ejpmr, 2017,4(4), 128-134

SJIF Impact Factor 4.161

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

CONSTITUENTS AND BIOLOGICAL ACTIVITIES OF IRANIAN *ACHILLEA* SPECIES.

Abdolhossein Rustaiyan Prof.[1]*, Afsaneh Faridchehr PhD.[2] and Mahdieh Ariaee Fard MSc.[3]

[1,2]Department of Chemistry, Faculty of Basic Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.

[3]Faculty of Pharmaceutical Chemistry, Department of Phytochemistry and Essential Oils Technology, Islamic Azad University, Pharmaceutical Sciences Branch (IAUPS), Tehran, Iran.

***Corresponding Author: Abdolhossein Rustaiyan Prof.**

Department of Chemistry, Faculty of Basic Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.

Article Received on 02/02/2017 **Article Revised on 22/02/2017** **Article Accepted on 14/03/2017**

ABSTRACT

Achillea is a group of flowering plants in the family Asteraceae described as a genus by Linnaeus in 1753. The genus was named after the Greek mythological character Achilles. According to legend, Achilles soldiers used yarrow to treat their wounds, hence some of its common names such as all-heal and bloodwort. The genus is native primarily to Europe, temperate areas of Asia, and North America. The common name "yarrow" is usually applied to *Achillea millefolium*, but may also be used for other species within the genus. These plants typically have frilly, hairy and aromatic leaves. The plants show large, flat clusters of small flowers at the top of the stem. The flowers can be white, yellow, orange, pink or red and are generally visited by many insects, and are thus characterized by a generalized pollination system.

KEYWORD: Iranian *Achillea* Species, Compositae, Constituents, Biological Activity.

INTRODUCTION

About 90 species of *Achillea* (tribe Anthemideae, family Compositae) were cited by the Candolle in 1837.[1] Chandler et al.[2] in 1982 compiled the uses and the chemical composition of the well-known *Achillea millefolium* (English: *yarrow*; French: *millefeuille*; German: *schafgrabe*) which has been used in traditional medicine since the Trojan War.

Nineteen species of the genus *Achillea* are found in Iran among which seven are endemic.[3] [4]

Plant substances play a major role in primary health care as therapeutic remedies in many developing countries until today.[5] Medicinal herbs contain physiologically active principles that over the years have been exploited in traditional medicine for the treatment of various ailments, as they contain anti-microbial properties.[6], [7] The antifungal and antibacterial activity exhibited by extract and essential oil of medicinal plants has been demonstrated by several researchers.[8]-[11]

Chemical studies on several *Achillea* species have resulted in the isolation of sesquiterpene lactones, phenolic and acetylenic compounds.[12]-[14]

Pharmacological studies have shown that these species have anti-microbial[15], anti-inflammatory and anti-allergic[16] activities e.g. *A. millefolium* is a popular anti-pyretic, having analgesic and anti-inflammatory effects as well.[17] and it has been used to reduce sweating and to stop bleeding.[18] It helps regulation of the menstrual cycle and reduces heavy bleeding and pain. The main component of the essential oil of *A. millefoium* is chamazulene which has anti-inflammatory and anti-allergic properties.[18] *A. santolina* is used as a tonic, vermifugal and carminative and also relieves stomach pain.[2] *A. biebersteinii* is used in Jordan because of its carminative properties[19], which in Turkey the plant is also used for abdominal pain, stomach-ache and for wound healing.[20]

Achillea eriophora DC.

Ninety constituents (98%) of the essential oil of the leaves and flowers of *Achillea eriophora* DC. (Compositae) were identified. The main constituents are 1, 8-cineole (34%) and the pinenes (13%). The oil contains only 7% of sesquiterpenes, mainly caryophyllene derivatives. Three new farnesol derivatives were isolated as trace constituents. The structures were confirmed by ^{1}H- and ^{13}C-NMR data.[21]

In another study, in the essential oil of *Achillea eriophora* 33 compounds representing 100%, were identified in which Camphor (21.5%), Artemesia ketone (13.8%), Alpha-Thujone (11.8%), Borneole (8.9%), Yomogi alcohol (7.7%), 1,8-cineole (5.2%), Terpinene-4-ol (4.2%) and Myrtenol (3.1%) were the major constituents. In addition, the antioxidant activity of ethyl acetate and ethanolic extracts of *Achillea eriophora* was analyzed using the 1, 1-diphenyl-2- picrylhydrazyl

