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Exploration, ethnomedicine and phytopharmaceutical upgradation of *Alhagi Maurorum* in Thar Desert

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Abstract
The Thar Desert, characterized by its harsh arid conditions, harbours a treasure trove of ethnomedicinal knowledge and biodiversity, including the medicinal plant *Alhagi maurorum*. This review delves into the exploration, ethnomedicine, and phytopharmaceutical potential of *A. maurorum* in the Thar Desert ecosystem. *A. maurorum*, commonly known as Camelthorn or Persian mannaplant, has long been revered in traditional medicine for its multifaceted therapeutic properties, ranging from anti-inflammatory to antimicrobial effects. The plant's rich phytochemical profile, comprising polysaccharides, glycosides, terpenoids, and flavonoids, underscores its pharmacological significance. Through ethnomedicinal exploration, indigenous communities have preserved invaluable knowledge regarding the use of *A. maurorum* in treating various ailments prevalent in the desert environment, such as rheumatic pains, gastrointestinal disorders, and urinary tract infections. Furthermore, phytopharmaceutical upgradation endeavors aim to leverage modern scientific techniques to enhance the efficacy and safety of *A. maurorum*-derived therapeutics. This comprehensive investigation underscores the importance of preserving traditional knowledge, advancing scientific research, and promoting sustainable utilization of *A. maurorum* for the betterment of human health in arid regions like the Thar Desert.

Keywords: Thar desert, ethnomedicine, *Alhagi maurorum*, biodiversity, desert ecosystem, phytochemicals, indigenous communities

Introduction

Alhagi maurorum Medik., Fabaceae (commonly known as Camelthorn, Camelthorn-bush, or Persian mannaplant) is a rare, halophytic, medicinal plant of desert ecosystem of Persia, Egypt, Syria, Pakistan, and India. The Latin name is given after the Arabic name alhag (Hamed *et al*. 2012). The plant is found in abundance dry lands, which is associated with less rainfall and areas of salty, sandy, rocky and dry soils. This plant is the favoured food of camels and is therefore known as camelthorn. This green, thorny, perennial shrub often growing up to 1.0 meter tall. It thrives in dry lands with low rainfall, and its roots can penetrate as deep as 5–7 meters, making it resilient in harsh environments characterized by high salinity and alkalinity. Regarding the literature, numerous phytochemical constituents have been identified from the plant such as polysaccharides, sitosterol, glycosides, terpenoids, coumarins, saponins, carotenoids, vitamins, tannins, phenolics and flavonoid compounds that act as natural antioxidants (Al-Snai *et al*. 2019) [7]. Traditionally, *A. maurorum* has been employed to remedy various conditions, including rheumatic pains, gastrointestinal discomfort, urinary tract, and liver diseases. Its versatile properties include diaphoretic, diuretic, expectorant, analgesic, antipyretic, anti-inflammatory, and laxative effects, while its efficacy in treating ulcers has been extensively reported (Khalifa *et al*. 2018; Kulieva *et al*. 1972; Ahmed *et al*. 2015) [26]. Pharmacological studies show that the Alhagi maurorum plant has antioxidant, antitumor, anti-diarrheal, and antimicrobial effects. This plant is beneficial against urinary and digestive disorders, rheumatism, hemorrhoids, and liver diseases (Ahmad *et al* 2015, Akbar and Akbar 2020) [4].

Alhagi species have been found to contain a diverse array of pharmacologically active secondary metabolites, including flavonoids, alkaloids such as alhacidin and alhacin, steroids, pseudalhagin A, phospholipids, and polysaccharides. These compounds have been isolated from various parts of the plant.

These Alhagi species exhibit a wide range of biological activities, including antioxidant, cardiovascular protection, anti-ulcer properties, hepatoprotective effects, antispasmodic actions, anti-diarrheal effects, pain relief (antinociceptive), fever reduction (antipyretic), anti-inflammatory properties, relief from rheumatic conditions, as well as antibacterial and antifungal activities. These beneficial effects have been attributed to different components found in different parts of the Alhagi plant.

Botanical description

A. maurorum, often known as the Thorny Saltbush, is a small perennial shrub with complicated branching that can reach heights of around 1m. Its root structure is significant, with roots capable of entering depths of 5-7m, with some extending up to 15m near the Dead Sea. Rhizomes are also prevalent, reaching depths of more than 2m in the soil and extending up to 8 meters. Additionally, the presence of root nodules has been recorded.

A. maurorum stems are greenish in color and ornamented with numerous axillaries spreading spines of roughly 2-4 cm in length, topped with a unique yellow tinge. Its leaves, distributed alternately along the stems, are simple and whole, ranging from elliptic to obovate in form, and Measure between 7 and 20 mm in length. These leaves are supported by short petioles that are around 1-2 mm long, and they are accompanied by 1millimeter-long stipules. The upper side of the leaves has a yellow-green hue with a leathery texture, but the lower surface is bluish-green and slightly hairy. *A. maurorum* flowers are pink to maroon in color, about 10mm long, and borne on short, slender pedicels. These flowers normally appear in clusters of one to six, coming from the plant's axillary spines. The fruit has the form of a tiny pod, ranging in length from 20 to 30mm, with a falcate shape and a reddish-brown hue when mature. These seed pods are closed (not dehiscent) and contain reniform, blackish-brown seeds with a polished look. The morphology of plant varies according to environmental factors. Thorns are smaller and less common in moister regions, but leaves are larger and more plentiful. Despite its distinguishing characteristics, *A. maurorum* is occasionally confused for the Russian salt tree (*Halimodendron halodendron*), a deciduous shrub brought to the United States for ornamental purposes. However, there are significant variations between the two species: the Russian salt tree has equally pinnate compound leaves with 2-6 leaflets each, branches with thorn tips, and black seed pods with no constrictions between seeds. However, there are noteworthy distinctions between the two species: the Russian salt tree has equally pinnate compound leaves with 2-6 leaflets each, branches with thorn tips, and black seed pods with no constrictions between the seeds.

