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DOI: [10.7275/R5571969](https://scholarworks.umass.edu/jmap/vol5/iss2/9)

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Phytochemical and Pharmacological Properties of Medicinal Plants from Uzbekistan: A Review

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Date received: September 24, 2015

Keywords: Biological activity, medicinal plants, phytochemistry, secondary metabolites, Uzbekistan.

ABSTRACT

Medicinal plants are a reservoir of biologically active compounds with therapeutic properties that over time have been discovered and used by diverse groups of people for treatment of various ailments. In this regard, Uzbekistan has an excellent historic research base of herbal medicines with about 70% of Uzbek households using medicinal plants to meet their health needs for several centuries. The flora of Uzbekistan includes more than 4500 species of vascular plants and over 600 of these plants are used in traditional or conventional medicines, significantly surpassing other areas by the absolute number of endemics and the percentage of endemism. The plants are a reservoir of secondary metabolites, suitable for use in pharmacological studies with a high possibility of observing biologically active constituents. The present review provides an up-to-date a report on the phytochemicals and pharmacological activity of the medicinal plants widely used in Uzbekistan. As a country, Uzbekistan appears to be a source of novel herbal drugs that have not yet been fully evaluated. We trust the present report will be useful for further investigations on the medicinal activity of indigenous plant species in Uzbekistan.

INTRODUCTION

The idea that plants are a reservoir of biologically active compounds with therapeutic properties has been well established, and since ancient time they have been used worldwide for the treatment of various ailments, including asthma, gastro-intestinal problems, skin disorders, respiratory and urinary complications, and hepatic and cardiovascular disease (Cousins and Huffman, 2002; Tian et al., 2014). The interest on demand for more plant derived drugs, which sometimes are considered as safe when compared to synthetic drugs, is increasing rapidly.

The medicinal value of these plants lies in chemical substances that produce a positive physiological action on the human body (Edeoga et al., 2005), and since plants synthesize an extremely diverse range of chemical compounds, they represent a great potential for the discovery and development of new pharmaceuticals (McChesney et al., 2007).

While numerous studies have validated the traditional use of medicinal plants by investigating the
phytochemicals present in active extracts (Van-Wyk and Wink, 2005; Palombo, 2006), many plants have not yet been scientifically studied to provide reports on their phytochemical constituents and their potential medicinal applications.

Traditional medicine of Central Asia is not widely known, and only in recent times has the scientific community focused attention on these plants and the medicinal uses developed in Uzbekistan. Until now, few sources of information are available in the literature (Mamedov et al., 2004; Sezik et al., 2004; Egamberdieva et al., 2013; Mamedov and Craker, 2001), and the sources of information in the literature make evident that new additional investigations and new scientific reports are necessary.

The flora of Uzbekistan includes more than 4500 species of vascular plants of which 9% are considered endemic. Over 600 of these plants have traditionally been used with many continuing to be used in traditional and conventional medicine for treatment of medical problems (Mamedov et al., 2004; Aripov, 1995a; National Biodiversity Strategy Committee 1998).

The diverse nature of the flora native to Uzbekistan has left many plants relatively unstudied that may well contain compounds with potential usefulness in new pharmaceuticals. The traditional use of medicinal plants in Uzbekistan is widespread and over 70% of Uzbek households have used medicinal plants for centuries, coming from a variety of plant families and suggesting that pharmacological studies would have a high probability of detecting active compounds. The majority of these plants, however, grow under harsh environmental conditions that limited access to plant material.

Investigative studies have demonstrated that many of the endemic plants of Uzbekistan contain flavonoids, alkaloids, tannins, saponins, phenolic compounds, coumarins, terpenes and ecdysteroids that could be potential sources for several effective drugs (Tulyaganov and Kozimova, 2005; Gapparov et al., 2007; Mamadalieva et al., 2011; Gapparov and Aripova, 2011; Siddikov et al., 2011; Yuldasheva et al., 2014). For example, Kogure et al. (2004) reported that plant species such as Ferula pallida, F. penninervis, Inula macrophylla, Prangos pabularia, P. tschimganica, and Rheum maximowiczii contain previously unknown antioxidants. Some of these antioxidants seem to have a unique mechanism of action. Several pharmacological activities of medicinal plants and their constituents, such as antimicrobial (Mamadalieva et al., 2008), anti-inflammatory, and antioxidative (Mulaudzi et al., 2013), cytotoxic (Manosroi et al., 2014), along with anabolic activity and chologentic action (Abdulkadirov et al., 2004), have been reported.

The purpose of this report is to summarize to date scientific studies on the phytochemical and pharmacological properties of plants native to Uzbekistan that may have significant medicinal attributes (Table 1).

**Phytochemical Profile**

The pharmacological benefits of medicinally important plants are primarily due to bioactive phytochemicals produced in the plant tissues as primary and secondary metabolites. These constituents have been identified as alkaloids (Varsha et al., 2013), glycosides (Firn, 2010), flavonoids (Varsha et al., 2013), phenolics (Puuponen-Pimiä et al., 2001), saponins (Vashist and Sharma, 2013), tannins (Varsha et al., 2013), and essential oils (Martinez et al., 2008), steroids (Madziga et al., 2010).