(DPPH) free radical scavenging. According to antioxidant activity outcomes, the amount of IC_{50} of ethyl acetate and ethanolic extracts of the aerial parts of *Achillea eriophora* and also butylated hydroxyl toluene (BHT) as a standard was 245.20 ppm, 89.25 ppm and 45.58 ppm, respectively. Ultimately, it was highlighted that the antioxidant activity of the ethyl acetate extract was weaker than that of the ethanolic extract. The antioxidant activity of both of them was also weaker than BHT as a synthetic antioxidant. Some compounds like 1, 8-cineole and terpinen-4-ol can be responsible for antioxidant and antimicrobial activity, while Camphor and borneol have not been proven to be strong antioxidant agents as emphasized elsewhere.[22]

In another study, The major composition of the essential oil of *Achillea eriophora* from aerial parts growing wild in Iran analyzed by GC and GC-MS. The essential oil of *Achillea eriophora* DC. were identified and major compounds were camphor (30.40 %), 1,8 cineol (25.24 %) and camphene (6.21 %).[23]

***Achillea talagonica* Boiss. and *Achillea vermicularis* Trin.**

The composition of the oils from leaves and flowers of two Iranian *Achillea* species (*A. talagonica* Boiss. and *A. vermicularis* Trin) was analyzed by GC and GC/MS. During the flowering period, all two oils consisted mainly of monoterpenes. 1, 8-Cineole and camphor were the predominant compounds in the oils of *A. talagonica* (27% and 20%) and *A. vermicularis* (29% and 32%) respectively.[24]

Achillea Tenuifolia LAM.

The water-distilled essential oil from dried aerial parts of *Achillea tenuifolia* Lam. Was analyzed by GC and CG/MS. 48 Components were characterized representing 88% of the total oil. Camphor (18%), 1, 8-cineole + limonene (9%) and spathulenol (7%) were the major constituents of the oil obtained in a yield of 0.23%.[25]

In another study, the water distilled flower oil of *Achillea tenuifolia* Lam. grown in Iran was analyzed by GC and GC/MS. Among 24 constituents identified, camphor 06.9%) was the major volatile compound.[26]

In another study, Plant material (flower, leaf and stem) was collected in Khalkhal – Ardabil road area, at an altitude of 1650 m in Northwest of Iran. Plant materials were air dried 150g of flower 150g of leaf and 200g of stem were subjected to 3h of hydro-distillation in a Clevenger-type apparatus, separately. The hydro-distilled essential oils were analyzed by GC and GC/MS methods. Antibacterial activities of the oils were evaluated by the disc diffusion method using Mueller-Hinton agar for bacteria. The main components of the oil of flower, leaf and stem were limonene, α-cadinol, α- pinene and spathulenol, but Borneol, bornyl acetate, camphor, α- and β-thujone, and 1, 8-cineol were found as the main components of essential oils of many other *Achillea* species. These variations may be attributed mainly to variation in their agroclimatic and geographical conditions. The results indicated that three oils were found to be active against bacteria, the oil from the flower was found to be more active than the oil from the leaf and stem.[27]

***Achillea albicaulis* C.A. Mey.**

The essential oil of the aerial parts of *Achillea albicaulis* C.A. Mey. was analyzed by capillary GC and GC/MS.
The major constituents were 1, 8- cineol (10.1%), camphor (9.2%), germacrene D (7.8%), piperitone (6.2%), α-pinene (5.9%) and artemisia ketone (5.7%).[28]

***Achillea aucheri* Boiss. and *Achillea kellalensis* Boiss. et Hausskn**

The essential oil of *Achillea aucheri* Boiss. and *Achillea kellalensis* Boiss. et Hausskn, which are endemic to Iran, have been analyzed by GC and GC/MS.

The oil of *Achillea aucheri* was found to contain 1, 8-cineol (40.7%), α- terpineol (11.3%), β- pinene (10.8%) and α-pinene (10.3%) as major constituents. The oil of *Achillea kellalensis* was characterized by a higher amount of camphor (34.0%), borneol (12.6%), α-thujone (12.5%), 1, 8- cineol (11.3%) bornyl acetate (7.3%) and camphene (7.0%).[29]

***Achillea pachycephala* Rech.f.**

The water-distilled essential oils from the aerial parts of *Achillea pachycephala* Rech.f. which is endemic to Iran was analyzed by GC and GC–MS. The oil of *A. pachycephala* was found to contain 1, 8-cineole (27.7%) and camphor (27.4%) as the major constituents.[30]