Exploring phytochemical assets

A. maurorum, a plant with a rich history in traditional medicine, has attracted scientific interest for its diverse phytochemical composition. Phytochemical analysis of *Alhagi* species has unveiled the presence of various constituents, including fatty acids and sterols, coumarins and alkaloids, proanthocyanidins, vitamins, and lupeol (Laghari *et al*., 2011; Muhammad *et al*. 2015, Ahmed *et al*., 2015) [36]. For the first time, a significant quantity of lupeol, a bioactive triterpenoid, has been successfully isolated from the root barks of *Alhagi maurorum* using a straightforward extraction and isolation procedure. Additionally, a novel and adaptable LC-MS method has been developed in this study, where various parameters were optimized to enable the swift and accurate determination of lupeol in plant extracts (Laghari *et al*. 2010). Three new oleanane-type triterpene glycosides and four known glycosides were isolated from *A. maurorum* roots (Hamed *et al*. 2012). Their structures were determined using 1D and 2D-NMR experiments and ESI-MS analysis. Antiproliferative activity was assessed against MCF-7, A549, PC-3, and U937 cancer cell lines. *In vitro* study examined the impact of phenolic fraction extracted from *A. maurorum* roots on oxidative damage to protein/lipids in human blood platelets and plasma post-treatment with hydrogen peroxide (H_2O_2), a potent biological oxidant and inflammatory mediator (Olas *et al*. 2015) [38]. The phenolic fraction exhibited antioxidant properties, potentially serving as a natural protective factor against diseases linked to oxidative stress. Six primary flavonoid glycosides, including kaempferol, chrysoeriol, isorhamnetin, chrysoeriol-7-O-xyloside, kaempferol-3-galactorhamnoside, and isorhamnetin-3-O-β-D-apiofuranosyl (1→2)-β-D-galactopyranoside, were first isolated from the ethanol extract of A. maurorum (Olas *et al*. 2015) [38]. The present study aimed to isolate and identify flavonoids from the experimental plant using IR and GC-MS techniques, revealing the plant's potential in providing diverse and beneficial phytochemicals (Dhaniya and Parihar, 2018). Chemical analysis of *A. maurorum* aerial parts using GC-MS revealed thirty-nine compounds in petroleum ether extract, thirty-two in methanolic extract, and seventeen in aqueous extract. Ten new anticancer compounds were identified, indicating the plant's potential for drug development, with petroleum ether being the most effective solvent (Mostafa and Essawy 2019) [34]. Evaluation of methanol and dichloromethane (DCM) extracts from *A. maurorum* roots revealed higher phenolic and flavonoid contents in methanol, correlating with potent antioxidant activity and enzyme inhibition. UHPLC-MS identified 18 secondary metabolites in methanol, suggesting its potential as a source of natural antioxidants and enzyme inhibitors (Saleem *et al*. 2020) [41]. The nutritional value of camelthorn at different growth stages was investigated (Kazemi and Bezdi 2021) [25], revealing varying chemical compositions. Partial replacement of conventional forage with camelthorn had mixed effects on animal performance, with no adverse effects observed at vegetative or flowering stages but caution needed at seeding stage. *In vitro* studies highlighted the superior nutritional value of camelthorn at the vegetative stage. The root ethanolic extract of *A. maurorum* was analyzed using GC-MS, revealing 32 chemical constituents including oxalic acid, sulfone, and various ketones. These compounds possess diverse bioactivities such as anti-inflammatory, antibacterial, and anticancer properties, indicating the potential therapeutic value of *A. maurorum* roots (Mohammed and Abd-alkadhemand 2022) [32]. Chromatographic analysis of leaves, stems, and seeds revealed flavonoids like dehydroquercetin and rutin, known for their antioxidant properties and medicinal benefits (Kholmurodov *et al*. 2023) [28]. Kumar and Kasera (2023) [29] investigated the fluctuation of secondary metabolites (saponin, total tannin, anthraquinone) across the vegetative, flowering, and fruiting phases of Alhagi maurorum from the Rajasthan desert. Using HPLC, titrimetric, and GC/MS/MS methods, they found maximal levels of total tannins and saponin during flowering, with anthraquinone peaking during the vegetative stage, underscoring the importance of developmental stage in enhancing secondary metabolite production. In conclusion, the diverse phytochemical repertoire of *A. maurorum*, spanning flavonoids, oleanane glycosides, triterpenoids, and other bioactive compounds, positions this plant as a valuable resource for various applications, from traditional medicine to nutrition and pharmaceuticals. Further research is warranted to unravel the full therapeutic potential of the compounds identified in *A. maurorum*.