Early studies on native Uzbekistan plants detected anthocyanins and coumarins (Pulatova, 1969) and essential oils (Nuriddinov et al., 1997) in Perovskia scrophularifolia Bunge (Lamiaceae). Several alkaloids, iridoids, and secoiridoid glycosides, and flavonoid glycosides of Gentiana olivieri (Gentianaceae) have been reported (Rakhmatullaev et al., 1969; Ersöz et al., 1991). Another native plant from Uzbekistan, Helichrysum sp. (Asteraceae), contains flavonoids, phloroglucinol derivatives, and diterpenes (Suzgec et al., 2005). Su et al. (2000) identified several novel compounds from the roots of Ferula pallida (Apiaceae), a native plant of Uzbekistan that contains sesquiterpenes, phenylpropanoid derivatives, pallidones, and sesquiterpene chromone derivatives. The aerial part of Crambe kotschyanana Boiss. (Brassicaceae), an endemic plant in Uzbekistan, has been reported to contain coumarins, vitamin C, and β-carotene (Nikonov et al., 1965).
Alkaloids

Alkaloids, a class of nitrogen-containing organic compounds, are widely distributed in nature with more than 18,000 alkaloids having been discovered. These compounds have a lot of structural diversity and, in some instances, having the presence of one or more nitrogen atoms seems to be the only common feature among molecules of different chemical structures and of different sources. Alkaloids can be of microbial, plant and animal origin (Cushnie et al., 2014).

Alkaloids are mainly present in higher plants, especially in dicots, whereas only a few have been noted in lower plants. The alkaloids can occur in the whole plant or be limited to specific plant organs. Although the function(s) for some alkaloids still remain unclear, alkaloids can play fundamental roles in plants as deterrents for herbivores, protection from pathogens, and inhibitions of competitors (Cushnie et al., 2014).

Plant alkaloids have been investigated and used in traditional medicine in different regions of various countries with possible health improvement being the main focus of the research in pharmacognosy and pharmaceutical applications. Earlier studies on 320 plant species of Uzbekistan (belonging to 33 families) were investigated for increasing an understanding on their alkaloid contents (Aripov, 1995) and more than 540 new compounds associated with quinoline, isoquinoline, indole, pyrrolizidine, amaryllis, steroid, quinazolone, sulfur-containing, pyrrolidine, diterpenes have been identified from 292 species (Aripov, 1995).

Ungernia victoris Vved (Amaryllidaceae), a widespread endemic plant on the Gissar and Alay ranges across the Fergana Valley south of western Tien Shan. Several alkaloids have been detected in the leaves and bulbs of the plant (Yunusov and Abduazimov, 1960; Berkov, 2009). Malikova and Rakhmanberdyeva (2013) have isolated and identified galacturonic anhydride from the plant leaves.

The tulip tree, Liriodendron tulipifera L. (Magnoliaceae), contains the aporphine alkaloids liriodenine, lycisamine, O-methylmoschatoline, lanuginosine and the alkaloid proaporphine (N-methylcrotsparine, remerine) (Ziyaev et al., 1987). Tulyaganov and Kozimova (2005) have isolated and identified many alkaloids from Nitraria schoberi L. (Zygophyllaceae), namely schoberine, nitraraine, nitrarramine, dehydrosoberine, sibiridine, vasicinone, peganol along with others. Convolvulus subhirsutus (Convulvulaceae) contains the alkaloids convolvine, convolamine, convolidine, phyllalbine, phyllalbine N-oxide, nortropine, and conpropine (Gapparov et al., 2007). Another plant, Convolvulus pseudocantabrica Schrenk, contains convolvine, convolamine, convolvidine, convolicine, phyllalbine, convolidine, and convoline (Gapparov and Aripova, 2011).

All of the above ground and below ground parts of Arundo donax L. (Poaceae), a native Uzbekistan plant, contains alkaloids, such as deoxyvasicinone, arundine, aridine, donaxarine, donaxanone, donaxaridine, done, arundinine, arundamine, arundacine, arundarine, arundavine, arundafine, and butotene (Khuzhaev, 2004). Okhunov et al. (2011) observed that the aerial part of Crambe kotschyania Boiss. (Cruciferae), endemic for Uzbekistan, contains the alkaloids goitrin and goitrinid, whereas the aerial parts of Delphinium corymbosum Rgl. (Ranunculaceae) contain diterpenoid alkaloids, such as corumidine, curumidine, curidine and delcorinine (Salimov, 2004).

Akhmedzhanova et al. (2010) identified alkaloids from the aerial part of Haplophyllum leptomerum Lincz. et Vved. (Rutaceae), indigenous to Uzbekistan, and reported several alkaloids, providing also quantitative data, such as skimmianine, γ-fagarine, N-methyl-2-phenylquinolin-4-one, leptomel, acutine, 2-heptylquinolin-4-one and dictamine.

Lipids

Lipids, a broad class of organic compounds that includes fats, phospholipids, glycolipids, and sterols, are widely distributed in bacteria, plants, and animals. Many of these lipids are suitable for use in cosmetics and pharmaceuticals (Ramadan et al., 2009). Recently, pharmaceutical uses of lipids have been hypothesized as new therapeutic target for the treatment of cancer (Zhang et al., 2012).

Scutellaria ramosissima is an endemic plant that contains glycolipids, neutral lipids, and phospholipids with palmitic and linoleic acids dominating the phospholipids (Yuldasheva et al., 2014). Mirzaeva et al. (2011) studied lipid composition on Silybum
marianum (Asteraceae) and identified parafinic, olefinic, and isoprenoid hydrocarbons along with fatty acid esters and triterpenols, sterols, triacylglyc- cerins, chlorophylls, pheophytins, triterpene acids, and pheophytins. The qualitative compositions of the Althaea nudiflora and A. armeniaca (Malvaceae) lipids contained hydrocarbons and esters of sterols and triterpenes, triacylglycerines, free fatty acids, triterpenols, diacylglycerines, sterols, plus some unidentified components (Sagdullaev et al., 2001).

Gleditsia triacanthos L. (Cesalpinaceae) contains neutral lipids, glycolipids, and phospholipids (Rakhmanberdyeva et al., 2002), whereas Solenanthus turkestanicus (Regel and Smirn.) and Onosma irrigans (Boraginaceae) contain neutral lipids, glycolipids, and phospholipids (Yuldasheva et al., 2013). The fatty-acid compositions in all lipid groups included the presence of γ-linolenic and stearidonic lipids.

