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REVIEW ARTICLE

The Genus *Artemisia*: A Comprehensive Review

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Abstract

Context: Medicinal plants are nature′s gift to human beings to make disease free healthy life, and play a vital role to preserve our health. They are believed to be much safer and proven elixir in the treatment of various ailments. The genus *Artemisia* (Astraceae) consists of about 500 species, occurring throughout the world. The present review comprises the ethnopharmacological, phytochemical and therapeutic potential of various species of *Artemisia*.

Objective: The aim of this this review is to bring together most of the available scientific research conducted on the genus *Artemisia*, which is currently scattered across various publications. Through this review the authors hope to attract the attention of natural product researchers throughout the world to focus on the unexplored potential of *Artemisia* species.

Methods: This review has been compiled using references from major databases such as Chemical Abstracts, Medicinal and Aromatic Plants Abstracts, ScienceDirect, SciFinder, PubMed, King′s American Dispensatory, Henriette′s Herbal Homepage, Dr. Duke′s Phytochemical and Ethnobotanical Databases.

Results: An exhaustive survey of literature revealed that the different species of *Artemisia* have a vast range of biological activities including antimalarial, cytotoxic, antihepatotoxic, antibacterial, antifungal and antioxidant activity. Some very important drug leads have been discovered from this genus, notably artemisinin, the well known antimalarial drug isolated from the Chinese herb *Artemisia annua*. Terpenoids, flavonoids, coumarins, caffeoylquinic acids, sterols and acetylenes constitute major classes of phytoconstituents of the genus.

Conclusion: Various species of *Artemisia* seems to hold great potential for in-depth investigation for various biological activities, especially their effects on the central nervous and cardiovascular systems.

Keywords: Antimalarial, antimicrobial, *Artemisia*, cytotoxic, flavonoids, terpenoids.

Introduction

A survey by the World Health Organization reported that about 80% of the world′s populations rely on non-conventional medicines, especially herbal sources, in their primary healthcare (Chan, 2003). Medicinal herbs are the local heritage with global importance. The world is endowed with a rich wealth of medicinal herbs. Owing to the global trend towards improved "quality of life", there is considerable evidence of an increase in demand for medicinal plants (Kotnis et al., 2004). Use of plants for treating various ailments of both humans and animal is a practice as old as human life itself. India is richly endowed with a wide variety of plants having medicinal value. These plants are widely used by all sections of society whether directly as folk remedies or indirectly as pharmaceutical preparations of modern medicine (Bhagwati, 2003). In the current scenario, focus on plant research has increased all over the world and a large body of evidence has collected to show the immense potential of medicinal plants used in various traditional systems. Medicinal plants are a major source of biodynamic compounds of therapeutic value, but the different variety of plants with different therapeutic properties is quite astonishing (Harsha et al., 2002).

The present review emphasizes the botanical, ethnopharmacological, phytochemical, and pharmacological

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reports and clinical studies on the various species of *Artemisia*. Through this review, the authors hope to attract the attention of natural product researchers throughout the world to focus on the unexplored potential of the *Artemisia* species. This genus needs to be investigated systematically so that potential species can be exploited as therapeutic agents.

The genus *Artemisia*

The genus *Artemisia* is one of the largest and most widely distributed genera of the family Astraceae (Compositae). It is a heterogenous genus, consisting over 500 diverse species distributed mainly in the temperate zones of Europe, Asia and North America. These species are perennial, biennial and annual herbs or small shrubs (Watson et al., 2002; Mehrdad et al., 2007).

General morphology

General morphological features of the genus *Artemisia* is described as leaves alternate, capitula small, usually racemouse, paniculate or capitate, inflorescence, rarely solitary; involucral bracts in few rows, receptacle flat to hemispherical, without scales and sometimes hirsute; florets all tubular, achenes obovoid, pappus absent or sometimes a small scarious ring (Heywood & Humphries, 1997; Mucciarelli & Maffel, 2002; Polyakov & Shishkin, 1995).