Ethnomedicine: Bridging tradition and modern understanding

The ethnobotanical applications of *A. maurorum* in traditional healing practices have been meticulously documented, offering a bridge between age-old traditions and contemporary scientific exploration. Camel thorn, a perennial desert plant found across Persia, Syria, Egypt, Pakistan, and India, holds significant medicinal value in various traditional systems. Known for its emollient, expectorant, and aphrodisiac properties, it is used in Unani, Ayurvedic, and Arabian medicines for conditions ranging from piles to liver ailments. Phytoconstituents like β-sitosterol and cinnamic acid contribute to its diverse therapeutic effects, including antioxidant, anti-inflammatory, and analgesic activities. Extracts have shown efficacy against diabetes, gastric ulcers, and nephrotoxicity, making camel thorn a promising botanical in herbal medicine (Akbar and Akbar 2020) [4]. Ethnobotanical research in rural Algerians Sahara, highlighted its usage in treating ailments like fever and gastrointestinal disorders, warranting further pharmacological exploration (Chakou *et al*. 2021b) [13]. Ali-Shtayeh *et al*. (2000) conducted an ethnobotanical survey in Palestine, acknowledging the healing potential of *A. maurorum*. The study categorizes its traditional medicinal uses, enhancing our understanding of community perceptions and utilization. In Mashhad city, Northeastern Iran, an ethnobotanical survey identified 37 plants from 26 families, commonly used by traditional healers to treat jaundice. Fabaceae, Polygonaceae, and Asteraceae were among the prominent families. Plants like *Cichorium intybus, Salix alba,* and *Alhagi maurorum* were frequently cited for jaundice treatment (Amiri *et al*. 2014). Decoction was the preferred method, administered orally 2 to 3 times daily for a week to a month. Further clinical studies are recommended to scientifically evaluate these traditional remedies. This comprehensive review by Asghari *et al*. (2016) examines the phytopharmacological effects and traditional uses of Alhagi species (*A. maurorum, A. camelorum, A. persarum, A. pseudoalhagi,* and *A. kirgisorum*). The authors synthesized data from various databases, highlighting significant biomedical properties, such as antimicrobial activity and biochemical effects on blood factors. While *A. camelorum* and *A. maurorum* exhibit potent antimicrobial effects, caution is advised due to observed DNA damage with *A. pseudoalhagi* ingestion. In conclusion, *A. maurorum* demonstrates rich ethnobotanical significance across various cultures, presenting promising avenues for further pharmacological exploration. Further studies are needed to validate its traditional uses and assess safety considerations for broader therapeutic applications.

Exploring the medicinal potency of *Alhagi maurorum*

Various studies underscore the rich medicinal properties of *A. maurorum*, commonly known as camel thorn. Alqasoumi *et al*. (2008) emphasized its hepatoprotective effects, while Ahmad *et al*. (2015) provided insights into its traditional uses and pharmacological significance. Investigation by Ahmad *et al*. (2015) revealed its potential as a source of natural antibacterial and antioxidative agents. Numerous researchers (Marashdah and Al-Hazimi 2010; Neamah 2012; Gargoum *et al*. 2013; Asghari *et al*. 2016; Shahrivar *et al*. 2017) [37, 42] have contributed to understanding its phytopharmacological properties. Saleem *et al*. (2020) [41] and Tavassoli *et al*. (2020) [45] enhanced our understanding of its phytochemistry and therapeutic effects, while Urabee *et al*. (2021) [46] explored extraction methods and therapeutic applications. These collective findings highlight the diverse medicinal contributions of *A. maurorum* as follows: -

Antiviral potential

Several studies have explored the antiviral properties of *A. maurorum*, also known as camel thorn. Shakiba *et al*. (2016) [44] investigated its anti-FMDV potential, revealing significant activity at non-cytotoxic concentrations, suggesting its use for FMDV control with a CC50 of approximately 30 µg/mL, reducing virus titer by at least 2 × 3.5 log. In a subsequent study (Shakiba *et al*., 2018) [43], *A. maurorum* extracts exhibited anti-FMDV activity across virus replication stages, with GC-MS identifying 1,2-Benzenedicarboxylic acid, diisooctyl ester as a major compound. Additionally, in a human study by Gargoum (2023) [17], camel thorn showed promising activity against HBV, significantly reducing viral load. Further research is needed to elucidate its mechanism of action. These findings collectively suggest *A. maurorum's* potential in combating viral infections, particularly FMDV, with implications for broader antiviral applications.

Anticancer potential

Numerous studies have underscored the anticancer properties of *A. maurorum*, with Behbahani (2014) identifying cytotoxic compounds in various plants, including lutein, lupeol, and eugenol, which upregulated apoptosis-related genes and downregulated bcl-2 expression in breast cancer cells. Bahamin *et al*. (2021) [11] further demonstrated *A. maurorum's* synergistic effect with docetaxel (DTX) in inhibiting breast cancer cell migration and inducing apoptosis, while *Amygdalus haussknechtii* reduced DTX IC50 alone. Additionally, Bahamin *et al*. (2023) found that *A. maurorum* combined with DTX significantly suppressed β-cat, MMP2, and FZD7 expression, suggesting a potential antiangiogenic therapy for breast cancer. Molaei-Kordabad *et al*. (2024) [33] explored Dodder's anticancer effects on breast and colorectal cancer cells grown on fennel and camelthorn hosts, indicating its potential to enhance the anticancer properties of medicinal plants economically. Moreover, studies involving the synthesis of titanium, nickel, and gold nanoparticles from *A. maurorum* extract revealed significant anticancer effects against breast cancer (Ye *et al*., 2021) [47], human ovarian cancer (Yuan *et al*., 2022) [48], and prostate carcinoma (Zhao *et al*., 2022) [49], highlighting the plant's versatile applications in cancer research and treatment.

Wound healing potential

In a study by Pourali and Yahyaei (2019) [39], the wound healing properties of a gel combining alginate from *Pseudomonas aeruginosa* with *A. maurorum* aqueous extract were investigated. After isolating *P. aeruginosa* strains and assessing their alginate production, strain K1, which exhibited the highest production, was selected. The *A. maurorum* extract demonstrated dose-dependent toxicity, leading to the preparation of a non-toxic mixture of alginate and *A. maurorum* extract. In a rat model, the alginate-*A. maurorum* extract complex showed superior wound healing activity compared to individual treatments, suggesting a potential novel wound dressing with enhanced properties. In another study, El-Zahar *et al*. (2022) [16] explored the healing activity of *A. maurorum* against oral ulcers in rats. Their analysis of polyphenol-rich fractions revealed isorhamnetin-3-O-rutinoside as a major phenolic compound in the ethyl acetate fraction (EFAM), quantified using UPLC-PDA-UV. UPLC-PDA-MS/MS analysis identified 25 polyphenolic compounds in EFAM, which exhibited potent antioxidant activity against DPPH. EFAM significantly reduced TNF-α and IL-2 levels while increasing PCNA expression, indicating its potential for treating oral ulcers. Collectively, these studies underscore the promising wound healing potential of *A. maurorum*. They not only elucidate the bioactive compounds responsible for the healing effects but also highlight diverse approaches, including polyphenol-rich fractions and innovative gel formulations, in harnessing the plant's therapeutic benefits for wound management.