In another study, Gas chromatography and gas chromatography-mass spectrometry (GC/MS) analysis of the isolated essential oil obtained by steam distillation from the flowers, leaves and stems of two plants, known to have medicinal activity, *Achillea pachycephala* Rech.f. and *Achillea santolina* L., collected from Khorasan, Northeast of Iran, as well as constituents obtained by solvent (hexane-ether and methanol) extractions of the aerial parts, resulted in the identification of 46 to 60 constituents (95.4 to 98.8% of the total oil and extracts) and 48 to 59 constituents (95.9 to 98.0% of the total oil and extracts), respectively. The hydro-distilled oil of three parts and the solvent extracts of *A. pachycephala* contain camphene, sabinene, 1, 8-cineole, camphor, borneol, terpinen-4-ol and β-caryophyllene as major constituents. In essential oils and extracts of *A. santolina*, 1, 8-cineole, camphor, terpinene-4-ol, fragranol, fragranyl acetate, α- terpinyl acetate, caryophyllene oxide, α- muurolol and some alkanes, alkanoic acids and esters were principle components. In vitro antimicrobial activity of essential oil of three parts and crude extracts (hexane-ether and methanol extract) of *A. pachycephala* Rech.f. and *A. santolina* L. were investigated by disc diffusion method and the minimum inhibitory concentration (MIC) and

minimal bactericidal concentration (MBC) determination. The studied samples were active against gram positive and gram negative bacteria. The maximum antimicrobial activities of both plants were shown by the essential oils and the hexane-ether extracts, as compared to methanolic extracts. Both oils and extracts exhibited higher activities against the gram negative tested bacterial strains.[31]

***Achillea oxyodonta* Boiss.**

Hydro-distilled volatile oils from the aerial parts of *Achillea oxyodonta* (collected from two different locations), which is endemic to Iran, was analyzed by GC and GC/MS. In the oil of *A. oxyodonta* from Shemshak sample, 54 compounds representing 95.68% of the total oil were characterized with camphor 13.18%; spathulenol 11.19%; 1,8-cineole 10.51%; salvial-4(14)-en-1-one 4.82%; eudesm-4-en-6-one 3.17%; caryophyllene oxide 3.07%; filifolone 3.03% as the major components. In the oil obtained from *A. oxyodonta* sample collected in Soleghan, 49 compounds representing 97.98% of the oil were characterized. spathulenol 13.13%; camphor 12.83%; 1,8-cineole 11.15%; cis-β- Farnesene 8.21%; α- Cadinol 4.83%; salvial- 4(14)en-1-one 4.19%; bornyl acetate 4.16%; isospathulenol 3.64%; germacrene D 3.45%; endo 1,5-Epoxysalvial-4(14)-ene 3.09% was found as the main components. The results showed that there are qualitative similarities between the oils although the amounts of some corresponding compounds are different indicating that environmental factors strongly influence its chemical composition.[32]

In another study, The water-distilled essential oils from the aerial parts of *Achillea oxyodonta* Boiss., which is endemic to Iran was analysed by GC and GC–MS. The oil of *A. oxyodonta* was characterized by higher amounts of 1, 8-cineole (38.5%) and artemisia ketone (23.0%).[30]

***Achillea biebersteinii* Afan.**

The composition of the oil from leaves and flowers of *A. biebersteinii* Afan. was analyzed by GC and GC/MS. The oils consisted mainly of monoterpenes and the major components of the oil of *A. biebersteinii* were ascaridole (37%), piperitone (17%) and camphor (12%).[24]

In another study, The water-distilled essential oils from stems, leaves and flowers of *Achillea biebersteinii* Afan., were also analysed by GC and GC–MS. The oils obtained from stems and leaves of *A. biebersteinii* were rich in camphor (38.1% and 33.7%, respectively) and borneol (22.6% and 20.8%, respectively). The other main component of the stem oil was 1, 8-cineole (13.5%). In the flower oil of the plant, camphor (36.3%) and 1, 8-cineole (22.3%) were the predominant compounds. All oils were richer in oxygenated monoterpenes.[30]

In another study, three wild *Achillea* species: *A. biebersteinii*, *A. millefolium*, and *A. wilhelmsii* collected in East Azerbaijan (Iran) during the flowering period. The chemical combination of the isolated oils was examined by gas chromatography-mass spectrometry. In *A. biebersteinii* the major compounds were α-terpinen (41.42%), 2-carene (13.96%), m-cymene (13.41%) and 1,8-cineole (8.91%). In *A. millefolium*, the major compounds were 1, 8-cineole (28.0%), camphor (19.2%), borneol (98.8%) and β-pinene (6.3%). In *A. wilhelmsii* the major compounds were carvacrol (29.2%), linalool (10.3%), 1, 8-cineole (11.0%), (E)-nerolidol (8.4%) and borneol (5.04%).[33]

