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Therapeutic Potential of Fagonia bruguieri and Tamarix dioica: Phytochemistry, Bioactivity, and Clinical Prospects

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Abstract

Fagonia bruguieri and Tamarix dioica represent important medicinal species with established traditional use in the management of several diseases. This review summarizes their phytochemical profiles, highlighting flavonoids, saponins, tannins, and phenolic compounds as key bioactive constituents. Experimental studies reveal significant antioxidant, anti-inflammatory, antimicrobial, anticancer, and hepatoprotective activities, supporting their traditional uses. Emerging evidence suggests potential applications in metabolic disorders, wound healing, and immune modulation. Although promising, most data are preclinical, and rigorous clinical trials remain limited. Systematic pharmacological analysis, standardized isolation techniques, and extensive toxicological studies are indispensable for validating medicinal properties and supporting the development of evidence-based herbal medicines from these botanical sources

INTRODUCTION

Fagonia bruguieri and Tamarix dioica are well-known medicinal plants with a long history of traditional use across Asia and the Middle East for managing fever, infections, liver disorders, and inflammatory conditions (Ahmed et al., 2023). Their therapeutic promise stems from diverse phytochemical constituents, including flavonoids, alkaloids,

saponins, tannins, terpenoids, and phenolic acids, which collectively contribute to broad-spectrum pharmacological effects.

Phytochemical investigations reveal that Fagonia bruguieri contains saponins, flavonoids such as quercetin and kaempferol, and significant phenolic compounds known for antioxidant and cytoprotective properties. Tamarix dioica, likewise, is rich in tannins, ellagitannins, flavonoids, and triterpenes, compounds that exhibit strong antimicrobial and anti-inflammatory activities. These bioactive molecules function synergistically to modulate oxidative stress, scavenge free radicals, and enhance the body's natural defence mechanisms.

Pharmacological studies support these plants' traditional uses. Extracts of Fagonia bruguieri demonstrate potent antioxidant, anti-inflammatory, hepatoprotective, and anticancer effects, with experimental evidence showing inhibition of cancer cell proliferation and protection against chemically induced liver injury (Nabila et al., 2024). Similarly, Tamarix dioica exhibits antimicrobial activity against pathogenic bacteria and fungi, along with anti-inflammatory and wound-healing properties. Both plants have also shown potential for regulating blood glucose and lipid levels, suggesting benefits in metabolic disorders.

Despite these encouraging findings, most available data are derived from in vitro assays and animal models. Robust clinical trials assessing efficacy, optimal dosage, and long-term safety are still lacking. Moreover, variation in extraction techniques, plant parts used, and environmental factors can influence the concentration of bio-active constituents, highlighting the need for standardized methods and quality control. Future research should focus on isolating and characterizing specific active compounds, elucidating molecular mechanisms of action, and evaluating potential herb–drug

interactions (Fasinu et al., 2012). Rigorous, randomized clinical trials are essential to substantiate therapeutic claims and to develop evidence-based guidelines for clinical practice. Equally, comprehensive toxicological evaluations are necessary to confirm safety for human use

Fagonia bruguieri and Tamarix dioica represent promising natural resources for novel drug discovery and development. Their rich phytochemistry and demonstrated bio-activities underscore significant potential in managing oxidative stress-related diseases, infections, cancer, and metabolic disorders. Integrating traditional knowledge with modern pharmacological research may facilitate the transformation of these species into standardized, plant-based pharmaceuticals, providing effective and affordable therapeutic options (Manisha et al., 2025).

FAGONIA BRUGUIERI DC

Fagonia bruguieri is a tiny, erect under shrub that is spiny and somehow glandular. Its branches are slender, glabrous, triate, and terete. While this branching and the erect herb is woody at the base.

Scientific Name	Fagonia bruguieri DC
Local Name	Damasa
Family	Zygophyllaceae
Parts used	Whole plant

THE STEM

The stems of Fagonia bruguieri are distinctly angular, characterized by alternating thick and thin ridges. In contrast, stems described as 'terete' exhibit uniformly rounded ridges (Rathor et al., 2016).

THE STIPULES

Fully free stipules are possessed by Fagonia bruguieri that are spiny or pointed at the apex. Stipules are in the form of two pairs of sharp, slender thorns with a length of 12 mm. The spines of the stipules is usually recurved and somewhat lengthier (6-12 mm) than the leaves.

