



A survey on antibacterial effects of Iranian medicinal herbs on *Staphylococcus aureus*

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Abstract

Due to the increasing prevalence of *Staphylococcus aureus* infections and resistance to long-term treatment with currently available antibiotics, *S. aureus* is well known. The search for new drugs, especially from natural sources, is underway. The use of plants for healing has been popular since ancient times. The benefits of herbs are minimal side effects, availability and usually low cost. Herbal research has become increasingly popular over the past few decades. Here, essential oils and various extracts (methanol, ethanol, ethyl acetate, ether, or aqueous extracts) from 31 genera of medicinal plants containing 83 species of *S. aureus* and its most common resistant strain, methicillin. The purpose is to evaluate the antibacterial activity of the review on the introduction of Methicillin-Resistant *S. aureus* (MRSA) as a potent therapeutic agent. This review describes species with known activity from which active compounds have not been isolated. Data from the present study supported, but limited, recommendations for routine use of Iranian herbs for the treatment of *S. aureus* infections. Iranian herbs have proven to be worthy of further clinical research to identify pure herbal compounds.

Keywords: Iranian medicinal herbs, *Staphylococcus aureus*, Methicillin-resistant *S. aureus* (MRSA), Antimicrobial activity.

1. Introduction

Infectious diseases are the second leading cause of death worldwide [1-2]. In recent years, the emergence of drug resistance has become a problem in the treatment of infectious

diseases [3]. Therefore, there is an urgent need to find newer, safer and more effective antibiotics that are less prone to resistance [2]. For many years, the World Health Organization (WHO) has endorsed traditional medicine as a safe treatment for bacterial and non-bacterial diseases. According to a 2013 WHO report, more than 80% of the world's population depends on traditional medicine for primary health care [4]. On the other hand, almost a third of pharmaceuticals are derived from plants [5]. Plants contain different compounds

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that fight different pathogens. This means that plants have a wide range of activities against different types of pathogens, including antibiotic-resistant bacteria [6-7]. Recently, research has progressed towards plants that are safer, cheaper, more accessible and more acceptable to humans than synthetic antibiotics.

Staphylococcus aureus is one of the essential and problematic infectious agents. Staphylococci are Gram-positive bacteria characterized by a single coccus [8]. More than 30 types of staphylococci can infect humans, but most infections are initiated by *S. aureus*. *S. aureus* is an opportunistic pathogen, often asymptotically transmitted [9-10]. This bacterium is naturally present in the skin and nasopharynx and causes various infections of the skin, nose, urethra, vagina, and gastrointestinal tract [8]. It is a significant cause of lower respiratory tract infections and postoperative wound infections. This pathogen is the second most common cause of nosocomial bacteremia, pneumonia, and cardiovascular infections [11]. *S. territories* is a common cause of postoperative wound infections [12]. The emergence of antibiotic-resistant forms of pathogenic *S. aureus* is a global problem in clinical medicine [13]. Methicillin-resistant *Staphylococcus aureus* [MRSA] is the most common antibiotic resistance of all antibiotic resistance threats. MRSA was first identified 50 years ago [14]. Since then, MRSA infections have spread worldwide [15-16].

The diversity of climates has created diverse flora in Iran. Therefore, it is possible to identify the active substances of various plants native to the country and extract these substances for industrial-scale production of large quantities

of these substances. Evaluation of these possibilities is particularly important in lesser-studied plants, particularly in Iran.

This review aimed to find out whether a plant widely distributed in Iran could be used as an alternative treatment for infectious diseases. This review describes the number of plant species in Iran to screen for most of the plant species that are valuable as potential therapeutic agents against *S. aureus* and its commonly resistant strain MRSA.

2. Materials and Methods

This review includes searching the available literature for plants and plant compounds active against *Staphylococcus aureus* and MRSA. To find articles of interest, we searched PubMed, Science Direct, Scopus, Springer Link, Wiley Online Library, and Google Scholar databases on Iranian medicinal plants, Iranian medicinal herbs, herbal antibacterial extracts, *Staphylococcus aureus*, and MRSA. We surveyed all relevant articles and collected and categorized all relevant data published between 1 January 1974 and 1 January 2015. All herbs described below are summarized in **Table 1** (after references), along with details of plant parts, extract type, maximum inhibitory concentration (MIC), zone of inhibition, and researcher use. Finally, among the 78 extracted articles, 49 articles were selected. Nine articles were duplicates and 18 articles were excluded due to non-compliance with the necessary criteria and lack of access to their full text.

3. Results and Discussion

This study aimed to introduce some medicinal and indigenous species of Iran with anti-*S. aureus* effects.

The results may provide economic optimization of medicinal cultivation. Also, the results may cause Iran to be considered a medicinal reserve of the region and are of special importance due to new findings on medicinal plants. All plants have adaptability to ecological conditions. The results showed that precious medicinal plants from areas of Iran belonging to 31 plant families have effective antibiotic effects. The results indicate that among the factors influencing the level of awareness of medicinal plants in the Iran region, the relationship between awareness and health center accessibility for local antibiotics is significant.

Dicyclophora

The genus *Dicyclophora* has only one species worldwide, *D. persica* Boiss, which belongs to the *Apiaceae* family. It is a species endemic to southern Iran [Fars, Bushehr, Khuzestan, Hormozgan, and “Sistan and Baluchestan” provinces] (fig. 1). In 2005, Salehi et al. studied the antimicrobial activity of essential oils extracted from the aerial parts of *D. persica*. Boss was extracted at the flowering stage from the Fars province using the disc diffusion method. *S. aureus* growth was inhibited with a 20 mm zone of inhibition and a minimum inhibitory concentration [MIC] of 1.2mg/mL. The penicillin-associated zone of inhibition was 13mm [17].

Nepeta

The *Nepeta* genus belongs to the *Lamiaceae* family, which includes 75 species growing in Iran [18]. *N. Menthoid* and *N. Cripsa* are widely used as aromatic and medicinal plants in Iran. *N. Menthoid* is of great interest to traditional Iranian medicine in Ardabil province. *N. cripsa* is

of great interest in traditional Iranian medicine, especially in Hamadan province (fig. 1) [18-19].



Figure 1. the map of Iran country with showing all provinces to better understand the geographic location of the plants harvested.

The drink obtained from the aerial parts of *N. crisper* has a calming, relaxing, and digestive effect on the central nervous system and the respiratory tract. The aerial parts of *N. menthoid* have traditionally been used as a sedative, blood purifier, and to treat abdominal pain, hypertension, rheumatism, and nervous disorders [20].

Sonboli et al, in 2004 and 2009, evaluated the antimicrobial activity of an essential oil extracted from the aerial parts of *N. cripser* and the antimicrobial potential of an essential oil from the aerial parts of *N. menthoid* in the flowering stage disk diffusion, respectively. The results showed the highest antimicrobial activity, with *S. aureus* being the most sensitive with a zone of inhibition of 19.5 mm for *N. cripser* oil [15 µl/disk] and 21 mm for *N. menthoid* oil [10 µl/disk]. The zone of inhibition for ampicillin [10 µg/disk] was much smaller than that of essential oil N at 13 mm. *Crips* oil and *N. mentoid*. A MIC of 3.6 mg/ml was obtained from *N. menthoid* [18-19].

Terminalia

Terminalia chebula belongs to the comb family. This aromatic plant is common in different parts of Iran. It is widely used in Unani, Ayurvedic, and homeopathic medicine. *Terminalia chebula* is a popular traditional medicine in Asian and African countries due to its wide range of pharmacological activities related to biologically active chemicals. Antioxidant, antidiabetic, antibacterial, antiviral, antifungal, anticancer, antiulcer, antimutagenic, and wound healing properties have been reported [20-21].

In 2004, Shahidi Bonjar demonstrated the antimicrobial activity of a methanol extract from both mature and immature seeds of *T. chebula* against certain bacteria, among which *S. aureus* was more sensitive to extracts from immature seeds. MIC values of 5 mg/ml and 2.5 mg/ml, respectively, were obtained for mature and immature seeds [22].

Myrtus

Myrtus Communis Linn. (Family, Myrtaceae) is a fragrant evergreen shrub or small tree. Its homeland is in Southern Europe, North Africa, and Western Asia. This plant has a wide pharmacological spectrum as a medicine, antiseptic, hypoglycemic, laxative, analgesic, hemostatic, tonic, and hair stimulant. The root is reported to have antibacterial properties [23].

In a 2004 study by Shahidi Bonjar, the antibacterial effect of the methanolic extract of the leaves and seeds of *Myrtus communis* was investigated. The growth of *S. aureus* was strongly inhibited by both extracts. The zone of inhibition for leaf extract was 26 mm at 20 mg/ml and 10 mm at 5 mg/ml, while the zone

of inhibition was 16 mm and 9 mm for seed extract at 20 mg/ml and 0.62 mg/ml, respectively. Thus, the antimicrobial properties of *M. communis* leaf extracts are significantly higher than those of seed extracts [23]. The same results were obtained in 2006 by Yadegarnia et al. reported [24].

Citrullus

Citrullus colocynthis [L.] Schrad. (colocynth or wild gourd or bitter apple) is a hardy, herbaceous perennial vine from the family of the cycads. In southeastern Iran, *Citrullus colocynthis*, locally known as Abu-Jahl watermelon, is a recognized herb in traditional medicine and has been used by rural people as a laxative, antidiabetic, and insecticidal [25]. Two studies by Shahid Bonjar in 2004 described the antimicrobial potential of methanolic extracts of *Citrullus colocynthis* fruits and seeds. As a result, both extractions are effective against *S. aureus* [22, 26].

Salvia

One of the largest genera of the mint family, *Salvia* L., has more than 900 species and is widespread worldwide [27]. There are 58 species of this genus in the flora of Iran, 17 of which are endemic. Sage species are commonly used to heal wounds and relieve pain in the stomach, liver, and rheumatism, and mainly to treat the common cold, bronchitis, tuberculosis, bleeding, and menstrual irregularities [28-31]. The antimicrobial activity of some essential oils of the genus *Salvia* against microbes has been reported in the literature. This is due to the presence of chemical constituents like germacrene and linalool [32]. Sage and its essential oils are used today in food flavorings,

cosmetics, preservatives, pharmaceuticals, and perfumes [28-29].

In 2007, Yousefzadi et al. studied the antimicrobial properties of essential oil from the aerial parts of three species of *Salvia*, *S. multicaulis*, *S. sclarea*, and *S. verticillata* native to Tehran province (**fig. 1**). *S. aureus* was sensitive to oils with MIC values of 7.5 mg/mL for *S. multicaulis* and *S. verticillata* and 15 mg/ml for *S. sclarea* [28]. Similar results were obtained for the essential oil of two other *Salvia* species, *S. limbata* and *S. choloroleuca*, Paknejadi et al., 2012. The results showed a MIC value of 15 mg/mL for *S. limbata* and 7.5 mg/mL for *S. choloroleuca* in *S. aureus*-associated assays [33]. Another study by Karamian et al. determined the antimicrobial activity of a methanol extract of *S. multicaulis* (**fig. 1**) collected in Fars province against penicillin-resistant *S. aureus*. The result showed a zone of inhibition of 10 mm [34]. In a 2004 study by Shahidi Bonjar, the activity of a methanolic extract of a whole plant of another *Salvia* species, *S. officinalis* were examined. The methanol extract was active against *S. aureus* with a zone of inhibition of 16 mm [22]. The antimicrobial activity of a methanolic extract from aerial parts of another *Salvia* species, *S. sahendica*, collected in north-western Iran was reported by Lotfipour et al. A MIC value of 1.2 mg/mL, and an inhibition zone of 14 mm was achieved for *S. aureus*. The MIC value of gentamicin was also 1.2 mg/ml [35]. In 2012, Ghomi et al. prepared a study to detect the antimicrobial activity of *S. reuterana* collected in the Kashan region [Isfahan province] (**fig. 1**). *S. reuterana* flower and leaf methanol extract were active against *S. aureus*

with MIC values of 0.5 mg/mL and 0.25 mg/mL, respectively. The MIC value for gentamicin was 0.5 mg/ml. It is likely that *S. aureus* is more sensitive to the methanol extract of *S. sahendica* leaves [29]. In 2009, Javadnia and colleagues evaluated the antimicrobial potential of a methanol extract from the aerial parts of *S. reuterana* from the province of Fars (**Fig. 1**). The extract at 4 mg/disk showed a zone of inhibition of 12.2 mm. A MIC value of 1 mg/mL was reached. In this study, the antimicrobial activity of the methanol extract of *S. santolinifolia*, *S. mirzayanii*, *S. microsiphon*, and *S. eremophila*. The extract at 4 mg/disk showed a zone of inhibition of 12.2 mm for *S. santolinifolia* and *S. mirzayanii*, 14.2 mm for *S. microsiphon*, and 10 mm for *S. eremophila*. A MIC value of 1 mg/ml was obtained for all extracts [36].

