Antimicrobial Properties of Bee Products and Medicinal Plants

Laïd Boukraâ*, Fatiha Abdellah and Leïla Ait-Abderrahim

Laboratory of Research on Local Animal Products Ibn-Khaldoun University. 14000 Tiaret, Algeria
*Corresponding author Email: laid_bouk@hotmail.com ; Tel: +213 7 95306930

1. Introduction

Natural medicinal products have been used for millennia for the treatment of multiple ailments. Although many have been superseded by conventional pharmaceutical approaches, there is currently resurgence in interest in the use of natural products by the general public. In addition, the pharmaceutical industry continues to examine their potential as sources of novel medicinal compounds to identify novel growth factor, immunomodulatory and potential anti-microbial activity [1]. In recent years, multiple drug resistance in human pathogenic microorganisms has developed due to indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious diseases. This situation has necessitated a search for new antimicrobial compounds [2]. Natural products are both fundamental sources of new chemical diversity and integral components of today's pharmaceutical compendium. The search for new antimicrobial substances exhibiting minimal side effects is warranted because of the severe side effects of some drugs currently in use [4]. So, there is an increasing need for new substances with antiviral and antimicrobial activity. Natural products have opened the ways to new therapeutic approaches, contributed to the understanding of numerous biochemical pathways and have established their worth as valuable tools in biological chemistry and molecular and cellular biology [5].

2. Antimicrobial properties of bee products

Antimicrobial action comprises antibacterial, antifungal and antiviral action. These properties of the bee products are important for fighting infections provoked by microbes. The two most important antimicrobial bee products are honey and propolis [6].

2.1. Honey

The use of honey as a traditional remedy for microbial infections dates back to ancient times. Honey exhibits potent antimicrobial activities against pathogenic and non-pathogenic bacteria, yeast and fungi [7, 8]. Laboratory studies have demonstrated that honey is effective against several human pathogens, including *Escherichia coli, Enterobacter aerogenes, Salmonella typhimurium, Staphylococcus aureus*, Methicillin-resistant *S. aureus* (MRSA), haemolytic streptococci and vancomycin resistant Enterococci (VRE) [9, 10]. In a recent study, Alzahrani et *al.*, have found that four varieties of honey of different botanical origins were effective against *Staphylococcus aureus* Oxa R and *S. aureus* Oxa S, *Pseudomonas aeruginosa* and *Candida albicans*[11].The antimicrobial activity of honey has been attributed to several properties of honey including its osmotic effect, naturally low pH and the presence of inhibine which consists of hydrogen peroxide as well as phenolic acids, flavonoids and lysozyme [12].

Reports indicated that honey had promising activity against *Candida albicans* and *Aspergillus niger*. Sheikh et al. [13], reported that honey is effective against dermatophytes *(Microsporum ferrugineum, Trichophyton longfeuseus, T. mentag*rophyte, *T. semmie, T. ton*surance), parasitic fungi *(Allescheria boydii),* saprophytes *(Mucor* mucaralis) and species of *Aspergillus*. Little investigation has been done regarding the antiviral activity of honey. Zeina *et al.* [14] demonstrated the efficient anti-rubella activity of honey at varying concentrations. Ghapanchi et al. showed that honey at different concentrations could inhibit the growth of HSV1, so it can be considered as a therapeutic choice in folk medicine [15]. In studies done by Critchfield et al., it was noticed that honey flavonoids, such as chrysin, acacetin, and apigenin, inhibit the activation of HIV-1 in latent models of infection through a mechanism that probably includes inhibition of viral transcription[16]. Takaisi and Scjoncjer suggested that this is due to the action of the flavonone pinocembrin and the flavonol galangin, and caffeic acid phenethyl ester, whose action mechanism is based on the inhibition of bacterial RNA polymerase [17]. Cushnie and Lamb reported that other flavonoids such as galangin also exhibit antibacterial action[18]. The action mechanism involves degrading the cytoplasm membrane of the bacteria, which leads to a loss of potassium ions and the damage caused provoking cell autolysis. Quercetin, which is also found in honey, increases membrane permeability, and dissipates its potential, leading the bacteria to lose their capacity to synthesis ATP, their membrane transport, and motility [19]. Flavonoids such as quercetin and rutin, which are found in both honey and propolis [20, 21], have shown antiviral activity against HSV, syncytial virus, poliovirus, and Sindbis virus [22, 23]. The action mechanisms proposed for these compounds are related with the inhibition of viral polymerase

and the binding of viral nucleic acid or viral capsid proteins [22]. Table 1 summarises the effect of honey against pathogenic bacteria.

Table 1 Antibacterial activity of honey against bacteria causing life-threatening infection to humans (Mandal 2011) [24]

Bacterial strain	**Clinical importance**
Proteus spps	Septicemia, urinary infections, wound infections
Serratia marcescens	Septicemia, wound infections
Vibrio cholerae	Cholera
S. aureus	Community acquired and nosocomial infection
P. aeruginosa	Wound infection , diabetic foot ulcer, Urinary infections
S. maltophilia	Pneumonia, urinary tract infection, blood stream infection, nosocomial infection
A. baumannii	Opportunistic pathogen infects immunocompromised individuals through open wounds, catheters and breathing tubes
A. schubertii *H. paraphrohaemlyticus* *Micrococcus luteus* *Cellulosimicrobium cellulans* *Listonella anguillarum* *A. baumannii*	Burn- wound infection
H. pylori	Chronic gastritis, peptic ulcer, gastric malignancies
Salmonella enterica serovar Typhi	Enteric fever
Mycobacterium tuberculosis	Tuberculosis

2.2. Propolis

Propolis is a resinous substance collected from various plants by bees. It is used in the construction of, and to seal the cracks in, the bee hive. For this reason, propolis is often referred to as "bee glue." It is a mixture of resin, essential oils and waxes, and also contains amino acids, minerals, ethanol, vitamin A, B complex, E, and flavonoids [25]. Propolis displays strong antimicrobial activity and has been used as a chemotherapeutic agent since ancient times. It was used in folk medicine as early as 300 BC for medical and cosmetic purposes, and as an anti-inflammatory drug and wound-healing agent. Propolis is one of the most potent natural antibiotics characterized by a very wide spectrum of effect. Its therapeutic application does not induce germ resistance and does not destroy useful microflora [26]. Propolis has been proven effective against strains of bacteria that resist chemical antibiotics and it also has promising antiviral properties against herpesviruses. *In vitro* research has shown that propolis has activity against herpes simplex virus type1, reducing viral activity and replication. Antimicrobial activity of bee propolis (including its antiviral activity) is highly attributed to the phenolic compounds such as flavonoids. Among the most potent microbicidal compounds in propolis are flavanone pinocembrin (5,7-dihydroxyflavanone) and its 3-OH analogue flavonol galangin (3,5,7-trihydroxyflavon). Caffeic acid (3,4-dihydroxycinnamic acid) and its esters, volatile fractions with phenols and/or terpenoids and chrysin (5,7-dihydroxyflavone) possess notable antimicrobial activities as well. The action mechanism involves degrading the

