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REVIEWED BY

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University of Pretoria, South Africa
Misbah Sehar,
National Sun Yat-sen University, Taiwan

*CORRESPONDENCE

Abdulrahman Mohammed Alhudhaibi
✉ amalhudhaibi@imamu.edu.sa
Emad M. Abdallah
✉ 140208@qu.edu.sa

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Lycium shawii (Solanaceae): nutritional composition, phytochemistry, biological activities, and food-use prospects of an underexplored desert edible plant

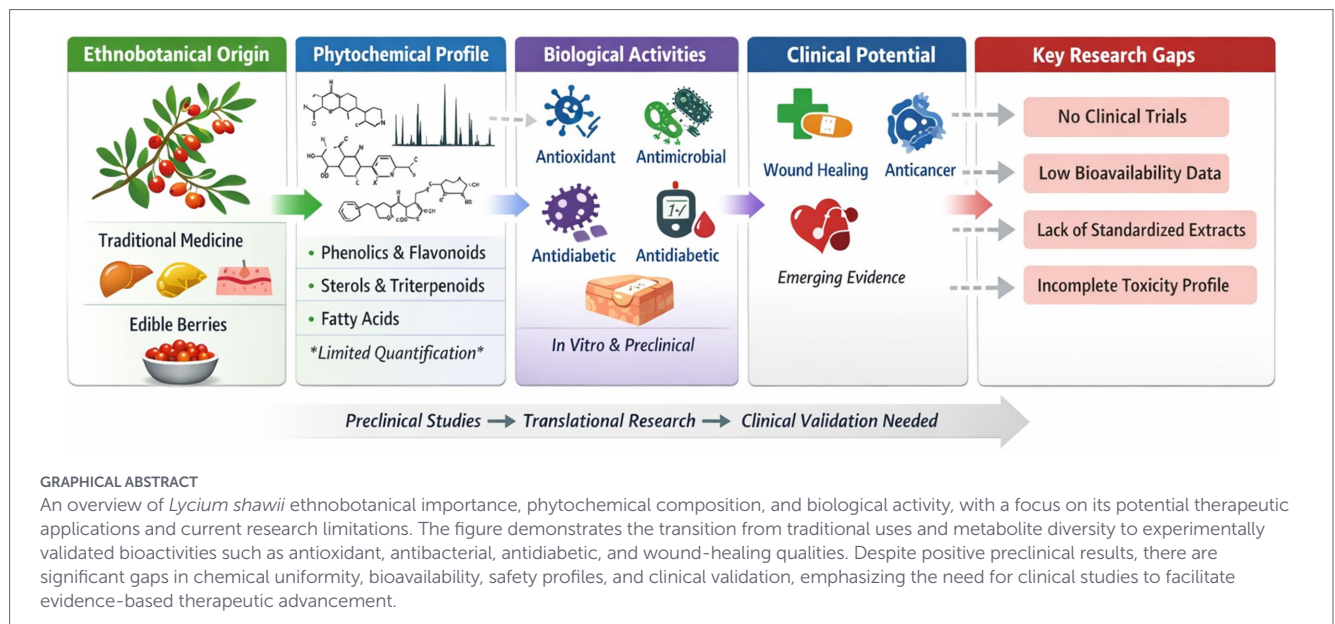
Emad M. Abdallah^{1*}, Abdulrahman Mohammed Alhudhaibi^{2*}
and Hammad Ahmad Jan³

¹Department of Biology, College of Science, Qassim University, Buraydah, Saudi Arabia, ²Department
of Biology, College of Science, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi
Arabia, ³Department of Botany, University of Buner, Swari, Pakistan