Ethnopharmacology

Traditionally, *Artemisia absinthium* (L.) has been used as an antispasmodic, febrifuge, stomachic, cardiac stimulant, anthelmintic, for the restoration of declining mental function and inflammation of the liver, and to improve memory (Wake et al., 2000; Guarrera, 2005). *Artemisia afra* (Jacq.) has been used in the treatment of a variety of ailments such as coughs, colds, headaches, dyspepsia, colic, malaria, diabetes, bladder and kidney disorders, and also used as a purgative (Thring & Weitz, 2006). *Artemisia annua* (L.) listed in the Chinese pharmacopoeia has been used as a remedy for various fevers including malaria (Mueller et al., 2000). *Artemisia asiatica* (Nakai) have been used in traditional oriental medicine for the treatment of cancer, inflammation, infections and ulcerogenic diseases (Lim et al., 2008). *Artemisia douglasiana* (Bess.) has been used to treat premenstrual syndrome and dysmenorrhea (Garcia & Adams, 2005). *Artemisia dracunculus* (L.) has been used as antidiabetic and anticoagulant (Swanston-Flatt et al., 1991; Shahriyary & Yazdanparast, 2007). *Artemisia judaica* (L.), an Egyptian medicinal plant has been used in the treatment of gastrointestinal disorders (Liu et al., 2004). In the western USA, *Artemisia tripartite* (Rydberg) (three-tip sagebrush) has been used in the treatment of colds, sore throats, tonsillitis, headaches and wounds by Native Americans (Moerman, 1998). *Artemisia verlotorum* (Lamotte) has been used in folk medicine of some countries of Tuscany, Italy, as a remedy for hypertension (Calderone et al., 1999). *Artemisia vestita* (Wall. ex Bess.) is a common traditional Tibetan medicinal plant which has been used widely in China for treating various inflammatory diseases (Ye et al., 2008). *Artemisia vulgaris* (L.) has been used as an analgesic, antiinflammatory, antispasmodic and in liver diseases (Gilani et al., 2005; Temraz & El-Tantawy, 2008).

Phytochemistry

An exhaustive literature survey on phytochemical reports of the genus *Artemisia* reveals that the *Artemisia* species comprise mainly terpenoids, flavonoids, coumarins, caffeoylquinic acids, sterols and acetylenes. Amongst various species of *Artemisia*, *A. absinthium*, *A. afra*, *A. annua, A. maritima* and *A. scoparia* (Waldst et Kit) are especially rich in terpenoids. Table 1 summarizes the phytoconstituents of various species of *Artemisia*, and Figure 1 represents the chemical structures of the most commonly occurring major volatile compounds.

Pharmacological and clinical reports

The essential oils distilled from the aerial parts of *A. absinthium* inhibited *in vitro* growth of *Candida albicans* and *Saccharomyces cerevisiae* (Juteau et al., 2003). Free-radical scavenging activity of *A. absinthium* extracts has been reported (Jasna et al., 2004). The antioxidative activity was tested by measuring their ability to scavenge stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical and reactive hydroxyl radical during the Fenton reaction trapped by 5,5-dimethyl-1-pyrroline-*N*-oxide, using electron spin resonance spectroscopy. It has been reported that crude aqueous extracts and crude ethanol extracts of the aerial parts of *A. absinthium* exhibit anthelmintic activity in comparison to albendazole against the gastrointestinal nematodes of sheep (Tariq et al., 2009). Recently, we have shown that *A. absinthium* exhibited neuroprotective effects against focal ischemia and reperfusion-induced cerebral injury in rats (Adams & Garcia, 2006).

Remberg et al. (2004) reported that a nasal spray formulation containing an extract characterised by a mixture of essential oils and flavonols from the *A. abrotanum* genotype "Tycho", appear to be clinically useful and suitable for the prophylactic and therapeutic management of patients with allergic rhinitis and adjuvant symptoms. Flavonols isolated from the methanol extract of *A. abrotanum* exhibited spasmolytic activity against carbacholine-induced contraction of guinea-pig trachea (EC_{50} value 20-30 μm) (Bergendorff & Sterner, 1995). Moreover, *A. abrotanum* extract exhibited *in vitro* antimicrobial activity against *Malassezia* spp., *Candida albicans* and *Staphylococcus aureus.*

A. afra has been reported to have a broad spectrum of inhibitory activity against microorganisms (Muyima et al., 2002). All other pharmacological activities of this species have been reported by Liu et al. (2009).