Antimicrobial potential

Several studies have extensively explored the antimicrobial effectiveness of *A. maurorum*, revealing its efficacy against a wide range of microorganisms. Ghassan (2013) demonstrated inhibitory effects against various microorganisms, with MIC values spanning from 58.0 to 84.0 µg/mL. Bakht *et al*. (2014) found that butanol-extracted samples exhibited the highest potency against both bacterial strains and a fungal species. Additionally, Gilani *et al*. (2023) [20] evaluated different extracts for their phenolic content, antibacterial, antifungal, and cytotoxic activities, underscoring the significant antimicrobial potential of *A. maurorum*. Moreover, Mirzaei *et al*. (2022) [31] investigated its impact on Proteus mirabilis biofilm formation and quorum sensing genes, suggesting its role in preventing catheter-associated urinary tract infections.

These collective findings highlight *A. maurorum* is promising antimicrobial efficacy and its potential applications in combating microbial infections. The diverse methodologies employed in these studies, ranging from MIC assays to cytotoxic assessments and biofilm inhibition assays, provide a comprehensive understanding of the plant's antimicrobial properties. Such insights offer valuable contributions to the development of novel antimicrobial agents and strategies for managing microbial infections effectively.

Antifungal potential

The antifungal efficacy of A. maurorum has been extensively investigated, revealing its effectiveness against plant pathogenic fungi. Al-Askar (2012) explored the antifungal activity of A. maurorum among other Saudi plant extracts, contributing to its role in combating phytopathogens. Ahmed *et al*. (2015) demonstrated the inhibitory effects of hexane and ethanol extracts on fungi and bacteria, suggesting its utility in plant disease management. Alrabaea (2018) [5] highlighted A. maurorum's potential as an antifungal agent, expanding its agricultural applications. Al-Snai *et al*. (2019) [7] delved into the antifungal properties of A. maurorum phenolic extract, shedding light on its bioactive compounds. Hawar *et al*. (2022) [22] explored A. graecorum leaf extract for silver nanoparticle synthesis, showcasing cytotoxicity and antifungal activity. Reda *et al*. (2023) [40] evaluated the antimicrobial and antifungal effects of A. maurorum crude extract and fractions, identifying its bioactive components. These studies collectively underscore *A. maurorum* is diverse and potent antifungal potential, positioning it as a valuable natural resource for sustainable antifungal agents.

Antioxidant potential

A plethora of research has delved into unraveling the antioxidant potential of *Alhagi maurorum*, shedding light on its capacity to combat oxidative stress and contribute to overall health. In a seminal study by Ahmad *et al*. (2010), flavonoids from *A. maurorum* were meticulously identified and characterized. Among them, a novel flavonoid named isorhamnetin-3-O-[-α-l-rhamnopyranosyl-(1 → 3)]-β-d-glucopyranoside was discovered, alongside two known compounds, 3′-O-methylorobol and quercetin 3-O-β-d-glucopyranoside. These compounds were subjected to rigorous spectroscopic analysis, contributing to a deeper understanding of A. maurorum's antioxidant potential. The novel compound exhibited moderate antioxidant activity in the 2,2-diphenyl-1-picrylhydrazyl free radical scavenging assay, further corroborating the plant's antioxidative prowess. Moreover, Omar and Rashed (2014) explored the antioxidant, cytotoxic, and cytoprotective effects of A. maurorum extracts. Notably, the diethyl ether extract demonstrated potent radical scavenging activity, with an IC50 value of 0.083 ± 0.01 mg/mL. However, it also exhibited the highest cytotoxicity among the extracts, while all extracts displayed mild cytoprotective effects. Phytochemical analysis revealed the presence of triterpenes in petroleum ether, ether, and chloroform extracts, and flavonoids, triterpenes, and carbohydrates in methanol extract. Al-Rimawi *et al*. (2016) investigated the antioxidant activity, total phenolic content (TPC), and total flavonoid content (TFC) of *A. maurorum* root extracts obtained using different solvents. Their findings indicated that the choice of extraction solvent significantly influenced TPC, TFC, and antioxidant activity, with 80% ethanol exhibiting the highest TPC and antioxidant activity. This underscores the importance of solvent selection in optimizing the antioxidant potential of A. maurorum extracts. Additionally, Ahmed (2019) [3] evaluated the protective effects of aqueous extraction from *A. maurorum* leaves on spermatogenesis and antioxidant status in rats exposed to carbon tetrachloride (CCl_4)-induced oxidative stress. Significant improvements in sperm parameters and antioxidant levels were observed in rats treated with the extract alongside CCl_4, suggesting potential reproductive benefits and antioxidant effects. Furthermore, Al-Saleem *et al*. (2019) isolated fourteen flavonoids from the alcoholic extract of A. maurorum root. These compounds exhibited antioxidant and antiproliferative activities, with flavonoid glycosides demonstrating weak cytotoxicity against hepatocellular carcinoma cells. The total flavonoid fraction displayed significant hepatoprotective effects against CCl_4-induced hepatotoxicity, indicating the therapeutic potential of *A. maurorum* in liver disorders. Arjabi *et al*. (2021) [9] delved into the impact of solvent composition on the antioxidant and antibacterial efficacy of *A. maurorum* extracts. Their study highlighted significant variations in extract properties based on the solvent composition, underscoring the importance of solvent selection in optimizing antioxidant and antibacterial activities. Additionally, Chinnathambi and Alahmadi (2021) [14] ventured into the synthesis of zinc nanoparticles using *A. maurorum* leaf aqueous extract, showcasing antioxidant effects among other properties, thus expanding the plant's potential applications into nanotechnology. Several other studies, including Dhaniya and Parihar (2019) [15], Ghavipanje *et al*. (2022) [19], Laghari *et al*. (2012), Loizzo *et al*. (2014), and Sheweita *et al*. (2016), collectively contribute to the understanding of *A. maurorum's* antioxidant potential. In conclusion, the collective body of research on *A. maurorum's* antioxidant potential provides invaluable insights into its ability to mitigate oxidative stress and promote overall well-being. These investigations underscore the diverse applications and therapeutic benefits of *A. maurorum*, positioning it as a valuable natural resource in the quest for antioxidant agents and health-promoting botanicals.