Wild edible plants represent critical yet underutilized resources for enhancing dietary resilience in arid and semi-arid ecosystems. *Lycium shawii* Roem. & Schult., a thorny desert shrub native to the Arabian Peninsula and neighboring regions, produces edible berries and exhibits marked ecological adaptability to saline, drought-prone environments. Despite its traditional use and ecological importance, a comprehensive synthesis of its nutritional, phytochemical, and biological attributes has remained limited. This review critically integrates available literature on the taxonomy, morphology, ecological adaptations, ethnobotanical significance, nutritional composition, phytochemical profile, biological activities, and safety considerations of *L. shawii*. Current evidence confirms that the berries are moisture-rich and carbohydrate-dominant, with measurable phenolic content and mineral presence, although standardized micronutrient profiling and multi-regional compositional benchmarking remain scarce. Extract-based studies report antioxidant, antimicrobial, antidiabetic, wound-healing, and emerging antiparasitic activities, with wound healing supported by *in vivo* evidence. However, most pharmacological findings remain preclinical and exploratory, and clinical validation is lacking. From a sustainable food systems perspective, *L. shawii* should be positioned primarily as a climate-resilient desert berry with potential contribution to dietary diversification and land restoration initiatives. Integration into food value chains will require rigorous nutritional standardization, safety validation, bioavailability assessment, and agronomic feasibility studies. Strengthening this evidence base may support the strategic utilization of underexplored desert species in advancing sustainable nutrition and contributing to the Zero Hunger goal.

KEYWORDS

bioactive compounds, desert medicinal plants, *Lycium*, nutraceuticals, nutrition, wild edible plants



1 Introduction

Due to the limitation of traditional farming methods brought about by climate change and land degradation, wild edible plants are now considered major food security, nutrition, and health resources in arid and semi-arid areas globally (Åhlberg, 2025). Wild edible and medicinal plants constitute a major part of human diet and health, especially in areas where farming is limited by water shortages, low soil fertility and extreme temperatures (Yao et al., 2018; Yao et al., 2021). Wild edible plants (WEPs) in these ecosystems enhance dietary resilience through the availability of necessary macro- and micronutrients and sources of bioactive compounds. All these compounds (such as flavonoid, polyphenol, polysaccharides, alkaloid, and sterol) are linked with antioxidant, antimicrobial, anti-inflammatory, and anti-diabetic, which underscores the nutritional and pharmacological importance of WEPs (Ahmed et al., 2017; Ragab et al., 2023).

In addition to nutrition, the application of WEPs is consistent with the United Nations Sustainable Development Goal 2 (Zero Hunger) since plants can increase dietary diversity, alleviate micronutrient deficiencies, and serve as food sources at times of crisis and environmental pressure. Traditional knowledge passed through oral means in the Arabian Peninsula reflects the dependence on local biodiversity and underlines the socio-cultural significance of WEPs to support livelihoods and practices by health orientation (Al-Fatimi, 2021).

Plants adapted to desert have ecological, morphological, and physiological characteristics that facilitate their survival during drought, salinity, temperature stress (Abo Amin et al., 2025; Ragab et al., 2023). These characteristics are: deep root systems, high root-to-shoot ratios, osmotic adjustment, early stomatal closing, and increase in antioxidant capacity which decrease oxidative stress in limited water availability (Abo Amin et al., 2025). These adaptations also provide stability to the ecosystem in the form of the soil consolidation, dune fixation, and habitat retention (Abo Amin et al., 2025). Some of the species that have been found to colonize the sand dunes, regulate sodium uptake, and control transpiration include *Cymbopogon comosum* and *Haloxylon salicornicum*. The combination of ecological stabilization with the nutritional value is offered by shrubs and trees like

Salvadora persica and *Lycium shawii*, which proves the multifunctional character of desert plants in drylands ecosystems (Abo Amin et al., 2025).

In the above context, the genus *Lycium* L. (Solanaceae) is an ecologically and pharmacologically valuable group of deserts adapted plants. The genus has about 90 species spread throughout the tropical, subtropical, and arid areas of the Americas, Africa, and Eurasia, the centers of diversification being the Americas and Africa (Miller, 2002; Yao et al., 2018). The *Lycium* species are perennial shrubs with thorns, fleshy multi-seeding red berries and reproductive strategies of functional dioecy and hermaphroditism (Miller, 2002). The ethnobotanical data indicates that fruits, leaf, roots, and young shoots are commonly used as food and medicine due to their significance to the traditional health systems (Yao et al., 2021). Phytochemical works have reported the presence of polysaccharides, flavonoids, terpenoids, anthraquinones, steroids, and carotenoids that are associated with antioxidant, anti-inflammatory, anticancer and nephroprotective functions and can also be used as chemotaxonomic biomarkers (Almoulah et al., 2017; Rehman et al., 2018; Kowalczyk et al., 2022).

