on oregano supplementation. Oregano supplementation (40 mgkg(-1)) had a modulatory role on tissue lipid peroxidation and antioxidant profile in colon cancer-bearing rats, which suggested a possible anti-cancer property of oregano[14].

Antioxidant effect of Origanum vulgare extract in preventing selenite-induced cataract genesis was assessed. Ov extract have revealed a significant protective effect against selenite induced cataract when injected 1 and 2 day (2 times) before selenite injection. There is a protective effect of Ov against selenite induced cataract formation. It is supposed that the ant cataract effect of Ov extract could be based on direct or indirect antioxidant mechanisms [15].

The effects of a pre-formulated commercial plant extract mix, composed of equal parts of oregano essential oil and sweet chestnut wood extract, on performance, oxidative status and pork quality traits were evaluated. In the cooked meat samples, OC animals had the lowest L* and H° values and the highest a* values. The OC meat received higher scores for colour, taste and overall liking in both the blind and the labelled consumer tests [16].

The concentration of carnosol, rosmarinic and carnosic acids in rosemary (Rosmarinus officinalis L.) and oregano leaves (Origanum vulgare L.), and their effect on the oxidation and colour of model pork batters was examined. The

antioxidant effect of the studied extracts depends, not only on the concentration of phenol compounds (rosmarinic acid, carnosol and carnosic acid), but also on the extraction method and solvent [17].

The biotransformation and pharmacokinetics of OV-16, rats were orally administered OV-16 and oregano decoction. results showed that when OV-16 was orally administered, free forms of OV-16, PCA, and HBA were not present in blood and the major metabolites were the glucuronides/sulfates of PCA and HBA sulfate. The serum metabolites of OV-16 exhibited free radical scavenging activity. When oregano decoction was given, the glucuronides and sulfates of PCA were the major metabolites in blood [18].

Characterization of the essential oils from *O. glandulosum* collected in three locations of Tunisia, chemical composition and the evaluation of their antioxidant activities were carried out. A correlation was identified between the total phenolic content of the essential oils and DPPH radical scavenger capacity. The occurrence of a p-cymene chemotype of *O. glandulosum* in the northern region of Tunisia is demonstrated [19].

Three medicinal plants including oregano (*Origanum vulgare* L.), lavender (*Lavandula angustifolia*) and lemon balm (Melissa officinalis) was compared. Major phenolic acids identified in the analysed species were ferulic, rosmarinic, p-coumaric and caffeic, while predominant flavonoids were quercetin, apigenin kaempherol, which were present as glucosides [20].

The response surface methodology (RSM) based on a central composite rotatable design (CCRD), was used to determine optimum conditions for the extraction of antioxidant compounds from *Origanum vulgare* leaves. Results of the study indicated that phenolic compounds are powerful scavengers of free radical as demonstrated by a good correlation between TP contents and DPPH radical scavenging activity [21].

One-day-old Cherry valley meat-strain ducks were used to investigate the effect of supplemental dried oregano powder (DOP) in feed on the productivity, antioxidant enzyme activity, and breast meat quality. The results suggest that diets containing 0.5% and 1% DOP may beneficially affect antioxidant enzyme activity of GPx and SOD, improve meat cooking loss, and reduce TBARS values in breast meat at 5 d of storage in ducks [22].

Bio-efficacy

The bioactivity of the essential oil isolated from *Origanum vulgare* L. (EOv) was investigated. EOv presents antimicrobial activity against different Gram (-) and (+) strains, measured by disc-diffusion test and confirmed with a more accurate method, the AutoCad software. We postulate that EOv presents antibacterial, antioxidant and chemopreventive properties and could be play an important role as bioprotectoragent [23].

Anticancer

in vitro, the antiproliferative effect of *Origanum vulgare* against human breast adenocarcinoma (MCF-7), and human colon adenocarcinoma (HT-29) was evaluated. The results show that the EO is composed mostly of 4-terpineol and induces a high cytotoxicity effect in HT-29. In the MCF-7 cell line the EO was less effective. In conclusion, this study showed that O. vulgare main component is 4-terpineol and was effective in inducing cancer cell growth inhibition [24].

silver nanoparticles using the aqueous extract of *Origanum vulgare* (Oregano) was examined. The obtained nanoparticles were stable (-26±0.77mV) at ambient temperature. The biosynthesized nanoparticles were found to be impressive in inhibiting human pathogens. The green synthesized silver nanoparticles showed dose dependent response against human lung cancer A549 cell line (LD50 - 100µg/ml)[26].