In 2010, Ebrahimabadi et al. described the antimicrobial activity of essential oil and a methanol extract from the aerial parts of *S. eremophila* from the Kashan region. The results obtained in this work showed MIC values of 7.8 mg/ml and 0.5 mg/ml for essential oil and methanol extract, respectively. The MIC values for gentamicin and rifampin were 0.5 mg/mL and 0.25 mg/mL, respectively. This strongly suggests that the methanolic extract of *S. Eremophila* is more active against *S. aureus* than essential oil [37]. In another 2012 study, Farjam examined the antimicrobial activity of essential oil, ethyl acetate, and essential extracts from the aerial parts of *S. urmiensis* Bunge collected in the city of Ardabil, northwestern Iran (**fig. 1**) against certain types of bacteria and fungi. The results showed that the ethyl acetate extract [MIC 21.3 µg/mL] had the highest

activity against *S. golden*. Essential oil and ester extracts showed MIC values of 85.3 µg/mL and 37.3 µg/mL, respectively [27]. A study by Dadgar et al. from 2006 investigated the activity of ethanolic and aqueous extracts of *S. tomentosa* collected in Golestan Province [Northern Iran] (**fig. 1**) against MRSA and methicillin-susceptible *S. aureus* [MSSA] strains. The aqueous extract has no activity against *S. aureus*, but the ethanolic extract at 4 mg/disk has a zone of inhibition of 8.4 mm and 6.8 mm for MRSA and MSSA, respectively [38].

Alhagi

Alhagi maurorum (syn. *A. camelorum* and *A. pseudoalhagi*) is a columnar plant with intense, complex, and large spikes and belongs to the Fabaceae family. Aqueous extract of the whole plant *A. Maurum* is used in traditional medicine in southwestern Iran to treat heartburn caused by gastric reflux. The most common constituents in the plant are unsaturated sterols, triterpenes, tannins, carbohydrates, flavonoids, flavone glycosides such as Alhagitin and Alhagidin, and proanthocyanidins [39]. Two studies by Shahidi Bonjar in 2004 and 2006 demonstrated the antimicrobial activity of methanolic extracts of *A. maurum* gum. The zone of inhibition of the methanolic extract of *A. maurum* was 15 mm [22, 26].

Heracleum

There are about 125 species of *Heracleum* in the world. The genus *Heracleum* belongs to the umbelliferae family. *Heracleum rechingeri* includes five perennial species in Flora Iranica. In traditional medicine, some species of *Heracleum* are used as food additives as anti-

inflammatory, carminative, and digestive agents, as well as to relieve some pain. Interest in the use of this plant to treat various diseases, including high blood pressure, is increasing. In addition, an antimicrobial analysis in 2010 by Habibi et al. antimicrobial activity of the aerial part of the essential oil of *H. rechingeri* Iranian collected in the Mazandaran province (**fig. 1**). As a result, this species showed high activity against *S. aureus* with an inhibition zone of 16 mm [40]. In another study, Shahidi Bonjar (2004) reported that the methanolic fruit extract of *H. persicum* is active against *S. aureus* with an inhibition zone of 20 mm [22]. Torbati et al in 2013, examined the activity of aerial parts essential oil from two other species of *Heracleum*, *H. transcaucasicum* and *H. anisactis*. But they could not find a significant antibacterial activity for both essential oils [41].

Foeniculum

Foeniculum vulgare Mühle. (*F. vulgare*), commonly known as fennel, is a popular medicinal plant in the Apiaceae family. It grows wild in most parts of temperate Europe but is generally considered native to the Mediterranean. In Iran, it grows wild in the northern parts. It is mainly grown in southern France, Saxony, Galicia, Russia, India, and Iran [42]. Fennel extracts have shown various beneficial properties, including antioxidant, cytotoxic, anti-inflammatory, antimicrobial, bronchodilator, estrogenic, diuretic, lithotripsy, galactogic, emmenagogue, antithrombotic, hypotonic, gastroprotective, anti-hepatoprotective and memory hepatoprotective activity. Several reports have been published on the toxic effects of fennel [42-43]. The antibacterial effect of fennel seeds was studied. In this study, the

activity of essential oil of fennel seeds against *Escherichia coli* and *C. aureus* MIC value of 2% was obtained for *S. aureus* [44]. In a 2004 study by Shahid Bonjar, methanol extract of fennel root was effective against *S. aureus* with an inhibition zone of 12 mm [22].

Cuminum

Cuminum cyminum L., belonging to the family Apiaceae, is one of the ancient medicinal herbs widely grown in Asia, Africa, and Europe. This plant is well known as Dill and is named Zireh-Sabz or Cravieh in Persian. Its seeds have been commonly used for culinary and flavoring purposes and folk therapy since ancient times in various places [45]. Two species of *Cuminum* grow wild in Iran, *C. cyminum* L and *C. setifolium* Boisskos [46]. There is strong evidence supporting the therapeutic effects of *C. cyminum* in traditional Iranian medicine for gynecological and respiratory disorders, as well as in the treatment of toothache, diarrhea, and epilepsy. In 2010, Allahghadri et al evaluated the antibacterial properties of *C. cyminum* essential oil against several pathogens by agar diffusion and dilution method. The results of the disc diffusion method and determination of MIC and MBC showed that *S. aureus* was sensitive to *C. cyminum* essential oil with an oil dilution MIC value of 1/8 and an inhibition zone of 10 mm [10 µl/disc]. The total death time after exposure to *C. cyminum* oil was 120 min for *S. aureus* [47].

Shahidi Bonjar in 2004 prepared a study to find the antibacterial potential of methanolic extract of *C. cyminum* fruits using agar well diffusion. According to the result, the inhibition zone of *S. aureus* was 12 mm [22]. In another study in the same year, Shahidi Bonjar tested

the antimicrobial activity of methanolic extracts of *C. cyminum* seeds. The zone of inhibition obtained was greater than 15 mm [26]. In 2006, Dadgar et al. activity of aqueous and ethanolic extracts of *C. cyminum* seeds against *S. aureus* and MRSA. The results showed that the aqueous extract had no antimicrobial activity, while the ethanolic extract at a concentration of 4 mg/disc had an inhibitory effect on *S. aureus* and MRSA with inhibition zones of 8.5 mm and 11.5 mm, respectively [38].

Artemisia

This genus contains a variable number of species ranging from 200 to 400 and is distributed mainly in the northern temperate zone of the world. Twenty –nine of them are registered in Iran, some of them are endemic. Various pharmacological activities have been widely studied, including antimalarial, antiviral, antitumor, antipyretic, antihemorrhagic, anticoagulant, antioxidant, antihepatic, antiulcer, antispasmodic, antitumor, and interferon [48]. Antibacterial activity of methanol extract of aerial parts of four *Artemisia* species (*A. diffusa*, *A. oliveria*, *A. scorpioides*, *A. turanica*) collected from the northern region of Mashhad, Khorasan province, investigated by Ramezani et al. in 2004 with 16 mg/cup by agar cup-plate diffusion method and MIC determination by agar dilution method. The result showed that the zone of inhibition of *A. diffusa*, *A. oliveria*, *A. Scorpioides*, and *A. turanica* for *S. aureus* was 18.4 mm, 12.2 mm, 13.6 mm, and 11.9 mm, respectively. The MIC was 10 mg/ml in all species. The zone of inhibition for gentamicin (10 µg/ml) was 20.5 mm, and no zone of inhibition was observed for clotrimazole [1]. In another antimicrobial analysis in 2007 by

Mohsenzoda et al. A MIC value of 7.0% was determined for *A. Dracunculus* essential oil [38]. Antimicrobial activity of ethanolic and aqueous extracts of *A. dracunculus*, *A. herbaalba*, and *A. absinthium* species from Golestan province in northern Iran on clinical and standard strains of *S. aureus* and MRSA by Dadgar et al. in 2006. Only the aqueous extract of *A. herbaalba* had an antimicrobial activity with an inhibition zone of 12 mm for MRSA and 9 mm for *S. aureus* at 4 mg/disk. *A. Herbaalba*, with an inhibition zone of 22.5 mm for MRSA and 11 mm for *S. aureus* was the most active among the herbs tested. A MIC value of 0.39 mg/ml was obtained for clinical MRSA and *S. aureus*; 0.04 mg/ml for standard MRSA; and 0.02 for standard *S. aureus*, *A. dracunculus*, with an inhibition zone of 7 mm, was the least active species against the weeds tested. An inhibition zone of 9 mm was reported for the ethanolic extract of *A. absinthium* [38].

Pistacia

The genus *Pistacia* belongs to the *Anacardiaceae*, a cosmopolitan family that comprises about 70 genera and over 600 species [49] distributed in the Mediterranean and Middle Eastern areas. Various species of this genus are known effective against a variety of disorders including eczema, throat infections, renal stones, asthma, and stomach ache and it is used as an astringent, anti-inflammatory, antipyretic, antibacterial, and antiviral. Several members of the Genus *Pistacia* have been chemically investigated. They are characterized mainly by the presence of flavonoids and flavonoid glycosides [50]. Malekzadeh in 1974 described that aqueous extract from leaves and fruit epicarps of *Pistacia vera* and *P. mutica*

were active only against gram-positive bacteria including *S. golden*. The agar-well diffusion method showed a zone of inhibition of 32 mm for *P. vera* and 18 mm for *P. mutica* fruit extract for *S. aureus*. The diameter of the zone of inhibition associated with *P. vera* and *P. mutica* leaf extract was 22 mm [51]. In a study by Taran et al. from 2010, the activity of three types of extracts [chloroform, ethyl acetate, ethyl alcohol, diethyl ether] from the leaves of another pistachio species, *P. khinjuk*, collected in Kermanshah province in western Iran was the responsibility of *S. aureus* with MIC measurement. MIC values of 0.04 mg/mL, 0.13 mg/mL, 0.09 mg/mL, and 0.42 mg/mL were obtained for extracts from chloroform, ethyl acetate, ethyl alcohol, and diethyl ether, respectively [52]. In another 2010 study, a raw and purified extract of green pistachio shells from Yazd province, Iran, by Rajaie et al. tested for antimicrobial properties. The results of a disc diffusion test showed that *S. aureus* with a zone of inhibition of 11.7 mm [at 1200 µg/dish] was sensitive to this extract [53].

In 2014, Habibi Najafi et al. the antimicrobial properties of gum mastic essential oil of *P. atlantica* from the city of Marvdasht (Fars Province), Iran. Based on these results, the essential oil has inhibitory activity against *S. aureus* at concentrations of 10 µL/disc and 20 µL/disc with a zone of inhibition of 11 mm and 13 mm, respectively [54].

Helichrysum

The genus *Helichrysum*, which belongs to the daisy family, has more than 400 species. It is widespread worldwide. Nineteen species of this

genus are found in Iran, eight endemic. *Helichrysum* species are widely distributed in Iran, Turkey, and other parts of the world for their various biological properties including anti-inflammatory, antioxidant, antimicrobial, cytotoxic, and gastric acid-secreting properties. Several reports have been published on the effects of this plant on the gallbladder.

Ghasemi et al in 2011 showed the potential of antimicrobial activity of flower extract of *Helichrysum scabrum* growing in Isfahan and Charmahal and Bakhtiari provinces against some pathogen strains. Inhibition zone and MIC values related to flower extracts collected from the two provinces were different. MIC value varied from lower than 19 µg/ml to 5000 µg/ml for *S. aureus* and the inhibition zone varied from 9 mm to 19 mm for *S. aureus*. The extract of *Helichrysum scabrum* has stronger antibacterial activity than the positive antibacterial standards [55].

In a study by Oji et al. in 2012, the antimicrobial activity of oils from flowers, leaves, and stems of *Helichrysum armenium* native to Ardabil was determined by the agar diffusion plate method using 50 µL 8 mm diameter oil plates. The acquired zone of inhibition for *S. aureus* was 12.4 mm, 11.22 mm, and 10.8 mm for flower oil, leaf oil, and stem oil, respectively. The zone of inhibition of amoxicillin for *S. aureus* was 33 mm [56].

Scrophularia

Scrophulariaceae is a large family of angiosperms widespread in the deciduous and coniferous forests of Central Europe, Central Asia, and North America, especially the Mediterranean. This plant family represents about 3000 species and 220 genera [57].

Scrophularia striata from the Scrophulariaceae family grows in the northeastern part of Iran and is used as a traditional herb for various inflammatory diseases [58].

Bahrami et al. in 2010 determined the antimicrobial activity of ethanolic extract from *Scrophularia striata* leaves collected from Ilam province alone and in combination with antibiotics (Doxycyclin and Ofloxacin) against *S. aureus* using measurement of MIC and MBC values as well as by time-kill assay. MIC and MBC values of *S. striata* ethanolic extract for *S. aureus* were 50.6 µg/ml and 60.3 µg/ml while MIC and MBC values of Doxycycline were 4 µg/ml and 3.9 µg/ml and MIC and MBC values of Ofloxacin were 2.4 µg/ml and 4.9 µg/ml, respectively. The MIC and MBC values of the leaves extract were higher than those related to antibiotics but the activity of antibiotics against *S. aureus* was increased when those were combined with leaves ethanolic extract. Therefore, antibiotics have synergistic effects in combination with ethanolic extract of *S. striata* leaves [59].