Lycium shawii Roem. & Schult. is indigenous to the Arabian Peninsula and the southern region of Africa and can be distinguished according to a set of morphological, ecological, and phytochemical characteristics (Ragab et al., 2023). It is a thorny perennial shrub up to 3 m in height, straight stems, leaves are elliptic, solitary, small, and multi-seeded berries (Yao et al., 2021). The species thrives in gravel valley, hillsides, wadis and sandy ridges whereby it develops nabkhas, which increase soil stability and nutrient retention. Its ecological potential is demonstrated by a deep taproot system, high root-to-shoot ratio, adaptive leaf phenology, and the capacity to grow in nutrient-poor and alkaline soils, which means that it is ecologically resilient and useful in restoration of arid-lands (Ragab et al., 2023). Its possible use in forestation and restoration against desertification and in rehabilitation of damaged soils is emphasized through restoration techniques, such as tissue culture-based propagation.

Lycium shawii has a variety of bioactive compounds. There are sesquiterpene lactones, anthraquinone, flavanol, triterpenoids, and steroids which include compounds like dehydrocostus lactone, costunolide, and emodin derivatives reported in the stems and leaves and

are not reported previously in the other members of the genus or family (Rehman et al., 2018). Metabolites have been found to vary seasonally with the highest concentrations of water, nitrogen, and lipids during the winter season, and carbohydrate levels during the summer and autumn season, which are related to environmental stress (Ahmed et al., 2017). The predominant osmotic regulators and stress tolerants include free sugars, which include arabinose, ribose, fructose, galactose, glucose, and sucrose and are found in leaves, and protein hydrolysates and amino acids, including proline and histidine, which are found in leaves and stems (Ahmed et al., 2017). Fatty acids, hydrocarbons, and sterols aid the stability of the membranes in arid conditions. Its ethnomedicinal application in hepatic, gastrointestinal and respiratory conditions is supported by the presence of flavonoids, tannins, saponins, and alkaloids (Ahmed et al., 2017).

Taxonomic and genetic investigations provide a difference between *Lycium shawii* and other species in the Arabian Peninsula. Molecular studies with ITS sequences and SCoT markers indicate distinct separation with *Lycium europaeum* and *Lycium schweinfurthii*, whereas anatomical analyses reveal species-specific features in the structure of the epidermis, cuticle thickness, and vascular arrangement (Ragab et al., 2023). This distinction is also supported by pollen morphology, whereby typical monad and isopolarity and zonotricolporate types of grains with recognizable micromorphological features are observed even though exine patterns are alike across the genus (Ragab et al., 2023). Metabolic profiling with GC–MS also determines the diagnostic phytochemicals that aid it in chemotaxonomic separation (Ragab et al., 2023; Rehman et al., 2018).

Ethnobotanical reports facilitate the preservation and sustainable utilization of desert plants. Traditional knowledge is incorporated within cross-cultural frameworks, as it quantifies the significance of species based on indices such as Cultural Importance Index (CII), Relative Frequency of Citation (RFD), Use Value (UV), and Fidelity Level (FL) (Yao et al., 2021). The use of these techniques with respect to *Lycium* species, such as *Lycium shawii*, underscores the fact that these species remain relevant in terms of human health, cultural heritage, and biodiversity conservation in western Asia and the Arabian Peninsula (Yao et al., 2021).