The phospholipid composition of Crataegus phostatidylcholine, phosphatidyl glycerol, phosphatic acid, phosphafidylethanol-amin (Gazizov et al., 1995). Bakker et al. (2003) studied lipid components of Crambe kotschyana Boiss. (Cruciferae) and reported the presence of hydrocarbons along with waxy ethers, triterpenol, and sterol fatty-acid esters, acetates of cyclic alcohols, triacylglycerols, isoprenes, triterpenes, and sterols. Capparis spinosa L. (Capparidaceae) contained glycolipids (monogalactosyldiacylglycerides, digalactosyldiacylglycerides, sterolglycosides, and their esters (Yili et al., 2009) along with phospholipids (phosphatidy-linositols, phosphatidylethanolamines, and phosphatidylcholines) (Yuldasheva et al., 2008).

**Essential oils**

Essential oils, also known as volatile oils, ethereal oils, aetherolea, or oil of the plant from which the oil was isolated, are hydrophobic liquids that can be extracted from many plants. An essential oil is a complex mixture of volatile plant constituents characterized by low molecular weight components, such as terpenes, terpenoids, and other aromatic and aliphatic chemical compounds associated with the plant material from which the oil is extracted, the time of harvest, and the extraction procedure. The lipophilic nature of essential oils enables the oil to cross the cell membrane and reach the cytoplasm (Gautam et al., 2014), thus interacting with organelles and cytoplasmic compounds to play an active biological role. Many medicinal plants contain useful essential oils and have been widely used in traditional medicine for respiratory tract infections (Gautam et al., 2014), for anticancer treatment (Russo et al., 2013), for anti-inflammatory activity (Ramos et al., 2013) for antimicrobial properties (Nikolić et al., 2014) 2013), for antioxidant activity (Abdelhady and Aly, 2012), and analgesic-like activity (Chandrashekar and Prasanna, 2010).

Hypericum scabrum and H. perforatum (Hypericaceae) are native plants of Uzbekistan that have been reported to contain about 0.2% essential oil (Baser et al., 2002a), consisting of β-caryophyllene, caryophyllene oxide, spathulenol, and α-pinene, whereas H. scabrum contains α-pinene, spathulenol, p-cymene, acetophenone, and carvacrol. In later studies, Baser et al. (2002b) investigated the essential oil of Arischrada korolkowiithat Regel et Schmalh. Pobed. (Lamiaceae), a plant that grows in Uzbekistan. The oil analysis characterized 88 constituents, representing 98% of the essential oil. Major oil components were 1,8-cineole, camphor, β-caryophyllene, bornyl acetate, caryophyllene oxide, and borneol.

Dzhumaev et al. (1990) isolated and identified essential oil from leaves of Hyssopus seravschanicus (Lamiaceae). The composition of the essential oil included sabinene, β-pinene, myrcene, p-cymene), 1,8-cineole, pinocamphone, and carvacrol. Artemisia balchanorum Krasch. (Compositae) yielded 1.2% oil with 60 components that included 1,8-cineole, α-thujone, camphor, β-thujone, and cis-2,7-dimethyl-4-octen- 2,7-diol as the major constituents (Baser et al., 1997).

The essential oil of Anethum graveolens (Apiaceae) seeds include carvone, limonene, cis-dihydrocarvone, diplaniol (1-allyl-2,5-dimethoxy-3,4-methylenedioxybenzene), and 1,2-diethoxyethane, that collectively accounted for 99.2% of the total essential oil composition (Yilli et al., 2009). The epigal part of Artemisia baldshuanica Krasch. et Zarp. (Asteraceae) has an essential oil that contains α- and β-pinenes, tujilic alcohol, tujilacetate, and tujil-valerate (Goryaev
et al., 1962). The essential oil of *Origanum tyttanthum* Gontsch (Lamiaceae) contains thymol, carvacrol, ursolic and oleanolic acids, 15-methylhexadecanoic acid, and coumarin substances (Platova, 1972; Baser et al., 1997; Asilbekova et al., 2000). In other studies, several compounds, such as thymol-β-D-glucoside (Passreiter et al., 2004), naringenin (Ohmoto et al., 1997), eryodictiol (Rivero-Cruz et al., 2004), rosmarinic acid (Petersen and Simmonds, 2003) have been identified.

Flavonoids

Flavonoids, a group of plant secondary metabolites in which the molecular framework is characterized by variable phenolic structures, are widely distributed in plants (Xia et al., 2013). Many flavonoids are known to possess anticancer activity (Kim et al., 2003). The indigenous medicinal plants of Uzbekistan *Thermopsis altherniflora* Rgl. et Schmalh (Fabaceae) contains flavonoids (Faizieva et al., 2003), flavones, isoflavones (Satimov et al., 1977), formononetin, chrysoeriol, apigenin, luteolin, thermoposide, and cynaroside (Faizieva et al., 2003). Other plants native to Uzbekistan, such as *Vicia subvillosa* L. (Fabaceae), contain flavonoids, including asapigenin, luteolin, quercetin, and cinaroside (Yuldashev, 2005). *Ammothamnus lehmannii* Bunge (Fabaceae) contains ammothamnidin, lehmannin, luteolin, cynaroside, quercetin, and isoquercetin (Abdullaev et al., 1983).