cytoplasm membrane of the bacteria, which leads to a loss of potassium ions and the damage caused provoking cell autolysis [27]. Other in-vitro research has also shown that the flavonoids found in propolis caused a reduction of intracellular replication of herpes virus strains. An *in vitro* study showed that propolis suppresses the replication of HIV-1 virus, as well as modulates immune responses [25]. Based on Schnitzler [28], bee propolis flavonoids act by:

a) Preventing virus from entering the host cell.
b) Reducing intracellular replication activities. This process contributes to suppress the growth and development of virus. This can be done by the process called reverse transcriptase. This process stops some specific enzymes disabling virus capability to synthesize their RNA or DNA.
c) Stimulating the immune system to fight back against virus infection (Antiviral properities ofbee propolis blog). Table 2 gives a summary about the antimicrobial effect of propolois.

Table 2 Effects of propolis against pathogenic microorganisms[29].

Gram-positive bacteria	*Bacillus cereus, Bacillus mesentericus, Corynebacterium spp., Corynebacterium diphtheriae, Diplococcus pneumonae, Enterococcus spp., Mycobacteria sp., Mycobacterium tuberculosis, Staphylococcus aureus, Streptococcus: critecus, epidermis, faecalis, mutans, pyogenes, viridans, sobrinus,*
Gram negative bacteria	*Branhamella catarrhalis, E. coli, Helicobacter pylori*, *Klebsiella ozaemae, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella: choleraesuis, dublin, enteritidis, exneri, gallinarum, pullorum, , paratyphi-A, paratyphi-B, typh;i Shigella: dysinteriae, sonnei*
Fungi	*Aspergillus sp., Candida: albicans, guiliermondi, parapsilosis, tropicalis; Cryptococcus sp., Cryptococcus neoformans, Histoplasma encapsulatum, Madurella mycetomi, Microsporum*: *audoinini, canis, cepleo, distortum, ferrugeneum, gypseum; Piedra hortae, Phialophora jeanselmei, Saccharomyces sp. , Trichophyton: sp., mentagrophytes, rubrum, Trichosporon cutaneum*
Viruses	Adenovirus, Coronavirus, Herpes symplex, Influenca A and B, Newcastle disease, Polio virus, Vaccinia, Rotavirus; Vesicular Stomatitis Virus, Coronar virus
Parasites	*Cholomonas paramecium, Eimeria: magna, media, perforans*; *Giardia lambia, Trichomonas vaginalis, Trypanosoma cruzi*

2.3. Royal Jelly

Royal jelly is a substance produced by worker honeybees. If fed to an ordinary female during the larval stage, royal jelly will transform her into the queen. Bee RJ is of particular interest because, as a natural material, it offers probably the greatest potential to find new substances with pharmaceutical potential. Royal Jelly contains approximately 12% protein, 5-6% lipids and 12-15% carbohydrates. Its B vitamin content is high, and with 17 amino acids, including all 8 essential amino acids, it is a nutritious hormone-rich substance with a wide spectrum of potential benefits. Royal Jelly also contains around 15% aspartic acid, which is important for tissue growth, muscle and cell regeneration. Royal Jelly contains amino and gamma globulin, which helps the immune system fight infections. A lot of studies showed a wide range of medical activities in RJ. Some of these effects are: anti-microbial effects [30], suppression of allergic reactions, lowering the amount of blood cholesterol [31], preventing cell damage in cancer and HIV patients, as well as wound healing and growth acceleration.

Researchers report that royal jelly works like a strong antibiotic. It kills all sorts of bacteria and microbes. It inhibits both gram-positive and gram-negative bacteria, but the first group is strongly inhibited. Royal jelly is the only natural source of pure acetylcholine. It has antibacterial and antimicrobial properties and has been implicated as beneficial in a wide range of health conditions.The potency of antibacterial properties of RJ might be related to a particular fatty acid present in the ether-soluble fraction of RJ called trans-10-hydroxy decanoic acid (10-HDA)[32]. Protein and peptides from RJ can participate in defense mechanism of honeybee against microbial pathogens by means of direct inactivation of microorganism occurring in honeybee products, as well as through induction of cytokines participating in regulation of transcription of defensive proteins and peptides.

2.4. Pollen

Pollen is a fine, powder-like material produced by flowering plants and gathered by bees. A pollen grain contains the male gametophyte. Bee pollen, a mass of pollen that has been packed by worker honeybees into granules with added honey or nectar [33], contains lipids, sugars, proteins, amino acids, vitamins, carotenoids, polyphenolics such as

flavonoids and carbohydrates [34].The phenolic composition of pollen principally consists of flavonol glycosides and of hydroxycinnamic acids [35]. This composition tends to be species-specific and has been related to the therapeutic properties (antibiotic, antineoplasic, antidiarrhoeic and antioxidant) of pollen [36]. Kacániova et *al.* [37] studied the antimicrobial activity of bee pollen and found that the extracts of bee pollen was active against different Gram-positive and Gram negative pathogenic bacteria (*Listeria monocytogenes, Staphylococcus aureus, Pseudomonas aeruginosa*, *Salmonella enteric*, *Escherichia coli*) microscopic fungi (*Aspergillus fumigatus, Aspergillus flavus, Aspergillus niger)* and yeasts (*Candida krusei*, *Candida albicans*, *Candida glabrata*, *Candida parapsilosis*, *Candida tropicalis*, *Geotrichum candidum*, *Rhodotorula mucilaginosa).*This activityisdue to different phenolic compounds in pollen.

Antibacterial activity of Turkish bee pollen was studied against 13 different bacterial species pathogens for plants (*Agrobacterium tumefaciens, A. vitis, Clavibacter michiganensis* subsp. *michiganensis, Erwinia amylovora, E. carotovora* pv. *carotovora, Pseudomonas corrugata, P. savastanoi* pv. *savastanoi, P. syringae* pv. *phaseolicola, P. syringae* pv. *syringae, P. syringae* pv. tomato, Ralstonia solanacearum, Xanthomonas campestris pv. *campestris and X. axonopodis* pv. *vesicatoria*).The results showed that the Turkish bee pollen extract have an inhibitory effect against all pathogens [38]. Pollen bread was found to possess an antibacterial activity against *Staphylococcus aureus* and *Staphylococcus epidermidis* [39]. In a recent study with 80 % ethanol extracts of Brazilian pollen antibacterial activity was exhibited against *Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa* and *Klebsiella* sp. [40].The antibacterial substances of pollen, active against *Streptococcus viridans* are similar to those found in propolis and honey combs. Pollen has also significant antifungal activity against different pathogens [41].