Despite its documented ecological, ethnobotanical, and phytochemical significance, a comprehensive synthesis encompassing the taxonomy, morphology, ecology, chemical composition, and traditional uses of *Lycium shawii* remains limited. Addressing this gap is essential to inform conservation strategies, guide restoration and bio-prospecting efforts, and improve understanding of the broader role of desert-adapted species in food security, medicinal applications, and ecosystem stability. Accordingly, the current study aimed to comprehensively synthesize and critically evaluate the existing literature on *Lycium shawii*, with a particular focus on its taxonomy, morphology, ecological adaptation, nutritional composition, phytochemical profile, and reported pharmacological activities. Specifically, this review sought to integrate available ethnobotanical knowledge with experimental evidence from phytochemical, molecular, and bioactivity studies, while assessing the strength and limitations of the reported data. In addition, the study aimed to identify key knowledge gaps and research priorities related to the conservation, sustainable utilization, and translational relevance of *Lycium shawii*, and to highlight its potential role as a model desert-adapted species for understanding plant resilience, ecosystem restoration, and food–health interactions in arid environments. Importantly, this review integrates recent studies published in 2024–2025, including metabolomics profiling,

phytochemical isolation, and *in vivo* bioactivity investigations, to provide an updated and contemporary assessment of *Lycium shawii* research.

2 Methodology

This review was conducted as a structured narrative synthesis to evaluate the nutritional composition, phytochemical characteristics, ethnobotanical relevance, biological activities, and potential food-industry applications of *Lycium shawii*, with strict emphasis on species-specific evidence. A comprehensive literature search was performed in Scopus, Web of Science, PubMed/MEDLINE, and Google Scholar for studies published up to January 2026 using combinations of the keywords “*Lycium shawii*” with terms related to phytochemistry, nutrition, bioactivity, traditional use, and wild edible plants. Titles and abstracts were screened first, followed by full-text assessment according to predefined inclusion criteria requiring explicit identification of *L. shawii* and traceable experimental methodology; studies lacking species confirmation or primary data were excluded. From eligible publications, data were extracted on plant part, geographic origin, analytical methods, detected compounds, experimental models, and reported outcomes. Because of the limited number and methodological heterogeneity of available studies, findings were synthesized qualitatively rather than through meta-analysis. To ensure cautious interpretation and avoid overstatement, biological evidence was categorized by experimental level (human, *in vivo*, *in vitro*, or *in silico*), and conclusions were restricted accordingly. The following sections are organized thematically to provide a structured synthesis of taxonomy, morphology, ecology, phytochemistry, biological activities, and food-use prospects of *L. shawii*, followed by stakeholder relevance and future research priorities.

3 Taxonomy, botanical description, and ecology

3.1 Taxonomic classification

The genus *Lycium* L. belongs to the family Solanaceae and was formally described by Linnaeus in 1753. It comprises approximately 70–100 species distributed across subtropical, temperate, and arid regions worldwide, where species frequently inhabit saline, marginal, or environmentally stressed habitats. Members of the genus display pronounced morphological diversity, particularly with respect to leaf form, floral structure, and fruit morphology, reflecting substantial interspecific variation within the group (Sayadi and Mehrabian, 2016; Poggioni et al., 2025).

In Saudi Arabia and adjacent regions, three *Lycium* species are predominantly recorded: *Lycium barbarum* L., *Lycium europaeum* L., and *Lycium shawii* Roem. & Schult. The currently accepted nomenclature recognizes *Lycium barbarum* L. (syn. *Lycium vulgare* Dunal), *Lycium europaeum* L., and *Lycium shawii* Roem. & Schult. (syn. *Lycium persicum* Miers; *Lycium arabicum* Schweinf. ex Boiss., nom. Illeg.). Two infraspecific taxa are recognized within *Lycium shawii*: *Lycium shawii* var. *shawii* and *Lycium shawii* var. *leptophyllum* (Dunal)

Tackh. & Boulos ex A. Baytop. Species delimitation within the genus is primarily based on diagnostic morphological traits (Chaudhary, 2000). *Lycium barbarum* is widely cultivated for its berries and is characterized by a red corolla that is nearly as broad as long and by exerted stamens. *Lycium europaeum* exhibits an elongated corolla ranging from white to purplish in color, a small calyx, included stamens, and densely pubescent young branches. In contrast, *Lycium shawii* is a thorny desert shrub with a short calyx, bluish corolla, and included stamens, reflecting clear adaptations to arid and saline environments (Ahmed and Al-Dousari, 2017; Andrews, 1950/1952; Ghazanfar, 1994).