Plants of the genus *Scutellaria* L. (Lamiaceae) are rich sources of flavonoids (Malikov and Yuldashev, 2002). For example *S. cordifrons* Juz. and *S. phyllochachya* Juz. contain baikalein, 5,7-dihydroxy-2′-methoxyflavone, and chrysin (Chemesova et al., 1994; Siddikov et al., 2006). *S. immaculate* and *S. ramosissima* contain scutellarin, chrysirin, apigenin, apigenin-7-O-glucoside, cynaroside, and pinocembrin (Mamadalieva et al., 2011). *Scutellaria ocellata* Juz. contains oxyxyl A, wogonin, apigenin, cinaroside, baicalin, and wogonoside (Yuldashev and Karimov, 2001). *Scutellaria nepetoides* M. Pop. contains apigenin-7-O-β-D-glucuronide, norwogonoside scutellanin, and flavoneglycoside nepetoside A, and 5,8-dihydroxy-7-O-β-D-galacturonidopyranoysl flavone (Yuldashev and Karimov, 2001), while *S. phyllochachya* contains chrysin-

Phenolic compounds

The phenolic compounds are important secondary metabolites of medicinal plants and show a wide range of pharmacological activities including anticancer, anti-inflammatory (Li et al., 2013), cardiovascular diseases, osteoporosis, diabetes mellitus, and neurodegenerative diseases (Daglia, 2012). In the human diet, the source of these plant constituents is mainly consumed by fruits and beverages, including tea, coffee, and red wine. Abdulladzhanova et al. (2001) studied phenolic compounds of a medicinally important plant, *Euphorbia ferganensis* B. Fedtch. (Euphorbiaceae), and noted that the plant contains about 9.1% polyphenols in air-dried raw tissue. The polyphenols consisted of nine compounds, namely gallic acid, quercitin, quercetin, kaempferol-3-O-glucoside, 3-O-geraniin, 1-O-galloyl-4,6-trihydroxy-3,4,3′-trimethoxydiphenoyl-β-D-glucose, 2,3-di-O-galloyl-β-D-glucose, and 1,2,3-tri-O-galloylβ-D-glucose. *Bergenia hissarica* Boriss. (Saxifragaceae), a rich source of phenolic compounds along with anthraquinones, aloe-emodin, physisone, aloe-emodin8-O-β-glucoside, chrysophanein, and emodin 1-O-β-D-glucopyranoside (Yuldashev et al., 1993).

Other indigenous medicinally important plants namely *Rhodiola litvinovii* (Crassulaceae) contains p-tyrosol, salidroside, gallic acid, epigallocatechin-3-O-gallate (Melikuziev et al., 2013). *Geranium saxatile* Kar. (Geraniaceae) contains gallic acid, ellagic acid, quercetin-3-O-glucoside (Siddikov et al., 2011).

Glycosides

The term glycoside is a generic term for a class of natural products composed of two molecules, a sugar and the aglycone. The sugar molecule is primarily D-glucose, but also can be L-rhamnose and L-fructose. The aglycone can be any natural product,
such as a flavonoid or a terpene (Tian et al., 2014; Zahmanov et al., 2015).

Glycosides from native plants of Uzbekistan have been investigated in a few reports. In early studies, Takeda et al. (1999) isolated bitter secoiridoid glycosides, oliverosides, gentiopicroside, sweroside, 69-O-β-D-glucosyldentiopicroside, swertiamarin, eustomoside, eustomorusside, and septemflidoside from whole plants of Gentiana olivieri (Gentianaceae). Takeda et al. (2008) isolated and characterized a new phenolic glucoside, 4-O-β-D-glucopyranosylbenzyl-3’-hydroxyl-4’-methoxy-benzoate, from the aerial parts of Origanum tyttanthum (Lamiaceae). Astragalus unifoliotatus Bunge (Fabaceae) contains triterpene glycosides, namely oleanolic acid and cyclounsiferone, as well as 5,5-dimethyl-1-ethyl-1,3-cyclopentadiene, tetratriacetate, and nonacosane; the monoterpenoids 1,8-cineole, α-thujone, β-thujone, and camphor; the sesquiterpenoid chrysanthone; and the sesquiterpene lactone ambrosine. An endemic plant Scutellaria holosericea Gontsch ex Juz. (Lamiaceae) contains β-sitosterol, chrysins, 5-hydroxy-7-methoxyflavone, 3, 5-dihydroxy-7-methoxyflavone, apigenin, 7-ketolagatin, and chrysins-7-O-β-glucoside (Kamoldinov et al., 2012).

Ajuga turkestanica (Rgl.) Brig. (Labiatae) is an endemic plant of Uzbekistan and contains a number of effective biologically active compounds, such as phytoecdysteroids and natural glycosides (Mamatkhanov et al., 1998). Abdukadirov et al. (2005) identified ecdysterone, cyasterone, ajugalactone, ajugasterone, α-ecdysone, and turkesterone from A. turkestanica. Climati et al. (2012) isolated and identified an active antibacterial diterpene, methyl carnosate, against Bacillus cereus from ethanolic extracts of Salvia officinalis leaves.

Other compounds

Other compounds with a wide range of pharmacological activities have also been sourced from indigenous plants of Uzbekistan. For instance, Takeda et al. (2007) isolated and characterized compounds, such as rosmanol, epirosmanol, carnosol, 12-O-methylcarnosic acid, diosmetin, eugenol β-D-glucopyranoside, salidroside, uridine, and (6S,9R)-roseoside from the aerial parts of Perovskia scrophularifolia (Labiatae). Among those compounds, rosmanol, epirosmanol, carnosol exhibit antioxidant activity (Nakatani and Inatani, 1984; Masuda, 2004). Shikishima et al. (2001a) isolated and characterized several compounds, including phenyl butanoids, stilbene dimers, rhododendrol, epirosmanol, lindleyin, torachrysons, resveratrol, and physcion from Rheum maximowiczii (Polygonaceae). Ferula sambul (Umbelliferae) contains furanocoumarin esters - fesmutuinor A, B, bicoumarin, fesmutuinor C, spirobicoumarins, fesmutuinor D, E, F, G, and H with some of these compounds exhibiting anti-HIV activity and a very weak inhibition of cytokine release (Zhou et al., 2000). Sdykov and Abduazimov (2000) investigated dioxanelylignins (DLA) of soap root, Allochhriza paniculata (Fabaceae), and licorice root, Glycyrrhiza glabra (Caryophyllaceae), and detected cresol, guaiacol, Guaiacyl ethane, Guaiacyl propan-1-ol.