Antiproliferative potential

Several studies have explored the antiproliferative activity of *A. maurorum*, revealing its potential in inhibiting cell growth and suggesting novel therapeutic applications.

Loizzo *et al*. (2014) demonstrated both antiproliferative and antioxidant properties in *A. maurorum* aerial parts, highlighting its multifaceted bioactivity and potential as a natural anticancer agent. Additionally, Reda *et al*. (2023) [40] investigated antimicrobial and antifungal activities, indirectly contributing to understanding *A. maurorum's* broader bioactivity. Motafeghi *et al*. (2023) [35] evaluated antibacterial properties and cytotoxicity, implying potential antiproliferative effects and expanding the plant's therapeutic applications. Further research is needed to fully elucidate *A. maurorum* is mechanisms and therapeutic potential in proliferation-related disorders.

Antibacterial potential

A. maurorum has garnered significant attention for its potent antibacterial properties, as evidenced by a plethora of studies. Bakht *et al*. (2014) delved into the antibacterial effects of *A. maurorum* extracts sourced from Peshawar valley. Their investigation encompassed testing six extracts against a spectrum of bacterial strains, revealing butanol extracts as most efficacious, while hexane extracts exhibited minimal efficacy. Notably, *Pseudomonas aeruginosa* displayed notable resistance. Abdulbary (2019) [2] further explored the antibacterial potential of *A. maurorum*, focusing on its methanolic extract. Despite high expectations, the study revealed a lack of antibacterial activity against *Bacillus cereus* and *Proteus mirabilis*, even at concentrations up to 200 mg/ml. In a groundbreaking study, Hassanshahian *et al*. (2020) [21] pioneered the production and characterization of nanoemulsion from *A. maurorum* essential oil, showcasing superior antibacterial and antibiofilm activity compared to the free oil. The remarkable efficacy was evidenced through Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration for Biofilm (MBCB) determinations, highlighting its potential as a potent antimicrobial agent. Hussain *et al*. (2023) [24] extended the exploration to essential oils from both *Microcephala lamellata* and *A. maurorum*, shedding light on their primary and secondary metabolites. The antibacterial evaluations underscored the potency of *A. maurorum* essential oils against various bacterial strains, emphasizing its superiority over *Microcephala lamellata* oils. Motafeghi *et al*. (2023) [35] contributed to the understanding by evaluating the antibacterial properties of ethanolic extracts from *A. maurorum* against *Staphylococcus aureus* and Pseudomonas aeruginosa. The findings elucidated its higher efficacy against S. aureus, further cementing its reputation as a formidable antibacterial agent. Lastly, Reda *et al*. (2023) [40] conducted extensive fractionation of *A. maurorum* extract, unveiling promising antimicrobial and antifungal activities across various fractions. Noteworthy inhibition zones against Proteus vulgaris were observed, alongside antifungal activity against Candida albicans, underscoring the multifaceted potential of A. maurorum in combating microbial infections.

In summation, the cumulative findings underscore the formidable antibacterial prowess of *A. maurorum*, advocating for continued exploration to elucidate the bioactive compounds and mechanisms underpinning its antibacterial effects. This comprehensive understanding holds promise for the development of novel antimicrobial agents derived from *A. maurorum*, addressing the escalating global challenge of antibiotic resistance.

Anti-inflammatory potential

Several studies have examined the anti-inflammatory properties of *A. maurorum*, indicating its potential therapeutic use in managing inflammatory conditions. Shaker *et al*. (2010) investigated the anti-inflammatory and anti-ulcer effects of *A maurorum* extract, revealing reduced gastric fluid volume and acidity, along with protection against liver enzyme elevation and oxidative stress. Histopathological analysis highlighted gastric inflammation and vascular changes, emphasizing the need for further research into natural plant extracts for treating gastric issues. Abdulbary (2018) [1] conducted a study to identify active compounds in *A. maurorum* extract obtained via soxhlet extraction with methanol. Chemical analysis revealed the presence of glycosides, tannins, alkaloids, and phenolics. *In vitro* tests showed the extract's effectiveness in inhibiting albumin denaturation and heat-induced hemolysis, suggesting its anti-inflammatory potential compared to aspirin and negative controls. Additionally, Chakou *et al*. (2021a) [12] investigated the anti-inflammatory and antihyperglycemic effects of water-soluble polysaccharides extracted from *A. maurorum* seeds collected in the Algerian Sahara. The polysaccharide extracts, WSPAM1 and WSPAM2, displayed dose-dependent inhibition of α-amylase activity and Bovine Serum Albumin denaturation. These findings indicate the potential pharmacological benefits of *A. maurorum* in traditional medicinal practices. In summary, the collective evidence suggests that *A. maurorum* exhibits significant anti-inflammatory activities, making it a promising candidate for the development of anti-inflammatory agents and complementary therapies. Further research is warranted to elucidate its mechanisms of action and therapeutic potential in treating inflammatory disorders.