3.2 Comparative morphology

Species of *Lycium* are generally shrubs or small trees with spiny branches, exhibiting considerable variation in plant stature. *Lycium barbarum* typically reaches heights of 1–4 m, *Lycium europaeum* grows up to 1.5 m, while *Lycium shawii* attains heights of 1–3 m. Leaves are simple, arranged alternately or in clusters, and vary from linear to lanceolate forms. In *Lycium shawii*, leaves are sub-succulent, grayish-green, and measure approximately 10–28 mm in length and 3–9 mm in width. Intraspecific leaf variation is particularly pronounced in *Lycium barbarum*, where lanceolate, ovate-lanceolate, and ovate leaf forms have been documented (Poggioni et al., 2025).

Anatomical features associated with arid adaptation include thick cuticles, amphistomatic leaf surfaces, and anomocytic stomata, as reported in South African representatives of the genus (Figure 1; Joubert et al., 1984). Flowers are solitary or axillary clusters, tubular to funnel-shaped, and display species-specific coloration. The corolla is red in *Lycium barbarum*, white to purplish in *Lycium europaeum*, and pale pink to white or bluish in *Lycium shawii*. Stamens typically number four to five, are inserted at or above the midpoint of the corolla tube, and may be either included or exerted. Flowering

phenology varies among species, with *Lycium shawii* flowering primarily from September to April (Figure 1; Ahmed and Al-Dousari, 2017; Poggioni et al., 2025). Fruits are globose to ovate berries. *Lycium barbarum* produces red-orange fruits measuring approximately 28.77 × 9.17 mm and containing 3–69 seeds per fruit, whereas *Lycium shawii* bears smaller red fruits of approximately 4 mm in diameter with numerous edible seeds (Ahmed and Al-Dousari, 2017; Poggioni et al., 2025). Seeds are typically reniform, compressed, and brown (Figure 1; Andrews, 1950/1952). Young stems are ridged, with cortical tissues composed of collenchyma and parenchyma layers. Thorns, which may reach up to 70 mm in some South African species, are particularly well developed in *Lycium shawii*. These structural features, together with reduced leaf surface area, sub-succulent foliage, and deep rooting systems, contribute to drought tolerance, herbivory deterrence, and effective seed dispersal under extreme environmental conditions (Ahmed and Al-Dousari, 2017; Ghazanfar, 1994; Joubert et al., 1984).

3.3 Comprehensive morphological characterization of *Lycium shawii*

Lycium shawii Roem. & Schult. (Arabic name is Awsaj) is a spiny, intricately branched shrub typically reaching heights of 1–3 m, occasionally developing into a small tree under favorable conditions. The species is characterized by small leaves in fascicles of 2–6, petioles of 2–5 mm, and laminae that are herbaceous to semi-succulent, oblanceolate to obovate or elliptic in shape. Flowers are bisexual and five-merous, and fruits are globose berries that mature to red or orange. This morphological variability has been documented in comparative taxonomic studies of *Lycium* species (Ragab et al., 2023). Flowers are axillary, solitary or paired among fascicled leaves, and sessile to shortly pedicellate; pedicels are typically 2–5 mm long at anthesis. The plant has a rigid and branched habit, having straight stems, which are

	<i>L. barbarum</i>	<i>L. europaeum</i>	<i>L. shawii</i>
Leaves	 Lanceolate	 Narrow-Oblong	 Narrowly Obovate
Flowers	 Red, Tubular	 White/Lilac, Funnel-Shaped	 Pale Pink to White, Funnel-Shaped
Berries	 Ovate, Red-Orange	 Round, Red	 Small, Red (~4 mm)
Thorns	 Moderately Thorny	 Sparsely Thorned	 Highly Thorny