2.5. Bee venom

Bee venom contains several physiologically active components. It includes phospholipase A2, hyaluronidase, acid phosphomonoesterase, α-D-glucosidase, and lysophospholipase [42, 43]. Among them, melittin, a water-soluble cationic amphipathic 26 amino acid α-helical peptide, is a very nonspecific cytolytic peptide that attacks all lipid membranes leading to significant toxicity [44]. Phospholipase A2 comprises 10-12% of peptides and it is the most destructive component of apitoxin. It is an enzyme which degrades the phospholipids which cellular membranes are made of.The antibacterial properties of bee venom as a natural antibacterial agent have been extensively studied, and bee venom therapy has been suggested to be used as an alternative to antibiotic therapy [45]. A strong antibacterial activity of bee venom against both Gram negative and Gram positive bacteria has been reported [46]. Nakatuji et al. [47] also reported that bee venom could control the growth of *Staphylococcus aureus*. Moreover, bee venom also exhibited antibacterial activities against skin bacteria such as *Propionibacterium acnes, Staphylococcus epidermidis* and *Streptococcuspyogenes pyogenes* [48]. In a study done by Yu et al. [49]it has been found that bee venom exhibited prominent antifungal activities against *Trichophyton mentagrophytes* and *Trichophyton rubrum* which is much stronger than that of fluconazole, one of the commercial antifungal drugs used in the treatment and prevention of superficial and systemic fungal infections**.**

2.6. Bee Wax

Bee wax is also a product of bees, secreted from the wax gland of bee workers. It is a mixture of esters, fatty acids, higher alcohols and saturated hydrocarbons in addition to aromatic substances and pigments[50].The antimicrobial character of beeswax has been documented in European and Asian holistic remedies for centuries. It was found to be particularly active against *Bacillus alvei, Proteus vulgaris, Salmonella gallinarum* and *Bacillus subtilis.* In a study done by Ghanem et *al.*, it was found that the bee wax sample was effective against gram positive and gram negative bacteria and showed pronounced inhibitory effect against *Candida albicans*. In a study done by Kacániova[37], it was found that the extracts of beeswax were effective against pathogenic bacteria (*Listeria monocytogenes*, *Pseudomonas aeruginosa*; *Staphylococcus aureus*; *Salmonella enteric*, *Escherichia coli*) and microscopic fungi (*Aspergillus fumigatus, Aspergillus flavus, Aspergillus niger,* and different strains of yeasts *Candida krusei*, *Candida albicans*, *Candida glabrata*, *Candida parapsilosis*, *Candida tropicalis*, *Geotrichum candidum*, *Rhodotorula mucilaginosa)*.

3. Medicinal plants

Medicinal plants are the richest bio-resource of drugs of traditional systems of medicine, modern medicines, neutraceuticals, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for synthetic drugs [51]. Medicinal plants produce a large number of secondary metabolites with antimicrobial effects on pathogens. All parts of plants individually or in combination show antimicrobial properties. It has been estimated that 14 - 28% of higher plant species are used medicinally and that 74% of pharmacologically active plant derived components were discovered after following up on ethnomedicinal use of the plants [52].

It is also known that the by-products of some vegetables and fruits represent an important source of sugars, minerals, organic acid, dietary fiber and phenolics that have a wide range of action, which includes antitumoral, antiviral, antibacterial, cardioprotective and antimutagenic activities. Thus new aspects concerning the use of the wastes therapeutically are very attractive. Fruit and vegetable peels can be utilized as a source of antimicrobials. Recent

research has revealed that fruit peels and seeds, such as grape seeds and peels, pomegranate peel, wampee peel and mango seed kernel may potentially possess antimicrobial property. According to Chanda et *al.*, [2] who carried out a study on the antimicrobial activity of peels of seven fruit and Vegetables: *Mangifera indica* L (mango), *Lagenaria siceraria* (long melon), *Solanum tuberosum* L. (Potato), *Ananas comosus* (pineapple), *Luffa acutangula* L.(vegetable gourd), *Momordica charantia* L. (bitter melon), *Moringa oleifera* Lam. (drumstick tree); against 11 microorganisms: *Staphylococcus aureus, Staphylococcus subflava, Corynebacterium Rubrum, Salmonella typhimurium, Enterobacter aerogenes, Klebsiella pneumoniae, Proteus mirabilis, Cryptococcus luteolus, Candida albicans, Candida tropicalis, Candida glabrata,* revealed that *Mangifera indica* peel showed best and promising antimicrobial activity.

3.1. *Thymus*

The aromatic and medicinal properties of the genus *Thymus* have made it one of the most popular plants all over the world. *Thymus* species are commonly used as herbal tea, flavoring agents and medicinal plants [53]. The published results reveal that major volatile constituents obtained from the aerial parts of the plant are geranial, linalool, *γ*-terpineol, carvacrol, thymol and *trans*-thujan-4- ol/terpinen-4-ol [54]). Recent studies have shown that *Thymus* species have a strong antibacterial, antifungal, antiviral, antiparasitic, spasmolytic and antioxidant activities [53]. In a study done in Algeria by Abdellah et al., [55], it was found that the powder of *Thymus ciliatus* has shown a strong antibacterial effect against *Staphylococcus aureus* OxaR, *Escherichia coli* and *Pseudomonas aeruginosa*. Juven et *al.* [56] explained its antibacterial action by the fact that thymol binds to the membrane protein and increases the permeability of bacterial cell membrane. Other studies suggested that this volatile compound was responsible for the inactivation of an enzyme implicated in syntheses of structural constituents [57].

3.2. *Eugenia caryophyllata* (EC)

Eugenia caryophyllata (Clove) has been used in traditional public medicine to relieve nasal obstruction and musculoskeletal pain which imply anti-inflammatory activity for the plant .The plant has a strong phenolic smell and sharp acrid taste. It contains tanene 13% fixed oil and essential oil at 15-20%, in which the main constituents are eugenol (80-90%), β-caryophyllene (9%), eugenyl acetate (7%).

Analgesic, anesthetic, spasmolytic and antibacterial effects of EC were demonstrated by several scientific studies [58]. (EC) was found to be effective against egg and adult of *Pediculus capitis* [59]. It has antiseptic as well as bacteriostatic and bactericidal activity against several bacteria including *Escherichia coli*, *Staphylococcus aureus* [60, 61] and the growth of *Helicobacter pylori* [62]. Clove oil also showed an acaricidal activity against *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus* [63].