THE LEAVES

The foliar morphology of Fagonia bruguieri consists of simple, opposite leaves bearing flattened to rarely terete leaflets in counts of 2-7 (Kubitzki et al., 1993). These leaflets generally present fleshy textures, while leaflet enumeration serves as a consistent diagnostic character within the species. Leaflets are ovate to oblong, having 4-12 mm in length. The leaves are petiolate, and the leaflets are petiolulate in Fagonia bruguieri. Usually, the basal leaves are mostly petiolate, such as upper unifoliolate and trifoliolate. Upper leaves are sessile and subsessile, possessing a 5 mm long petiole. Leaves are arranged alternately, having 1 to 3 foliate. Their petioles are of various lengths, ranging from 3 - 30 mm long, and are slender and deeply striated. Leaflets of the plant are sessile, linear, and acute, having very small petiolules.

THE TRICHOMES

Trichomes are present in Fagonia bruguieri as they could be present sparsely on some parts of the plant, including pedicels, young stems, and sepals (Abdel et al., 2012). Unicellular secretary cells with multicellular stalks are present within mature glands. Developing glands exhibit a single-celled stalk configuration. Trichome development occurs through epidermal cell detachment from underlying mesophyll tissue, with the stalk structure featuring a unique morphological trait characterized by intercellular gaps within the outer epidermal cell layer.

THE FLOWERS

The inflorescence of Fagonia is usually helicoid or asymmetrical as one lateral branch originates from each flowering branch. Flowers have the same number of sepals and petals, i.e. five of each. The petals are twice the length of the sepals. Flowers are purplish or pale-pink, usually small, i.e., 8-10 mm across, shortly pedunculated, and have a pedicel (5 mm). Sepals are 2-2.5 mm in length, pubescent, acute-acuminate, persistent, and morphologically lanceolate-ovate. While the petals are 3.5-4 (-6) mm in length, the obtuse ones have long filaments and are broad at the apex and tapered to the base.

THE FRUIT

The fruit Fagonia is capsular and inverted cone-shaped with a persistent style and possesses hairs. Trichome size can be quantified by measuring the length of mature hairs (Dastagir et al., 2023). The capsule typically dehisces through splitting of the endocarp and exocarp, most often beginning at the base as the pedicel bends downward Fruit are globulicidal. From each locule, shedding of seeds occurs before the ripened fruits drop. These features of Fagonia bruguieri are very distinct.

THE SEEDS

The seeds of F. bruguieri are small, and the hilum is even shorter than the seeds. The outer and inner dicot of Fagonia bruguieri comprises uniform layers formed by cells without having any specified internal structures.

THE POLLEN GRAINS

The Fagonia possesses tricolpate, reticulate pollen grains that are morphologically prolate to prolate-spheroidal (Ayaz et al., 2023). The exine of pollen grains is thicker than the endexine. Pollen size in Fagonia bruguieri DC is characterized by 28-32 µm length and 16-20 µm width.

GEOGRAPHICAL DISTRIBUTION AND HABITAT

The natural range of Fagonia bruguieri encompasses extensive African territories, stretching from Mauritania to Egypt along the northern margin and across the southern Sahel zone (15°–20°N). Distribution continues eastward through the eastern Mediterranean region to Pakistan and Afghanistan, with additional populations documented in Yemen (Puri & Bandari, 2014). The species thrives in gypsum- or limestone-rich gravel and sandy soils. The species characteristically inhabits rocky inclines, ephemeral watercourses, and grassland areas at elevations up to 2300 m above sea level. It normally forms a leading part of the vegetation. In Pakistan, it is found from west to north.

TAXONOMY

Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Zygophyllales
Family	Zygophyllaceae
Genus	Fagonia L.
Specie	Fagonia bruguieri DC

CHEMICAL COMPOSITION

Fagopyrum species contains terpenoids, saponins, coumarins, sterols, alkaloids, proteins, flavonoids, amino acids, and trace elements (Jing, et al., 2016). It contains about seven flavonol glycosides, such as kaempferol 3-O-rhamnosylgalactoside, quercetin 3-galactoside, and quercetin-3-rhamnosylgalactoside for in the genus Fagonia L. Fagonia bruguieri's aerial parts contained confirmed by x-ray crystallography diterpenes of

erythroxantype, specifically 16-O-acetylfagonone and 15, 16-dihydroxy-7-oxo-cis-ent-erythrox-3-ene (fagonone). **s**. Moreover, five substituted8-methoxyflavones were also discovered. In a study in Libya, F. bruguieri was composed of alkaloids, flavonoids, and saponins, while tannins, terpenes, coumarins, and anthraquinones were absent. The IC50 value of F. bruguieri was 12.50±1.15 compared to that of ascorbic acid. Moreover, total polyphenols (TPC) and total flavonoids (TFC) concentrations of leaves of F. bruguieri were 249.28±54.48 and 349.28±54.48, respectively. Comparable findings from another study indicated that Fagonia bruguieri exhibited the highest levels of ascorbic acid (Javaid et al., 2025b)