Selected spices used in Jordan were chemically analyzed and investigated for their antiproliferative activity to the adenocarcinoma of breast cell line (MCF7) was investigated. The major constituent of *O syriacum* was the carvacrol (47.10%), whereas that of O vulgare was trans-sabinene hydrate (27.19%). The ethanol crude extracts of O *syriacum, L nobilis, and S triloba* showed antiproliferative activity to MCF7 with IC (50) values 6.40, 24.49, and 25.25 microg/mL, respectively. However, none of the hydrodistilled essential oils of the tested plant species or their aqueous extracts demonstrated cytotoxic activity [27].

The effect of Origanum vulgare ethanolic extracts on redox balance, cell proliferation, and cell death in colon adenocarcinoma Caco2 cells was investigated. Findings suggest that oregano amounts found in the Mediterranean

diet can exert proapoptotic effects, which are selective for cancer cells. Moreover, whole extract, instead of a specific component, can be responsible for the observed cytotoxic effects [28].

Anticancer and antioxidant

The antioxidant activities of five different crude extracts were determined. The antiproliferative activities of the extracts were determined. Results showed the antiproliferative and antioxidant properties and detailed phytochemical screening of *O. vulgare* ssp. viride (Boiss.) Hayek [55].

Radioprotective

The radioprotective effects of Origanum vulgare extract against genotoxicity induced by (131)I in human lymphocytes was investigated. Origanum extract also exhibited an excellent and dose-dependent radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl-free radicals. This study has important implications for patients undergoing nuclear medicine procedures. The results indicate a protective role for *origanum* extract against the genetic damage induced by radiopharmaceutical administration [25].

Anti-thrombin activity

Aristolochic acid I, aristolochic acid II, and D-(+)-raffinose were isolated from *Origanum vulgare*. Their inhibition of thrombin and activity against leukemia were evaluated. Aristolochic acid I and II have high inhibition of thrombin activity and were confirmed to possess activity against cancer [29].

Antibacterial Activities

The major constituents of the ethanolic *Origanum vulgare* extract was identified and the cytotoxic, antioxidant, and antibacterial properties of the extract was examined .The extract also exhibited antimicrobial properties against Gram-positive and Gram-negative bacterial strains including clinical isolates. In conclusion, the oregano extract has cytotoxic, antioxidant, and antibacterial activities mostly attributed to carvacrol and thymol [30].

Chemical compositions and inhibitory effects of essential oils of Turkish oregano , bay laurel , Spanish lavender, and fennel on Escherichia coli, Listeria monocytogenes, Salmonella typhimurium, and Staphylococcus aureus were determined. Result revealed that carvacrol (68.23%), 1,8-cineole (60.72%), fenchone (55.79%), and trans-anethole (85.63%) were the predominant constituents in Turkish oregano, bay laurel, Spanish lavender, and fennel essential oils, respectively[32].

Overnight exposure of Salmonella entericaserovar Typhimurium to sublethal amounts of Origanum vulgare essential oil (OV) and carvacrol (CAR) did not result in direct and cross-bacterial protection. Cells subcultured with increasing amounts of OV or CAR survived up to the MIC of either compound, revealing few significant changes in bacterial susceptibility[33].

Antibacterial potential of infusion, decoction and essential oil of oregano (Origanum vulgare) against 111 Gram-positive bacterial isolates was examined. Infusion and essential oil exhibited antibacterial activity against *Staphylococcus saprophyticus, S. aureus, Micrococcus roseus, M. kristinae, M. nishinomiyaensis, M. lylae, M. luteus, M. sedentarius, M. varians, Bacillus megaterium, B. thuringiensis, B. alvei, B. circulans, B. brevis, B. coagulans, B. pumilus, B. laterosporus, B. polymyxa, B. macerans, B. subtilis, B. firmus, B. cereus* and B. *lichiniformis*. [34].