Artemisinin, an endoperoxide sesquiterpene lactone isolated from the Chinese medicinal plant *A. annua*, has provided a new class of highly effective antimalari-

Table 1. Phytoconstituents of various species of ***Artemisia***.

Species	Phytoconstituents
A. absinthium	**Essential oil** containing (Z)-thujone, (E)-thujone (Guarrera, 2005), myrcene, trans-sabinyl acetate (Daise et al., 2008), chrysanthenyl acetate, β-pinene, sabinene, 1,8-cineole, artemisia ketone **[1]**, linalool, hydrocarbon monoterpenes (Kordali et al., 2005), **sesquiterpene lactones** (Leung, 1980); **polyphenolic compounds** (Kordali et al., 2005), **flavonoid** (Oswiecimska et al., 1965); **tannins** (Slepetys, 1975); **lignans** (Greger & Hofer, 1980)
A. abrotanum	**Volatile oil** containing 1,8-cineole, linalool, davanone, thujyl alcohol (Tunon et al., 2006); **flavonols** (Remberg et al., 2004); **tannins** (Kolodziejski et al., 1959), caffeic acid (Kranen-Fiedler, 1956); **coumarins** (Tunon et al., 2006)
A. afra	**Volatile** and **non volatile** secondary metabolites such as **monoterpenoids**, **sesquiterpenes; glaucolides, guaianolides**; **flavonoids (**Liu et al., 2009)
A. annua	**Volatile oil** containing cineole, α-pinene, camphene, borneol, camphor, germacrene-D, hydroxyl amino isoartemisia ketone (Woerdenbag et al., 1994), **sesquiterpene lactones** artemisinin, artemisinic acid, arteanniun B, artemisinin derivatives artesunate, trioxanes, artemether artemisinin G and arteether (**He et al., 2009**; Bhakuni et al., 1990; Wei et al., 1992); **phenolic compounds**, **flavones** (Han et al., 2008; Han et al., 2007)
A. arborescens	**Terpenes** thujone, borneol, thujol (Rattu & Maccioni, 1953); **flavone** (Mazur & Meisels, 1955); **fatty acids** (Rattu & Maccioni, 1953)
A. asiatica	**Volatile oil** (Kordali et al., 2005); **flavone** (Min-Jung et al., 2005); **alkaloids** (Heo et al., 2000); **artemisolide** (Reddy et al., 2006)
A. capillaris	**Volatile oil** containing β-pinene (**Cha** et al., 2005), camphor, 1,8-cineole, β-caryophyllene, borneol (Kim et al., 2008); **flavonoids** (Min-Jung et al., 2005)
A. campestris	**Volatile oil** containing α- and β-pinene, 1,8-cineole, 1-thujone, thujyl alcohol, geraniol (Guven, 1963); **flavonoids** (Cavaleiro, 1986)
A. douglasiana	**Monoterpenes** such as cineole, camphor, linalool, isothujone, thujone (James & Cecilia, 2006), **Sesquiterpene lactones** such as vulgarin and psilostachyin (James & Cecilia, 2006)