Thymus

Thyme (*Thymus*, Lamiaceae) is a medicinal plant [60] that consists of about 400 species and is widespread worldwide the world. In Iran, 14 species are present, among which four are endemic. The oil of *thymus* species has been traditionally used as anthelmintic, bacteriostatic, antiseptic, and spasmolytic agents. The antimicrobial properties are often due to their phenol content [61]. Antimicrobial activity of leaves essential oil from two species of *Thymus*, *T. persicus* and *T. eriocalyx*, growing in Iran was assessed by Talei et al in 2007. Essential oil of *T. persicus* and *T. eriocalyx* showed

strong activities against *S. aureus* in dilution of 1 in 100 (0.5 µl/ml) [62]. In another study by Rasooli et al in 2002, the activity of essential oil from two other species of *Thymus*, *T. pubescens* and *T. serpyllum* from the Damavand area of Iran at pre and flowering stages was evaluated against some bacteria including *S. aureus*. *T. pubescens* in oil dilution of 1/8 has suitable antimicrobial activity against *S. aureus* with an inhibitory zone of 29 mm for pre and 34 mm for flowering stages. *T. serpyllum* in oil dilution of 1/4 has good antimicrobial activity against *S. aureus* with an inhibition zone of 14 mm for pre and 22 mm for flowering stages [63]. Mehregan et al 2008 illustrated the antimicrobial potential of methanolic extract from aerial parts of *T. pubescens* collected from Hamadan province. The results indicated that *T. pubescens* has antimicrobial activity against *S. aureus* and MRSA strains with growth inhibition zone diameters ranging from 8 to 16 mm [64]. In 2007, Mohsenzadeh et al described that essential oil of leaves from Iranian *T. vulgaris* has activity against *S. aureus* with a MIC value of 0.1% [44]. In other research by Tohidpour et al. in 2012, the essential oil of *T. vulgaris* had an inhibitory effect on *S. aureus* and 14 species of MRSA strains. MIC value of 18.5 µg/ml and inhibition zone of 19 mm was acquired for *S. aureus*. Essential oil had a good inhibitory effect against MRSA strains with the lowest inhibition zone of 20mm and the highest inhibition zone of 35 mm. Five of the MRSA strains had a MIC value of 18.5 µg/ml and nine strains had a MIC value of 37 µg/ml [65]. an inhibitory zone of 10 mm in the MIC [5 mg/ml] of methanolic extract from the whole plant of *T. vulgaris* was determined by Shahidi Bonjar in 2004 [22]. In a study by Dadgar et al in 2006,

ethanolic extract of *T. vulgaris* in the amount of 4 mg/disc had an inhibitory effect on *S. aureus* and MRSA strains with an inhibition zone of 9 mm and 10.5 mm, respectively [38]. In this study activity of *Thymus carmanicus* ethanolic extract against MRSA and MSSA was evaluated too. This extract in the amount of 4 mg/disc showed an inhibition zone of 11.2 mm and 9 mm for MRSA and MSSA, respectively [38]. The antimicrobial activity of other species of *Thymus*, *T. caucasicus*, was evaluated by Haji Aghie et al in 2009. The MIC value of *T. caucasicus* was 0.31 µg/ml. The essential oil has activity against MRSA with a MIC value of 2.5 µg/ml [66].

Mentha

Mentha, the genus of the Labiatae family, includes 20 species that are spread all over the world. The flowering aerial parts of *Mentha pulegium* L. have been traditionally used for its antiseptic for treating cold, sinusitis, cholera, food poisoning, bronchitis, and tuberculosis and also as antifatulent, carminative, expectorant, diuretic, antitussive, menstruate. Mahboubi et al 2008 studied the antimicrobial activity of essential oil from flowering aerial parts of *Mentha pulegium* collected in the Kazeran region (Fars province, Iran). A total of 1 µl of the oil showed significant activity against *S. aureus* with a zone of inhibition of 21 mm and MIC and MBC values of 0.5 µl/ml, while the zone of inhibition associated with vancomycin was 19 mm [67]. Mohsenzade evaluated the activity of *Mentha pulegium* leaf essential oil against *S. aureus* in 2007. The result showed a MIC value of 0.5% for *S. aureus* [44]. The antimicrobial activity of the essential oil of another *Mentha* species, *M.*

piperita, was reported by Yadegarnia et al. examined. The MIC value of *M. piperita* for *S. aureus* was 2 µl/ml [24]. In a 2007 study by Mohsenzadeh, *M. piperita* leaf essential oil had a MIC value of 0.4% against *S. aureus* [44]. In another study, the activity of aqueous and ethanolic extracts from *M. piperita* leaves against MRSA and *S. aureus* strains were investigated by Dadgar et al. in 2006. The results showed that the ethanolic extract of 4 mg/disk had an inhibitory effect on MRSA with a 7.5 mm zone of inhibition and on *S. aureus* with an 8.5 mm zone of inhibition. An aqueous extract at a concentration of 4 mg/disc has an inhibitory effect on MRSA and *S. aureus* with zones of inhibition of 7 mm and 7.5 mm, respectively [38].

Peganum

Peganum harmala is a wild-growing flowering plant belonging to the Zygophyllaceae family. It is found abundantly in the Middle East and North Africa. There are several reports in the literature indicating a great variety of pharmacological activities for *P. harmala* such as antimicrobial, antitumor, antinociceptive, and MAO-inhibitor. The smoke of *P. harmala* seeds is traditionally used as a disinfectant agent in Iran [68]. Shahverdi et al in 2005 reported the inhibitory effect of smoke preparations from *P. harmala* seeds growing in Abyaneh [Isfahan province] against different strains of bacteria and fungi. The results showed the antimicrobial activity of smoke preparation from *P. harmala* seeds against some bacteria including *S. aureus*. The antimicrobial effect of smoke dichloromethane extract at different concentrations was examined. The dichloromethane smoke

condensate did not show antibacterial activity against any of the strains at the lowest content (0.156 mg), whilst the higher contents of this extract showed suitable antimicrobial activity with an inhibitory zone of 15.7 mm for *S. aureus* in 5 mg of smoke condensate [68]. In another study by Darapour et al in 2011, the antimicrobial activity of methanolic extract of flower, leave, stem, seed, and root from *P. harmala*, collected from Khuzestan province of Iran, was evaluated on MRSA. According to obtained results, the root and seed extracts of *P. harmala* have good activity against MRSA while flower, leaves, and stem extracts presented relatively poor activity. Obtained inhibition zone in the amount of 400 mg/ml for flower, leaves, stem, seed, and root methanolic extract was 5.5 mm, 10 mm, 11 mm, 22 mm, and 24.5 mm, respectively. MIC of 0.625mg/ml was obtained for both seed and root extracts [69]. In Dadgar et al study in 2006 antimicrobial effect of aqueous and ethanolic extract of *P. harmala* growing in the Golestan province of Iran was assessed on *S. aureus* and MRSA. The obtained results revealed that the aqueous extract has no activity against *S. aureus* while is active against MRSA with an inhibition zone of 7.4 mm in the amount of 4mg/disc. 4 mg/discs from ethanolic extract have presented an inhibitory effect on MRSA with an inhibition zone of 18 mm and on *S. aureus* with an inhibition zone of 20 mm. MIC value of 0.02 mg/ml was acquired for the ethanolic extract [38].

Grammosciadium

The genus *Grammosciadium* belonging to the family Apiaceae is represented in the flora Iranica by 5 species, 3 of which grow in Iran

[70]. Members of the genus *Grammosciadium* are classified as the most important aromatic plants. The commercial value of the essential oils of this genus has already been reported [71]. Sonboli et al 2005 studied the antimicrobial activity of essential oil from aerial parts of *Grammosciadium platycarpum* from Iran using the disc diffusion method and micro-dilution broth susceptibility assay. *G. platycarpum* with an inhibition zone of 18mm and MIC value of 1.9 mg/ml showed high activity against *S. aureus*. The inhibition zone of Ampicillin [10 µg/disc] was 13 mm [70]. In another study in 2005, Sonboli et al. evaluated the antimicrobial activity of essential oil from aerial parts of another species of *Grammosciadium*, *G. scabrid*. Based on the results, essential oil of aerial parts showed activity against *S. aureus* with an inhibition zone of 14 mm [10 µg/disc]. The MIC value of essential oil was 1.2 mg/ml whilst the inhibition zone of Ampicillin [10 µg/disc] was 15 mm [71].

Onosma

Onosma dichroanthum Boiss. from Boraginaceae, is used as an anti-inflammation and antiseptic to treat skin burns and wound healing. Moghadam et al described the antimicrobial potential of methanolic and ethanolic extract from the root of *O. dichroanthum* using the good diffusion method and agar dilution method. The results showed that the diameter of inhibitory zones for *S. aureus* for both methanolic and ethanolic extract was 15 mm (0 µl/well) while the inhibitory zone of Erythromycin and Gentamicin were 29 mm and 24 mm, respectively. MIC values of methanolic and

ethanolic extracts were 0.156 mg/ml and 0.312 mg/ml, respectively [72].

Scutellaria

The genus *Scutellaria*, which belongs to the mint family, has about 300 species. This genus consists of 20 species and 2 hybrids in Iran, of which 10 species and 2 hybrids are endemic. Plants in this genus have numerous medicinal properties, including antioxidant, antimicrobial, cytotoxic, anti-inflammatory, and anticancer properties [73]. Fazly Bazzaz et al. examined the antimicrobial activity of *S. litwinowii* and *S. lindbergii* found in Iran in separate studies in 2011 and 2013. The results showed that a methanolic extract obtained from the aerial parts of both species collected in Khorasan Razavi province in north-eastern Iran had activity against several bacteria, including *S. aureus*, with a MIC value of 6 .25 mg/mL [73-74].

Oliveria

Oliveria decumbens, from the Umbelliferae family, is commonly found in the south of Iran and South West of Anatolia, Syria, and Iraq. Motamedi et al 2010 illustrated the antimicrobial potential of this species. The results indicated that ethanolic and methanolic extracts of aerial parts from this plant are active against both Gram-negative and Gram-positive bacteria including *S. aureus*. The obtained MIC value for *S. aureus* for both extracts was 20 mg/ml [75].

Teucrium

The genus *Teucrium* [germander] belongs to the family Lamiaceae. *Teucrium polium* L. has long been recognized in folk medicine in treating of

many pathophysiological implications such as gastrointestinal disorders, inflammations, diabetes, and rheumatism [76]. Darabpour et al 2010 explored the antibacterial effect of the alcoholic extracts of aerial parts of *T. polium* on some pathogenic bacteria. The MIC value of *S. aureus* was 40 mg/ml [77]. In another study in 2010, Meshkibaf et al evaluated the antimicrobial activity of hydroalcoholic from *T. polium* collected from Fasa, Fars province using the disc diffusion method. the inhibition zone of *S. aureus* was acquired at 20 mm [78].

Stachys

More than 270 species from the *Stachys* genus, belonging to the Lamiaceae family, were reported in the world. This genus has 34 species in Iran. Different species of *Stachys* were used in folk medicine [79]. Lotfipour et al 2008 investigated the activity of methanolic extract from aerial parts of *S. fruticulosa* and *S. schtschegleevii* using the paper disc diffusion method. These two species showed activity against *S. aureus* with an inhibition zone of 12 mm for *S. fruticulosa* and 13 mm for *S. schtschegleevii*. MIC values of 2.5 mg/ml and 1.25 mg/ml were acquired for *S. fruticulosa* and *S. schtschegleevii*, respectively [35]. Semnani et al in 2007 assessed the antimicrobial activity of methanolic extract from four *Stachys* species including *S. byzantia*, *S. inflata*, *S. lavandulifolia*, and *S. laxa*. Results showed that *S. byzantia* with an inhibition zone of 8.4 mm (with concentration of 100 µg/ml), *S. inflata* with inhibition zone of 8.3 mm (with a concentration of 250 µg/ml), *S. lavandulifolia* with an inhibition zone of 8.6 mm [with concentration of 500 µg/ml] and *S. laxa* with inhibition zone of 8.6 mm [with concentration

of 100 µg/ml] have activity against *S. aureus* [3]. In 2012, Yousefi et al studied the antimicrobial activity of another species of *Stachys*, *S. grandiflora*. According to the results, the essential oil extracted from aerial parts is moderately active against *S. aureus* with an inhibitory zone of 12 mm [80]. the antimicrobial activity of methanolic extract from aerial parts of *S. obtusirena* was evaluated by Javadnia et al in 2009. The results revealed that this extract has an inhibitory effect on *S. aureus* with an inhibition zone of 9.2 mm in an amount of 4 mg/disc [36].

Hymenocrater

The genus of *Hymenocrater*, with about 9 species in Iran is a member of the Lamiaceae family. Although *Hymenocrater* species are not abundant in the Iranica flora, four of them are endemic: *H. longiflorus* Benth., *H. platystegius* Rech. f., *H. yazdianus* Rech. f., and *H. incanus* Bunge. The species of this genus are used as house fresheners, anti-mosquito agents, and for some medical practices. Ahmadi et al in 2010 showed that polar fractions of essential oil from *H. longiflorus* have moderate activity against *S. aureus*. The result from the disc diffusion method, followed by measurement of MIC value indicated that polar sub-fraction was more sensitive with a higher inhibition zone (31 mm) and lower MIC value (40 µg/ml) than that related to essential oil [81].