Essential oils obtained from flowers, leaves and stems of Origanum vulgare L. ssp. viride (Boiss.) Hayek., growing wild in Ardabil Province (north-west Iran), were analyzed The essential oils were evaluated for their antibacterial activity against 10 selected microorganisms[35].

A synergistic effect between the essential oils *Origanum vulgare*, *Pelargonium graveolens* and *Melaleucaalternifolia* was investigated .the result showed that The essential oil O. vulgare is the most effective, inhibiting all the Candida species evaluated in this study. Some combinations of Nystatin and P. graveolens essential oil did not have any synergistic interactions for some of the strains considered. Associations of Nystatin with M. alternifolia essential oil had only an additive effect(36). the efficacy of *Origanum vulgare L.* essential oil (OVEO) and carvacrol in inhibiting the growth of Pseudomonas aeruginosa ATCC 9027 assessed. Bacterial cells progressively subcultured in meat-based broth with increasing amounts of the tested substances survived up to the

MIC of OVEO and to 1/2 MIC of carvacrol. The results reveal a lack of induction of tolerance in P. aeruginosa by exposure to OVEO or carvacrol in meat-based broth and in a meat model[37].

Variation in the quantity and quality of the essential oil (EO) of wild population of *Origanum vulgare* at different phenological stages, including vegetative, late vegetative, and flowering set, is reported. The oils of various phenological stages showed high activity against all tested bacteria, of which Bacillus subtilis was the most sensitive and resistant strain, respectively. Thus, they represent an inexpensive source of natural antibacterial substances that exhibited potential for use in pathogenic systems [38].

The ability to inhibit biofilm formation was investigated at sub-MIC levels of 200, 100, and 50 m g/ml by staining sessile cells with safranin. Sample E showed the highest average effectiveness against all tested strains at 50 m g/ml and had inhibition percentages ranging from 30 to 52%. In the screening that used preformed biofilm from the reference strain P. aeruginosa, essential oils A through E were inactive at 200 m g/ml; F was active with a percentage of inhibition equal to 53.2%. Oregano essential oil can inhibit the formation of biofilms of various food pathogens and food spoilage organisms [39].

The interaction effect of phenolic, nonphenolic fractions, and volatile oil of *Origanum vulgare* with ciprofloxacin was found. Result shows that not only the formulation using O. vulgare and ciprofloxacin can overcome multidrug resistance but also will reduce the toxic effects of ciprofloxacin [40].

Enterotoxin

the influence of the essential oil from *Origanum vulgare* L. on the enterotoxin production, membrane permeability and cell surface characteristics of Staphylococcus aureus was evaluated. Result demonstrated that O. vulgare essential oil could be rationally applied in food products both to inhibit the growth of S. aureus and to suppress the synthesis of staphylococcal enterotoxins [41].

Antimicrobial

The essential oils were also evaluated for their antibacterial activity against 10 selected microorganisms. The result showed that the essential oils as natural preservatives for food products, due to their positive effect on their safety and shelf life [41].

The effect of solvent polarity (methanol and pentane) on the chemical composition of hydro distilled essential oils (EO's) of Lippiagraveolens H.B.K. (MXO) and *Origanum vulgare* L. (EUO) was studied by GC-MS. EO's showed good stability after 3 months storage at 4°C, where antimicrobial activity of microencapsulated EO's remained the same, while free EO's decreased 41% (MXO) and 67% (EUO) from initial activity. Microencapsulation retains most antimicrobial activity and improves stability of EO's from oregano [42].

In an ongoing project to evaluate essential oils as modulators of antibiotic resistance, the essential oil from Origanum vulgare L. (OVEO), as well as its individual constituents carvacrol (CAR) and thymol (THY), were investigated.The results presented here represent, as far as we know, the first report of OVEO, CAR and THY as putative efflux pump inhibitors. Broadly, these findings indicate that essential oils could serve as potential sources of compounds capable of modulating drug resistance [43].