A. dracunculus	**Volatile oil** containing menthol, anethole, anisol, anisic acid, d-sabinene, estragole, limonene, myrcene, ocimene, α-phellandrene, anisaldehyde (Bayrak et al., 1986), β-pinene, 1-methoxy-4-(2-Propenyl)-benzene, 1R-α-pinene (Zhang et al., 2005); **coumarins** (Hofer et al., 1986); **polyphenolic compounds** (Govorko et al., 2007); **glucosides** (Jakupovic et al., 1991)
A. judaica	**Volatile components** piperitone, trans-ethyl cinnamate (Abdelgaleil Samir et al., 2008), Judaicin (Saber & Khafagy, 1958b); **phenolic contents** (Saber & Khafagy, 1958a)
A. maritima	**Volatile oil** containing β-thujone, α-thujone, α-pinene, sabinene, p-cymene, sabinol cuminaldehyde, isobutyrate, isovalerate, sesquiterpene peroxysemiketal **[2]** (Ishibashi et al., 1965), 1,8-cineole, camphor, borneol, chrysanthenone (Jaitak et al., 2008), **sesquiterpene lactones** santonin **[3]** (Kaczmarek & Malek, 1955); **fatty acids** (Borsutzki, 1955)
***A. mogoltavica* (Poljakov)**	**Essential oil** containing camphor, thujone, cineole (Goryaev & Shabanov, 1953), **sesquiterpene lactone** (Sinitsyn & Sinitsyn, 1960)
A. monospermal	**Eudesmane sesquiterpenes** (Stavri et al., 2005); **coumarins** (Hammoda et al., 2008)
A. nilagirica	**Terpenoids**; **alkaloids**; **amino acids**; **flavonoids**; **quinines**; **tannins** (Abdul & Waheeta, 2010)
A. scoparia	**Volatile oil** containing α-pinene, methylheptenone, 1,8-cineole, carvone, 1-thujone, α-thujadicarboxylic acid, 1-thujyl alcohol, geranyl acetate, eugenol, semicarbazone, (Z)-beta-ocimene, γ-terpinene (Singh et al., 2009), beta-myrcene, p-cymene and dl-limonene (Singh et al., 2008); **fatty acids** (Parihar & Dutt, 1950); c**oumarins** (Ali et al., 2003); **pyrogallol tannins** (Maksudov et al., 1962); **cholagogic components** (Qi-Wei et al., 2002); **flavonoids** (Chandrasekharan et al., 1951), **flavones** (Lin et al., 2004)
A. tripartite	**Guaianolides** cumambrin B (Irwin & Geissman, 1969); biologically-active **polysaccharides** (Xie et al., 2008)
A. verlotorum	**Volatile principles** 1-camphene, cineole, fenchone, α-phellandrene, β-thujone, thujyl alcohol, cadinene; **fatty acids** valeric acid, palmitic acid (Covello, 1941)
A. vestita	**Essential oil** containing 1,8-cineole, α-, β-, γ-himachalene, caryophyllene, germacrene D, himachalol, santolina alcohol **[4]**, thujones, thujanols (Weyerstahl et al., 1987); **flavonoids** (Trumpowskaand & Olszewski, 1968)
A. vulgaris	**Terpenes** p-cymene, fenchone, α- and β-thujone, cineole, camphor, β-pinene, 4-terpinenol, borneol (Trumpowskaand & Olszewski, 1968; Govindaraj et al., 2008), α-thujone, α-terpineol, geraniol, caryophyllene (Govindaraj et al., 2008); **coumarins** (Murray & Stefanovic, 1986); **sterols** (Ragasa et al., 2008); **caffeoylquinic acids** (Carnat et al., 2000)