Mukhamatkhanova et al. (2011) investigated the phytochemistry of the epigallic part of Artemisia baldshuanica Krass (Asteraceae) and observed the main constituents were the hydrocarbons 5,5-dimethyl-1-ethyl-1,3-cyclopentadiene, tetratriacetate, and nonacosane; the monoterpenoids 1,8-cineole, α-thujone, β-thujone, and camphor; the sesquiterpenoid chrysanthone; and the sesquiterpene lactone ambrosine. An endemic plant Scutellaria holosericea Gontsch ex Juz. (Lamiaceae) contains β-sitosterol, chrysins, 5-hydroxy-7-methoxyflavone, 3, 5-dihydroxy-7-methoxyflavone, apigenin, 7-ketolagatin, and chrysins-7-O-β-glucoside (Kamoldinov et al., 2012).

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The high diversity of ecdysteroid derivatives in medicinal plants of Uzbekistan has been reported. Saatov et al. (1999) described the distribution of phytoecdysteroids in the family: Lamiaceae (A. turkestanica); Asteraceae (Rhaponticum integrifolium C.Winkl., Rhaponticum nanum Lipsky, Serratula sogdiana Bunge, Serratula algida Iljin); and Caryophyllaceae (Silene brahuica Boiss., S. scabrifolia Kora., S. wallichiana Klotzch, Meandrum turkestanicum Rgl. and Dianthus hoelzleri Winkl.).

Studies have shown that A. turkestanica has many diverse ecdysteroids, namely ecdysterone, cyasterone, ajugalactone, ajugasterone B, 22-acetylcyasterone, α-ecdysone, ecdysterone 2, 3-mono-acetonide, turkesterone (Saatov et al., 1999). S. wallichiana contains ecdysteroids, namely viticosterone E, 20-hydroxyecdysone-22-benzoate, 2-deoxyecdysone-22-benzoate, viticosterone E-22-benzoate, 2-deoxy-20-hydroxyecdysone, 2-deoxyecdysone, 20-hydroxy-ecdysone, 3-benzoate-2-deoxy-20-hydroxyecdysone, 22-benzoate-2-

**Pharmacological Activities**

Several pharmacological studies have confirmed that medicinal plants exhibit a broad range of biological activities and that plant species can contain a diverse range of bioactive molecules responsible for a collection of pharmacological properties (Polya, 2013). For example, Tada et al. (2002) identified coumarins, terpenoids, and glycosides from the roots of Prangos pabularia (Apiaceae), in which constituents exhibited anti-bacterial activity and inhibited release of cytokine.

Flavonoids of Scutellaria immaculata and S. ramosissima (scutellarin, chrysin, apigenin, apigenin-7-O-glucoside, cynaroside and pinocembrin) significantly inhibit cell growth against HeLa, HepG-2, and MCF-7 cells, along with antimicrobial activity (Mamadalieva et al., 2011). Plant derived flavonoids, such as quercetin, herbacetin, luteolin, and 4-methoxyscutarellin, are characterized by anti-ulcer activity (Barnaulov et al., 1982). A. turkestanica contains many biological active compounds including ecdysteroids, iridoids (Soatov et al., 1994), and carbohydrates (Abdukadirov et al., 2004) that have anabolic activity and chologenic action.

Scutellaria ramosissima is traditionally used in Uzbekistan folk medicine to treat epilepsy, allergies, inflammations, nervous disorders, and hypertension (Khodjimatov et al., 1995; Parajuli et al., 2009). The plant extract exhibits cytotoxic activity against several cancer cell lines (Mamadalieva et al., 2011). Ethanol extracts of Geranium saxatile exhibit antihypoxic properties for acute normobaric and hemic hypoxia (Siddikov et al., 2011). Perovskia scrophularifolia has been used for treatment of dermatitis and human intestinal parasites (Takeda et al., 2007).

The flavonoid dictamnine derived from Haplophyllum leptomerum exhibits cytotoxic activity against the human cancer-cell lines HeLa and HCT-116 (Akhmedzhanova et al., 2010), Arctium lappa is used in folk medicine for treatment of rheumatism, eczema, ulcers, skin eruptions, and festering wounds (Azizov et al., 2012), Althaea nudiflora and A. armeniaca are used to treat pneumonia, hemostasis, kidney problems, and as expectorants (Kholmatov and Kosimov, 1994). Origanum tyttanthum, which has antimicrobial, hypcholesterolemic, and hypolipidemic activity, is used for treating tuberculosis and human intestinal parasites (Tkachenko et al., 1999; Nuraliyev and Zubaidova, 1994).

**Rheum maximowiczii** is widely used for the treatment of stomach disorders (Shikishima et al., 2001b). The roots of Ferula varia have been traditionally used for the treatment of fever and intestinal parasites, and as a mouth rinse (Sakhobiddinov, 1955). Bergenia hissarica is used as an astringent, hemostatic, and as an antiphlogistic agent in diseases of the gastro-intestinal tract and in obstetric-gynecological practice (Yuldashev et al., 1993). *Euphorbia ferganensis* is used for treatment of dysentry, diarrhea, and viral infections, including AIDS. Milk thistle *Silybum marianum* has hepatoprotective, antioxidant, and regenerative membrane-protective properties (Minakhmetov et al., 2001).