In another study, The major composition of the essential oil of A. biebersteinii from aerial parts growing wild in Iran analysed by GC and GC-MS. The major compounds of A. biebersteinii Afan. were 1,8-cineole (32.82 %), carvacrol (10.85 %) piperitone (7.34 %).[23]

***Achillea millefolium* L.**

The antioxidant potential of *Achillea millefolium* on the basis of the chemical compositions of oils obtained by hydro-distillation, which have been identified 24 compounds, representing the 83.7% of the total oil.

The major constituents of the oil were described as α-pinene (10.12%), camphene (4.23%), limonene (5%), borneol (5%), γ-terpinene (8%), carvone (5%), bornyl acetate (2.43%), thymol (15.32%), and carvacrol (20.43%). The oils were also subjected to screening for their possible antioxidant activity using 2, 2-diphenyl-1-picrylhydrazyl test. The antioxidant activity guided fractionation resulted in the separation of the main antioxidant compound which were identified as thymol (65%) and carvacrol (25%).[34]

In another study, The in vitro antimicrobial and antioxidant activities of the essential oil and methanol extracts of *Achillea millefolium* subsp. *millefolium Afan.* (Asteraceae) were investigated. GC-MS analysis of the essential oil resulted in the identification of 36 compounds constituting 90.8% of the total oil. Eucalyptol, camphor, alpha-terpineol, beta-pinene, and borneol were the principal components comprising 60.7% of the oil. The oil strongly reduced the diphenylpicrylhydrazyl radical (IC_{50}=1.56 micro g/ml) and exhibited hydroxyl radical scavenging effect in the Fe^{3+}-EDTA-H_2O_2 deoxyribose system (IC_{50}=2.7 micro g/ml). It also inhibited the nonenzymatic lipid peroxidation of rat liver homogenate (IC_{50}=13.5 micro g/ml). The polar phase of the extract showed antioxidant activity. The oil showed antimicrobial activity against Streptococcus pneumoniae, Clostridium perfringens, Candida albicans, Mycobacterium smegmatis, Acinetobacter lwoffii and Candida krusei while water-insoluble parts of the methanolic extracts exhibited slight or no activity. This study confirms that the essential oil of *Achillea millefolium* possesses antioxidant and antimicrobial properties in vitro.[35]

In another study, the evaluated antimicrobial effects of yarrow (*Achillea millefolium*) essential oils against

Staphylococcus spp., fourteen clinical isolates of *Staphylococcus* cultured from patients. The disc diffusion method was used for determination of antimicrobial activity of essential oil. Results showed that this inhibitory effect is dose-dependent to wit, by increasing the concentration of the extract in the culture media; reduction in growth was obviously revealed. In conclusion, it can be stated that yarrow essential oils have inhibitory effect against *Staphylococcus* spp.[36]
In another study, from MeOH extract of aerial parts of *Achillea millefolium* L. collected from Golestan province of Iran, three glycosylated phenolic compounds, luteolin 7-O-glucoside, apigenin 7-O-glucoside and caffeic acid glucoside were isolated and identified by spectroscopic analyses. Immunological properties of different fractions of plant extract were studied on humoral immune system of BALB/c mice by Microhaemagglutination test. Among these fractions only two fractions at 125 mg kg-1 and 61.5 mg kg-1 showed a significant decrease in the anti- SRBC titer of mice ($P<0.05$). The immunological properties of the latter fractions may be due to glycosylated derivatives of caffeic acid.[37]