als. Artemisinin-based combination therapies are now generally considered as the best current treatment for uncomplicated *Plasmodium falciparum* malaria (He et al., 2009). In addition, the essential oil has shown antioxidant activity equivalent to 18% of the reference compound (α-tocopherol). Dihydro-epideoxyarteannuin B and deoxyartemisinin isolated from the sequiterpene lactone-enriched fraction obtained from the crude ethanol extract of *A. annua* exhibited antiulcerogenic activity against ethanol and indomethacin-induced ulcer models in rats (Foglio et al., 2002). It has been reported that oral administration of artemisinin (35 or 75 mg/kg) isolated from *A. annua* can adversely affect post-implantation development and pregnancy in the rat (Boareto et al., 2008).

Essential oil isolated from *Artemisia arborescens* (L.) has been shown antiviral activity against HSV-1 and HSV-2 (Saddi et al., 2007).

DA-9601, a standardized extract of *A. asiatica* has been shown to exhibit chemopreventive effects against

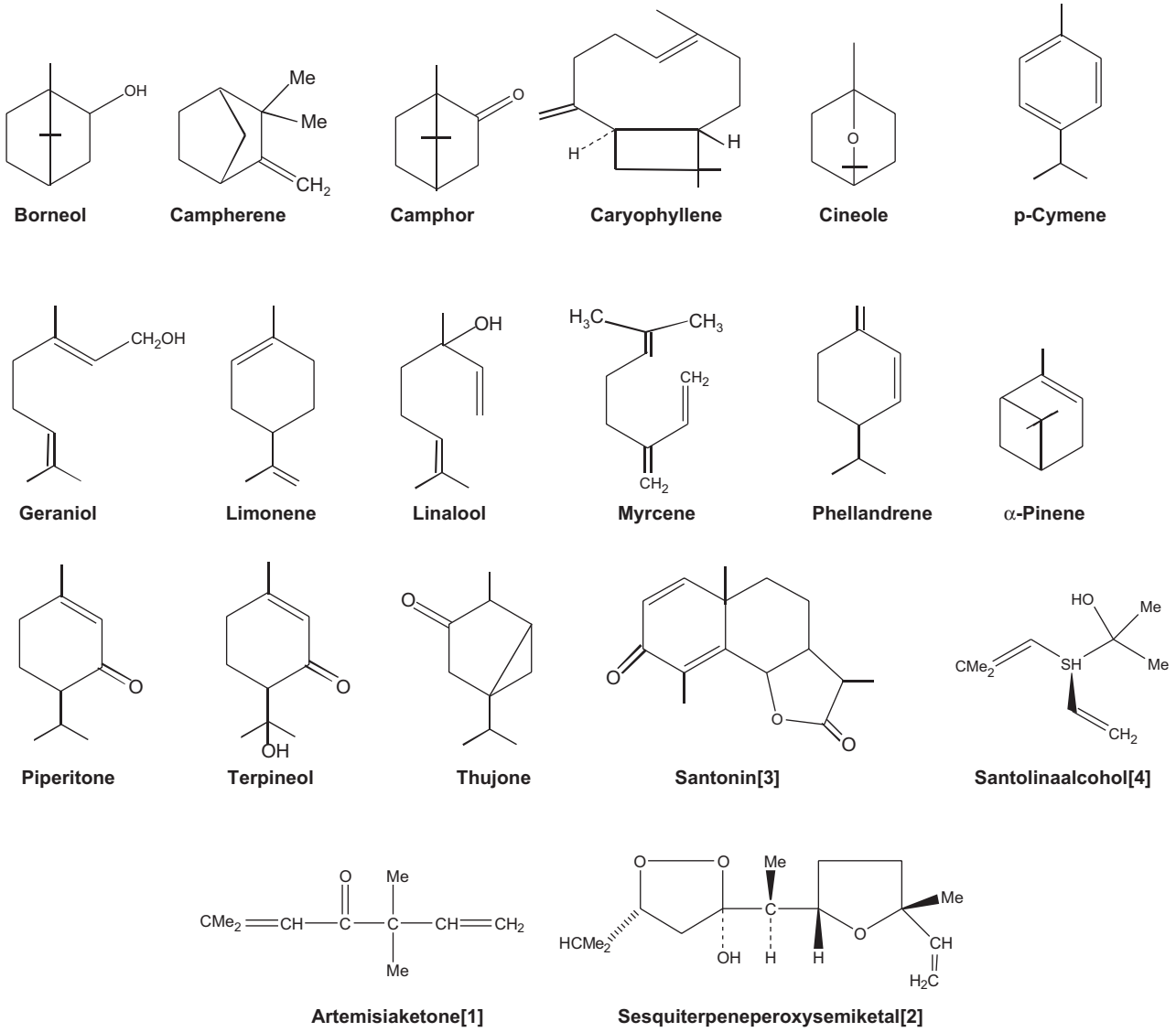

Figure 1. Chemical structures of the commonly occurring major volatile components of *Artemisia* species.

azoxymethane-initiated and dextran sulfate sodium-promoted mouse colon carcinogenesis (Ryu et al., 1998). The ethanol extract of *A. asiatica* has been reported to inhibit inflammatory activation of mouse microglial cells as determined by the production of nitric oxide and the expression of inducible nitric oxide synthase and inflammatory cytokine. The extract also protected nerve growth factor-differentiated PC12 cells against microglial cytotoxicity (Lim et al., 2008). The monoterpene alcohol fraction isolated from *A. asiatica* exhibited antibacterial and antifungal activity (Kalemba et al., 2002).