Phlomis

The genus *Phlomis* (Labiatae) is represented by about 70 species found in the world, mainly in Asia. It has been represented in Iran by 17 endemic species [82]. Some species of *Phlomis* are used in folk. Many studies have

shown various activities such as anti-inflammatory, immunosuppressive, free radical scavenging, antimicrobial, antiulcerogenic, and antimutagenic activities. Essential oils of the *Phlomis* genus are used as flavoring for foods and as a fragrance in the perfume and cosmetic industry. They have been proposed as natural preservative agents for cosmetic preparations because of their antimicrobial activities [83]. Lotfipour et al 2008 determined the antimicrobial potential of methanolic extract of aerial parts of one species of *Phlomis*, *P. caucasica*. The MIC value of this extract was 1.25 mg/ml for *S. aureus* [35]. Semnani et al evaluated the antimicrobial activity of methanolic extract of three other *Phlomis* species, *P. buruguieri*, *P. herbaventi*, and *P. Oliveri* collected from Mazandaran province. Obtained MIC for *S. aureus* was 10 mg/ml for *P. herbaventi* and *P. buruguieri* and 25 mg/ml for *P. oliveri*. The inhibition zone in 1 mg/ml was 16.7 mm, 12.2 mm, and 13.1 mm for *P. buruguieri*, *P. herbaventi*, and *P. oliveri*, respectively [84].

Torilis

The genus *Torilis*, belonging to the Apiaceae family, comprises species distributed in Europe, North Africa, and southwest Asia. It is represented in Iran by 9 species. *Torilis leptophylla* has been used in folk medicine for treating gastrointestinal illnesses. Maleki et al 2008 studied the antimicrobial potential of ethanolic extract from *T. leptophylla* collected from Izeh in the Khuzestan province of Iran. This extract has an inhibitory effect against *S. aureus* in the concentration of 0.4g/ml. Ethanolic extract in this concentration showed an inhibition zone of 10 mm [82].

Tanacetum

Tanacetum is an aromatic perennial plant in the northern hemisphere [85], represented in Iran's flora by 26 species including 12 endemics [86]. Many sesquiterpenoids and sesquiterpene lactones have been isolated from *Tanacetum* species which might be responsible for the effect exhibited by these plants [87]. Essential oils and extracts of some members of the genus *Tanacetum* exhibit anti-inflammatory, antibacterial, and antifungal effects [85]. In 2008, Lotfipour et al revealed that dichloromethane extract of *T. balsamita* growing in the North-west of Iran was active against *S. aureus* with a MIC value of 2.5 mg/ml [35]. The antimicrobial potential of *T. parthenium* was assessed by two groups [Izadi et al and Mohsenzadeh et al] in 2011. Izadi et al tested the activity of essential oil from *T. parthenium*. *S. aureus* in different amounts of essential oil (2.5, 5, 7.5, 15 μ l) has an inhibition zone of 18.5 mm, 34 mm, 39 mm, and 42 mm, respectively while the inhibition zone related to Vancomycin was 28 mm. The MIC value was 1 μ g/ml. inhibition zone in bio-assessment of the effect of *T. parthenium* essential oil was more than the effect of Vancomycin [88]. Mohsenzadeh et al. in 2011 evaluated the antibacterial activity of essential oil of *T. parthenium* in different developmental stages. The results showed that the inhibition zone related to the flowering stage for *S. aureus* [24 mm] was more related to the pre-flowering [18 mm] and post-flowering [22 mm] stages. the inhibition zone related to chloramphenicol was 25 mm. Obtained MIC value for *S. aureus* was 8 μ g/ml [85]. In another study, the antimicrobial potential of aerial parts essential oil from *T.*

pinnatum boiss was investigated by Esmaeili et al. in 2011. It exhibited the best activity with an inhibition zone of 24.2 mm while, no inhibitory zone was seen in the culture of *S. aureus* with Gentamycin, Penicillin, Cefazolin, and Norfloxacin [87].

Achillea

The genus *Achillea*, from the Asteraceae family, is represented by about 115 species found in the Northern Hemisphere, mostly in Europe and Asia [89-90]. It has been represented in Iran by 19 species including 7 endemics [86]. *Achillea* species are used both for pharmaceutical purposes and in folk medicine. Antimicrobial, antioxidant, antitumor, spasmolytic, anti-inflammatory, antidiabetic, antiulcer, choleric, hepatoprotective activity, and cytotoxic effects of different *Achillea* species have been reported [91-92]. *Achillea* species contain a complex of different pharmacological compounds [93]. Most of the effective compounds of *Achillea* species were found in their oils of them [94]. Screening of the antimicrobial activity of *Achillea* species essential oils showed the constituents of *Achillea* include monoterpenes, sesquiterpene lactones, flavonoids, and phenolic acids [95]. In the study of Lotfipour et al in 2008 the antimicrobial activity of the methanolic extract of *A. millefolium* growing in the North-west of Iran was revealed with a MIC value of 0.625 mg/ml for *S. aureus* [35]. In another study by Mazandarani et al in 2013 essential oil obtained from aerial parts of *A. millefolium* collected from two regions of North-west of Iran, Golestan province (**Fig. 1**), showed effective bactericidal activity with a MIC value of 15.4 µg/ml and inhibition zone of

31.4 mm for *S. aureus* in one region and 27.5 µg/ml and 19.8 mm for the other region [96]. Antimicrobial potential of essential oil of flowers, leaves, stems, and crude extracts (Hexan-ether and methanolic extract) of aerial parts from two other *Achillea* species, *A. pachycephala*, and *A. santolina*, collected from Khorasan, North-east of Iran (**Fig. 1**), were investigated by disc diffusion method and MIC determination by motavalizadeh kakhky et al in 2013. The studied samples were active against *S. aureus*. MIC values of 6.25 mg/ml and 12.5 mg/ml were obtained for Hexan-ether and methanolic extract, respectively. Obtained inhibition zone for *A. pachycephala* was 14 mm for Hexan-ether extract and 6 mm for methanolic extract. Obtained inhibition zone for *A. santolina* was 7 mm for Hexan-ether extract and 5 mm for methanolic extract. The inhibition zone related to essential oil from the flower, leaves, and stem of *A. pachycephala* was 12 mm, 10.5 mm, and 8 mm, respectively, and for *A. santolina* was 9 mm, 7.5 mm, and 6.5 mm, respectively. According to the results, the maximum antimicrobial activity of both plants was related to essential oils and Hexan-ether extract as compared to methanolic extract [94]. Shafaghat in 2009 described the antimicrobial activity of volatile oils from different parts [flower, leaves, and stems] of *A. tenuifolia*, growing in the North-west of Iran. The results showed inhibitory zone of *S. aureus* cultivated with flower, leaf, and stem oils were 14 mm, 9 mm, and 8 mm, respectively [97]. In 2014, Hoseini Alfatemi et al. studied about in vitro antimicrobial activity of *A. wilhelmsii* essential oil against MRSA and MSSA strains. The results showed that the maximum level of

essential oil (200 μ l) has an inhibitory effect against MSSA and MRSA with an inhibition zone of 27 mm for MSSA and 19 mm for MRSA [98]. In another study by Mohammadi Sichani et al in 2011, the antimicrobial potential of different concentrations of methanolic extract from *A. wilhemsii* was examined. Growth of *S. aureus* in the concentration of 400 mg/ml of methanolic extract has been most inhibited with an inhibitory zone of 19 mm [99].

Otostegia

Otostegia, from the Lamiaceae family, consists of about 33 species that grow mainly in the Mediterranean region and adjoining Asia Minor [100]. In Iran, only three species are available, *O. aucheri*, *O. Michaux*, and *O. persica*, of which the last two are endemic to Iran [101]. *O. persica* is widely distributed in the south and south-east of Iran [102].

Asghari et al. in 2006 examined the effect of three extracts (hexane, chloroform, and methanol) from aerial parts of *O. persica*, collected from Sistan and Baluchestan province (**Fig. 1**), against several microorganisms including *S. aureus* using a healthy plate, MIC, and MBC methods. *O. persica* chloroform extract showed the best antimicrobial activity against *S. aureus* with MIC and MBC values of 1.25 mg/ml and 5 mg/ml, respectively, and an inhibition zone of 15.4 mm. MIC value of 3.12, MBC value of 25 mg/ml, and inhibition zone of 15.6 mm were obtained for methanolic extract. Hexane extract showed a MIC value of 10 mg/ml an MBC value of 20 mg/ml and an inhibition zone of 11.4 mm [103]. In other research in 2009, Javadnia et al evaluated the antimicrobial activity of methanolic extract of

aerial parts from *O. persica* against some gram-positive and gram-negative strains of bacteria. The results revealed that *O. persica* methanolic extract has good activity against gram-positive bacteria including *S. aureus* with an inhibition zone of 9.7 mm in the concentration of 4 mg/disc [36].

Berberis

Berberis vulgaris is a shrub in the family *Berberidaceae*, native to central and Southern Europe, North-west Africa, and Western Asia. Medicinal properties for all parts of this plant have been reported and it has been used in some cases like cholecystitis, cholelithiasis, jaundice, dysentery, leishmaniosis, malaria, and gall stones [104]. Dadgar et al in 2006 assessed the antimicrobial effect of aqueous and ethanolic extracts of *B. vulgaris* root on standard and clinical strains of *S. aureus* and MRSA. The results revealed that ethanolic extract with an inhibition zone of 12.5 mm for MRSA and 15.5 mm for *S. aureus* in the concentration of 4 mg/disc has more activity against both types of strains. For aqueous extract inhibition zone of 8.4 mm and 7 mm were obtained for MRSA and *S. aureus*, respectively. For ethanolic extract for both MRSA and *S. aureus* strains MIC value of 0.39 mg/ml was obtained for clinical strains and a MIC value of 0.04 mg/ml was obtained for standard strains [38]. In another study in 2004 by Shahidi Bonjar, the antimicrobial effect of methanolic extract from the fruit of *B. vulgaris* was examined. An inhibition zone of 17 mm was obtained for this extract against *S. aureus* [22].

Ferulago

The genus *Ferulago* belonging to the Apiaceae family is represented by 40 species in the world.

Eight species exist in Iran of which three are endemic [105]. The species of the *Ferulago* genus have sedative, tonic, digestive, and anti-parasitic effects [106-107]. The essential oil of seeds and aerial parts of this plant contains various components with different therapeutic effects [108].

In a study in 2005 by Khalighi-Sigaroodi antimicrobial activity of the essential oil from aerial parts of *F. Bernardii* was evaluated using the measurement of MIC value and showed weak activity against *S. aureus* with MIC of 250 µg/ml [105]. In another research in 2010, Taran et al describe the antibacterial effects of essential oils obtained from aerial parts and seeds of *F. angulata* subsp. *Carduchorum*. MIC of 15 µg/ml and $> 4 \times 10^3$ µg/ml were obtained for essential oils of *F. angulata* aerial parts and seeds against *S. aureus*, respectively [108].

Eucalyptus

Eucalyptus is one of the world's most important and most widely plant genera. It belongs to the Myrtaceae family and includes 140 genera and about 3800 species distributed in tropical and subtropical regions of the world [108-110]. The leaf extract or essential oil of *Eucalyptus* spp. has been reported to possess antifungal, antibacterial, mosquito-repellent, and antioxidant properties [111]. GC/MS analysis identified Eucalyptol (47.2%), Spathulenol [15.6%], and α -Pinene (15.4%) as major compounds of the *Eucalyptus* essential oil [65]. Of all the species, *Eucalyptus globulus* is the most widely cultivated in subtropical and Mediterranean regions [112]. In a study by Dadgar et al in 2006 antimicrobial effect of ethanolic and aqueous extracts from leaves of *E. globulus* was illustrated against standard and

clinical strains of *S. aureus* and MRSA strains. The results showed that ethanolic extract with an inhibition zone of 17 mm for MRSA and 15.5 mm for *S. aureus* in the concentration of 4 mg/disc has a better inhibitory effect than aqueous extract. Inhibition zone of 14 mm and 11 mm were obtained for MRSA and *S. aureus*, respectively. MIC value of 0.39 mg/ml was acquired for clinical and standard strains of *S. aureus*. MIC values of 0.18 mg/ml for clinical MRSA and 0.09 mg/ml for standard MRSA were obtained [38]. In another study by Tohidipour et al in 2010, *E. globulus* essential oil was assessed for its putative antimicrobial activity against *S. aureus* and 14 clinical MRSA strains. The antibacterial activity of *E. globulus* essential oil could be associated with the presence of Eucalyptol in this plant as the most characteristic component of the essential oil. Results revealed essential oil to possess degrees of antimicrobial activity against MRSA strains with the lowest MIC of 34.24 µg/ml and the highest MIC of 85.6 µg/ml. lowest inhibition zone of 10 mm and highest inhibition zone of 30 mm were obtained for MRSA strains. The essential oil has an inhibitory effect on *S. aureus* with an inhibition zone of 17 mm and MIC value of 51.36 µg/ml [65].

The review focused mainly on plants used in traditional Iranian health systems. To date, no bioactive compounds have been isolated from these plants; however, biologically active drugs are derived from plants. The result is a document that shows the value of using traditional Iranian crops to start drug discovery programs. The results have asked researchers for helpful collaboration in identifying pure compounds derived from native plants of Iran. The results suggest that several extracts on a

biologically active approach against *S. aureus*, but researchers have not yet studied their active ingredients.

The comparison between the pharmaceutical effects of different parts of a medicinal plant can give a good vision for accomplishing further study with more efficiency. This study was a review that for the first time attempted to compare the antibacterial activity of the different parts of some Iranian medicinal plants used to treat *S. aureus*. According to the comparison done in **Table 1**, essential oil of *Thymus caucasicus* with the MIC value of 0.31 µg/ml for *S. aureus* and 2.5 µg/ml for MRSA has the best inhibitory effect on *S. aureus*.