MEDICINAL PROPERTIES

According to the previous research on Fagonia, a genus comprised of 45 species, is acknowledged as a potent medicinal plant effective against various diseases (Ali et al., 2021). Although this species is not subjected to any research or clinical study in Pakistan, extensive research on the medicinal applications of Fagonia species has highlighted their potential as analgesic, antitumor, astringent, and antioxidant agents, with traditional use also documented in various regions of Pakistan.. Fagonia sp. was reported as anticancer treatment as well as for toothache, stomach-ache, renal diseases, asthma, and fever. In a research study, Fagonia bruguieri was reported to possess strong free radical scavenging activity with an IC50 value of 32.7332 µM, total antioxidant activity of 130 µg AA equivalent/mg methanol extract, and total reducing power of 141 µg AA equivalent/mg methanol extract.

In another study, an aqueous extract of Fagonia bruguieri was claimed to have anti-allergic activity and found to possess LD50 values of 10.75 & 11.5 g/kg in rats and mice, respectively. An intravenous dose of 200 mg/kg of the plant extract has been

shown to induce bronchoconstriction in albino guinea pigs. The plant was documented to be used as a febrifuge and tonic in Peshawar Valley (ULLAH, et al., 2019). Moreover, it is administered as a prophylactic drug for smallpox in children. The leaves and twigs are thought to have exhilarating effects. Methanol extract of Fagonia bruguieri was reported to possess anti-fungal properties against four fungal strains, i.e., Aspergillus niger, Aspergillus fumigatus, Aspergillus flavus, and Mucor mycosis. Previous studies have identified phytoestrogens such as daidzein, quercetin, genistein, and kaempferol in Fagonia bruguieri, with documented proliferative effects on MCF-7 breast cancer cells.

An aqueous extract demonstrated notable anticancer activity, either alone or in combination with other agents, by inhibiting breast cancer cell proliferation through p53 expression and FOXO3a-mediated DNA damage responses. Alcoholic extracts have demonstrated wound-healing and anti-inflammatory effects in rat paw edema and excision wound models, while freeze-dried extracts have exhibited ant allergic activity. Evidence suggests that the crude extract of Fagonia bruguieri (Fb.Cr) possesses anti-inflammatory properties and protective activity against gastric and duodenal injury (Javaid et al., 2025). Ethnobotanical reports indicate its use by desert communities for treating skin disorders, sores, otitis, eruptions, venereal diseases, and as an antipyretic and analgesic. Ethanolic leaf extracts have also demonstrated analgesic and antimicrobial properties. Laboratory assays further confirmed its antitumor and cytotoxic potential, including DNA damage activity (Naphade, et al., 2018). Additionally, they are similarly active against Helicobacter Pylori as Cleistocalyx operculatus (Tianh et al., 2024).Traditionally, Fagonia species are valued for treating inflammation, leprosy, haemorrhoids, wounds, fever, and sores. F. Canarium schweinfurthii has been applied for managing skin eruptions and boils, while F. cretica methanolic extracts exhibited

antimicrobial efficacy and significant free radical scavenging activity. Collectively, Fagonia spp. demonstrates diverse pharmacological properties, including thrombolytic, analgesic, anti-inflammatory, and antipyretic effects.

TAMARIX DIOICA ROXB

Scientific Name	Tamarix dioica Roxb. ex Roth
Local Name	Lai, Jhau
Family	Tamaricaceae
Parts used	Areal Part

BOTANICAL CHARACTERISTICS

T. dioica (Tamaricaceae) is locally known as ban jhau. This is a perennial shrub or small tree (1-18 m height) characterized by reddish bark, sheathed leaves, and purple fluorescence.

Leaves	• 1.5-3 mm long • Glabrous • Vaginate • Abruptly acuminate • Broad whitish margins
Flowers	• Pentamerous • Purplish pink to purple • Subsessile
Sepals	• 5 in number, 2 mm long, 1.5 mm broad • Obtuse • Orbicular • Ovate to broadly ovate

Petals	• 5 in number • 2.5 mm long and 1—1.25 mm broad • Obovate • Free • Obtuse
Stamens	• 5 in count and 1.75—2 mm long • Filiform filaments • Emarginated notches • Obtuse anthers • Abortive in female flowers
Styles	• 3 in count, • Long as ovary or slightly short • Exserted • Triquetrous Ovary 1—1.5 mm long • Absent/ abortive in male flowers

GEOGRAPHICAL DISTRIBUTION AND HABITAT

Tamarix, genus, from the family Tamaricaceae and is commonly known as "tamarisk" or "salt cedar". The genus comprises about 60 species whose plants can be grown nearly worldwide. The needle-like leaves of these halophyte plants are covered with salt, usually secreted from the salt glands. The habitat of these plants is in hot and dry climates, although these plant species can also be grown in temperate climates. : Tamarix species are better suited to drought-prone environments than to wet climates, where their invasive nature creates competitive pressure that impedes native vegetation development (About et al., 2011). Tamarix species are deep-rooted and groundwater-

dependent for their water supply. These plant species are facultative as they can adapt to varying salt and drought conditions.