Extract of *Artemisia campestris* (L.) has been reported to scavenge radicals formed by carbon tetrachloride treatment resulting in protection against carbon tetrachloride-induced liver toxicity (Aniya et al., 2000).

Hong and Lee (2009) reported that the ethyl acetate fraction of *Artemisia capillaris* (Thunb.) (ACE) exhibit excellent protective effect by strengthening the antioxidant defense system, reducing the generation of reactive oxygen species (ROS) and damaging oxidative substances in the liver of high-fat diet induced obese mice. Moreover, ACE also exhibited significant ROS scavenging and protective effect against DPPH radical, superoxide, hydroxyl and nitric oxide radical (Hong et al., 2007). Chloroform extract of *A. capillaris* has been reported to have anticarcinogenic activity versus DMBA-induced mouse epidermal carcinogenesis (Kim et al., 2008). Flavonoids and a coumarin (6,7-dimethylesculetin) isolated from the buds of *A. capillaris*, showed significant antihepatotoxic activity by means of carbon tetrachloride-induced liver lesions *in vivo* and *in vitro* (Kiso et al., 1984). Tablets prepared from *A. capillaris* have potential antiviral activity against hepatitis B virus replication *in vitro* (Jin et al., 2005). Capillin, a component of the essential oil isolated from *A. capillaris* exhibited antimicrobial activity against *Trichophyton mentagrophytes, Pyricularia oryzae, Candida albicans, Bacillus subtilis, Escherichia coli* and *Cochliobolus miyabeanus* (Tanaka, 1961). Wu et al. (2001) reported that flavonoids, artemisidin A, coumarins, artemicapins A, B, C and D, and 70 other known com-

pounds isolated and characterized from the aerial part of *A. capillaris* exhibited antiplatelet aggregation activity, and significant activity against HIV replication in H9 lymphocytic cells. It has been shown that water extract of *A. capillaris* greatly increased the volume of bile secreted and its dry weight without any significant change in the IR spectrum (Mashimo et al., 1963). *A. capillaris* extract has been shown to protect beta cells on cytokine-induced beta-cell damage, by suppressing NF-kappaB activation (Kim et al., 2007). A water extract of *A. capillaris* exhibited protective effects against oxidative stress induced by 2,2′-azobis (2-amidinopropane) dihydrochloride in Sprague-Dawley male rats (Han et al., 2006). It has been reported that β-pinene, β-caryophyllene and capillene isolated from *A. capillaris* exhibited antimicrobial activity against 15 different genera of oral bacteria (Cha et al., 2005).

A. douglasiana was, and still is, used to treat premenstrual syndrome and dysmenorrhea (Garcia & Adams, 2005). The tea prepared from *A. douglasiana* has been used to relieve premenstrual syndrome. Dysmenorrhea is treated by chewing *A. douglasiana* seeds (James & Cecilia, 2006).

Ethanol extract of *A. dracunculus* has shown antihyperglycemic activity in diabetic and non-diabetic animals (Ribnicky et al., 2006). Benli et al. (2007) reported that methanol, chloroform and acetone extracts of *A. dracunculus* exhibit antimicrobial activity against nine bacteria and four yeasts strains by the disc diffusion method. Methanol extract and chloroform fraction of *A. dracunculus* at a concentration of 200 mug/mL, inhibited platelet adhesion to laminin coated wells by 50% and 60%, respectively (Shahriyary & Yazdanparast, 2007).

Two flavones, 4′,6,7-trihydroxy-3′,5′-dimethoxyflavone and 5′,5-dihydroxy-3′,4′,8-trimethoxyflavone isolated from *A. giraldii* showed antibiotic activity against *Staphylococcus aureus, Sarcina lutea, Escherichia coli, Pseudomonas aeruginosa, Aspergillus flavus* and *Trichoderma viride* (Zheng et al., 1996). Santolinylol, a monoterpene isolated from *Artemisia giraldii* (Pamp.) has been reported to have antifungal activity (Tan et al., 1999).

The ethanol-soluble part of a hot-water extract from *Artemisia iwayomogi* (Kitam.) has been reported to inhibit liver fibrosis induced by carbon tetrachloride in rats (Park et al., 2000).