It should be noted that essential oil of *Tanacetum parthenium*, *Achillea millefolium*, *Thymus vulgaris*, leaves of *Thymus eriocalyx* and *Thymus persicus*, ethanolic extract of *Peganum harmala*, flower extract of *Helichrysum umscabrum* and ethyl acetate extract of *Salvia urmiensis* with MIC value lower than 22 µg/ml have also the acceptable inhibitory effect against *S. aureus* growth. In addition, in comparison of antibacterial assays against MRSA, we found that ethanolic extract of *S. tomentosa*, seeds of *Cuminum cyminum*, *Artemisia dracunculus*, *Artemisia herbalba*, *Artemisia absinthium*, *Thymus caramanicus*, *Achillea wilhelmsii* C. Koch, ethanolic and aqueous extract of *Menthapiperita*, the root of *Berberis vulgaris*, essential oil and ethanolic extract of *Thymus vulgaris*, Methanolic extract of seed, leaves, stem, root, flower and ethanolic extract of *Peganum harmala*, ethanolic extract, aqueous extract and essential oil of leaves of *Eucalyptus globulus* have effective inhibitory effect against MRSA. It is noteworthy that the methanol extract from the roots of *Peganum*

harmala had the best effect compared with other parts of this plant. It should be noted that *Slviam ulticaulis* (methanol extract) is the only plant with activity against penicillin-resistant *S. aureus*. Further studies on the molecular basis of each extract's activity against clinical *S. aureus*, especially MRSA, should be performed in the future.

In this study, we reviewed the studies that determined the antimicrobial potency of essential oil and different extract (methanolic, ethanolic, ethyl acetate, ether, or aqueous extracts) from 31 genera of medicinal plants including 83 species against *Staphylococcus aureus*. Among all of evaluated medicinal herbs, antimicrobial effect of 11 species including *S. tomentosa*, *Cuminum cyminum*, *Artemisia dracunculus*, *Artemisia herbalba*, *Artemisia absinthium*, *Thymus vulgaris*, *Thymus caramanicus*, *Mentha piperita*, *Peganum harmala*, *Achillea wilhelmsii*, *Berberis vulgaris* and *Eucalyptus globules*, are also studied against MRSA. Ethyl acetate extract of some of them in contrast to other extract types has been no active against MRSA. Essential oil of *Thymus caucasicus* with MIC of 2.5µg/ml is the most active against MRSA.

4. Conclusion

Based on the results of the study, studies demonstrate that most of the plants grown in Iran evaluated with an acceptable MIC or zone of inhibition have antibacterial activity, especially against *S. aureus* and other its most common resistant strain, MRSA. Therefore, targeted natural extracts, especially *Thymus caucasicus* essential oil, may be a candidate for the design of alternative drugs to conventional

antibiotics aimed at the treatment of *S. aureus* infections. However, clinical trial studies in different aspects are needed to find out new insights such as in vivo effects and side effects of using herbal plant extracts as antibiotics.

Conflict of interest

The authors declare to have no conflict of interest.

References

- [1] Ramezani M, Fazli-Bazzaz BS, Saghafi-Khadem F, Dabaghian A. Antimicrobial activity of four *Artemisia* species of Iran. *Fitoterapia* (2004)75:201-203.
- [2] Mehrgana H, Mojab F, Pakdamanc S, Poursaeed M. Antibacterial Activity of *Thymus pubescens* Methanolic Extract. *Iranian J. Pharmaceutical Res.* (2008)7:291-295.
- [3] Semnani M, Mahdavi M, Rahimi F. Antimicrobial effects of methanolic extracts of some species of *Stachys* and *Phlomis*. *J. Mazandaran Univ. Med. Sci.* (2007)17:57-66.
- [4] Mazandarani M, Mirdeilami SZ, Pessaraki M. Essential oil composition and antibacterial activity of *Achillea millefolium* L. from different regions in North east of Iran. *J. Med. Plants Res.* (2013) 7:1063-1069.
- [5] Izadi Z AM, Esna-Ashari M, Davoodi P. Determining Chemical Composition and Antimicrobial Activity of Feverfew (*Tanacetum parthenium* L.) Essential Oil on Some Microbial Strains. *Zahedan J. Res. Med. Sci.* (2012)15:8-13.
- [6] Raji T, Kumar P, Rathee R, Dubey KK. Screening of some medicinal plants for their antimicrobial activities. *Int. J. Pharm. Sci.* (2016) 8(5):202-206.
- [7] Banothu V, Adepally U, Lingam J. In vitro total phenolics, flavonoids contents, antioxidant and antimicrobial activities of various solvent extracts from the medicinal plant *Physalis minima* linn. *Int. J. Pharm. Sci.* (2017);9(3):192-198.
- [8] Harris LG, Foster SJ, Richards RG: An introduction to *Staphylococcus aureus*, and techniques for identifying and quantifying *S. aureus* adhesins in relation to adhesion to biomaterials: review. *Eur. Cell Mater.* (2002) 4:39-60.
- [9] Leite GC, Padoveze MC, Moretti ML: Methicillin-resistant *Staphylococcus aureus* DNA electrophoretic pattern: temporal changes in an endemic hospital environment. *Rev. Panam. Salud. Publica.* (2011) 30:535-539.
- [10] Joshi S, Ray P, Manchanda V, Bajaj J, Chitnis DS, Gautam V, Goswami P, Gupta V, Harish BN, Kagal A, Kapil A, Rao R, Rodrigues C, Sardana R, Devi Kh S, Sharma A, Balaji V. Methicillin resistant *Staphylococcus aureus* [MRSA] in India: Prevalence & susceptibility pattern. *Indian J. Med. Res.* (2013) 137:363-369.
- [11] Klein E, Smith DL, Laxminarayan R. Hospitalizations and deaths caused by methicillin-resistant *Staphylococcus aureus*, United States, 1999-2005. *Emerg. Infect. Dis.* (2007) 13:1840-1846.
- [12] Chambers HF, DeLeo FR. Waves of Resistance: *Staphylococcus aureus* in the Antibiotic Era. *Nat. Rev. Microbiol.* (2009) 7:629-641.
- [13] Ventola CL. The Antibiotic Resistance Crisis: Part 1: Causes and Threats. *Pharm. Ther.* (2015) 40:277-283.
- [14] Spellberg B, Gilbert DN. The future of antibiotics and resistance. A tribute to a career of leadership by John Bartlett. *Clin. Infect. Dis.* (2014) 59:71-75.
- [15] Rossolini GM, Arena F, Pecile P, Pollini S. Update on the antibiotic resistance crisis. *Curr. Opin. Pharmacol.* (2014) 18:56-60.
- [16] Zargari A. Medicinal plants. 6th ed. . Tehran. Tehran Univ. Press 1999;200-205.
- [17] Salehi P, Sonboli A, Mohammadi F. Composition and antimicrobial activity of the essential oil of *Dicyclophora persica* Boiss. from Iran. *Z. Naturforsch C.* (2006) 61:315-318.
- [18] Sonboli A, Gholipour A, Yousefzadi M, Mojarrad M. Antibacterial activity and composition of the essential oil of *Nepeta menthoides* from Iran. *Nat. Prod. Commun.* (2009) 4:283-286.
- [19] Sonboli A, Salehi P, Yousefzadi M. Antimicrobial activity and chemical composition of the

essential oil of *Nepeta crispa* Willd. from Iran. *Z. Naturforsch. C.* (2004) 59:653-656.

[20] Naghibi F MM, Mohammadi Motamed S, Ghorbani A. Labiatae family in folk medicine in Iran: from ethnobotany to pharmacology. *Iran J. Pharm. Res.* (2005) 2:63-79.

[21] SuryaPrakash DV Sree Satya N, Sumanjali A, Meena V. Pharmacological Review on *Terminalia Chebula*. *Int. J. Pharm. Biomed. Res.* (2012) 3:679-683.

[22] Bonjar S. Antibacterial screening of plants used in Iranian folkloric medicine. *Fitoterapia* (2004) 75:231-235.

[23] Sabiha S, Ahmad MA, Asif M, Akhtar M. *Myrtus communis* Linn. A review. *Indian J. Nat. Prod. Resour.* (2011) 2[4]:395-402.

[24] Yadegarinia D, Gachkar L, Rezaei MB, Taghizadeh M, Astaneh SA, Rasooli I. Biochemical activities of Iranian *Mentha piperita* L. and *Myrtus communis* L. essential oils. *Phytochemistry* (2006) 67:1249-1255.

[25] Sanadgol N NS, Vafadar Ghasemi L, Motalleb G, Estakhr J. A study of the inhibitory effects of *Citrullus colocynthis* (CCT) using hydro-alcoholic extract on the expression of cytokines: TNF- α and IL-6 in high fat diet-fed mice towards a cure for diabetes mellitus. *J. Pharmacognosy Phytother* (2011) 3:81-88.

[26] Bonjar S. Evaluation of antibacterial properties of some medicinal plants used in Iran. *J. Ethnopharmacol.* (2004) 94:301-305.

[27] Farjam MH. Comparative study of the antimicrobial activity of essential oil and two different extract from *Salvia urmiensis* Bunge. *Asian Pac. J. Trop. Biomed.* (2012)1680-1682.

[28] Yousefzadi M, Sonboli A, Karimic F, Ebrahimi SN, Asghari B, Zeinalia A. Antimicrobial activity of some *Salvia* species essential oils from Iran. *Z. Naturforsch. C.* (2007) 62:514-518.

[29] Ghomi JS, Masoomi R, Kashi FJ, Batooli H. In vitro bioactivity of essential oils and methanol extracts of *Salvia reuterana* from Iran. *Nat. Prod. Commun.* (2012) 7:651-654.

[30] Javdan N EJ. In vitro antioxidant studies of various extracts of *Salvia hypoleuca*. *Res. J. Pharmacol.* (2011) 5: 86-89.

[31] Tosun M, Ercisli S, Sengul M, Ozer H, Polat T, Ozturk E. Antioxidant properties and total phenolic content of eight *Salvia* species from Turkey. *Biol. Res.* (2009) 42:175-181.

[32] Adio AM. Germacrenes A-E and related compounds: thermal, photochemical and acid induced transannular cyclizations. *Tetrahedron* (2009) 65:1533-1552.

[33] Paknejadi M, Foroohi F, Yousefzadi M. Antimicrobial activities of the essential oils of five *Salvia* species from Tehran province, Iran. *J. Param. Sci.* (2012)3:12-18.

[34] Karamian R, Pakzad R. Essential oil compositions and in vitro antioxidant and antibacterial activities of the methanol extracts of two *Salvia* species [Lamiaceae] from Iran. *Int. J. Agri. Crop. Sci.* (2013) 5:1171-1182.

[35] Lotfipour F, Nazemiyeh H, Fathi-Azad F, Garaei N, Arami S, Talat S, Sadegpour F, Hasanpour R. Evaluation of Antibacterial Activities of Some Medicinal Plants from North-West Iran. *Iran J. Basic. Med. Sci.* (2008)11:80-85.

[36] Javadnia K, Miri R, Assadollahi M, Gholami M, Ghaderi M. Screening of selected plants growing in Iran for antimicrobial activity. *Iran J. Sci. Tech. Trans.* (2009) 33:329-333.

[37] Ebrahimabadi AH, Mazoochi A, Kashi FJ, Djafari-Bidgoli Z, Batooli H. Essential oil composition and antioxidant and antimicrobial properties of the aerial parts of *Salvia eremophila* Boiss. from Iran. *Food Chem. Toxicol.* (2010) 48:1371-1376.

[38] Dadgar T, Asmar M, Saifi A, Mazandarani M, Bayat H, Moradi, A, Bazueri, M, Ghaemi, E. antibacterial activity of certain Iranian medicinal plants against methicillin-resistant and sensitive staphylococcus aureus. *Asian J. Plan. Sci.* (2006) 5:861-866.

[39] Mohammad Kazem Gharib Naseri SAM. Gastroprotective effect of alhagi maurorum on experimental gastric ulcer in rats. *Pak. J. Med. Sci.* (2007) 23:570-573.

[40] Habibi Z, Eshaghi R, Mohammadi M, Yousefi M. Chemical composition and antibacterial activity of essential oil of *Heracleum rechingeri* Manden from Iran. *Nat. Prod. Res.* (2010) 24:1013-1017.