In another study, the aerial parts of plant were collected from two different regions (700 to 2300m) and the essential oils were obtained by hydro-distillation. Essential oil compositions were analyzed by Gas chromatography-mass spectrometry (GC-MS). Different compounds were identified and their yield was 99.43 and 99.70%, respectively in Maraveh Tapeh and Charbagh regions. 1, 8-cineole (18.6%), camphor (13.9%), borneol (9.4%), terpinolene (8.6%), γ-terpinene (6.8%) and thujone (4.3%) were the major components oil in 2300 m, whereas terpinolene (81%) followed by borneol (4.2%), β-pinene (3.5%) and chamazulene (2.9%) were identifiedin the flower oil in 700 m. The antibacterial activities were studied in vitroagainst 9 Gram positive and negative bacteria. The bacterial strains tested were found to be more sensitive to essential oil in which obtained in 2300 m and showed a very effective bactericidal activity with minimum inhibitory concentrations (MIC) ranging from 12.6 to 112 g/ml. *S. epidermicis*, *S. aureus*, *B. cereus*, *E. faecalis* and *E. coli* were the most sensitive bacteria from oil of 2300 m, whereas *S. aureus* was the most sensitive bacteria, *B. cereus*, *E. coli* and *S. typhimorium* have moderate sensitivity and other bacteria were resistant to the oil of 700 m. *E. coli* and *E. faecalis* with 16.5 and 14.2 mm inhibition zone were sensitive Gram negative bacteria with MIC 22.8 and 63.8 g/ml, respectively. Results demonstrate that the oil of *A. millefolium* L. can become potentials for controlling certain important Gram positive and negative bacteria which produces many infectious diseases, but their effective is varied in different region.[38]

***Achillea nobilis* L.**
Water-distilled essential oils from the aerial parts of *Achillea nobilis* L. were analyzed by GC and GC-MS. The oil of *Achillea nobilis* was characterized by higher amounts of artemisia ketone (46.7 %), among the thirty components comprising 95.4 % of the total oil detected.[39]

In another study, the major composition of the essential oil of *Achillea nobilis* L. from Iran analysed by GC and GC-MS. The essential oil of *A. nobilis* L. subsp *neilreichii* (Kerner) Formanek was found to contain: α-thujone (34.06 %), 1, 8-cineole (14.14 %) and β-cedren epoxide (9.63 %) as the major constituents.[23]

***Achillea wilhelmsii* C. Koch.**
This plant is from medicinal plants in Iran customary medicine. The aim of this study was to appraise of effects of the leaves essential oil and methanol extract of the *Achillea wilhelmsii* on the growth of the bacteries. In this study after collecting and provision plant, leaves essential oil were obtained by hydro-distillation and leaves methanol extract were obtained using a Soxhlet apparatus. The effects of methanol extract antimicrobial were assessed using Agar Well Diffusion method and also using Dilution Test method. The effects of essential oil antimicrobial were determined by using Agar Dilution Assay. Dates were analyzed using Chi-square and AVONA test in the $p<0/001$. Leaves methanol extract had more effect against *Bacillus cereus* and *Staphylococcus aureus* bacteries and showed weak effect against *Escherchia coli* and was not observed any growth inhibition effect against *Pseudomonas aeroginosa*, also leaves essential oil had inhibition effect against *Bacillus cereus*, *Staphilococcus aureus* and *Escherchia coli* and did not have any inhibition effect against *Pseudomonas aeroginosa*. Leaves methanol extract and essential oil of *Achillea wilhemsii* have antibacterial effects, therefore we will be able perform researches with extraction of this plant effective compound for the treatment of infectious diseases.[40]

In another study, the major composition of the essential oil of *Achillea wilhelmsii* from aerial parts growing wild in Iran analysed by GC and GC-MS. The oil of *A. wilhelmsii* C. Koch. was characterized by higher amounts of camphor (19.66 %), 1,8 cineole (9.06 %) and α-pinene (10.00 %).[23]

In another study, Composition of the volatile oil of the aerial parts of *Achillea wilhelmsii* C. Koch (Compositae) was investigated by GLC and GC-MS. Fifty-seven components representing 98.5% composition of the essential oil were characterized. The main components of the oil were carvacrol (25.1%), linalool (11.0%), 1, 8-cineol (10.3%), E-nerolidol (9.0%) and borneol (6.4%).[41]

In another study, aerial parts of *A. Wilhelmsii* were tested against five bacterial strains including *Streptococcus iniae*, *Yersinia ruckeri*, *Vibrio angularum*, *Aeromonas hydrophila* and *Pseudomonas aeruginosa* and four pathogenic fungi namely *Saprolegnia* sp., *Fusarium solani*, *Candida albicans*and *Aspergillus*

flavus. Also, the oil constituents of *A. Wilhelmsii* were analyzed by gas chromatography/mass spectrometry (GC/MS). The major composition of the essential oil of *A. Wilhelmsii* was 1.8-cineol (25.2%), Camphor (18.9%), Linalool (6.9%), Borneol (5.7%) and Artemisia alcohol (4.3). All microorganisms showed more sensitivity to essential oil of *A. Wilhelmsii* than the control antibiotics. Maximum antibacterial and antifungal activity was observed against *Y. ruckeri* (25.4 mm) and *C. albicans* (25 mm) respectively, while *S. iniae* (16.4 mm) and *A. flavus* (14 mm) exhibited the least sensitivity. In addition, MIC test showed that minimum concentrations of the essential oil ranged from 125 to 800 µg/l were able to inhibit the growth of the selected bacterial and fungal pathogens.[42]