Piperitone and trans-ethyl cinnamate isolated from *A. judaica* showed pronounced insecticidal and antifeedant activity against the third instar larvae of *Spodoptera littoralis* (Boisd), and antifungal activity against four plant pathogenic fungi (Abdelgaleil-Samir et al., 2008).

Aqueous methanol extract of *Artemisia maritima* (L.) at a dose of 500 mg/kg has been reported to exhibit hepatoprotective activity against acetaminophen and carbon tetrachloride-induced hepatic damage (Janbaz & Gilani, 1995). Cineole, a volatile oil isolated from the seeds of *A. maritima* shown to have more toxic effect as compared to that of santonin solution (0.0175%) (Janot & Mouton, 1930).

Essential oil isolated from flowering tops and leaves of *Artemisia monospermal* (Delile) has shown insecticidal activity against *Musca domestica vicina* and *Drosophila melanogaster* (Fahmy et al., 1968). Moreover, air-dried powdered drug of *A. monospermal* exhibited antispasmodic activity in the treatment of colic or in conditions associated with arterial hypertension (Sharaf et al., 1959).

The chloroform, diethyl ether, ethanol, hexane, methanol and petroleum ether extracts of *Artemisia nilagirica* (C.B. Clarke) leaf exhibited antibacterial activity against clinical and phytopathogenic bacteria. Methanol and hexane extracts showed high inhibition against clinical and phytopathogens, respectively (Abdul & Waheeta, 2010).

The monoterpenoid-rich essential oil isolated from *A. scoparia* (25-200 μg/mL) has shown a strong antioxidant and radical scavenging activity against hydroxyl ion and hydrogen peroxide (Singh et al., 2008). The essential oil isolated from *A. scoparia* exhibited strong insecticidal activity against stored-product insects (Negahban et al., 2006). *A. scoparia* has been reported to have anticholesterolemic, antipyretic, antiseptic, antibacterial, diuretic, purgative and vasodilator activity. Moreover, it has been used in the treatment of hepatitis, jaundice, and gall bladder inflammation (Yeung, 1985).

Artemisetin and chrysosplenetin isolated from *A. sieversiana* exhibited marked antitumor activity against melanoma B16, but only weakly retarded growth of *Pliss lymphosarcoma* (Chemesova et al., 1987). Moreover, essential oil isolated from *A. sieversiana* exhibited marked anti-inflammatory properties, apparently due to the azulenes in essential oil (Saratikov et al., 1986).

Biologically active polysaccharide fractions isolated from *A. tripartita* have been reported to exhibit macrophage-activating activity, enhancing production of intracellular ROS and release of nitric oxide, interleukin 6, interleukin 10, tumor necrosis factor alpha, and monocyte chemotactic protein 1. In addition, all fractions exhibited scavenging activity for ROS generated enzymatically or produced extracellularly by human neutrophils (Xie et al., 2008). Moreover, *A. tripartite* has been shown to have anti-fungal property (Tan et al., 1998).

Aqueous dried extract of *A. verlotorum* showed marked, but transient, hypotensive activity on the blood pressure of anaesthetized rats and on *in vitro* rat′s isolated aortae. This effect was mediated by a strong vasodilator action, closely linked to the release of endothelial nitric oxide and to the nitric oxide-guanosine 3′,5′-cyclic monophosphate pathway, caused by muscarinic receptor agonism (Calderone et al., 1999). Methanol and aqueous extracts of *A. verlotorum* exhibited *in vitro* antimycotic activity against *Saprolegnia ferax* (Macchioni et al., 1999).

The ethanol extract of the *A. vestita* exhibited significant inhibitory activity against the picryl chloride-induced contact hypersensitivity in mice. Cirsilineol, apigenin and 6-methoxytricin found to be responsible

for the immunosuppressive activity of *A. vestita* (Ye et al., 2008). In addition, the potential of these three components suggested new effective remedies for the treatment of T cell-mediated inflammatory diseases.