3.3. *Eucalyptus*

Native to Australia, the Eucalyptus is a traditional aboriginal remedy for a variety of ailments. Today, it is used worldwide in pills, liquids, inhalers, salves, and ointments for many common problems. Internally, Eucalyptus appears to help relieve symptoms of colds, flu, chest congestion, sore throat, bronchitis, pneumonia, and respiratory infections. Eucalyptus, also referred to as *Eucalyptus globulus*, is used to treat urinary and respiratory tract infections due to its high Eucaliptol content. Eucalyptus is used as an antiseptic for external use. In addition to being an antibacterial, Eucalyptus also has antifungal properties[64].

3.4. *Cinnamomum*

Cinnamon is one of the spices often used in cooking or as traditional medicine. Research interest has focused on Cinnamon that possess chemopreventive, antispasmodic, anti-ulcer, choleretic, sedative, hypothermic, antifungal, antibacterial, antiviral, antipyretic, lipolytic, antiseptic, anesthetic, anodyne, cytotoxic, hypolipidemic, antiplatelet properties and also stimulate immune system[65].The activity of cinnamon is due to the presence of cinnamaldehyde, an aromatic aldehyde that inhibits amino acid decarboxylase activity [66], and has been proven to be active against many pathogenic bacteria [67]. Cinnamon bark is rich in cinnamaldehyde (50.5%), which is highly electro-negative. Such electro-negative compounds interfere in biological processes involving electron transfer and react with nitrogen-containing components, e.g. proteins and nucleic acids, and therefore inhibit the growth of the microorganisms[68].The fungistatic or fungicidal effect of cinnamon spice and its oil is due to the inhibitory action of natural products. The mechanisms involved are cytoplasm granulation, cytoplasmic membrane rupture and inactivation and/or inhibition of intracellular and extracellular enzymes. These biological events could take place separately or concomitantly, culminating with mycelium germination inhibition [69].

3.5. Garlic

Garlic is one of the edible plants which have generated a lot of interest throughout human history as a medicinal panacea. A wide range of microorganisms including bacteria, fungi, protozoa and viruses have been shown to be

sensitive to crushed garlic preparations [70]. The antimicrobial activity of garlic has been attributed to the presence of thiosulfinates (*eg*, allicin). Allicin acts by totally inhibiting RNA synthesis and partially inhibiting DNA and protein synthesis. Bacterial susceptibility to garlic may also depend on structural differences of the bacterial strains. The polysaccharide and lipid contents of the cell wall have an effect on the permeability of allicin and other garlic constituents; this may be responsible for the difference in susceptibility to garlic between gram negative and gram-positive [71].Various garlic preparations have been shown to exhibit a wide spectrum of antibacterial activity against species of *Escherichia, Salmonella*, *Staphylococcus, Streptococcus, Klebsiella*, *Proteus*, *Bacillus*, *Clostridium* and *Helicobacter pylori* and even acid-fast bacteria such as *Mycobacterium tuberculosis*[72, 73]. Garlic extracts can also prevent the formation of *Staphylococcus* enterotoxins A, B, and C1 and also thermonuclease [60]. Fresh garlic extracts have been shown to have an *in vitro* and *in vivo* antiviral activity. Among the viruses which are sensitive to garlic extracts are the human cytomegalovirus, influenza B, herpes simplex virus type 1, herpes simplex virus type 2, parainfluenza virus type 3, vaccinia virus, vesicular stomatitis virus, and human rhinovirus type 2 [74]. Garlic extracts also have a strong antifungal effect and inhibit the formation of mycotoxins like the aflatoxin of *Aspergillus parasiticus*. Allicin was assumed to be the main component responsible for the inhibition of fungal growth. The mode of action of allicin on the fungal cell has not yet been elucidated but it is assumed to function on thiol enzymes (e.g. alcohol dehydrogenase, thioredoxin reductase, and RNA polymerase) which can affect essential metabolism of cysteine proteinase activity involved in the bacteria virulence [69].Table 3 summarises the antimicrobial activity of some plants.

Table 3 Antimicrobial activity of some plants[75,76]

Plant (plant parts)	Activity
Clausena anisata (stem)bark)	Antibacterial and antifungal activity
Cassia alata (leaves)	Antibacterial activity against *Staphylococcus aureus*, coagulase positive *Staplylococcus aureus*, *Bacillus subtilis, Bacillus stearothermophillus, Escherichia coli, Salmonella typhi* and *Salmonella dysentriae Klebsiella pneumoniae Vibrio cholera*
Semecarpus anacardium (leaves, twigs, green fruits, dry nuts)	Antibacterial properties, Bactericidal activity against *Escherichia coli, Salmonella typhi, Proteus Vulgaris, Staphylococcus aureus* and *Corynebacterium diphtheria*
Amona glabra (stem bark)	Antibacterial, antifungal and moderate insecticidal, sporicidal and cytotoxic activities
Eugenia caryophyllus	Antibacterial activity
Thymus vulgaris	
Cinnamonum zeylanium	
Cuminum cyminum	
Nandhi mezhugh	Antifungal activity against 14 strains of *Candida albicans*
Parangi pattai choornam	
Erasa kenthi mezhugu	
Vaan mezhugu	
Azadirachta indica (leaves)	Anti-dermatophytic activity against 88 clinical isolates of dermatophytes
Eucalyptus globulus	Antimycotic activity against *Pestalotiopsis mangiferae*
Catharanthus roseus	
Ocimum sanctum	
Azadirachta indica	
Ricinus communis	
Lawsonia inermis	
Jatropha curcas	
Santolina chamaecyparissus (essential oil	Antifungal activity

Aegle marmelos (essential oil)	Antifungal activity
Cassia alata	Antifungal activity
Withania somnifera (roots)	Antifungal activity
Terminalia belerica	Anti HIV-1, antimalarial and antifungal activity
Phyllanthus amarus	Anti hepatitis B virus
Glycyrrhiza glabra	Inhibition of the DNA viruses (Chandripura virus, Measles virus, Polio wild type viruses 1,2 and 3) and RNA viruses (Herpes type 1 and 2 viruses)
Rhizophora mucronata (bark)	Inhibition of HIV adsorption to the cells.
Exoecaria agallocha (leaves)	
Rhizophora apiculata,	
Rhizophora lamarckii	
Artemisia japonica,	anti-malarial (Plasmodium falciparum) activity
Artemisia maritimia	
Artemisia nilegarica	
Swertia charata	Antileishmanial (Leishmania donovani) activity
Parthenium hysteroporus (flowers)	Antitrypanosomial (Trypanosoma evansi) activity
Citrus hystrix	Epstein-Barr virus
Eucommia ulmoides	Human immunodeficiency virus type 1
-Prunella vulgaris *Ocimum basilicum*	Adenoviruse and Enteroviruses
Kaempferia parviflora	Dengue virus
Stemona tuberose	
Thymus linearis	Herpès simplex virus
Serissa japonica	Herpes simplex virus type 1 & type 2 and Adenovirus