**Crataegus turkestanica** is used for the treatment of nervous and cardiovascular diseases (Yu et al., 1995), whereas *Helichrysum* sp. possess antimicrobial (Guida et al., 1999), anti-inflammatory, antioxidative (Sala et al., 2002), and cytotoxic activity (Bigović et al., 2011). Yamura et al. (2008) has noted that the methanol extract of *H. maracandicum* was the most effective as compared with other plants on transformed somatostatin (SST) signaling cells on SENCAR mouse skin. Satimov et al. (1998) noted that flavonoids isolated from *Thermopsis altherniflora* inhibited the development of hyperlipidemia induced in experimental animals by injections of Triton WR-1339. *G. oliverihas* has been used for treating wounds, diarrhea, common colds, and ease of digestion (Honda, 1999).

Lehmanin (a flavonone) and ammothamnidiin (a chalcone) isolated from the endemic plant *Ammothamus lehmannii*, have demonstrated an
ability to increase resistance of the gastric mucosa to neurogenic and toxic-dystrophic lesions (Syrov et al., 2010), thus, suggesting the use of these plant extracts in the treatment of gastric ulcers. *Vicia subvillosa* has a history of use in folk medicine for ascites, paralysis, epilepsy, and flu (Yuldashev, 2005). The essential oils of *Anethum graveolens* have demonstrated antimicrobial activity toward *Candida albicans* and *Staphylococcus aureus* (Yili et al., 2009).

In other studies, several plants of *Silene* genera, namely *S. walchiana*, *S. viridiflora*, and *S.brahuica* have shown antibacterial activity against gram positive and gram negative bacterial pathogens (Mamadalieva et al., 2008)

### Conclusion

The medicinal plants of Uzbekistan reported can be considered as a potential source of useful drugs. Structurally diverse compounds isolated and identified from the indigenous plants have demonstrated biological activities. Extracts isolated from medicinal plants of Uzbekistan have been proven to have biological activity *by in vitro* and *in vivo* assays. Many plant extracts exhibit pharmacological activity, including antimicrobial, antioxidant, antiulcer, expectorant, anti-hemorrhagic, astringent, hemostatic, and antiphlogistic. These extracts are also used for the treatment of dermatitis, intestinal parasites, pneumonia kidney ailments, rheumatism, eczema, ulcers, skin eruptions, wound healing, dysentery, diarrhea, and viral infections, including AIDS. Based on many published reports, indigenous medicinal plants of Uzbekistan would appear to be a promising source of novel drugs and potentially useful new pharmaceuticals. Further investigations of endemic plants of Uzbekistan and their constituents are necessary to fully understand the molecular mechanisms of their action *in vitro* and *in vivo* and to assure the plant extracts are safe for human use.

### Table 1. Pharmaceutical properties of medicinal plants from Uzbekistan.

<table>
<thead>
<tr>
<th>Plant species &amp; family</th>
<th>Pharmacological properties &amp; treatments</th>
<th>Phytochemical constituents</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ajuga turkestanica</em></td>
<td>Anabolic activity and cholagogic action</td>
<td>Ecdysterone, cyasterone, ajugalactone, ajugasterone, α-ecdysone, turkesterone</td>
<td>[4, 5]</td>
</tr>
<tr>
<td><em>Althaea armeniaca</em></td>
<td>Pneumonia, kidney ailments, anti-hemorrhagic agents</td>
<td>Hydrocarbons and esters of sterols, triacylglycerines, free fatty acids, triterpenols, diacylglycerines, &amp; sterols</td>
<td>[39, 89]</td>
</tr>
<tr>
<td><em>Althaea nudiflora</em></td>
<td>Pneumonia, kidney ailments, anti-hemorrhagic agents</td>
<td>Hydrocarbons and esters of sterols, triacylglycerines, free fatty acids, triterpenols, diacylglycerines, &amp; sterols</td>
<td>[39, 89]</td>
</tr>
<tr>
<td><em>Ammothamnus lehmannii</em></td>
<td>Gastric ulcer disease</td>
<td>Ammothamnidin, lehmannin, iuteolin, cynaroside, quercetin, &amp; isoquercetin</td>
<td>[2, 103]</td>
</tr>
<tr>
<td><em>Amorpha fruticosa</em></td>
<td>Antibacterial, heart problems, atherosclerosis</td>
<td>Glycosides, aglycones, &amp; amorphin</td>
<td>[38]</td>
</tr>
<tr>
<td><em>Anethum graveolens</em></td>
<td>Antimicrobial activity</td>
<td>Carvone, limonene, cis-dihydrocarvone, diplaniol, &amp; 1,2-diethoxyethane</td>
<td>[119]</td>
</tr>
</tbody>
</table>