In another study, *chillea wilhelmsii* C-Koch is an endemic plant that has relatively wide distribution in different parts of Iran. The concentrations of 20, 30, 50 and 400 mg/ml of methanol extract were prepared. Antibacterial activities were examined by agar dilution and well diffusion methods against S*taphylococcus aureus*, *Bacillus cereus*, *E. coli* and *Pseudomonas aeroginosa*. Minimum Inhibitory Concentration (MIC) or Minimum Bactericidal Concentration (MBC) was carried out by tube dilution and well-diffusion methods. Methanol extracts exhibited inhibitory effects on *S. aureus*, *B. cereus* and *E. coli* with a range of MIC values extended from 6.25 to 25 mg/ml. Essential oil at concentration of 1000µg/ml was active against *S. aureus*, *B. cereus* and *E. coli*. They did not have any activity on *P. aeroginosa*. Methanol extract and essential oil of aerial part of *Achillea wilhelmsii* inhibited growth of pathogenic bacteria especially gram positive bacteria. Clinical applications of these materials needed further investigations.[43]

A total of 94 compounds were identified in six species of *A. millefolium*, *A. filipendulina*, *A. tenuifolia*, *A. santolina*, *A. biebersteinii* and *A. eriophora*. The major constituents of the leaves in the tested genotypes were determined as germacrene-D, bicyclogermacrene, camphor, borneol, 1,8-cineole, spathulenol and bornyl acetate. As far the major compounds, four chemotypes were defined as: (I) spathulenol (1.6–34.3%) + camphor (0.2–15.6%) (7 accessions); (II_1) germacrene-D (18.7–23.9%) + borneol (7.9–8.26%) + bornyl acetate (11.5–14.6%) (5 accessions); (II_2) germacrene-D (13.2–36.2%) + bicyclogermacrene (5.9–8.4%) + 1, 8-cineole (15.2–19.4%) + camphor (14.9–23.3%) (2 accessions); (III) borneol + camphor (52.04–63.2) (2 accessions); (IV) germacrene-D (45.8–69.6%) (3 accessions) . The relationships of chemotypes with soil type and climatic conditions of collected regions were assessed, as probable reasons of high variations in essential oil components, and discussed.[44]

CONCLUSION

As mentioned in this review constituents and including *Achillea albicaulis* C.A. Mey.; *A. aucheri* Boiss.; *A. biebersteinii* Afan.; *A. eriophora* DC.; *A. kellalensis* Boiss. et Hausskn; *A. millefolium* L.; *A. nobilis* L.; *A. oxyodonta* Boiss.; *A. pachycephala* Rech.f.; *A. Tenuifolia* LAM.; *A. talagonica* Boiss.; *A. vermicularis* Trin. And *Achillea wilhelmsii* C. Koch. have been described.

Achillea species produce at least three classes of compounds Terpenoids especially sesquiterpene lactones, Flavonoids and Polyacetylenes. Most attention has been focused on sesquiterpene lactones. The Iranian species has been investigated chemically and presence of monoterpenes, sesquiterpenes and essential oils reported. In fact, the Iranian *Achillea* species has yielded a considerable amount of new, interesting terpenoids.

ACKNOWLEDGMENT

The authors thank Dr. V. Mozaffarian for identification of the plant materials.