Gastroprotective potential

Alhagi maurorum, also known as camel thorn, has garnered attention in research for its gastroprotective properties. Awaad *et al*. (2006) identified six flavonoid glycosides in its ethanol extract, such as kaempferol and chrysoeriol, showcasing significant antiulcerogenic activity, with curative ratios reaching up to 77.93%. Naseri and Mard (2007) explored the gastroprotective potential of *A. maurorum* aqueous extract (AME) in rats. Pre-treatment with AME demonstrated dose-dependent protection against water immersion restraint-stress and ethanol-induced ulcers. AME also elevated pH levels, reduced gastric acid content, and exhibited no toxicity at high doses, indicating substantial mucosal protection. Khalifa *et al*. (2018) [26] investigated the analgesic, anti-inflammatory, and anti-ulcerogenic effects of A. maurorum methanolic extract in rodents, expanding its therapeutic scope to pain, inflammation, and ulcer prevention. Additionally, Khalifa *et al*. (2020) [27] revealed the aqueous extract's protective effects against norfloxacin-induced hepato-nephrotoxicity in rats, suggesting potential benefits for gastrointestinal health beyond its primary focus on liver and kidney protection. Gargoum *et al*. (2022) [18] contributed to understanding *A. maurorum* is gastroprotective effects by assessing its impact on ethanol-induced gastric damage in mice. Their findings indicated a protective role against ethanol-induced gastric damage, highlighting its potential as a gastroprotective agent. In summary, these studies collectively underscore *A. maurorum* is gastroprotective effects, positioning it as a promising candidate for further investigation in the development of natural remedies for gastric disorders.

Antiurolithiatic potential

Numerous investigations have probed into the potential therapeutic advantages of *A. maurorum* concerning urological well-being, particularly focusing on conditions like urolithiasis and associated complications. El-Nabtity *et al*. (2019) delved into the antiurolithiatic impact of a combined therapy involving Cymbopogon Proximus and A. Maurorum in rabbits afflicted with sulfadimidine-induced urolithiasis. Their findings underscore the plant's potential role in managing urological disorders. Hoseini *et al*. (2020) [23] conducted a randomized controlled trial exploring the efficacy of camel milk and Tarangabin (manna of *A. maurorum*) in combination therapy on glomerular filtration rate in chronic kidney disease patients, offering valuable insights into *A. maurorum* is effects on renal function. Additionally, Ammar *et al*. (2022) [8] investigated the anti-urolithiatic activity of *A. maurorum* harvested wild in Al-Ahsa, Saudi Arabia, providing insights into its potential in preventing urinary stone formation and enhancing understanding of its role in urological health. Aryaeefar *et al*. (2022) [10] carried out a single-blind randomized trial to assess the effect of *A. maurorum* distillate on ureteral stone expulsion, furnishing clinical evidence supporting its potential in facilitating ureteral stone expulsion. Moreover, Mehrabi *et al*. (2023) [30] conducted a prospective study comparing the impact of the hydroalcoholic extract of *A. maurorum* with hydrochlorothiazide on kidney and ureteral stone excretion in adults, further adding to the clinical evidence backing the potential urological benefits of *A. maurorum*. In summary, the collective evidence from these studies suggests a promising role for *A. maurorum* in promoting urological health, emphasizing the need for continued exploration and clinical research in this field.

Conclusion

In summary, *Alhagi maurorum*, or camel thorn, exhibits diverse therapeutic potential in traditional medicine, pharmaceuticals, and nutrition due to its rich phytochemical composition and pharmacological activities. Its ethnomedicinal significance highlights the importance of blending traditional knowledge with modern scientific exploration. With notable antimicrobial, antioxidant, anti-inflammatory, gastroprotective, and antiurolithiatic properties, *A. maurorum* offers promise in managing various health conditions. Further research is needed to understand its mechanisms, optimize extraction methods, and validate traditional uses. This ongoing investigation paves the way for novel therapeutics and preventive interventions. Overall, *A. maurorum* holds significant promise in addressing contemporary health challenges, emphasizing the value of utilizing nature's resources for human well-being and advancement.

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References

1. Abdulbary M. Detection about the Anti-Inflammatory Effect in Alcoholic Extract of *Alhagi maurorum in vitro*. International Journal for Research in Applied Sciences and Biotechnology (IJRASB),2018:5(5):1-3.
2. Abdulbary M. Study of some properties and antibacterial activity of (*Alhagi maurorum* Medik) collected from the desert of Al–Najaf. In Journal of Physics: Conference Series, IOP Publishing, 2019:1294:6:062081.
3. Ahmed MA. Protective effect of aqueous extract of *Alhagi maurorum* in spermatogenesis and antioxidant status of adult rats exposed to carbon tetrachloride. Iraqi Journal of Veterinary Sciences,2019:33(1):1-7.
4. Akbar S, Akbar S. *Alhagi maurorum* Medik. (Fabaceae/Leguminosae) (Syns.: *A. camelorum* DC; *A. pseud Alhagi* (M. Bieb.) Fisch; Hedysarum *Alhagi* L.). Handbook of 200 Medicinal Plants: A Comprehensive Review of Their Traditional Medical Uses and Scientific Justifications, 2020, 129-133.
5. Alrabaea EAA). *Vitro* study of the antifungal activity of *Alhagi maurorum* and *tamarix aphylla* extracts against some plant pathogenic fungi. Pak. J. Biotechnol,2018:15(1):155-158.
6. Al-Saleem MS, Al-Wahaib LH, Abdel-Mageed WM, Gouda YG, Sayed HM. Antioxidant flavonoids from *Alhagi maurorum* with hepatoprotective effect. Pharmacognosy Magazine,2019:15(65):592-599.
7. Al-Snai AE, Al-Kamel ML, Esmael ME. Antifungal effect of *Alhagi maurorum* phenolic extract. IOSR Journal of Pharmacy,2019:9(8):7-14.
8. Ammar RB, Khalifa A, Alamer SA, Hussain SG, Hafez AM, Rajendran P. Investigation of the potential anti-urolithiatic activity of *Alhagi maurorum* (Boiss.) grown wild in Al-Ahsa (Eastern Province), Saudi Arabia. Brazilian Journal of Biology,2022:84:e259100.
9. Arjabi A, Anarjan N, Jafarizadeh-Malmiri H. Effects of extracting solvent composition on antioxidant and antibacterial activities of *Alhagi maurorum* extracts. Journal of Food Processing and Preservation,2021:45(3):e15300.
10. Aryaeefar MR, Khakbaz A, Akbari S, Movahedi A, Gazerani A, Bidkhori M, *et al*. Effect of *Alhagi maurorum* distillate on ureteral stone expulsion: A single-blind randomized trial. Journal of Herbal Medicine,2022:34:100567.
11. Bahamin N, Ahmadian S, Rafieian-Kopaei M, Mobini G, Shafiezadeh M, Soltani A. A comparative study on anticancer effects of the *Alhagi maurorum* and *Amygdalus haussknechtii* extracts alone and in combination with docetaxel on 4T1 breast cancer cells. Evidence-Based Complementary and Alternative Medicine, 2021.
12. Chakou FZ, Boual Z, Hadj MDOE, Belkhalfa H, Bachari K, El Alaoui-Talibi Z, *et al*. Pharmacological investigations in traditional utilization of *Alhagi maurorum* Medik. in saharan Algeria: *In vitro* study of anti-inflammatory and antihyperglycemic activities of water-soluble polysaccharides extracted from the seeds. Plants,2021a:10(12):2658.
13. Chakou FZ, Boual Z, Ould El Hadj MD, Badreddine A, El Alaoui-Talibi Z, El Modafar C, *et al*. Ethnobotanical utilization of *Alhagi maurorum* Medik. in traditional recipes of Algerian Sahara Illizi Wilaya. Euro-Mediterranean Journal for Environmental Integration,2021b:6:1-8.
14. Chinnathambi A, Alahmadi TA. Zinc nanoparticles green-synthesized by *Alhagi maurorum* leaf aqueous extract: Chemical characterization and cytotoxicity, antioxidant, and anti-osteosarcoma effects. Arabian Journal of Chemistry,2021:14(4):103083.