4. Essential oils

Spices, herbs and plant essential oils added to food primarily as flavoring agents have been shown to possess a broad range of antimicrobial activities. Essential oils are volatile, natural, complex compounds characterized by a strong odour and are formed by aromatic plants as secondary metabolites. They are concentrated or stored either in particular region of the plant or in various organs in the same plants and are usually obtained by steam or hydro-distillation, first developed in the Middle Ages by Arabs. Known for their antiseptic, i.e. bactericidal, virucidal and fungicidal, and medicinal properties and their fragrance; they are used in embalmment, preservation of foods and as antimicrobial, analgesic, sedative, anti-inflammatory, spasmolytic and locally anesthesic remedies. Up to the present day, these characteristics have not changed much except that more is now known about some of their mechanisms of action, particularly at the antimicrobial level [77]. Their antimicrobial activity is attributed to the presence of small terpenoid and phenolic compounds [78]. The main constituents of essential oils are phenylpropanoides such as carvacrol, thymol, eugenol and cinnamaldehyde [79]. The mechanism of action of EOs has not been fully elucidated. This is complicated by the fact that there are a large number of chemical compounds present in EOs and often they are all needed for antibacterial activity. Thus the antimicrobial mechanism of EOs may not be attributable to one specific mechanism, but rather there may be several targets in the cell [80]. It is thought that constituents of essential oils cause an increase in the permeability of the cell membrane and thus leads to the leakage of the vital intracellular components of the bacteria outside the membrane. This causes a disturbance in the equilibrium of inorganic ions and possible impairment of

bacterial enzyme system and cell respiration [81]. Table 4 gives a summary about the antimicrobial activity of some essential oils.

Table 4 The antimicrobial activity of some essential oils[78].

EO	Organism
Origanum	*Candida albicans*
Eucalyptus robusta *Eucalyptus saligna*	*Staphylococcus aureus Escherichia coli ; Candida albicans*
Pinus densiflora *Pinus koraiensis* *Chamaecyparis obtusa*	*Salmonella typhimurium, Listeria monocytogenesis, Escherichia coli* *Staphylococcus aureus, Klebsiella pneumoniae, Candida albicans*
Houttuynia cordata *Methyl n-nonylketone* *Lauryl aldehyde* *Capryl aldehyde*	*HSV-1, Influenza virus, HIV-1*
Melissa officinalis	*Pseudomonas aeruginosa, Escherichia coli, Salmonella, Sarcina lutea, Micrococcus flavus, Staphylococcus, Bacillussubtilis, Trichophyton, Microsporum canis, Epidermophyton floccosum, Candida albicans*
Ziziphora clinopodioides *Pulegone* *1,8-cineole*	*Staphylococcus epidermidis Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Enterococcus faecalis, Klebsiella pneumoniae* *Pseudomonas aeruginosa*
Cinnamomum zeylanicum	*Escherichia coli, Yersinia enterocolitica, Pseudomonas aeruginosa, Salmonella choleraesuis, Listeria monocytogenes, Staphylococcus aureus, Bacillus cereus*
Thymus vulgaris *Origanum vulgare*	*Enterococcus faecalis, Penicillium islandicum, Aspergillus flavus, Candida albicans*
Artemisia herba-alba	*Leishmania tropica* *Leishmania major*

5. Olive oil and olive tree parts

Olive oil is a fat obtained from the olive (the fruit of Olea europaea; family Oleaceae), a traditional tree crop of the Mediterranean Basin. The oil is produced by grinding whole olives and extracting the oil by mechanical or chemical means. It is commonly used in cooking, cosmetics, pharmaceuticals, and soaps and as a fuel for traditional oil lamps. Olive oil is composed mainly of the mixed triglyceride esters of oleic acid and palmitic acid and of other fatty acids, along with traces of squalene and sterols. Olive oil contains a group of related natural products, called natural phenols, with potent antioxidant properties that give extra-virgin unprocessed olive oil its bitter and pungent taste and are esters of tyrosol and hydroxytyrosol, including oleocanthal and oleuropein[82]. Olive oil is a source of at least 30 phenolic compounds [83]. Other phenolic constituents include aldehydic secoiridoids, flavonoids and lignans (acetoxypinoresinol, pinoresinol). The latter two compounds are only present in extra virgin oil [84]. In vitro studies have demonstrated the antimicrobial activity of hydroxytyrosol, tyrosol, and oleuropein against several strains of bacteria implicated in intestinal and respiratory infections. It has been proposed that this action is due to the two ortho-positioned phenolic groups in their structure. A recent study found virgin olive oil has bactericidal action against *Helicobacter pylori,* the primary cause of gastric ulcers and linked to gastric cancers [85].

Evidence also suggests that hydroxytyrosol exerts important effects against human microbial infections. Furneri et *al.* [86] demonstrated that an extremely low concentration of hydroxytyrosol inhibited 25 strains of mycoplasma. Medina et *al.* [87] investigated the antibacterial effects of a range of olive oils and isolated polyphenols. Virgin olive oils were shown to have powerful broad spectrum antibacterial effects against 14 different strains of bacteria including *E. coli*, *Salmonella enterica*, and *Staphylococcus aureus*. These important effects were observed after only 60 minutes. Additionally, the antibacterial effects observed were directly correlated to polyphenol concentrations; virgin olive oils had the greatest effects while sunflower and corn oils, which have no or minimal polyphenols, exerted no antibacterial

effects. In a study done by Boukraâ [88], it has been demonstrated that the Algerian olive oil has an antibacterial effect against *Staphylococcus aureus* and *Escherichia coli.*

References

[1] Ghosh S and Playford R. Bioactive natural compounds for the treatment of gastrointestinal disorders. *Clinical Science*. 2003; 104: 547–556

[2] ChandaS, Baravalia Y, Kaneria M and Rakholiya K. Fruit and vegetable peels - strong natural source of antimicrobics" In: Current Research, Technology and Education Topics in Applied Microbiology and Microbial Biotechnology, FORMATEX Research Center, Badajoz, Spain. 2010; 1: 444-450.