REFERENCES

1. Candolle, A.P. de**,** Prodromus Systematis Naturalis. Pub. Treuttel et Wurtz. Paris, 1873; 31.
2. Chandler RF, Hooper SN, Harvey MJ. 1982. Ethnobotany and phytochemistry of yarrow, Achillea millefolium, Compositae. Econ Botany, 1982; 36(2): 203-223.
3. Rechinger K.H., *Achillea* In: Flora Iranica, Compositae, Hedge I.C. (eds.), Akademische Druk and Verlagsanstalt, Graz, Austria: 1987, 67.
4. Mozaffarian V. A Dictionary of Plant Names; Tehran, Farhang Moaser Publishers, 1996.
5. Zakaria M. Isolation and characterization of active compounds from medicinal plants. Asia Pac. J. Pharmacol. 1991; 6: 15-20.
6. Kelmanson JE, Jager AK, Van Staden J. Zulu medicinal plants with antibacterial activity. J. Ethnopharmacol. 2000; 69: 241-246.
7. Srinivasan D, Sangeetha N, Suresh T, Perumalsamy PL. Antimicrobial activity of certain Indian medicinal plants used in folkloric medicine. J. Ethnopharmaco, 2001; 74: 217-220.
8. Delgado B, Palop A, Fernandez PS, Periago PM. Combined effect of thymol and cymene to control the growth of *Bacillus cereus* vegetative cells. Eur. Food Res. Technol., 2004; 218: 188-193.
9. Nasar-Abbas SM, Kadir HA. Antimicrobial effect of water extract of sumac (*Rhus coriaria* L.) on the growth of some food borne bacteria including pathogens. Int. J. Food Microb. 2004; 97: 63-69.
10. Ozcan M, Erkmen O. Antimicrobial activity of the essential oils of Turkish plant spices. Eur. Food Res. Techno., 2001; 212: 658-660.
11. Fazeli MR, Amin GhR, Ahmadian AMM, Ashtiani H, Jamalifar H, Samadi N. Antimicrobial activities of Iranian sumac and avishan-e-shirazi (*Zataria multiflora*) against some food-borne bacteria. Food Control, 2007; 18: 646-649.
12. Rustaiyan A, Nazarians L. Isolation of the Sesquiterpene Lactone Deacetoxy malricarin from