- [41] Torbati M, Nazemiyeh H, Lotfipour F, Asnaashari S, Nemati M, Fathiazad F. Composition and antibacterial activity of heracleum transcaucasicum and heracleum anisactis aerial parts essential oil. *Adv. Pharm. Bull.* (2013) 3:415-418.
- [42] Rahimi R, Ardekani MR. Medicinal properties of *Foeniculum vulgare* Mill. in traditional Iranian medicine and modern phytotherapy. *Chin. J. Integr. Med.* (2013) 19:73-79.
- [43] Sheidai M KN, and Poorneydanei A. Cytogenetic study of some populations of *Foeniculum vulgare* [Umbelliferae] in Iran. *Caryologia* (2007) 60:257-261.
- [44] Mohsenzadeh M. Evaluation of antibacterial activity of selected Iranian essential oils against *Staphylococcus aureus* and *Escherichia coli* in nutrient broth medium. *Pak. J. Biol. Sci.* (2007) 10:3693-3697.
- [45] Javadinia K MR, Assadollahi M, Gholami M, Ghaderi M. Screening of selected plants growing in Iran for antimicrobial activity. *Iran J. Sci. Technol.* (2009) 33:329-333.
- [46] Gohari AR, Saeidnia, S. A Review on Phytochemistry of *Cuminum cyminum* seeds and its Standards from Field to Market. *Phcog. J.* (2011) 3:1-5.
- [47] Allahghadri T, Rasooli I, Owlia P, Nadooshan MJ, Ghazanfari T, Taghizadeh M, Astaneh SD. Antimicrobial property, antioxidant capacity, and cytotoxicity of essential oil from cumin produced in Iran. *J. Food Sci.* (2010) 75:H54-61.
- [48] Sadeghpour O, Asghari G, Shams Ardekani MR. Composition of Essential Oil of *Artemisia persica* Boiss. from Iran. *Iran J. Pharm. Res.* (2010) 3:65-67.
- [49] Bozorgi M MZ, Mobli M, Salehi Surmaghi M H, Shams-Ardekani MR, Rahim R. Five *Pistacia* species (*P. vera*, *P. atlantica*, *P. terebinthus*, *P. khinjuk*, and *P. lentiscus*): A Review of Their Traditional Uses, Phytochemistry, and Pharmacology. *Scientific World J.* (2013) 2013:1-33.
- [50] Moghtader M. Comparative survey on the essential oil composition from the leaves and fruits of *Pistacia mutica* Fischer Kerman province. *Middle East J. Sci. Res.* (2010) 5:291-297.
- [51] Malekzadeh F. an antimicrobial compound in two *pistacia* species. *Mycopathol Mycol. Appl.* (1974) 54:73-77.
- [52] Taran M. SM, Azizi E, Khanahmadi M. Antimicrobial Activity of the Leaves of *Pistacia khinjuk*. *J. Med. Plants* (2010) 1:81-85.
- [53] Rajaei A, Barzegar M, Mobarez AM, Sahari MA, Esfahani ZH. Antioxidant, anti-microbial and antimutagenicity activities of pistachio [*Pistachia vera*] green hull extract. *Food Chem. Toxicol.* (2010) 48:107-112.
- [54] Habibi Najafi MB, Hajimohamadi Farimani R, Tavakoli J, Madayeni S. GC-MS Analysis and Antimicrobial Activity of the Essential Oil of Trunk Exudates of *Pistacia atlantica* var. *mutica*. *Chem. Nat. Com.* (2014) 50:376-378.
- [55] Ghasemi Pirbalouti A RGH, Malekpoor F, Roohi Broujeni H. Variation in antibacterial activity and phenolic content of *Hypericum scabrum* L. populations. *J. Med. Plants Res.* (2011) 5:4119-4125.
- [56] Oji KA, Shafaghat A. Constituents and antimicrobial activity of the essential oils from flower, leaf and stem of *Helichrysum armenium*. *Nat. Prod. Commun.* (2012) 7:671-674.
- [57] Ardeshiry Lajimi A, Rezaie-Tavirani M, Mortazavi SA, Barzegar M, Moghadamnia SH, Rezaee MB. Study of Anti Cancer Property of *Scrophularia striata* Extract on the Human Astrocytoma Cell Line (1321). *Iran J. Pharm. Res.* (2010) 9:403-410.
- [58] Azadmehr A, Hajiaghaee R, Zohal MA, Maliji G. Protective effects of *Scrophularia striata* in Ovalbumin-induced mice asthma model. *Daru* (2013) 21:56.
- [59] Bahrami A M. Effects of *Scrophularia striata* Ethanolic Leaves Extracts on *Staphylococcus aureus*. *Int. J. Pharm.* (2010) 6:431-434.
- [60] Mahdavi S, Karimzadeh G. Karyological and Nuclear DNA Content Variation in Some Iranian Endemic *Thymus* Species (Lamiaceae). *J. Agri. Sci. Tech.* (2010) 12:447-458.
- [61] Tabatabaei yazdi F. Antimicrobial effect of the aqueous and ethanolic *Teucrium polium* L. extracts on gram positive and gram negative bacteria "in vitro". *J. Param. Sci.* (2013) 4:55-61.
- [62] Talei GHR, Meshkat Alasvand M H, Mousavi Z. Antibacterial activity and chemical composition of essential oils from four medicinal plants of Lorestan Iran. *J. Med. Plants Res.* (2007) 6:45-52.

- [63] Rasooli I, Mirmostafa SA. Antibacterial properties of *Thymus pubescens* and *Thymus serpyllum* essential oils. *Fitoterapia* (2002)73:244-250.
- [64] Mehrgan H MF, Pakdaman S, Poursaeed M. Antibacterial activity of *Thymus pubescens* Methanolic Extract. *Iran J. Pharm. Res.* (2008)7:291-295.
- [65] Tohidpour AS, M. Omidbaigi, R. Yadegar, A. Nazemi, J. Antibacterial effect of essential oils from two medicinal plants against Methicillin-resistant *Staphylococcus aureus* [MRSA]. *Phytomedicine* (2010)17:142-145.
- [66] Hajiaghaee R RS, Ajani Y, Samadi N, Ashoury N, Agha-Mohammadzade S. Chemical Compounds of Essential oil and Antibacterial Effects of *Thymus caucasicus*. *J. Med. Plants* (2009)4:132-137.
- [67] Mahboubi M, Haghi G. Antimicrobial activity and chemical composition of *Mentha pulegium* L. essential oil. *J. Ethnopharmacol.* (2008)119:325-327.
- [68] Shahverdi AR, Monsef-Esfahani HR, Nickavar B, Bitarafan L, Khodae S, Khoshakhlagh N. Antimicrobial activity and main chemical composition of two smoke condensates from *Peganum harmala* seeds. *Z. Naturforsch C.* (2005) 60:707-710.
- [69] Darapour E, Poshtkouhian Bavi, A., Motamedi, H., Seyyed Nejad, S.M. Antibacterial activity of different parts of *Peganum harmala* l. Growing in Iran against multi-drug resistant bacteria. *Excli J* 2011;10:1611-2156.
- [70] Sonboli A, Eftekhari F, Yousefzadi M, Kanani MR. Antibacterial activity and chemical composition of the essential oil of *Grammosciadium platycarpum* Boiss. from Iran. *Z. Naturforsch. C.* (2005) 60:30-34.
- [71] Sonboli A, Salehi P, Kanani MR, Ebrahimi SN. Antibacterial and antioxidant activity and essential oil composition of *Grammosciadium scabridum* Boiss. from Iran. *Z. Naturforsch. C.* (2005) 60:534-538.
- [72] Moghaddam PZ, M. Zolfaghari, MR, Badeleh, MT and Ghaemi, EA Antibacterial and antioxidant activities of root extract of *Onosma dichroanthum* Boiss. in north of Iran. *Afr. J. Microbiol. Res.* (2012) 6:1776-1781.
- [73] Fazly-Bazzaz B S AA, Emami S A, Asili J, Hasanzadeh-Khayyat M, Sahebkar A. Antimicrobial and Antioxidant Activities of Methanol, Dichloromethane and Ethyl Acetate Extracts of *Scutellaria lindbergii* Rech.f. *Chiang. Mai. J. Sci.* (2013) 40:49-59.
- [74] Fazly Bazzaz B S HKM, Emami S A, Asili J, Sahebkar A, Javadi Neishabory E. Antioxidant and antimicrobial activity of methanol, dichloromethane, and ethyl acetate extracts of *Scutellaria litwinowii*. *Sci. Asia* (2011) 37:327-334.
- [75] Motamedi H DE, Gholipour M, Seyyed Nejad S M. Antibacterial effect of ethanolic and methanolic extracts of *Plantago ovate* and *Oliveria decumbens* endemic in Iran against some pathogenic bacteria. *Int. J. Pharmacol.* (2010) 6:117-122.
- [76] Tabatabaei Yazdi F. Antimicrobial effect of the aqueous and ethanolic *Teucrium polium* L. extracts on gram positive and gram negative bacteria "In vitro". *J. Paramed. Sci.* (2013) 4.
- [77] Darabpour E MH, Seyyed Nejad S M. Antimicrobial properties of *Teucrium polium* against some clinical pathogens. *Asian Pac. J. Trop. Dis.* (2010) 3:124-127.
- [78] Meshkibaf M H AA, Fasihi Ramandi M, Adnani Sadati S J, Moravvej A, Hatami S. Antibacterial effects of hydro-alcoholic extracts of *Ziziphora tenuior*, *Teucrium polium*, *Barberis corcorde* and *Stachys inflata*. *Koomesh* (2010) 11:240-244.
- [79] Moshafi M MA, Mehrabani M, Mehrabani M. Antibacterial Activities of Essential Oil and Composition of *Stachys acerosa* Boiss. *J.M.P.* (2010) 1:108-115.
- [80] Ahmadi F, Sadeghi S, Modarresi M, Abiri A, Mikaeli A. Chemical composition, in vitro antimicrobial, antifungal and antioxidant activities of the essential oil and methanolic extract of *Hymenocater longiflorus* Benth., of Iran. *Food Chem. Toxicol.* (2010) 48:1137-1144.
- [81] Ahmadi F, Sadeghi S, Modarresi M, Abiri R, Mikaeli A. Chemical composition, in vitro antimicrobial, antifungal and antioxidant activities of the essential oil and methanolic extract of *Hymenocater longiflorus* Benth., of Iran. *Food Chem. Toxicol.* (2010) 48:1137-1144.
- [82] Deylamsalehi M MM, Motavalizadeh A, Akbarzadeh M, Mahmudi J, Mirahmadi S F, Ebrahimi Z, Abedi F. Chemical Compositions and Antimicrobial

- Activity of Essential Oil of *Phlomis cancellata* Bunge. from Mazandaran, Iran. *J. Essent. Oil Bear. P.I.* (2013) 16:555-562.
- [83] Limem-Ben Amor I, Neffati A, Ben Sgaier M, Bhourri W, Boubaker J, Skandrani I, Bouhrel I, Kilani S, Ben Ammar R, Chraief I, Hammami M, Ghoul, Ghedira L.C, Ghedira K. Antimicrobial Activity of Essential Oils Isolated from *Phlomis crinita* Cav. ssp. *mauritanica* Munby. *J. Am. Oil Chem. Soc.* (2008) 85:845-849.
- [84] Maleki S, Seyyednejad SM, Damabi NM, Motamedi H. Antibacterial activity of the fruits of Iranian *Torilis leptophylla* against some clinical pathogens. *Pak. J. Biol. Sci.* (2008) 11:1286-1289.
- [85] Mohsenzadeh F, Chehregani A, Amiri H. Chemical composition, antibacterial activity and cytotoxicity of essential oils of *Tanacetum parthenium* in different developmental stages. *Pharm. Biol.* (2011) 49:920-926.
- [86] Mozaffarian V. *A Dictionary of Iranian Plant Names*. Farhang Moaser Publishers, Tehran, Iran 2007:11-22.
- [87] Esmaeili A. The in vitro antioxidant and antibacterial activities of *Tanacetum pinnatum* boiss. grown in Iran. *Bulg. Chem. Commun.* (2011) 43:532-537.
- [88] Izadi Z AM, Esna-Ashari M, Davoodi P. Determining Chemical Composition and Antimicrobial Activity of Feverfew (*Tanacetum parthenium* L.) Essential Oil on some Microbial Strains. *Z.J.R.M.S.* (2013) 15:8-13.
- [89] Nemeth E, Bernath J. Biological activities of yarrow species (*Achillea* spp.). *Curr. Pharm. Des.* (2008) 14:3151-3167.
- [90] Radulovic NS, Blagojevic PD, Skropeta D, Zarubica AR, Zlatkovic BK, Palic RM. Misidentification of tansy, *Tanacetum macrophyllum*, as yarrow, *Achillea grandifolia*: a health risk or benefit? *Nat. Prod. Commun.* (2010) 5:121-127.
- [91] Benedek B, Rothwangl-Wiltschnigg K, Rozema E, Gjoncaj N, Reznicek G, Jurenitsch J, Kopp B, Glasl S: Yarrow [*Achillea millefolium* L. s.l.] pharmaceutical quality of commercial samples. *Pharmazie* (2008) 63:23-26.
- [92] Akkol EK, Koca U, Pesin I, Yilmazer D. Evaluation of the Wound Healing Potential of *Achillea biebersteinii* Afan. (Asteraceae) by In Vivo Excision and Incision Models. *Evid. Based Complement Alternat. Med.* (2011) 2011:474026.
- [93] Aburjai T, Hudaib M. Antiplatelet, antibacterial and antifungal activities of *Achillea falcata* extracts and evaluation of volatile oil composition. *Pharmacogn Mag.* (2006) 2:191-198.
- [94] Motavalizadehkakhky A SA, Zamani H A, Akhlaghi H, Mohammad hosseini M, Mehrzad J, Ebrahimi Z. Compositions and the in vitro antimicrobial activities of the essential oils and extracts of two *Achillea* species from Iran. *J. Med. Plants Res.* (2013) 7:1280-1292.
- [95] Lemmens-Gruber R, Marchart E, Rawnduzi P, Engel N, Benedek B, Kopp B. Investigation of the spasmolytic activity of the flavonoid fraction of *Achillea millefolium* s.l. on isolated guinea-pig ilea. *Arzneimittel forschung* (2006) 56(8):582-588.
- [96] Mazandarani M. Essential oil composition and antibacterial activity of *Achillea millefolium* L. from different regions in North east of Iran. *J. Med. Plants Res.* (2013) 7:1063-1069.
- [97] Shafaghat A. Composition and Antibacterial Activity of the Volatile Oils from Different Parts of *Achillea tenuifolia* Lam. from Iran. *J. Med. Plants* (2009)3(31):93-98.
- [98] Alfatemi SMH, Rad JS, Rad MS, Mohsenzadeh S, da Silva JAT. Chemical composition, antioxidant activity and in vitro antibacterial activity of *Achillea wilhelmsii* C. Koch essential oil on methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* spp. *Biotech.* (2015) 5(1):39-44.
- [99] Mohammadi-Sichani M AL, Mohammadi-Kamalabadi M. Antibacterial activity of methanol extract and essential oil of *Achillea wilhelmsii* against pathogenic bacteria. *Z.J.R.M.S.* (2011) 13:14-19.
- [100] Khan A, Ahmad VU, Farooq U, Bader S, Arshad S. Two new flavonol glycosides from *Otostegia limbata* BENTH. *Chem. Pharm. Bull. (Tokyo)* (2009) 57:276-279.
- [101] Ayatollahi SAKF, Asgarpanah J, Rahmati Roodsari M, Fanai Gh, Choudhary M. Diterpenoids of

Otostegia persica (Burm) Boiss. DARU 2009;17:290-293.