[3] Kandil O, Radwan NM, Hassan AB, Amer AM, el-Banna HA and Amer WM. Extracts and fractions of *Thymus capitatus* exhibit antimicrobial activities. *Journal of Ethnopharmacology.* 1994; 44(1):19-24.

[4] Mehrgana H, Mojabb F, Pakdamanc S and Poursaeed M. Antibacterial Activity of *Thymus pubescens* Methanolic Extract. *Iranian Journal of Pharmaceutical Research.* 2008; 7(4): 291-295

[5] Spainhour CB . Natural products.*Drug Discovery Handbook*, by Shayne Cox Gad Copyright © 2005 by John Wiley & Sons, Inc.

[6] Bogdanov S. Functional and Biological Properties of the Bee Products: a Review Bee Products Science www.bee-hexagon.net, 1.February 2011.

[7] Zaghloul AA, El-Shattawy HH, Kassem AA, Ibrahim EA, Reddy IK and Khan MA. Honey, a prospective antibiotic extraction, formulation, stability. *Pharmazie.* 2001; 56: 643-647.

[8] Ghabanchi J, Bazazargani A, Daghigh Afkar M, Balady Foroshan S and Dad Ayeen S. In vitro Assessment of anti-*Streptococcus mutans* potential of honey. *Iranian Red Crescent Medical Journal.* 2010; 12: 61-64.

[9] Allen KL, Hutchinson G and Molan PC. The potential for using honey to treat wounds infected with MRSA and VRE. Paper presented at The First WorldHealing Congress, Melbourne, Australia. 2000.

[10] Kingsley A. The use of honey in the treatment of infected wound. *British Journal of Nursing.*2001; 10 (22): S13-S20.

[11] Alzahrani HA, Alsabehi R, Boukraâ L, Abdellah F, Bellik Y and Balkees BA. Antibacterial and Antioxidant Potency of Floral Honeys from Different Botanical and Geographical Origins. *Molecules.* 2012; 17(9):10540-10549.

[12] Molan PC. The antibacterial properties of honey. BeeWorld. 1992; 73: 59–76.

[13] Sheikh D, Zaman S, , Naqvi SB, Sheikh MR, and Ali G. Studies on the antimicrobial activity of honey. *Pakistan Journal of Pharmaceutical Sciences*. 1995; 8(1):51-62.

[14] Zeina B, Othman O, Al-Assad S. Effect of honey versus thyme on Rubella virus survival in vitro. *Journal of Alternative and Complementary Medicine.*1996; 2: 345-348.

[15] Ghapanchi J, Moattari A, Andisheh TA, Talatof Z, Shahidi SP and Ebrahimi H.The *In Vitro* Anti-Viral Activity of Honey on Type 1 *Herpes Simplex* Virus. *Australian Journal of Basic and Applied Sciences.* 2011; 5(12): 849-852.

[16] Critchfield JW, Butera ST and Folks TM. Inhibition of HIV activation in latently infected cells by flavonoid compounds. *AIDS Research and Human Retroviruses*. 1996;12: 39–46.

[17] Takaisi NB and Scjoncjer H. Electron microscopy and microcalorimetric investigations of the possible mechanism of the antibacterial action of a defined propole provenance. *Planta Med*. 1994; 60: 222–227.

[18] Cushnie TPT and Lamb AJ. Detection of galangin-induced cytoplasmic membrane damage in *Staphylococcus aureus* by measuring potassium loss. *Journa lof Ethnopharmacology.* 2005;101: 243–248.

[19] Mirzoeva OK, Grisjanin RN and Calder PC. Antimicrobial action of propolis and some of its components: the effects on growth, membrane potential and motility of bacteria. *Microbiology Research*. 1997; 152: 239–246.

[20] Yao L, Jiang YM, D'Arcy B, Singanusong R, Datta N, Caffin N and Raymont K. Quantitative high-performance liquid chromatography analyses of flavonoids in Australian Eucalyptus honeys. *Journal of Agriculture and food Chemistry*. 2004; 52(2):210–214.

[21] Orsolic N and Basic I. Water-soluble derivative of propolis and its polyphenolic compounds enhance tumoricidal activity of macrophages. *Journal of Ethnopharmacology.* 2005; 102(1):37–45.

[22] Selway JWT. Antiviral activity of flavones and flavans. In: Cody V, Middleton E, Harborne JB, editors. Plant flavonoids in biology and medicine: biochemical, pharmacological and structure activity relationships. New York: Alan R. Liss, Inc. 1986; 75–125.

[23] Middleton EJR, Chithan K. The impact of plant flavonoids on mammalian biology: implications for inmmunity, inflammation and cancer. In:Harborne JB, editor. The flavonoids: advances in research since 1986. London, U.K.: Chapman and Hall.1993; 145–166.

[24] Mandal MD and Shyamapada M. Honey: its medicinal property and antibacterial activity *Asian Pacific Journal of Tropical Biomedicine* .2011; 154-160

[25] Gene B. Bee Pollen, Propolis , Royal Jelly. Huntington College of Health Sciences. 2005.

[26] Ramanauskiene K, Inkeniene AM, Savickas A, Masteikova R and Brusokas V. Analysis of the antimicrobial activity of propolis and lysozyme in semisolid emulsion systems. *Acta PoloniaePharmaceutica - Drug Research*. 2009; 66(6): 681 - 688.

[27] Bellik Y and Boukraâ L. In: Beneficial Effects of Propolis for Health and Chronic Diseases.Chapter: The Antimicrobial Properties of Propolis pp: 189-203.*Nova Science Publishers, Inc* 400 Oser Avenue, Suite 1600Hauppauge, NY 11788-3619, USA

[28] Schnitzler P, Neuner A, Nolkemper S, Zundel C, Nowack H, Sensch KH and Reichling J. Antiviral activity and mode of action from extracts and selected compounds. *Phytotherapy Research*. 2010; 24(1): 20 – 28.

[29] Bogdanov S. Propolis: biological properties and medical applications. The Propolis Book, Chapter 2. Bee Product Science, www.bee-hexagon.net 30 March 2011.