continued
<table>
<thead>
<tr>
<th>Plant species &amp; family</th>
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</tr>
</thead>
<tbody>
<tr>
<td><em>Arctium lappa</em> L. (Asteraceae)</td>
<td>Rheumatism, eczema, ulcers, skin eruptions</td>
<td>Polysaccharide inulin, protein, essential oil, carotenoids, flavonoids, &amp; tanning agents</td>
<td>[10]</td>
</tr>
<tr>
<td><em>Arischradia korolkowii</em> Regel et Schmalh. Pobed. (Lamiaceae)</td>
<td>Antimicrobial activity</td>
<td>1,8-cineole, camphor, β-caryophyllene, bornyl acetate, caryophyllene oxide, &amp; borneol</td>
<td>[14]</td>
</tr>
<tr>
<td><em>Artemisia baldshuanica</em> Krasch. et Zopr. (Asteraceae)</td>
<td>Antiplasmodial activity</td>
<td>α- and β-pinenes, thujol alcohol, &amp; thujyl acetate, tetratriacontane, nonacosane, monoterpenoids, 1,8-cineole, camphor, sesquiterpenoids &amp; chrysantheneone</td>
<td>[39]</td>
</tr>
<tr>
<td><em>Arundo donax</em> L. (Poaceae)</td>
<td>Diaphoretic, diuretic, emollient, treatment of dropsy</td>
<td>Alkaloids, deoxyvasicinone, arundine, ardine, donaxarine, donaxanine, donaxaridine, donine, arundinine, arundacine, &amp; bufotenine</td>
<td>[41]</td>
</tr>
<tr>
<td><em>Bergenia hissarica</em> Boriss. (Saxifragaceae)</td>
<td>Astringent, hemostatic, antiphlogistic agents</td>
<td>Phenolic compounds, anthraquinones, aloë-emodin, physeion, emodin 8-O-β-glucoside, chrysophanein, &amp; emodin-1-O-β-D-glucopyranoside</td>
<td>[121]</td>
</tr>
<tr>
<td><em>Capparis spinosa</em> L. (Capparidaceae)</td>
<td>Healing wounds, asthma, gastrointestinal diseases, hepatitis</td>
<td>Monogalactosyldiacylglycerides, digalactosyldiacylglycerides, &amp; sterolglycosides; Phospholipids, phosphatidylinositolsoits, &amp; phosphatidylethanolamines</td>
<td>[38, 39]</td>
</tr>
<tr>
<td><em>Convolvulus subhirsutus</em> Regal &amp; Schmalh. (Convolvulaceae)</td>
<td>Gastrointestinal diseases, analgesic, anticonvulsant, asthma, lung tuberculosis</td>
<td>Convolvine, convolamine, convolidine, phyllalbine, phyllalbine N-oxide, nortropine, &amp; conpropine)</td>
<td>[30, 38, 39]</td>
</tr>
<tr>
<td><em>Crambe kotschyana</em> Boiss. (Brassicaceae)</td>
<td>Upper respiratory tract congestion</td>
<td>Goitrin &amp; goitridin; coumarins, carotene, triterpenol, tracylglycerols, isoprenes, triterpenes, &amp; sterols</td>
<td>[11, 72]</td>
</tr>
<tr>
<td><em>Crataegus turkestanica</em> Pojaark (Rosaceae)</td>
<td>Nervous and cardiovascular diseases</td>
<td>Phosphatidylinositol, phosphatidylcholine, phosphatidylglycerol, phosphatidic acid, phosphatidylethanolamin</td>
<td>[32, 117]</td>
</tr>
<tr>
<td><em>Euphorbia ferganensis</em> B. Fedtsch. (Euphorbiaceae)</td>
<td>Dysentery, diarrhea, and viral infections, including AIDS</td>
<td>Gallic acid, quercitrin, quercetin, kaempferol-3-O-glucoside, 2,3-di-O-galloyl-β-D-glucose, &amp; 1,2,3-tri-O-galloyl-β-D glucose)</td>
<td>[3]</td>
</tr>
<tr>
<td><em>Ferula pallida</em> Korvin (Apiaceae)</td>
<td>Antioxidant, skin wounds treatment</td>
<td>Sesquiterpene phenylpropanoid derivatives, pallidones, &amp; sesquiterpene chromone derivatives</td>
<td>[42, 101]</td>
</tr>
</tbody>
</table>

continued
<table>
<thead>
<tr>
<th>Plant species &amp; family</th>
<th>Pharmacological properties &amp; treatments</th>
<th>Phytochemical constituents</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Apiaceae)</td>
<td>gastric disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eudesmane, guaiane-germacrane-type sesquiterpene lactone glycosides</td>
<td>[44, 88]</td>
</tr>
<tr>
<td><em>Ferula varia</em> (Schrenk) Trautv.</td>
<td>Intestinal parasitosis, as mouth rinse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Apiaceae)</td>
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<td></td>
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</tr>
<tr>
<td><em>Geranium saxatile</em> Kar. (Geraniaceae)</td>
<td>Antihypoxic for acute normobaric and hemic hypoxia</td>
<td>Phenolic compounds (gallic acid, ellagic acid, quercetin-3-O-glucoside)</td>
<td>[99]</td>
</tr>
<tr>
<td><em>Gleditsia triacanthos</em> L. (Cesalpinaceae)</td>
<td>Spastic colitis, chronic cholecystitis, stomach ulcers, bronchial asthma</td>
<td>Neutral lipids (triacylglycerides, carotinoids, fatty acid esters, sterols, diacylglycerides), glycolipids, phospholipids, alkaloids</td>
<td>[83]</td>
</tr>
<tr>
<td><em>Glycyrrhiza glabra</em> L. (Fabaceae)</td>
<td>Antiviral, anti-inflammatory, antioxidant</td>
<td>Cresol, guaiacylpropan-1-ol, guaiacol</td>
<td>[50]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Haplophyllum leptomerum</em> Linz. et Vved. (Rutaceae)</td>
<td>Cytotoxic activity</td>
<td>Alkaloids, skimmianine, γ-fagarine, leptomerine, acutine, and 2-heptylquinolin-4-one, dictamine</td>
<td>[8]</td>
</tr>
<tr>
<td><em>Helichrysum maracandicum</em> M. Pop. (Asteraceae)</td>
<td>Antiproliferative activity, gall bladder disorders</td>
<td>Chalcone glycoside, isosalipurposide, naringenin chalcone</td>
<td>[116]</td>
</tr>
<tr>
<td><em>Helichrysum sp.</em> Acc. (Asteraceae)</td>
<td>Antimicrobial, anti-inflammatory, antioxidant</td>
<td>Flavonoids, phloroglucinol derivatives and diterpenes</td>
<td>[17, 38, 39]</td>
</tr>
<tr>
<td><em>Hypericum perforatum</em> L. (Hypericaceae)</td>
<td>Anti-inflammatory, antimicrobial, diarrhea</td>
<td>Essential oil, β-caryophyllene, caryophyllene oxide, spathulenol, α-pinene</td>
<td>[13, 39]</td>
</tr>
<tr>
<td><em>Hyssopus seravschanicus</em> (Dub.) Pazij (Lamiaceae)</td>
<td>Anti-inflammatory, rheumatism, gastrointestinal</td>
<td>Essential oil, sabinene, β-pinene, myrcene, p-cymene, 1,8-cineole, pinocamphene, carvacrol</td>
<td>[24]</td>
</tr>
<tr>
<td><em>Nitraria schoberi</em> L. (Zygophyllaceae)</td>
<td>Antispasmodic, antineuropathic, anti-arrhythmic agent</td>
<td>Schoberine, nitraraine, nitraramine, dehydrosoberine, sibiridine, vasicinone, peganol</td>
<td>[39, 104]</td>
</tr>
<tr>
<td><em>Origanum tyttanthum</em> Gontsch (Lamiaceae)</td>
<td>Antimicrobial, intestinal parasites, tuberculosis, hypolipidemic activity</td>
<td>Thymol, carvacrol, ursolic, oleanolic, rosmarinic acids, coumarins, thymol, β-D-glucoside, naringenin, eryodictiol</td>
<td>[15, 17, 68, 74, 77, 85, 108, 110]</td>
</tr>
<tr>
<td><em>Perovskia scrophularifolia</em> Bunge (Lamiaceae)</td>
<td>Dermatitis, intestinal parasites, antioxidant activity</td>
<td>Anthocyanin, coumarins, essential oils, rosmanol, epirosmanol, carnosol, diosmetin, eugenol b-D-glucopyranoside, salidroside</td>
<td>[59, 67, 69, 106]</td>
</tr>
</tbody>
</table>