Four separate samples of *Origanum onites* L., three separate samples of *Saturejathymbra L.*, *Origanum vulgare L. ssp. hirtum (Link) Ietswaart*, and *Thymus cilicicus Boiss*. & Bal. were collected from various regions of Mugla, Turkey. The antimicrobial activities of the essential oils varied depending on the species, subspecies, or variety. In fact, the essential oils of some plants belonging to the same species that were collected from different locations showed different levels of antimicrobial activities [44].

The essential oil-rich fractions were selectively precipitated in the second separator, and their chemical composition and antimicrobial activity were investigated. Linalool standards also showed antimicrobial activity against all of the microorganisms tested, with carvacrol being the most effective. Consequently, it was confirmed that essential oil from experiment 5, with the best antimicrobial activity, also presented the highest quantity of caracole[45].

Bioactivity
Important inhibitory activity on lipoxygenase (LOX) and acetylcholinesterase (AChE) was observed supporting potential anti-inflammatory, anti-Alzheimer and insecticidal activities, mainly due to carvacrol. These properties support the potential use of oregano EOs as natural cosmetic and natural pharmaceutical ingredients [46].

The decoction could be used for antioxidant purposes, while the hydroalcoholic extract could be incorporated in formulations for antimicrobial features. Moreover, the use of infusion/decoction can avoid the toxic effects showed by oregano essential oil, widely reported for its antioxidant and antimicrobial properties[47].

The essential oil production, chemical composition and biological activity of a crop of pink flowered oregano *[Origanum vulgare* L. subsp. vulgare L.*]* was investigated the oil from plants grown in single rows was rich in sabinene, while plants grown in double rows were richer in ocimenes. The essential oils showed antimicrobial action, mainly against Gram-positive pathogens and particularly Bacillus cereus and *B. subtilis*[48].

the in vitro antioxidant and antibacterial properties of oregano *[Origanum vulgare]* essential oil and extracts *[*in hot and cold water, and ethanol*]* was characterize and the chemical composition of its essential oil. *O. Vulgare* extracts and essential oil from Portuguese origin are strong candidates to replace synthetic chemicals used by the industry[49].

The cytotoxic effect
The antibacterial activities of the essential oils from *Origanum vulgare* L. (OV) and *Rosmarinus officinalis L.* (RO) was evaluated . Electron microscopy of cells exposed to the essential oils revealed severe changes in the plasma membrane, cytoplasmic appearance, and cell shape during the 6-h exposure period. OV and RO essential oils combined at sub-inhibitory concentrations could be rationally applied to inhibit the growth of *A. hydrophila* in food products, particularly minimally processed vegetables [50].

Antioxidant and antimicrobial activities of essential oils obtained from oregano (*Origanum vulgare ssp. hirtum*) were determined. The inhibitory effects on the 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) radical of essential oils obtained from oregano by using SFME and CH were similar[51].

The effect of oregano essential oil on Listeria monocytogenes cytoplasmic membrane was evaluated. The combined approach including microbiological and EPR analyses provided relevant information on membrane modification and cell response to essential oils. EPR approach was demonstrated to be an effective and helpful tool to comprehend the modifications exerted by essential oil on the bacterial membrane [52].

Anti-Diabetes
The therapeutic potential of *Origanum vulgare* L. ssp. hirtum (Greek oregano) leaf extract rich in biophenols for the treatment of T1D was evaluated. acting as an antioxidant, immunomodulator and in an anti-apoptotic manner, MOE protected mice from diabetes development. Seemingly, there is more than one compound responsible for the beneficial effect of MOE [53].

Genotoxicity
The genoprotective effect of O. vulgare ethanolic extract against CP-induced genotoxicity in mouse bone marrow cells was evaluated. *Origanum vulgare* ethanolic extract exerts a potent genoprotective effect against CP-induced genotoxicity in mice bone marrow, which might be possibly due to the scavenging of free radicals during oxidative stress conditions[54].