[30] Eshraghi S and Seifollahi F. Antibacterial Effects of Royal Jelly on Different Strains of Bacteria, *Iranian journal of public Health.* 2003; 32(1): 25-30
[31] Vittek J. Effect of Royal Jelly on serum lipids in experimental animals and humans with atherosclerosis. *Experientia*. 1995; 51(9 – 10): 927 - 935.
[32] Fujiwara S, Imai J, Fujiwara M, Yaeshima T, Kawashima T and Kobayashi K. A potent antibacterial protein in royal jelly. Purification and determination of the primary structure of royalisin. *Journal of Biological Chemistry.* 1990; 265(19): 11333-11337.
[33] Leblanc BW, Davis OK, Boue S, Delucca A and Deeby T. Antioxidant activity of Sonoran Desert bee pollen. *Journal of food Chemistry.* 2009; 115: 1299-1305.
[34] Human H and Nicolson SW. Nutritional content of fresh, bee-collected and stored pollen of Aloe greatheadii var. davyana (Asphodelaceae). *Phytochemistry.* 2006; 67:1486-1492.
[35] Campos MG, Markham KR, Mitchell KA and Proenca da Cunha A. An approach to the characterization of bee pollens via their flavonoid/phenolic profiles. *Phytochemical Analysis*. 1997; 8:181-185.
[36] Graikou K, Kapeta S, Aligiannis N, Sotiroudis G, ChondrogianniN, Gonos E and Chinou I. Chemical analysis of Greek pollen - Antioxidant, antimicrobial and proteasome activation properties. *Chemistry Central Journal.* 2011; 5:33.
[37] Kacániová M, Vuković N, Chlebo R, Haščík P, Rovná K, Cubon J, Džugan M and Pasternakiewicz A**.** The antimicrobial activity of honey bee pollen, loads and bees wax from Slovakia. *Archives of Biological Sciences, Belgrade.* 2012; 64(3), 927-934.
[38] Basim E, Basim H and Ozcan M. Antibacterial activities of Turkish pollen and propolis extracts againstplant bacterial pathogens. *Journal of Food Engineering.* 2006;77(4): 992-999.
[39] Baltrusaityte V, Venskutonis PR and Ceksteryte V. Antibacterial activity of honey and beebread of different origin against *S. aureus* and *S. epidermidis*. *Food Technology and Biotechnology*. 2007; 45(2): 201-208.
[40] Carpes ST, Begnini R, Dealencar SM and Masson ML. Study of preparations of bee pollen extracts, antioxidant and antibacterial activity. *Ciencia e Agrotecnologia*. 2007;31(6): 1818-1825.
[41] Bogdanov S. Pollen: Production, Nutrition and Health: A Review. Bee Product Science, www.bee-hexagon.net, 15 January 2012.
[42] Somerfield SD, Stach JL, Mraz C, Gervais F, and Skamene E. Bee venom inhibits superoxide production by human neutrophils. *Inflammation*. 1984; 8: 385–391.
[43] Banks BEC and Shipolini RA. Chemistry and pharmacology of honeybee venom. In Venoms of the Hymenoptera. Piek T (ed.). Academic Press, London, UK. 1986; 329–416.
[44] Pan H, Soman NR, Schlesinger PH, Lanza GM, and Wickline SA. Cytolytic peptide nanoparticles ('NanoBees') for cancer therapy. *Wiley Interdisciplinary Reviews-nanomedicine and Nanobiotechnology*. 2011; 3: 318–327.
[45] Saini SS, Peterson JW, and Chopra AK. Melittin binds to secretory phospholipase A2 and inhibits its enzymatic activity. *Biochemical and Biophysical Research Communications*. 1997; 238: 436–442.
[46] Perumal SR, Gopalakrishnakone P, Thwin MM, Chow TK, Bow H, Yap EH, and Thong TWJ. Antibacterial activity of snake, scorpion and bee venoms: A comparison with purified venom phospholipase A2 enzymes. *Journal of Applied Bacteriology*. 2007; 102: 650–659.
[47] Nakatuji T, Kao MC, Fang JY, Zouboulis CC, Zhang L, Gallo RL and Huang CM. Antimicrobial property of lauric acid against Propionibacterium acnes: Its therapeutic potential for inflammatory acne vulgaris. *Journal of Investigative Dermatology*. 2009; 129: 2480–2488.
[48] Han SM, Lee KG, Yeo JH, Baek HJ, and Park KK. Antibacterial and anti-inflammatory effects of honeybee (Apis mellifera) venom against acne-inducing bacteria. *Journal of Medicinal Plants Research.* 2010; 4: 459–464.
[49] Yu AR, Kim JJ, Park GS, Oh SM Han CS and Lee MY. The Antifungal Activity of Bee Venom against Dermatophytes. *Journal of Applied Biological Chemistry*. 2012; 55(1): 7−11.
[50] Ghanem Nevine B**.** Study on the antimicrobial activity of honey products and some Saudi Folkloric substances.*Research Journal of Biotechnology.*2011;6 (4): 38 – 43.
[51] Hammer KA, Carson CF and Riley TV. Antimicrobial activity of essential oils and other plant extracts. *Journal of Applied Microbiology*. 1999; 86(6): 985-990.
[52] Ncube NS, Afolayan AJ and Okoh AI.Assessment techniques of antimicrobial properties of natural compounds of plant origin: current methods and future trends.*African Journal of Biotechnology*. 2008; 7 (12): 1797-1806.
[53] Stahl-Biskup E and F Saez. Thyme. Taylor and Francis, London 2002, 346 page.
[54] Piccaglia R, Marotti M, Giovanelli E, Deans SG and Eaglesham E. Antibacterial and antioxidant properties of Mediterranean aromatic plants. *Industrial Crops and Products.* 1993; 2(1): 47–50.
[55] Abdellah F, Boukraâ L, Hammoudi SM, Alzahrani HA, and Bakhotmah B. Synergistic Effect of Honey and *Thymus Ciliatus* Against Pathogenic Bacteria. *The Open Nutraceuticals Journal.* 2012; 5:174-178.
[56] Juven BJ, Kanner J, Schved F and Weisslowiez H. Factors that interact with the antibacterial action of thyme essential oil and its active constituents*. Journal of Applied Bacteriology.* 1994 ; **7**6: 626-31.
[57] Trombetta D, Castelli F, Sarpietro MG, Venuti V, Cristani M, Daniele C,Saija A, Mazzanti G, and Bisignano G. Mechanisms of Antibacterial Action of Three Monoterpenes. Antimicrobial Agents Chemotherapy. 2005; 49(6): 2474–2478.
[58] Öztürk A and Özbek H**.**The anti-inflammatory activity of Eugenia caryophyllata essential oil: An animal model of anti-inflammatory activity**.***European Journal of General Medicine.* 2005; 2(4):159-163.
[59] Yang YC, Lee SH, Lee WJ, Choi DH and Ahn YJ. Ovicidal and adulticidal effects of Eugenia caryophyllata bud and leaf oil compounds on Pediculus capitis. *Journal of Agriculture and Food Chemistry.* 2003; 51(17):4884-4888
[60] Burt SA and Reinders RD. Antibacterial activity of selected plant essential oils against *Escherichia coli* O157:H7. *Letters in Applied Microbiology*. 2003; 36(3):162-167.
[61**]** Ernst E, Pittler MH, Stevinson C, et al, editors. The Desktop Guide to Complementary and Alternative Medicine: An Evidence-Based Approach. St Louis: Mosby, 2001.