FIGURE 1 Comparative morphological features of selected *Lycium* species. The schematic illustrates key comparative morphological characteristics of *Lycium barbarum*, *Lycium europaeum*, and *Lycium shawii*, highlighting differences in leaf morphology, floral structure, thorn development, and fruit characteristics. Illustrations are diagrammatic and intended for comparative purposes only; they do not represent exact specimens. Coloration, dimensions, and fine anatomical details may vary among natural populations due to environmental and developmental factors. This figure serves as a visual aid to facilitate interspecific morphological comparison.

covered with many thorns. Young stems have thorns that are 5–15 mm long and old branches have longer thorns. Shoots in certain forms can be white-tomentose, and the spines can be tomentose toward the base (Ahmed and Al-Dousari, 2017).¹ Leaf is simple and green, attached on short petioles of 2–5 mm. The leaf blade is either oblanceolate or obovate and elliptic with a length of 12 to 35 (and sometimes 50) mm and a width of 4 to 10 (and sometimes 15) mm. Some have smaller leaves (4–25(–30) × 2.5–6 mm), elliptic-oblong to narrow oblong, cuneate bases, obtuse apices.² The calyx is narrowly tubular, 2–4 mm long, with 5 unequal lobes about 0.3–1.5 mm long. The corolla is salver form to infundibular, commonly 9–13 mm long, white to pale mauve–purple, often with darker venation; lobes are spreading or slightly recurved, about 1.5–3.5 mm long. Stamens are usually 5 and unequal, with the longer anther exerted and 2–3 included; filaments are free for 1–7 mm. The ovary is smooth, ovoid to conical, about 1–2 mm long, and the style is typically 8–11 mm long (Edmonds, 2012). The fruits of *Lycium shawii* are small, fleshy berries that become orange to bright red at maturity. They are typically spherical to slightly ovoid and contain multiple flattened seeds. Seed morphology is consistent with other members of the tribe Lycieae, being discoid to kidney-shaped with smooth surfaces (Asiri et al., 2026). Flowering normally takes place between September and April, with some local differences reaching to November–January. The species does not grow in the summer months when the weather is hot, shedding leaves and then starts growing again when the conditions become favorable (Ahmed and Al-Dousari, 2017).³

Lycium shawii is adapted to live in xeric conditions and this can be seen in its structure. The basic structure of leaves is isobilateral, and mesophyll is not distinctly separated into palisade and spongy layers. However, under closer examination it is observed that there is two to three layers of palisade parenchyma, but spongy parenchyma is only two layered (Ragab et al., 2023).

The epidermis is made up of a one-layered radially elongated cell with a thick warty cuticle. The thickness of the cutin is between 5.2 and 6.7 µm of the upper and 7.2 to 9.2 µm of the lower epidermis. The collenchymatous tissue is formed one to two layers beneath each epidermal surface to provide structural support (Ragab et al., 2023).

Three bicollateral vascular bundles are located within the midrib region and are enclosed in a parenchymatous bundle sheath which is of an overall ovate shape. The epidermis in the wing region is also composed of one layer of radially elongated cells. The mesophyll is isobilateral and the palisade cells are well-developed. The number of lateral vascular bundles is 8 to 10. Crystal druses are also noted, which means storage and protective purposes (Ragab et al., 2023).

Ecologically, *Lycium shawii* is recognized as a desert-adapted shrub native to arid regions of Saudi Arabia and neighboring xeric environments. The species has been described as a stress-resilient plant occurring under harsh desert conditions, reflecting its adaptation to drought and environmental extremes. In addition to its ecological resilience, the plant produces berry-type fruits typical of the genus *Lycium*, and its persistence in desert ecosystems highlights its ability to survive in water-limited habitats (Asiri et al., 2026).

The species can easily survive in adverse environmental conditions, such as high temperature, drought, and salinity. It grows in

nutrient-deficient and moderate to slightly alkaline soils (pH 7.2–7.9) that are low in moisture and low in electrical conductivity. Its root system exhibits a horizontal growth (100–150 cm) during the uptake of moisture, but vertical growth is restricted by the hardness of soils (Ahmed and Al-Dousari, 2017).