[102] Sadeghi ZAM, Valizadeh J. *Otostegia persica* [Lamiaceae]: A review on its ethnopharmacology, phytochemistry, and pharmacology. *Avicenna J. Phytomed.* (2014) 4(2):79-88.

[103] Asghari G NH, Havaie SA, Issa L. Antimicrobial activity of *Otostegia persica* Boiss. extracts. *Res. Pharm. Sci.* (2006) 1:53-58.

[104] Doaa A. Ghareeb AEAE-W, Eman E. M. Sarhan, Marwa M. Abu-Serie, Maha A. El Demellawy. Biological assessment of *Berberis vulgaris* and its active constituent, berberine: Antibacterial, antifungal and anti-hepatitis C virus (HCV) effect. *J. Med. Plants Res.* (2013) 7:1529-1536.

[105] Khalighi-Sigaroodi FHA, Shahverdi A, Mozaffarian V, Shafiee A. Chemical composition and antimicrobial activity of the essential oil of *Ferulago Bernardii* Tomk. and M. Pimen. *DARU* (2005) 13(3):100-104.

[106] Ozturk B, Gür S, Coskun M, Kosan M, Erdurak C, Hafez G, Ozgunes O, Cetinkaya M. 237 Relaxant effect of *ferulago syriaca* root extract on human corpus cavernosum. *Eur. Urol. Suppl.* (2004) 3(2):62.

[107] Ozturk B, Gur S, Coskun M, Kosan M, Erdurak C S, Hafez G, Gonulalan U, Cetinkaya M, A new

relaxant on human corpus cavernosum: *Ferulago syriaca* root extract. *Afr. J. Pharm. Pharmacol.* (2012) 6:2652-2656.

[108] Taran M, Ghasempour, H R, Shirinpour, E. Antimicrobial activity of essential oil of *Ferulago angulata* subsp. *carduchorum*. *Jundishapur J. Microbiol.* (2010) 3:10-14.

[109] Ali N, Ahmed, G, Shah SW, Shah I, Ghias M, Khan I. Acute toxicity, brine shrimp cytotoxicity and relaxant activity of fruits of *callistemon citrinus* curtis. *BMC Complement Altern. Med.* (2011) 11:99.

[110] Akin M. AA, Nostro A. Antibacterial activity and composition of the essential oils of *Eucalyptus camaldulensis* Dehn. and *Myrtus communis* L. growing in Northern Cyprus. *Afr. J. Biotechnol.* (2010) 9:531-535.

[111] Salari MH, Amine, G., Shirazi, M. H., Hafezi, R., Mohammadypour, M. Antibacterial effects of *Eucalyptus globulus* leaf extract on pathogenic bacteria isolated from specimens of patients with respiratory tract disorders. *Clin. Microbiol. Infect.* (2006) 12:194-196.

[112] Takahashi T, Kokubo, R., Sakaino, M. Antimicrobial activities of eucalyptus leaf extracts and flavonoids from *Eucalyptus maculata*. *Lett. Appl. Microbiol.* (2004) 39:60-64.

Table 1. The name of the plant species with their related characterization are listed in the table. Plants that evaluated against MRSA too, are highlighted the MRSA with in their row. NA, means no activity. ND: was not done in the study.

Plant	Researcher	Using Part	Extraction	Inhibition zone	MIC
<i>Dicyclophora persica</i> Boiss.	Salehi et al [2005]	Aerial Part	Essential Oil	20 mm	1.2 mg/ml
<i>N. crispata</i>	Soboli et al [2004]	Aerial Part	Essential Oil	19.5 mm [15 µl/disc]	ND
<i>N. menthoid</i>	Soboli et al [2009]	Aerial Part	Essential Oil	21 mm [10 µL/disc]	3.6 mg/ml
<i>Terminalia chebula</i>	Shahidi Bonjar [2004]	Ripe And Unripe Seed	Methanolic Extract	ND	5 mg/ml for ripe seed 2.5 mg/ml for unripe seed
<i>Myrtus communis</i>	Shahidi Bonjar [2004]	Leaves And Seeds	Methanolic Extract	26 mm [20 mg/ml], 10 mm [5 mg/ml] for leaves 16 mm [20 mg/ml], 9 mm [0.62 mg/ml] for seeds	5 mg/ml [leaves] 0.62 mg/ml [for seed]
<i>Salvia multicaulis</i>	Yousefzadi et al [2007]	Aerial Parts	Essential Oil	ND	7.5 mg/ml
<i>Slvia multicaulis</i>	Karamian et al [2013]	ND	Methanolic Extract	10 mm [<i>S. aureus</i> penicillin resistant]	ND
<i>S. sclarea</i>	Yousefzadi et al [2007]	Aerial Parts	Essential Oil	ND	15 mg/ml
<i>S. verticillata</i>	Yousefzadi et al [2007]	Aerial Parts	Essential Oil	ND	7.5 mg/ml
<i>S. limbata</i>	Paknejadi et al [2012]	ND	Essential Oil	ND	15 mg/ml
<i>S. choloroleuca,</i>	Paknejadi et al [2012]	ND	Essential Oil	ND	7.mg/ml
<i>S. officinalis</i>	Shahidi Bonjar [2004]	Whole Plant	Methanolic Extract	16 mm	ND
<i>S. sahendica</i>	Lotfipour et al [2008]	Aerial Parts	Methanolic Extract	14 mm	1.2 mg/ml
<i>S. reuterana</i>	Ghomi et al [2012]	Flower And Leaves	Methanolic Extract	ND	0.5 mg/ml for flower, 0.25 mg/ml for leaves
<i>Slvia eremophila</i>	Ebrahimabadi et al [2010]	Aerial Parts	Methanolic Extract And Essential Oil	ND	7.8 mg/ml for essential oil, 0.5 mg/ml for methanolic extract
<i>Slvia eremophila</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	10 mm [4 mg/disc]	1 mg/ml
<i>S. reuterana</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	8 mm [4 mg/disc]	1 mg/ml
<i>Slvia mirzayanii</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	12.2 mm [4 mg/disc]	1 mg/ml

<i>Slviasantolinifolia</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	12.2 mm [4 mg/disc]	1 mg/ml
<i>Slviamicrosiphon</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	14.2 mm [4 mg/disc]	1 mg/ml
<i>Salvia urmiensis</i>	Farjam et al [2012]	ND	Ethyl Acetate Extract	ND	21.3 µg/ml
<i>Salvia urmiensis</i>	Farjam et al [2012]	ND	Essential Oil	ND	85.3 µg/ml
<i>Salvia urmiensis</i>	Farjam et al [2012]	ND	Ether Extracts	ND	37.3 µg/ml
<i>S. tomentosa</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	ND for MRSA & <i>S. aureus</i> strains	ND
<i>S. tomentosa</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	8.4 mm [4 mg/disc for MRSA] 6.8 mm [4 mg/disc for <i>S.aureus</i>]	ND
<i>Alhagi maurorum</i>	ShahidiBonjar [2004 and 2006]	Stem Gum	Methanolic Extract	15 mm	ND
<i>Heracleum rechingeri</i>	ShahidiBonjar [2004]	Fruit	Methanolic Extract	20 mm	ND
<i>H. transcaucasicum</i> and <i>H. anisactis</i>	Torbati et al [2013]	Aerial Parts	Essential Oil	ND	ND
<i>Foeniculum vulgare</i>	Mohsenzadeh [2007]	Fennel Seeds	Essential Oil	ND	2%
<i>Foeniculum vulgare</i>	ShahidiBonjar [2004]	Fennel Root	Methanolic Extract	12 mm	ND
<i>Cuminum cyminum</i>	Allahghadri et al [2010]	ND	Essential Oil	10 mm [10 µl/disc]	1/8 oil dilution
<i>Cuminum cyminum</i>	ShahidiBonjar [2004]	Fruit	Methanolic Extract	12 mm	ND
<i>Cuminum cyminum</i>	ShahidiBonjar [2004]	Seeds	Methanolic Extract	15 mm	ND
<i>Cuminum cyminum</i>	Dadgar et al [2006]	Seeds	Aqueous Extract	ND for MRSA and <i>S. aureus</i>	ND
<i>Cuminum cyminum</i>	Dadgar et al [2006]	Seeds	Ethanollic Extract	11.5 mm [4 mg/disc for MRSA] 8.5 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Artemisia diffusa</i> ,	Ramezani et al [2004]	Aerial Parts	Methanolic Extract	18.4 mm [16 mg/cup]	10 mg/ml
<i>Artemisia oliveria</i> ,	Ramezani et al [2004]	Aerial Parts	Methanolic Extract	12.2 mm [16 mg/cup]	10 mg/ml
<i>Artemisia scorpi</i>	Ramezani et al [2004]	Aerial Parts	Methanolic Extract	13.6 mm [16 mg/cup]	10 mg/ml
<i>Artemisia turanica</i>	Ramezani et al [2004]	Aerial Parts	Methanolic Extract	11.9 mm [16 mg/cup]	10 mg/ml
<i>Artemisia dracunulus</i>	Mohaenzadeh et al [2007]	ND	Essential Oil	ND	7.0%
<i>Artemisia dracunulus</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	8 mm [4 mg/disc] [for MRSA] 7 mm [4 mg/disc for <i>S. aureus</i>]	ND

<i>Artemisia dracunculus</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	ND [for MRSA & <i>S. aureus</i>]	ND
<i>Artemisia herbalba</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	22.5 mm [4 mg/disc] [for MRSA] 11 mm [4 mg/disc for <i>S. aureus</i>]	0.39 mg/ml [for clinical MRSA & <i>S. aureus</i> strains] 0.04 mg/ml [for standard MRSA strain] 0.02 mg/ml [for standard <i>S. aureus</i> strain]
<i>Artemisia herbalba</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	12 mm [4 mg/disc] [for MRSA] 9 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Artemisia absinthium</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	9 mm [4 mg/disc] [for MRSA] 8 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Artemisia absinthium</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	ND [for MRSA & <i>S. aureus</i>]	ND
<i>Pistaciavera</i>	Malekzadeh [1974]	Fruit	Extract	32 mm	ND
<i>Pistaciamutica</i>	Malekzadeh [1974]	Fruit	Extract	18 mm	ND
<i>Pistaciavera</i>	Malekzadeh [1974]	Leave	Extract	22 mm	ND
<i>Pistaciamutica</i>	Malekzadeh [1974]	Leave	Extract	22 mm	ND
<i>P. khinjuk</i>	Taran et al [2010]	Leave	Chloroform	ND	0.04 mg/ml
<i>P. khinjuk</i>	Taran et al [2010]	Leave	Ethyl Acetate	ND	0.13 mg/ml
<i>P. khinjuk</i>	Taran et al [2010]	Leave	Ethyl Alcohol	ND	0.09 mg/ml
<i>P. khinjuk</i>	Taran et al [2010]	Leave	Diethyl Ether	ND	0.42 mg/ml
<i>P. atlantica</i>	HabibiNajafi et al [2014]	Mastic Gum	Essential Oil	11 mm [10 µl/disc] 13 mm [20 µl/disc]	ND
<i>Helichrysumarmeniun m</i>	Oji et al [2012]	Flower, Leaf And Stem	Oil	12.4 mm, 11.22 mm and 10.8 mm [50 µl/cup]	ND
<i>Helichrysumscabrum</i>	Ghasemi et al [2011]	Flower	Extract	9 mm to 19 mm	MIC value varied from lower than 19 µg/ml to 5000 µg/ml