[62] Bae EA, Han MJ, Kim NJ and Kim DH. Anti-Helicobacter pylori activity of herbal medicines. *Biological & Pharmaceutical Bulletin.* 1998; 21(9): 990-992.
[63] Kim EH, Kim HK and Ahn YJ. Acaricidal activity of clove bud oil compounds against Dermatophagoides farinae and Dermatophagoides pteronyssinus (Acari: Pyroglyphidae). *Journal of Agriculture and Food Chemistry.* 2003; 51(4):885- 889.
[64] Antibacterial Activity of Medicinal Plants. Posted by adamgilicirist on July 1, 2011.https://www.easterndrugs.com/blog/general-health/health-tips/antibacterial-medicinal-plant. Accessed on 2013.
[65] Chaudhry NMA and Tariq P. Anti-microbial activity of *Cinnamomum cassia* against diverse microbial flora with its nutritional and medicinal impacts. *Pakistan Journal of Botany*. 2006; 38(1):169-174.
[66] Wendakoon CN and Sakaguchi M. Inhibition of amino acid decarboxylase activity of *Enterobacter aerogenes* by active components of spices. *Journal of Food Protection.* 1995; 58: 280-283.
[67] Suresh P, Ingle VK and Vijayalakshima V. Antibacterial activity of eugenol in comparison with other antibiotics. *Journal of Food Sciences and Technology*. 1992; 29: 254-256.
[68] Gupta C, Garg AP, Ramesh C, Uniyal RC and Kumari A. Comparative analysis of the antimicrobial activity of cinnamon oil and cinnamon extract on somefood-borne microbes.*African Journal of Microbiology Research*. 2008; 2(9): 247-251.
[69] Cowan MM. Plant products as antimicrobial agents. *Clinical Microbiology Review*. 1999; 12: 564-582.
[70] Ankri S and Mirelman D. Antimicrobial properties of allicin from garlic. *Microbes and Infection*. 1999; 2: 125-129.
[71] Eja ME, Asikong BE, Abriba C, Arikpo GE, Anwan EE and Enyi-Idoh KH. A comparative Assessment of the Antimicrobial Effects of Garlic (Allium sativum) and antibiotics on Diarrheagenic Organisms. *Southeast Asian Journal of Tropical Medicine and Public Health.* 2007; 38 (2): 343 – 348.
[72] Uchida Y, Takahashi T and Sato N, The characteristics of the antibacterial activity of garlic. *Japanese journal of antibiotics.* 1975; 28: 638–642.
[73] Cellini L, Di Campli E, Masulli M, Di Bartolomeo S and Allocati N. Inhibition of *Helicobacter pylori* by garlic extract (*Allium sativum*). *FEMS Immunology & Medical Microbiology*. 1996; 13:273–277.
[74] Tsai Y, Cole LL, Davis LE, Lockwood SJ, Simmons V and Wild GC. Antiviral properties of garlic: in vitro effects on influenza B, herpes simplex and coxsackie viruses, *Planta Medica*. 1985; 5: 460–461.
[75] Sher A. Antimicrobial activity of natural products from medicinal plants.*Gomal Journal of Medical Sciences*. 2009; 7(1): 72-78.
[76] Hafidh RR, Abdulamir AS, Jahanshiri F, Abas F, Abu Bakar F, and Sekawi Z.Asia is the mine of natural antiviral products for public health. *The Open Complementary Medicine Journal.* 2009; 1:58-68.
[77] Bakkali F, Averbeck S, Averbeck D and Idaomar M. Biological effects of essential oils – A review *Food and Chemical Toxicology.* 2008;46: 446–475.
[78] Negero G, Kelbessa U, Ashenif T, Hirut L, Daniel M and Kissi M. Antimicrobial activity of topical formulation containing Eugenia caryophyllata L.(krunfud) and Myritus communis essential oils on selected skin disease causing microorganisms. *Ethiopian Journal Health Sciences*. 2008;18(3): 101-107.
[79] Sabahat S and Perween T. In vitro antibacterial activity of clove against gram negative bacteria.*Pakistan Journal of Botany*. 2008; 40(5): 2157-2160.
[80] Kačániová M, Vukovič N, Hleba L, Bobková A, Pavelková A, Rovná K and Arpášová H. Antimicrobial and antiradicals activity of *Origanum vulgare L*. and *Thymus vulgaris* essential oils.*Journal of Microbiology,Biotechnology and. Food Sciences.* 2012; 2 (1): 263-271.
[81] Abu-Darwish MS, Al-Ramamneh EA, Kyslychenko VS, Karpiuk UV. The antimicrobial activity of essential oils and extracts of some medicinal plants grown in Ash-shoubak region - South of Jordan.*Pakistan Journal of Pharmaceutical Sciences.*2012;25(1):239-46.
[82] Tripoli E, Giammanco M, Tabacchi G, Di Majo D, Giammanco S, and La Guardia M. The phenolic compounds of olive oil: structure, biological activity and beneficial effects on human health.*Nutrition Research Reviews*. 2005; 18: 98–112.
[83] Tuck KL and Hayball PJ. Major phenolic compounds in olive oil: metabolism and health effects. *The Journal of Nutritional Biochemistry*. 2002; 13(11):636-644.
[84] Owen RW, Giacosa A, Hull WE, Haubner R, Spiegelhalder B and Bartsch H. The antioxidant/anticancer potential of phenolic compounds isolated from olive oil. *European Journal of Cancer.* 2000; 36 (10): 1235-1247.
[85] Romero C, Medina E, Vargas J, Brenes M and De Castro A. In vitro activity of olive oil polyphenols against Helicobacter pylori. *Journal ofAgriculture and Food Chemistry.* 2007; 55(3):680-686.
[86] Furneri PM, Piperno A, Sajia A and Bisignano G. Antimyoplasmal activity of hydroxytyrosol. *Antimicrobial agents and chemotherapy*. 2004; 48(12): 4892-4894.
[87] Medina E, de Castro A, Romero C, Brenes M. Comparison of the concentrations of phenolic compounds in olive oils and other plant oils: correlation with antimicrobial activity. *Journal of Agricultural and Food Chemistry*.2006;54: 4954–4961.
[88] Boukraa L. Susceptibility of *Staphylococcus aureus* and *Escherichia coli* to olive-tree parts. *Acta Horticulturae*.2009; 826: 21-24.

