MINI REVIEW

INTRODUCTION

Pseudomonas aeruginosa is a Gram-negative, aerobic bacterium found in water and soil. It is a normal flora of the skin and gastrointestinal tract of human beings (1, 2). This bacterium as an opportunistic pathogen is one of the most important microorganisms in nosocomial infections in immune-compro-
mised patients including patients with malignancies, cystic fibrosis and burns with multiple pathogenic factors and high rate of resistance to most of the antibiotics. The presence of glycocalyx in cellular membrane is responsible for easy binding of the bacterium to the host cell, biofilm formation and protection of bacteria against penetration of antimicrobial agents and phagocytic system (3).

In a previous study, *P. aeruginosa* has been isolated from nosocomial pneumonia (16%), nosocomial urinary tract infections (85%) and hospital blood infections (10%) which included 23% of total isolated bacteria from admitted patients (4). Selection of the appropriate treatment approach against *P. aeruginosa* is limited due to its resistance to common recommended antibiotics (5, 6).

Bacterial resistance to antibiotics is increasing which makes humans to apply effective antimicrobial agents with fewer side effects such as medicinal plants instead of medicines with less efficacy and greater side effects (7). Plants have different chemical compounds like secondary metabolites (8, 9) with many biochemical and bioactivity properties showing applications in various industries such as pharmaceutical, chemical, cosmetic and food industry (10-13). The aim of this study was to introduce the most important native medicinal plants of Iran being effective on *P. aeruginosa*.

**MATERIALS AND METHODS**

All required information was obtained by literature review using keywords including *P. aeruginosa*, medicinal plant extracts or essential oils of published articles in authentic scientific databases such as Science Direct, Wiley-Blackwell, Springer, Google scholar, Scientific Information Database (SID) and Magiran.

**RESULTS**

According to literature review, our results showed 12 different native medicinal plants were effective against *P. aeruginosa* in Iran including *Eucalyptus camadulensis, Marticaria chamomilla, Ferula gummosa Boiss, Lawsonia inermis, Ocimum gratissimum, Allium sativum, Satureja hortensis L, Satureja bachtiarica Bunge, Satureja khuzestanica (Jamzad), Thymus daenensis Celak, Thymus carmanicus Jalals and Camellia sinensis*. Effective medicinal plants against *P. aeruginosa* are listed in Table 1.

**DISCUSSION**

Secondary compounds have attracted particular attention to the plants in recent years. Medicinal plants are good alternatives for synthetic preservatives in food and drug industry due to their antimicrobial compounds. *E. camadulensis* (Eucalyptus) leaves are rich in polyphenols and terpenoids and eucalyptol or cineole (26). Phytochemicals results showed that alfa and beta-pinenes are the main ingredients of *Ferula gummosa Boiss* (galbanum) (27) and *Lawsonia inermis* (Henna) contains manitol, tanic acid, mucilage and galic acid but its most important ingredient is 2-Hydroxy-1,4-naphoquinone (Lawson) recognized as bioactive agent.

*Ocimum gratissimum* (basil) contains essential oils, tannins, glycosides, saponin, anthocyanin, eugenol, linalool, methyl cinnamate, camphor and thymol. Allicin is the major component of *Allium sativum* (28). Different species of *Satureja* (Savory) contain monoterpene, phenolic compounds especially carvacrol, thymol and eugenol as well as some of the sesquiterpenes. The main phytochemical essential oils of aromatic plants are hydrocarbons, aldehydes, ketones, alcohols, phenols, ethers and esters with phenolic and terpenic sources. The presence of linalool, alpha-pinene, beta-pinene, borneol, carvone, limonene, carvacrol, p-cymene and terpinenein essential oils of understudy plants showed antimicrobial properties particularly (28). These compounds with high hydrophobic properties can separate lipids from bacterial cell wall and thereby increase the permeability of the membrane which leads to ion expelling and electron imbalance and eventually cell death. The researchers demonstrated that plant species used in popular medicine are promising resources for antimicrobial treatments (13, 14, 29, 30).

**CONCLUSION**

Phytochemical analysis has shown that bioactive compounds of medicinal plants with their antioxidant and antimicrobial properties are good substitutions for synthetic drugs in food and drug industry.
Table 1. List of effective Iranian native medicinal plants against *P. aeruginosa* (PA)

| Scientific name                  | Plant Family | Persian name | Discussion                                                                 |
|----------------------------------|--------------|--------------|-----------------------------------------------------------------------------|
| *Eucalyptus camadulensis*         | Myrtaceae    | Eucalyptus   | Minimum inhibitory concentration (MIC) of alcoholic and aqueous extracts were 3.3 mg/ml and 17.5 mg/l. Increasing concentration of the extract prevented growth more effectively in comparison with control group (13). |
| *Marticaria chamomilla* (Galbanum) | Asteraceae   | Babooneh     | At a concentration of 0.5 mg/ml of essential oil the growth of PA was significantly lower than the positive control (14). |
| *Ferula gummosa Boiss.*           | Umbelliferae | Baryjeh      | MIC of methanol and ethanol extracts was 1.25 × 10⁴ and 625 × 10³ µg/ml, respectively (15). |
| *Lavsonia inermis*                | Lythraceae   | Henna        | MIC of aqueous and ethanol extracts was 10 and 3.5 mg/ml, respectively (16). |
| *Ocimum gratissimum* (Basil)      | Laminaceae   | Reyhan       | The inhibition zone diameter of ethanol extract with 100 and 200 mg/ml concentration were 8 and 12 mm (in diameter) but for aqueous extract (with the same concentration), they were 4 and 9 mm, respectively (17). |
| *Allium sativum*                  | Liliaceae    | Sir          | MIC of the extract at 220 µg/ml conc. had a 16 mm growth inhibition zone (in diameter) (18). In another study MIC and MBC of Allicin were 2.38 and 4.77 mg/ml, respectively (25). |
| *Satureja hortensis L.*           | Labiatae     | Marzeh       | Growth inhibition zone in disk diffusion method was 19.88 mm (in diameter) (19). |
| *Satureja bachtiarica* (Bunge)    | Labiatae     | Marzeh Bakhtyar | Growth inhibition zone in disk diffusion method was 22.22 mm (in diameter) (19). |
| *Satureja khuzestanica* (Janzad)  | Labiatae     | Marzeh Khoozestani | Growth inhibition zone in disk diffusion method was 18.33 mm (in diameter) (19). |
| *Thymus daenensis Celak*          | Laminaceae   | Avishan Denae | Growth inhibition zone in disk diffusion method was 21.88 mm (in diameter) (19). |
| *Thymus carmanicus*               | Laminaceae   | Avishan Kermani | Growth inhibition zone in disk diffusion method was 20.66 mm (in diameter) (19). |
| *Camellia sinensis*               | Theaceae     | Katchin      | MIC at 0.01 dilution was 7.24 µg/ml (24). |

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