The plant can be used ecologically as a windbreak and sand stabilizer. It creates nabkhas (sand mounds) that entrap floating sand, increase groundwater and raise nutrient supply. The structures help create microhabitats to promote the settlement of related plant life and offering protection to the fauna of insects, reptiles, and small mammals. *L. shawii* has high rates of survival and ability to withstand degraded environments, making it popular in reforestation and desert restoration initiatives (Ahmed and Al-Dousari, 2017).

The morphological properties of *Lycium shawii*, including thorn structure, leaf shape, floral morphology, and fruit attributes, are crucial for species identification and ecological function. Thorns protect against herbivory, while reduced leaf surface area and subsucculent tissues prevent water loss in arid environments. The morphology and pigmentation of flowers promote pollination, whereas succulent fruits assist in seed distribution by fauna. The structure of leaves, characterized by thick cuticles and isobilateral mesophyll, combined with broad root systems, facilitates survival in saline, nutrient-deficient soils and aids in soil stabilization in arid conditions. These traits jointly signify the species' adaption to arid environments and its ecological significance in sustaining desert ecosystem functions.

3.4 Distribution and habitat of *Lycium* sp.

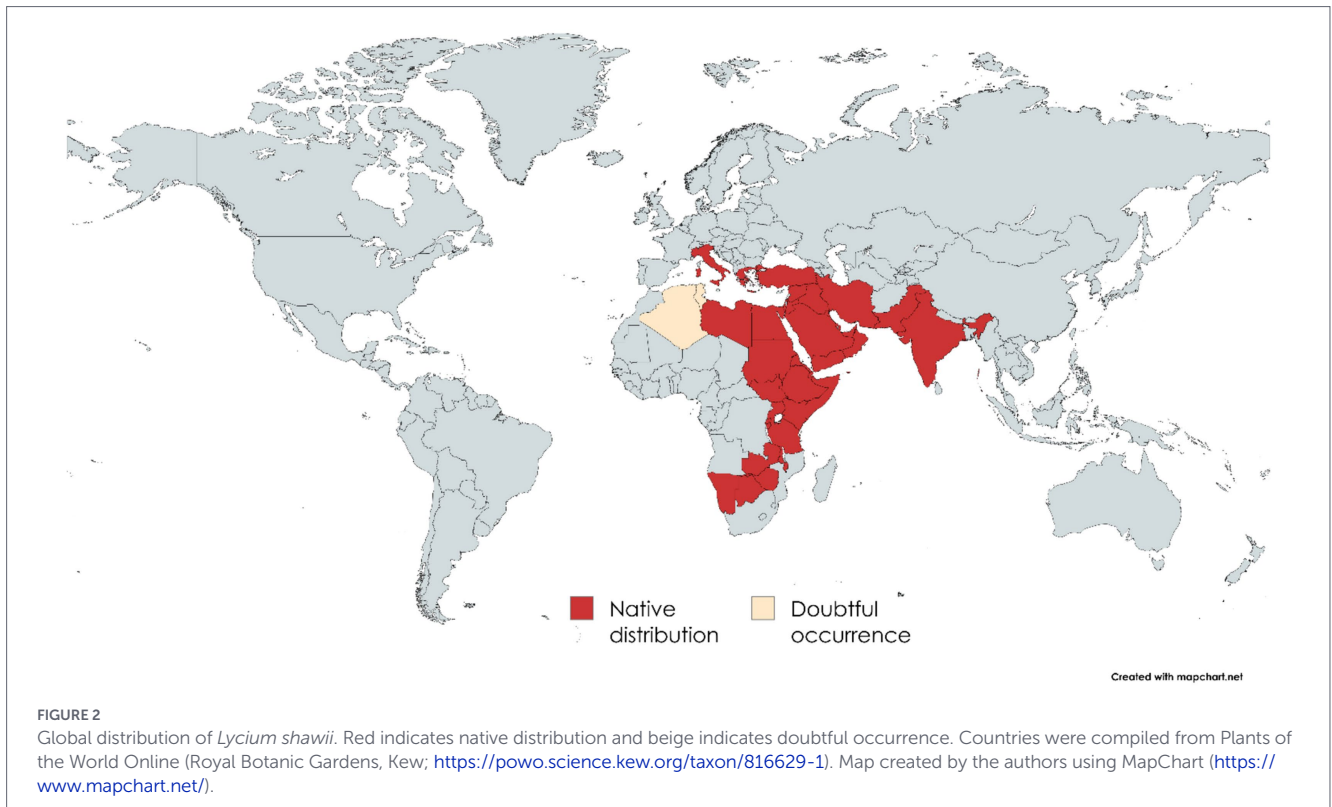
Species of *Lycium* demonstrate well-defined biogeographical patterns across Asia, Europe, and North Africa. *Lycium barbarum* is broadly distributed across China and parts of Europe, North Africa, Turkey, and the Arabian Peninsula. *Lycium europaeum* is predominantly Mediterranean in distribution, whereas its confirmed presence in Arabian territories remains limited and inconsistently reported. In contrast, *Lycium shawii* is extensively distributed throughout the Arabian deserts, including central and eastern Saudi Arabia, Egypt, the Red Sea coastal belt, and South Sinai, with further extension into North Africa, Iran, Turkey, and Pakistan (Zahran, 2010). The global distribution of *Lycium shawii* also includes parts of East Africa, southern Europe, and South Asia, with doubtful occurrence reported in Algeria and Tunisia (Figure 2).