Achillea eriophora DC. Fitoterapia, 1977; 48: 175-176.
13. Rustaiyan A, Sharif Z, Tajarodi A, Sadjadi A. Sesquiterpene Lactones from *Achillea micrantha*. Phytochemistry, 1987; 26: 2856-2857.
14. Greger H, Grenze M, Bohlmann F. Polyacetylenic Compounds. Part 260. Amides from *Achillea* Species and *Leucocyclus formosus*. Phytochemistry, 1981; 20: 2579-2581.
15. Mishurova SS, Abbasov RM, Malinovskaya TA, Mamedalieva FM. Rastit Resur, 1985; 21: 69.
16. Goldberg AS, Mueller EC, Eigen E, De Salva SJ. Isolation of the Anti-inflammatory Principles from *Achillea millefolium* (Compositae). J Pharm Sci, 1969; 58: 938.
17. Orkiszewska A, Lobarzewski R, Jędrzejewska M. Pol PL, 1985; 119: 889.
18. DerMarderosian A. The review of natural products. Missouri: Facts and Comparison press, 2001; 636-637.
19. Atta-ur-Rahman, Saeed HM, Ahmad VU. Pakistan Encyclopedia Planta Medica. Hamdard Foundation, Karachi, 1986; 126.
20. Alkofati A, Batshoun R, Owais W, Najib N. Fitoterapia, 1996; 57: 435-442.
21. Weyerstahl P, Marschall H, Seelmann I, Rustaiyan A. Constituents of the Essential Oil of *Achillea eriophora* DC. Flavour Fragrance J, 1997; 12: 71-78.
22. Maghsoodlou MT, Valizadeh J, Mottaghipisheh J, Rahneshan N. Evaluation of The Essential Oil Composition and Antioxidant Activity of *Achillea eriophora* as a Medicinal Plant. J. Herbal Drugs, 2015; 5(4): 187-192.
23. Ghani A, Azizi M, Hassanzadeh-Khayyat M, Phlavanpour AA. Essential Oil Composition of *Achillea eriophora*, *A. nobilis*, *A. biebersteinii* and *A. wilhelmsii* from Iran. J ESSENT OIL BEAR PL, 2008; 11(5): 460-467.
24. Rustaiyan A, Komeilizadeh H, Sanaei Shariatpanahi M, Jassabi AR, Masoudi S. Comparative Study of the Essential Oils of Three *Achillea* Species from Iran. J ESSENT OIL RES, 1998; 10: 207-209.
25. Rustaiyan A, Mojab F, Masoudi S, Yari M. The Composition of The Essential Oil of *Achillea tenuifolia* Lam. From Iran. Iran. J Chem Chem Eng, 1999; 18(2): 108-110.
26. Aghajani Z, Masoudi S, Rustaiyan A. Composition of the Essential Oil from Flowers of *Achillea tenuifolia* Lam. J ESSENT OIL RES, 2000; 12: 723-724.
27. Shafaghat A. Composition and Antibacterial Activity of the Volatile Oils from Different Parts of *Achillea tenuifolia* Lam. from Iran. J Med Plant, 2009; 8(31): 93-98.
28. Feizbakhsh A, Tehrani MS, Rustaiyan A. Composition of the Essential Oil of *Achillea albicaulis* C.A. Mey. J ESSENT OIL RES, 2003; 15: 21-22.
29. Rustaiyan A, Masoudi S, Yari M. The Essential Oil of *Achillea aucheri* Boiss. and *Achillea kellalensis* Boiss. et Hausskn from Iran. J ESSENT OIL RES, 1999; 11: 19-20.
30. Esmaeili A, Nematollahi F, Rustaiyan A, Moazami N, Masoudi S, Bamasian Sh. Volatile constituents of *Achillea pachycephala*, *A. oxyodonta* and *A. biebersteinii* from Iran. Flavour Fragrance J, 2006; 21(2): 253-256.
31. Motavalizadehkakhky AR, Shafaghat A, Zamani HA, Akhlaghi H, Mohammadhosseini 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(19): 1280-1292.
32. Shafiee Dastjerdi L, Mazoji A. Comparative chemical composition of the essential oils of Iranian *Achillea oxyodonta* from different ecological regions. J Appl Pharm Sci, 2015; 5(5): 106-109.
33. Dehghan GhR, Elmi F. Essential oil combination of three species of *Achillea* growing wild in East Azerbaijan- Iran. Adv Herb Med, 2014; 1(1): 22-28.
34. Kazemi M. Phytochemical and Antioxidant Properties of *Achillea Millefolium* from the Eastern Region of Iran. Int J Food Prop, 2015; 18(10): 2187-2192.
35. Candan F, Unlu M, Tepe B, Daferera D, Polissiou M, Sökmen A, Akpulat HA. Antioxidant and antimicrobial activity of the essential oil and methanol extracts of *Achillea millefolium* subsp. millefolium Afan. (Asteraceae). J Ethnopharmacol, 2003; 87(2-3): 215-220.
36. Issabeagloo E, Taghizadieh M, Abri B. Antimicrobial effects of yarrow (*Achillea millefolium*) essential oils against *Staphylococcus* species. Afr J Pharm Pharmacol, 2012; 6(41): 2895-2899.
37. Yassa N, Saeidnia S, Pirouzi R, Akbaripour M, Shafiee A. Three phenolic glycosides and immunological properties of *Achillea millefolium* from Iran, population of Golestan. DARU, 2007; 15(1): 49-52.
38. Mazandarani M, Mirdeilami SZ, Pessarakli 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(16): 1063-1069.
39. Rustaiyan A, Masoudi S, Ezatpour L, Danaii E, Taherkhani M, Aghajani Z. Composition of the Essential Oils of *Anthemis Hyalina* DC., *Achillea Nobilis* L. and *Cichorium intybus* L. Three Asteraceae Herbs Growing Wild in Iran. J ESSENT OIL BEAR PL, 2011; 14(4): 472-480.
40. Amjad L, Mohammadi-Sichani M, Mohammadi-Kamalabadi M. Potential Activity of the *Achillea wilhelmsii* Leaves on Bacteria. Int J Biosci Biochem Bioinf, 2011; 1(3): 216-218.
41. Javidnia K, Miri R, Sadeghpour H. Composition of the Volatile Oil of *Achillea wilhelmsii* C.Koch from Iran. DARU, 2004; 12(2): 63-66.

42. Adel M, Abedian Amiri A, Divband M, Safari R, Khalili E. Chemical Composition and Antimicrobial Activity of *Achillea wilhelmsii* C. Koch Essential Oil Against Selected Bacterial and Fungal Pathogens Isolated Fish. J Herbal Drugs, 2015; 6(2): 65-71.
43. Mohammadi-Sichanim M, Amjad L, Mohammadi-Kamalabadi M. Antibacterial Activity of Methanol Extract and Essential Oil of *Achillea wilhelmsii* Against Pathogenic Bacteria. Zahedan J Res Med Sci, 2011; 13(3): 14-19.
44. Rahimmalek M, Sayed Tabatabaei BE, Etemadi N, Goli AH, Arzani A, Zeinali H. Essential oil variation among and within six *Achillea* species transferred from different ecological regions in Iran to the field conditions. Ind Crops Prod, 2009; 29(2-63): 348-355.