15. Dhaniya S, Parihar SK. Evaluation of antioxidant potential of Dicoma tomentosa and *Alhagi maurorum* leaf and stem powder. Journal of Drug Delivery and Therapeutics,2019:9(4-A):207-211.
16. El-Zahar H, Menze ET, Handoussa H, Osman AK, El-Shazly M, Mostafa NM, Swilam N. UPLC-PDA-MS/MS profiling and healing activity of polyphenol-rich fraction of *Alhagi maurorum* against oral ulcer in rats. Plants,2022:11(3):455.
17. Gargoum H. A Human Study on The Effect of *Alhagi maurorum* (Camel Thorn) On Patients Suffering from Hepatitis B Virus. Journal Of Medicine and Pharmacy,2023:6(3):7-17.
18. Gargoum HM, Ejjhawe ZA, Abellatif AG, El-Mahjoob SM. Gastroprotective effect of *Alhagi maurorum* (camel thorn) in ethanol-induced gastric damage in mice. The Scientific Journal of University of Benghazi, 2022, 35(1).
19. Ghavipanje N, Vargas-Bello-Pérez E, Afshin M, Hosseini SA, Aghashahi A, Vatankhah AM. The Inclusion of *Alhagi maurorum* in Growing Camel Diet: Effect on Performance, Liver-Related Blood Metabolites, and Antioxidant Status. Frontiers in Veterinary Science,2022:9:863121.
20. Gilani S, Bibi Y, Afzal T, Baloch R. Cytotoxic and Antimicrobial Efficacy of *Alhagi maurorum*. Med Discoveries,2023:2(4):1036.
21. Hassanshahian M, Saadatfar A, Masoumipour F. Formulation and characterization of nanoemulsion from *Alhagi maurorum* essential oil and study of its antimicrobial, antibiofilm, and plasmid curing activity against antibiotic-resistant pathogenic bacteria. Journal of Environmental Health Science and Engineering,2020:18:1015-1027.
22. Hawar SN, Al-Shmgani HS, Al-Kubaisi ZA, Sulaiman GM, Dewir YH, Rikisahedew JJ. Green synthesis of silver nanoparticles from *Alhagi graecorum* leaf extract and evaluation of their cytotoxicity and antifungal activity. Journal of Nanomaterials, 2022, 1-8.
23. Hoseini SM, Anushiravani M, Mojahedi MJ, Hami M, Zibaee S, Rakhshandeh H, *et al*. The efficacy of camel milk and Tarangabin (manna of *Alhagi maurorum* (combination therapy on glomerular filtration rate in patients with chronic kidney disease: a randomized controlled trial. Avicenna Journal of Phytomedicine,2020:10(2):170.
24. Hussain A, Rashid A, Shah SMA, Akram M. Extraction, Characterization, Antibacterial and Analgesic Activity of Essential Oils Obtained from *Microcephala Lamellata* and *Alhagi maurorum*. Journal of Population Therapeutics and Clinical Pharmacology,2023:30(19):521-531.
25. Kazemi M, Bezdi KG. An investigation of the nutritional value of camelthorn (*Alhagi maurorum*) at three growth stages and its substitution with part of the forage in Afshari ewes' diets. Animal Feed Science and Technology,2021:271:114762.
26. Khalifa HA, Elattar AM, Eleiwa NZ. Possible analgesic, 1anti-inflammatory and anti-ulcerogenic effects of *Alhagi maurorum* methanolic extract in rats and mice. Slovenian Veterinary Research,2018:55:375
27. Khalifa HA, Shalaby SI, Abdelaziz AS. *Alhagi maurorum* aqueous extract protects against norfloxacin-induced hepato-nephrotoxicity in rats. Chinese Herbal Medicines,2020:12(2):156-162.
28. Kholmurodov BB, Ishimov UJ, Tadjiyeva MK, Akramova RR, Samadov OB. Analysis of the amount of flavonoids contained in the surface part of the *Alhagi maurorum* by chromatographic method. In IOP Conference Series: Earth and Environmental Science, IOP Publishing,2023:1284(1):012008.
29. Kumar R, K Kasera P. Saponin, total tannin, and anthraquinone contents in *Alhagi maurorum* from the Rajasthan desert. Indian Journal of Natural Products and Resources,2023:14(2):332-335
30. Mehrabi S, Beigi P, Salehpour Z. Comparison of the Effect of Hydroalcholic Extract of *Alhagi maurorum* and Hydrochlorothiazide on Excretion of 4–10 mm Kidney and Ureteral Stones in Adults: A Randomized Prospective Study. Advances in Pharmacological and Pharmaceutical Sciences, 2023.
31. Mirzaei A, Nasr Esfahani B, Ghanadian M, Moghim S. *Alhagi maurorum* extract modulates quorum sensing genes and biofilm formation in Proteus mirabilis. Scientific Reports,2022:12(1):13992.
32. Mohammed RK, Abd-alkadhemand NAD. Determination of Active Phytochemical Compounds of *Alhagi maurorum* using Gas Chromatography-Mass Spectroscopy (GC-MS). Iraqi Journal of Science, 2022, 87-97.
33. Molaei-Kordabad N, Alizadeh-Salteh S, Ghanbari-Jahromi M, Saber M. *In vitro* study on anticancer effect of Dodder grown on fennel (*Foeniculum vulgare*) and camelthorn (*Alhagi* maorurum) against human cancer cells lines. Journal of Herbal Medicine,2024:43:100819.
34. Mostafa RM, Essawy HS. Assessment of camel thorn (*Alhagi maurorum*) as new sources of bioactive compounds using GC-MS technique. Plant Omics,2019:12(1):70-76.
35. Motafeghi FS, Shokrzadeh M, Mohammadi H, Shokrzadeh S, Razaghi H. Evaluation of Antibacterial Properties and Cytotoxicity of Ethanolic Extract of *Alhagi maurorum*. Journal of Babol University of Medical Sciences,2023:25(1):340-347.
36. Muhammad G, Hussain MA, Anwar F, Ashraf M, Gilani AH. *Alhagi*: a plant genus rich in bioactives for pharmaceuticals. Phytotherapy research,2015:29(1):1-13.
37. Neamah NF. A pharmacological evaluation of aqueous extract of *Alhagi maurorum*. Global Journal of Pharmacology,2012:6(1):41-46.
38. Olas B, Hamed AI, Oleszek W, Stochmal A. Comparison of biological activity of phenolic fraction from roots of *Alhagi maurorum* with properties of commercial phenolic extracts and resveratrol. Platelets,2015:26(8):788-794.
39. Pourali P, Yahyaei B. Wound healing property of a gel prepared by the combination of *Pseudomonas aeruginosa* alginate and *Alhagi maurorum* aqueous extract in rats. Dermatologic therapy,2019:32(1):e12779.
40. Reda M, Eltamany EE, Ahmed S. Antimicrobial and Antifungal Activities of *Alhagi maurorum* Crude Extract and Its Fractions. Records of Pharmaceutical and Biomedical Sciences,2023:7(2):128-130.