<i>Scrophularia striata</i>	Bahrami et al [2010]	Leave	Ethanollic Extract	ND	50.6 µg/ml
<i>Thymus persicus</i>	Talei et al [2007]	Leave	Essential Oil	ND	0.5 µl/ml
<i>Thymus eriocalyx</i>	Talei et al [2007]	Leave	Essential Oil	ND	0.5 µl/ml
<i>Thymus pubescens</i>	Rasooli et al [2002]	Pre And Flowering Stages	Essential Oil	29 mm for pre and 34 mm for flowering	dilution of 1/8
<i>Thymus serpyllum</i>	Rasooli [2002]	Pre And Flowering Stages	Essential Oil	14 mm for pre and 22 mm for flowering	dilution of 1/4
<i>Thymus pubescens</i>	Mehregan et al [2008]	Aerial Parts	Methanolic Extract	8 to 16 mm	ND
<i>Thymus vulgaris</i>	Mohsenzadeh et al [2007]	Leave	Essential Oil	ND	0.1%
<i>Thymus vulgaris</i>	ShahidiBonjar [2004]	Whole Plant	Methanolic Extract	10 mm	5 mg/ml
<i>Thymus vulgaris</i>	Tohidipour et al [2010]	ND	Essential Oil	20 - 35 mm [for 14 clinical MRSA strains] 19 mm [for <i>S. aureus</i>]	18.5 µg/ml -37 µg/ml [for 14 clinical MRSA strains] 18.5 µg/ml [for <i>S. aureus</i>]
<i>Thymus vulgaris</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	10.5 mm [4 mg/disc for MRSA] 9.4 mg/disc for <i>S. aureus</i>	ND
<i>Thymus vulgaris</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	ND [for MRSA & <i>S. aureus</i>]	ND
<i>Thymus caramanicus</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	11.2 mm [4 mg/disc for MRSA] 9 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Thymus caramanicus</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	ND [for MRSA & <i>S. aureus</i>]	ND
<i>Thymus caucasicus</i>	Haji Aghie et al	ND	Essential Oil	ND	0.31 µg/ml for <i>S. aureus</i> 2.5 µg/ml for MRSA
<i>Menthapulegium</i>	Mahboubi et al	Flowering Aerial Parts	Essential Oil	21 mm [1 µl of oil]	0.5 µl/ml
<i>Mentha pulegium</i>	Mohsenzadeh [2007]	Leaves	Essential Oil	ND	0.5%
<i>Mentha apiperita</i>	Yadegarnia [2006]		Essential Oil	ND	2 µl/ml

<i>Mentha piperita</i>	Mohsenzadeh [2007]	Leaves	Essential Oil	ND	0.4%
<i>Mentha piperita</i>	Dadgar et al [2006]	Leaves	Ethanollic Extract	7.5 mm [4 mg/disc for MRSA] 8.5 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Mentha piperita</i>	Dadgar et al [2006]	Leaves	Aqueous Extract	7 mm [4 mg/disc for MRSA] 7.5 mm [4 mg/disc for <i>S. aureus</i>]	ND
<i>Peganum harmala</i>	Shahverdi et al [2005]	Seed Smoke	Dichloromet hane Extract	15.7 mm [5 mg of smoke condensate]	ND
<i>Peganum harmala</i>	Dadgar et al [2006]	Mature Plant	Aqueous Extract	7.4 mm [4 mg/disc] [for MRSA] ND [4 mg/disc]	ND
<i>Peganum harmala</i>	Dadgar et al [2006]	Mature Plant	Ethanollic Extract	18 mm [4 mg/disc] [for MRSA] 20 mm [4 mg/disc]	0.02 mg/ml [for clinical and standard MRSA strains] 0.02 mg/ml [for standard and clinical <i>S. aureus</i> strains]
<i>Peganum harmala</i>	Darapour et al [2011]	Seed	Methanollic Extract	22 mm [in concentration of 400 mg/ml for MRSA]	0.6 mg/ml
<i>Peganum harmala</i>	Darapour et al [2011]	Leaves	Methanollic Extract	10 mm [in concentration of 400 mg/ml for MRSA]	ND
<i>Peganum harmala</i>	Darapour et al [2011]	Stem	Methanollic Extract	11 mm [in concentration of 400 mg/ml for MRSA]	ND
<i>Peganum harmala</i>	Darapour et al [2011]	Root	Methanollic Extract	24.5 mm [in concentration of 400 mg/ml for MRSA]	0.6 mg/ml
<i>Peganum harmala</i>	Darapour et al [2011]	Flower	Methanollic Extract	5.5 mm [in concentration of 400 mg/ml for MRSA]	ND
<i>Grammosciadium platycarpum</i>	Sonboli [2005]	Aerial Parts	Essential Oil	18 mm	1.9 mg/ml
<i>Grammosciadium scabridum</i>	Sonboli [2005]	Aerial Parts	Essential Oil	14 mm [10 µg/disc]	1.2 mg/ml
<i>Onosmadi chroanthum Boiss.</i>	Moghadam et al [2012]	Root	Methanollic and Ethanollic Extract	15 mm [50 µl/well], 15 mm [50 µl/well]	0.1 mg/ml for methanollic extract and 0.3 mg/ml for ethanollic extract

<i>Scutellarialitwinowi</i>	FazlyBazzaz et al	Aerial Parts	Methanolic Extract	ND	6.2 mg/ml
<i>Scutellarialindbergii</i>	FazlyBazzaz et al	Aerial Parts	Methanolic Extract	ND	6.2 mg/ml
<i>Oliveriadicumbens</i>	Motamedi et al [2010]	Aerial Parts	Ethanollic and Methanolic Extracts	ND	20 mg/ml
<i>Teucriumpolium</i>	Darabpour et al [2010]	Aerial Parts	Alcoholic Extracts	ND	40 mg/ml
<i>Teucriumpolium</i>	Meshkibaf et al	ND	Hydroalcoholic	20 mm	ND
<i>Stachysfruticulosa</i>	Lotfipour et al	Aerial Parts	Methanolic Extract	12 mm	2.5 mg/ml
<i>Stachysschtscheglevii</i>	Lotfipour et al	Aerial Parts	Methanolic Extract	13 mm	1.2 mg/ml
<i>Stachysbyzantia</i>	Semnani et al	ND	Methanolic Extract	8.4 mm	100 µg/ml
<i>Stachysiniflate</i>	Semnani et al	ND	Methanolic Extract	8.3 mm	250 µg/ml
<i>Stachyslavandulifolia</i>	Semnani et al	ND	Methanolic Extract	8.6 mm	500 µg/ml
<i>Stachyslaxa</i>	Semnani et al	ND	Methanolic Extract	8.6 mm	100 µg/ml
<i>Stachys grandiflora</i>	Yousefi et al [2012]	Aerial Parts	Essential Oil	12 mm	ND
<i>Stachys obtusicrena</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	9.2 mm [4 mg/disc]	ND
<i>Hymenocrater longiflorus</i>	Ahmadi et al [2010]	Polar Sub-Fraction	Essential Oil	31 mm	40 µg/ml
<i>Pistachia vera</i>	Rajaie et al [2010]	Green Hull	Purified Extract	11.7 mm [at 1200 µg/plate]	ND
<i>Phlomis caucasica</i>	Lotfipour et al [2008]	Aerial Parts	Methanolic Extract	ND	1.25 mg/ml
<i>Phlomis buruguieri.</i>	Semnani et al	Aerial Parts	Methanolic Extract	16.7 mm	10 mg/ml
<i>Phlomis herbaventi</i>	Semnani et al	Aerial Parts	Methanolic Extract	12.2 mm	10 mg/ml
<i>Phlomisoliveri</i>	Semnani et al	Aerial Parts	Methanolic Extract	13.1 mm	25 mg/ml
<i>Torilisleptophyla</i>	Maleki et al [2008]	Aerial Parts	Ethanollic Extract	10 mm	0.4 g/ml
<i>Tanacetum balsamita</i>	Lotfipour et al [2008]	Aerial Parts	Dichloromethane Extract	ND	2.5 mg/ml
<i>Tanacetum parthenium</i>	Izadi et al [2011]	Whole Plant	Essential Oil	18.5 mm [2.5 µl], 34 mm [5µl], 39 mm [7.5 µl] and 42 mm [15 µl]	1 µg/ml
<i>Tanacetum. parthenium</i>	Mohsenzadeh et al [2011]	Flowering Stage	Essential Oil	24 mm	8 µg/ml

<i>Tanacetum parthenium</i>	Mohsenzadeh et al [2011]	Pre-Flowering Stage	Essential Oil	18 mm	8 µg/ml
<i>Tanacetum parthenium</i>	Mohsenzadeh et al [2011]	Post-Flowering Stage	Essential Oil	22 mm	8 µg/ml
<i>T. pinnatumboiss</i>	Esmaeili et al [2011]	Aerial Parts	Essential Oil	24.2 mm	ND
<i>Achillea millefolllum</i>	Lotfipour et al [2008]	ND	Methanolic Extract	ND	0.6 mg/ml
<i>Achillea millefolllum</i>	Mazandarani et al [2013]	ND	Essential Oil	31.4 mm [region 1] 19.8 mm [region 2]	15.4 µg/ml [region 1] 27.5 µg/ml [region 2]
<i>Achillea pachycephala</i> Rech. F.	motavalizadeh kakhky et al [2013]	Flowers	Essential Oil	12 mm	ND
<i>Achilleapachycephala</i> Rech. F.	motavalizadeh kakhky et al [2013]	Leaves	Essential Oil	10.5 mm	ND
<i>Achilleapachycephala</i> Rech. F.	motavalizadeh kakhky et al [2013]	Stems	Essential Oil	8 mm	ND
<i>Achilleapachycephala</i> Rech. F.	motavalizadeh kakhky et al [2013]	Aerial Parts	Hexan-Ether	14 mm	6.2 mg/ml
<i>Achilleapachycephala</i> Rech. F.	motavalizadeh kakhky et al [2013]	Aerial Parts	Methanolic Extract	6 mm	12.5 mg/ml
<i>Achillea santolina</i> L.	motavalizadeh kakhky et al [2013]	Flowers	Essential Oil	9 mm	ND
<i>Achillea santolina</i> L.	motavalizadeh kakhky et al [2013]	Leaves	Essential Oil	7.5 mm	ND
<i>Achillea santolina</i> L.	motavalizadeh kakhky et al [2013]	Stems	Essential Oil	6.5 mm	ND
<i>Achilleasantolina</i> L	Motavalizadehkakhky et al [2013]	Aerial Parts	Hexan-Ether	7 mm	6.2 mg/ml
<i>Achilleasantolina</i> L.	Motavalizadehkakhky et al [2013]	Aerial Parts	Methanolic Extract	5 mm	12.5 mg/ml
<i>Achillea tenuifolia</i> Lam.	Shafaghat [2009]	Flower	Volatile Oils	14 mm	ND
<i>Achillea tenuifolia</i> Lam.	Shafaghat [2009]	Leaves	Volatile Oils	9 mm	ND
<i>Achillea tenuifolia</i> Lam.	Shafaghat [2009]	Stems	Volatile Oils	8 mm	ND

<i>Achillea wilhelmsii</i> C. Koch	Hoseini Alfatermi et al [2014]	ND	Essential Oil	27 mm [200 µl for MSSA] 19 mm [200 µl for MRSA]	ND
<i>Achilleawilhelmsii</i>	Mohammadisi chani et al [2010]	ND	Methanolic Extract	19 mm [400 mg/ml]	ND
<i>Otostegia persica</i>	Asghari et al [2006]	Aerial Parts	Hexane Extract	11.4 mm	10 mg/ml
<i>Otostegia persica</i>	Asghari et al [2006]	Aerial Parts	Chloroform Extract	15.4 mm	1.25 mg/ml
<i>Otostegia persica</i>	Asghari et al [2006]	Aerial Parts	Methanolic Extract	15.6 mm	3.12 mg/ml
<i>Otostegia persica</i>	Javadnia et al [2009]	Aerial Parts	Methanolic Extract	9.7 mm [4 mg/disc]	ND
<i>Berberis vulgaris</i>	Dadgar et al [2006]	Root	Aqueous Extract	8.4 mm [4 mg/disc] [for MRSA] 7 mm [4 mg/disc]	ND
<i>Berberis vulgaris</i>	Dadgar et al [2006]	Root	Ethanollic Extract	12.5 mm [4 mg/disc] [for MRSA] 15.5 mm [4 mg/disc]	0.39 mg/ml [for clinical strain <i>S. aureus</i> & MRSA] 0.04 mg/ml [for standard strain <i>S. aureus</i> & MRSA]
<i>Berberis vulgaris</i>	ShahidiBonjar [2004]	Fruit	Methanolic Extract	ND	17 mm
<i>Ferulago angulata</i>	Taran et al [2010]	Aerial Parts	Essential Oil	ND	15 µg/ml
<i>Ferula goangulata</i>	Taran et al [2010]	Seeds	Essential Oil	ND	>4×10 ³ µg/ml
<i>Ferulago Bernardii</i>	Khalighi- Sigaroodi et al [2005]	Aerial Parts	Essential Oil	ND	250 µg/ml
<i>Eucalyptus globulus</i>	Dadgar et al [2006]	Leaves	Aqueous Extract	14 mm [4 mg/disc for MRSA] 11mm [4 mg/disc]	ND
<i>Eucalyptus globulus</i>	Dadgar et al [2006]	Leaves	Ethanollic Extract	17 mm [4 mg/disc for MRSA] 15.5 mm [4 mg/disc]	0.1 mg/ml [for clinical strain MRSA] 0.09 mg/ml [for standard MRSA strain] 0.39 mg/ml [for standard and clinical <i>S. aureus</i> strains]
<i>Eucalyptus globulus</i>	Tohidipour et al [2010]	ND	Essential Oil	10 to 30 mm [for 14 clinical MRSA strains] 17 mm [for <i>S.</i> <i>aureus</i>]	34.24 to 85.6 µg/ml [for 14 clinical MRSA strains] 51.36 µg/ml [for <i>S. aureus</i>]