The hydroalcohol extract of *A. vulgaris* at doses of 500 and 1000 mg/kg significantly inhibited abdominal contortions by 48 and 59%, respectively. Rutin, a flavonoid glycoside, and caffeic acid derivatives were identified in this hydroalcohol extract (Pires et al., 2009). Recently, antioxidant properties of this plant have shown correlation with oxidative stress defense and different human diseases. The aqueous extract exhibited scavenging potential with IC_{50} value of 11.4 μg/mL for DPPH, the values were found to be close to those of standard rutin (10 μg/mL). On the other hand, *A. vulgaris* extract exhibited nitric oxide scavenging activity with IC_{50} value of 125 mg/mL (Temraz & El-Tantawy, 2008). Both aqueous leaf extract, and essential oil obtained by steam distillation of the leaves of *A. vulgaris* have been shown to have insecticidal and larvicidal effects, whereas, the dry powder of *A. vulgaris* leaves was not found to be a contact poison for flies (Chopra et al., 1940; Ferrolino-Calumpang & Padolina, 1985). Aqueous leaf extract of *A. vulgaris* has been shown to have a protective effect on tissue damage brought about by ischemia-reperfusion injury in the rat mesentery (Tigno et al., 2000). The crude extract of the aerial parts of *A. vulgaris* exhibited hepatoprotective effects against D-galactosamine and lipopolysaccharide-induced hepatitis in mice (Gilani et al., 2005).

Discussion and conclusion

Herbal medicines are used worldwide in the traditional treatment of various ailments and diseases. Some of these have undergone *in vitro* screening but the efficacy of such herbal preparations has seldom been rigorously proven in controlled clinical trials. Conventional drugs provide effective therapeutic property for certain types of diseases, but for antibiotics there is an increasing issue of drug resistance, and consequently, a further need to discover new bioactive natural products. Although natural products are not necessarily safer than the synthetic analogues, still many patients undergoing treatment choose herbal medicines. Hence, health care professionals should be aware of the available pharmacological evidence of several herbal preparations.

The present review emphasizes the botanical, phytochemical, ethnopharmacological, pharmacological reports, clinical study and toxicological information on the various species of *Artemisia*. An exhaustive survey of literature revealed that sporadic information is available on more than 30 species. These species have been investigated for their phytoconstituents and pharmacological activities. Terpenoids, flavonoids, coumarins, caffeoylquinic acids and sterols constitute major classes of phytoconstituents of the genus. All species are rich in terpenoids but *A. absinthium*, *A. afra*, *A. annua, A. maritima, A. scoparia* and *A. vulgaris* possess high percentage of terpenoids. While *A. capillaris, A. annua, A. dracunculus* and *A. scoparia* are rich in flavonoids and coumarins.

A. absinthium, A. afra and *A. nilagirica* have been reported to have a broad spectrum of inhibitory activity against a variety of microorganisms due to presence of essential oil. Nasal spray formulation containing an extract characterised by a mixture of essential oils and flavonols from *A. abrotanum* is found to be clinically useful and suitable for the prophylactic and therapeutic management of patients with allergic rhinitis and adjuvant symptoms (Remberg et al., 2004).

A Chinese medicinal plant, *A. annua*, has provided a new class of highly effective antimalarials due to presence of an endoperoxide sesquiterpene lactone, artemisinin. Artemisinin-based combination therapies are now considered as the best current treatment for uncomplicated *Plasmodium falciparum* malaria (He et al., 2009). DA-9601, a standardized extract of *A. asiatica* exhibits hepatoprotective and chemopreventive effect; *A. capillaries*, *A. scoparia* and *A. vulgaris* exhibits significant ROS scavenging and protective effect against DPPH radical, superoxide and hydroxyl radicals (Aniya et al., 2000; Hammoda et al., 2008; Temraz & El-Tantawy, 2008) due to presence of flavonoids and volatile oil. Moreover, tablets of *A. capillaris* have potential antiviral activity (Jin et al., 2005).

Despite a long tradition of use of some species of *Artemisia* for treatment of various ailments, little pharmacological work so far has been carried out to validate their traditional uses. Some species of *Artemisia* seem to hold great potential for in-depth investigation for various biological activities, especially their effects on the central nervous system (CNS) and cardiovascular system. Presently, the authors are involved in evaluating the CNS effects of traditionally used medicinal plants with a view to isolating bioactive constituents following the bioactivity directed fractionation protocols.

Declaration of interest

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