41. Saleem H, Sarfraz M, Khan KM, Anwar MA, Zengin G, Ahmad I, *et al*. UHPLC-MS phytochemical profiling, biological propensities and in-silico studies of *Alhagi maurorum* roots: a medicinal herb with multifunctional properties. Drug development and industrial pharmacy,2020:46(5):861-868.
42. Shahrivar T, Mokhtari M, Alipour V. An Investigation into the Effects of Alcoholic Extract of *Alhagi maurorum* on Lipid Profiles In Streptozotocin-Induced Diabetic Male Rats. Journal of Alternative Veterinary Medicine,2017:1(2):70-79.
43. Shakiba Y, Rezatofighi SE, Nejad SMS, Ardakani MR. Inhibition of Foot-and-Mouth Disease Virus Replication by Hydroalcoholic and Aqueous-Acetic Acid Extracts of *Alhagi maurorum*. Iranian Journal of Pharmaceutical Sciences,2018:14(1):85-96.
44. Shakiba Y, Rezatofighi SE, Nejad SMS, Ardakani MR. Antiviral activity of *Alhagi maurorum* Medik’s methanolic extract on foot and mouth disease virus (FMDV) in cell cultures. Jundishapur Journal of Natural Pharmaceutical Products,2016:11(3):e59720
45. Tavassoli AP, Anushiravani M, Hoseini SM, Nikakhtar Z, Baghdar HN, Ramezani M, *et al*. Phytochemistry and therapeutic effects of *Alhagi* spp. and tarangabin in the Traditional and modern medicine: a review. Journal of Herbmed Pharmacology, 2020, 86-104.
46. Urabee MC, Abdulsattar JO, Nasif ZN, Al-Garawi ZS. Extraction methods of *Alhagi maurorum* (camel thorn) and its therapeutic applications. In Journal of Physics: Conference Series, IOP Publishing,2021:1853(1):012053.
47. Ye J, Shi J, Zhang M, Zhang Y, Tao J, Jiang S, *et al*. Novel *Alhagi maurorum* leaves mediated synthesis of titanium nanoparticles for human breast carcinoma applications: a preclinical trial study. Arch Med Sci, 2021.
48. Yuan C, Jiang B, Xu X, Wan Y, Wang L, Chen J. Anti-human ovarian cancer and cytotoxicity effects of nickel nanoparticles green-synthesized by *Alhagi maurorum* leaf aqueous extract. Journal of Experimental Nanoscience,2022:17(1):113-125.
49. Zhao W, Wang L, Chen H, Qi L, Yang R, Ouyang T, Ning L. Green synthesis, characterization and determination of anti-prostate cancer, cytotoxicity and antioxidant effects of gold nanoparticles synthesized using *Alhagi maurorum*. Inorganic Chemistry Communications,2022:141:109525.