Liver toxicity
The protective effects of O. vulgare extract on CP-induced liver toxicity was evaluated. results reveal that O. vulgare with high amount of flavonoids and phenolic compounds induces potent hepatoprotective mechanisms against CP. Therefore, O. vulgare might help defend the body against the side effects, particularly hepatic damages induced by chemotherapeutic agents[56].

the protective effect of an extract of *Origanum vulgare L. (Lamiaceae*), an antioxidative medicinal plant, against CP-induced oxidative lung damage in mice was evaluated. Results revealed that O. vulgare protects lung tissues from CP-induced pulmonary damage and suggest a role for oxidative stress in the pathogenesis of lung disease

produced by CP. Because O. vulgare has been extensively used as an additive agent and is regarded as safe, it may be used concomitantly as a supplement for reducing lung damage in patients undergoing chemotherapy [57].

Antiviral activities
Six new phenolic compounds (1-6) along with five known ones were isolated from the ethanol extract of the whole plants of *Origanum vulgare*. Twelve of them including two new compounds exhibited significant antioxidant activity comparable to that of ascorbic acid. In addition, the antiviral effects against respiratory syncytial virus (RSV), Coxsackie virus B3 (CVB3) and herpes simplex virus type 1 (HSV-1) were tested by cytopathic effect (CPE) reduction assay[58].

Hepatoprotective effect
The effect of an aqueous extract of *Origanum vulgare* (OV) leaves extract on CCl4-induced hepatotoxicity was investigated in normal and hepatotoxic rats. Result suggests O. vulgare showed protective activity against CCl4-induced hepatotoxicity in Wistar rats and might be beneficial for the liver toxicity[59].

Antiurolithic activity
The crude extract of *Origanum vulgare* for possible antiurolithic effect, to rationalize its medicinal use was investigated. These data indicating the antiurolithic activity in Ov.Cr, possibly mediated through inhibition of CaOx crystallization, antioxidant, renal epithelial cell protective and antispasmodic activities, rationalizes its medicinal use in urolithiasis[60].

Antimelanogenesis
Antioxidant and antimelanogenesis activities of protocatechuic acid (1) from Origanum vulgare (oregano) were investigated. The antioxidative capacity of 1 was confirmed from its free-radical-scavenging activities, inhibition of lipid peroxidation, and suppression of reactive oxygen species in H(2)O(2)-induced BNLCL2 cells. [61].

Low-density lipoproteins
The antioxidative capacity effect of essential oils and aqueous tea infusions obtained from oregano, thyme and wild thyme on the oxidation susceptibility of low-density lipoproteins (LDL) has been studied. The results indicate a dose-dependent protective effect of the tested essential oils and aqueous tea infusions on the copper-induced LDL oxidation. The protective effect of essential oils is assigned to the presence of phenolic monoterpenes, thymol and carvacrol, which are identified as the dominant compounds in these essential oils. [62].

Inhibitory activity
Five polar constituents of *Origanum vulgare* L. ssp. hirtum were investigated . The order of the inhibitory activity of the remaining compounds was: rosmarinic acid >12-hydroxyjasmonic acid 12-O-beta-glucopyranoside > p-menth-3-ene-1,2-diol 1-O-beta-glucopyranoside. Docking studies have been undertaken to gain insight into the binding mode of the investigated compounds at the active site of ALR2. The predicted hydrogen bonding and hydrophobic interactions may explain the observed inhibitory activity[63].

Antilisterial activities of *Thymbracapitata* and *Origanum v*ulgare essential oils were tested against 41 strains of Listeria monocytogenes. Antioxidant activity was also tested, the essential oil of *T. capitata* showing significantly higher antioxidant activity than that of O. vulgare. Use of *T. capitata* and O. vulgare essential oils can constitute a powerful tool in the control of L. monocytogenes in food and other industries[64].

1,1-Dipehnyl-2-picrylhydrazyl (DPPH) radical scavenging activities were found in the extract of dried leaves of oregano (*Origanum vulgare*). The scavenging activity of 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl protocatechuate was almost the same as that of quercetin and rosmarinic acid, but that of 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybennzyl 4-O-methylprotocatechuate was less than that of quercetin, rosmarinic acid and 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl protocatechuate. The amount of 4'-O-beta-D-glucopyranosyl-3',4'-dihydroxybenzyl protocatechuate was estimated to be 3.8 mg/1 g of dried leaves by an HPLC analysis[65].

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