continued
Table 1. Pharmaceutical properties of medicinal plants from Uzbekistan (continued).

<table>
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<tbody>
<tr>
<td>Prangos pabularia Lindl. (Apiaceae)</td>
<td>Antibacterial, inhibition of cytokine release</td>
<td>Coumarins, terpenoids, glycosides, ( \beta )-pyrone, pabularin A, B, &amp; C</td>
<td>[105]</td>
</tr>
<tr>
<td>Rhaponticum integrifolium C. Winkl. (Asteraceae)</td>
<td>Improving of the reparative functions of the organism</td>
<td>Ecdysteroids (Ecdysterone, Integristerone A, dehydromakisterone A)</td>
<td>[9]</td>
</tr>
<tr>
<td>Rheum maximowiczii Losins Polygonaceae)</td>
<td>Stomach disorders &amp; antioxidant</td>
<td>Phenyl butanoids, stilbene dimers, rhododendrol, epirhododendrin, lindleyin, torachrysone, resveratrol</td>
<td>[42, 96]</td>
</tr>
<tr>
<td>Rhodiola litvinovii Litvinov (Crassulaceae)</td>
<td>Treat tiredness &amp; neurotic ailments, adaptogenic activity</td>
<td>( p )-Tyrosol, salidroside, gallic acid, epigallocatechin-3-O-gallate</td>
<td>[60]</td>
</tr>
<tr>
<td>Scutellaria ramosissima Popov (Lamiaceae)</td>
<td>Epilepsy, allergy, inflammations, nervous disorders, hypertension, cytotoxic activity</td>
<td>Scutellarin, chrysin, apigenin, apigenin-7-O-glucoside, cymaroside and pinocembrine, lipids (glycolipids, neutral lipids, phospholipids)</td>
<td>[19, 38, 76, 115]</td>
</tr>
<tr>
<td>Serratula sogdiana Bunge (Asteraceae)</td>
<td>Heal wounds, liver diseases</td>
<td>Ecdysteroids (ecdysterone, viticosterone E, viticosterone E, sogdysterone)</td>
<td>[87]</td>
</tr>
<tr>
<td>Silene brahuica Boiss. (Caryophyllaceae)</td>
<td>Stress-protective effects</td>
<td>Ecdysteroids: (viticosterone E, polydropine B, ecdysterone, integristerone A, sileneoside A, ( \alpha )-ecdysone-22-sulfate)</td>
<td>[47, 87]</td>
</tr>
<tr>
<td>Silybum marianum (L.) Gaertn. (Asteraceae)</td>
<td>Hepatitis, gastrointestinal disorders, anti-inflammatory, antioxidant, &amp; anti-metastatic activity</td>
<td>Parafinic, olefinic, and isoprenoid hydrocarbons, fatty acid esters with triterpenols and sterols, triacylglycerins, triterpene acids, pheophytins</td>
<td>[65]</td>
</tr>
<tr>
<td>Thermopsis altherniflora Rgl. et Schmalh. (Fabaceae)</td>
<td>Hypolipidemic, antiscerotic activity</td>
<td>Flavones and isoflavones, formononetin, chrysoeriol, apigenin, luteolin, thermopsiside, cymaroside</td>
<td>[28]</td>
</tr>
<tr>
<td>Ungernia victoris Vved (Amaryllidaceae)</td>
<td>Bronchitis, ulcers, poliomyelitis, neurological diseases</td>
<td>Galanthamine, narwedine, lycorine, ungerine, ungeridine, hippeastrine, haemanthidine, tazettine, &amp; nortazettine</td>
<td>[16, 38, 50]</td>
</tr>
<tr>
<td>Vicia subvillosa L. (Fabaceae)</td>
<td>Ascites, paralysis, epilepsy, flu</td>
<td>Flavanoids (apigenin, luteolin, quercetin, cinaroside)</td>
<td>[120]</td>
</tr>
</tbody>
</table>
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