Tamarix dioica is indigenous to South and Central Asian regions, with natural populations occurring across Pakistan, India, Afghanistan, Iran, Myanmar, Bhutan, Nepal, and Bangladesh. In Pakistan, the species demonstrates highest abundance in Sindh and Khyber Pakhtunkhwa provinces.

CHEMICAL COMPOSITION

Tamarix species have been subjected to several phytochemical studies, which discovered the phytochemical series including important polyphenols such as flavonoids, phenolic acids, and tannins. . Phytochemical analysis of T. dioica shows that phlorotannins and steroids are present in all parts of the plant. Leaves, flowers, and roots of these plant species contain tannins, phenols, and flavonoids, which are abundant in all three parts. In contrast, terpenoids and saponins are more frequently found in flowers, stems, and leaves. In this research study, flower oil was determined as a mixture of different chemical constituents such as octadecane (5.60%), 1-hexadecene (6.93%), E-15-heptadecenal (4.98%), dodecanoic acid (5.22%), and hexahydrofarnesyl acetone (5.64%). Leaf oil was reported to contain phytochemicals such as dihydroactindiolide (10.27%), 2-methoxy-4-vinylphenol (17.70%), 1-hexadecene (5.10%), and mega stigmatrienone (5.53%).

Flavonoids: Flavonoids, a major class of dietary polyphenols, are broadly divided into six subgroups: flavanols, flavonols, flavones, flavanones, anthocyanins, and isoflavones (Garg et al., 2019). A substantial proportion of flavonoids have been identified in Tamarix species, with flavonols, characterized by the 3-hydroxyflavone backbone, being particularly abundant. Reports indicate that Tamarix contains quercetin in the form of

multiple glycosides, along with tamarixetin and rhamnetin, which occur in diverse glycosylated forms.

Tannins: Tannins, a subgroup of polyphenols, bind complex proteins and are known to have astringent activity. These are further categorized into ellagic acid and gallic acid derivatives, tannins, and proanthocyanidins. Hydroalcoholic, aqueous, and aqueous-acetone plant extracts of Tamarix reported to yield tannins. Ellagitannins are found in abundance compared to gallotannins. Aerial parts stem callus, and shoots of Tamarix are found to have tamarixinins and hirtellins (Orabi, et al., 2021).

Terpenes: Terpenes constitute secondary metabolic compounds characterized by their volatile nature and contribution to plant aromatic profiles. Multiple triterpenoid compounds, including β-amyrin, β-sitosterol, and ursolic acid, have been identified within Tamarix species. T. dioica has been documented to produce various volatile monoterpenes such as camphene, along with sesquiterpenes including iso-carveol and safranal. These volatile terpenoids are unlikely to represent primary bioactive constituents in T. dioica due to their relatively modest concentrations, ranging from 0.5-1.57% (Li et al., 2024).

MEDICINAL PROPERTIES

Moreover, Tamarix dioica is familiar as an astringent in some medical conditions, such as vaginal discharge and leucorrhea, etc. Antifungal activity of three microbes, including Aspergillus fumigatus, Candida glabrata, and Trichophyton rubrum, was inhibited by Tamarix dioica. It was also found to hinder bacteria such as K. pneumonia and P. aeruginosa.

In another study, the high antibacterial activity of leaves and flower essential oils was recorded against E. coli as compared to that of S. aureus (Bachir et al., 2012). The results demonstrated a significant reduction in E. coli colonies than that of S. aureus.

CONCLUSION

The medicinal value of Fagonia bruguieri and Tamarix dioica is substantiated by their abundant phytochemical constituents, particularly flavonoids, saponins, and phenolic metabolites. Preclinical studies consistently demonstrate antioxidant, antimicrobial, anti-inflammatory, anticancer, and hepatoprotective effects, aligning with their traditional uses in various ailments. These findings highlight their promise as sources of novel therapeutic agents and natural drug leads. However, standardized extraction protocols, dose–response studies, and comprehensive toxicity evaluations are urgently needed. Future investigations should emphasize rigorously designed clinical trials to establish safety and efficacy, thereby supporting the evidence-based incorporation of these plants into modern pharmacotherapy and advancing the development of plant-derived pharmaceuticals.

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