Members of the genus occupy a wide spectrum of arid and semi-arid ecosystems, including scrublands, wadis, gravel plains, rocky hillsides, valleys, sandstone ridges, and drainage basins. These habitats are typically characterized by sandy–silty substrates that are saline, alkaline (pH 7.2–7.9), nutrient-poor, and often compacted. Tolerance to high temperatures, irregular and minimal rainfall, and prolonged drought constitutes a central adaptive feature of the genus. Notably, *Lycium shawii* functions as an ecosystem engineer in desert landscapes by forming sand nabkhas that enhance soil stabilization, generate localized microhabitats, and facilitate the recruitment of associated plant species, while simultaneously providing structural refuge for desert fauna (Ahmed and Al-Dousari, 2017; Zahran, 2010). Population density and productivity of *Lycium* species vary considerably depending on habitat characteristics and geographic location. In Egypt, *Lycium* shrubs have been reported at densities of approximately 120 individuals per 100 m², with a mean above-ground biomass of 1,413.53 g per shrub and a tissue water content of 42.4% (Ahmed and Lotfy, 2015). These data suggest that,

¹ <https://powo.science.kew.org/>; <http://www.efloras.org/>

² <https://powo.science.kew.org/>; <http://www.efloras.org/>

³ <https://powo.science.kew.org/>; <http://www.efloras.org/>



although *Lycium* species may occur in relatively sparse stands under extreme desert conditions, they can contribute substantially to local biomass accumulation and ecosystem functioning in arid landscapes.

The genus *Lycium* comprises salt- and drought-tolerant species that exhibit characteristic halophytic adaptations at morphological, physiological, and ecological levels. Physiologically, *Lycium* species maintain ionic homeostasis through the compartmentalization of sodium (Na^+) and chloride (Cl^-) ions within vacuoles and the selective uptake of potassium (K^+), thereby preserving cytoplasmic function. In certain species, specialized epidermal salt glands facilitate the excretion of excess salts, preventing toxic ion accumulation (Flowers et al., 2010; Ragab et al., 2023).

The accumulation of compatible solutes, including proline and sugar alcohols, further supports osmotic adjustment and cellular turgor under extreme salinity stress. Morphological plasticity manifested as reduced leaf surface area, sub-succulent tissues, and thorny branching minimizes water loss and herbivory. Collectively, these adaptations enable *Lycium* species to stabilize soils, support desert fauna, and serve as promising candidates for revegetation and medicinal cultivation in marginal landscapes, underscoring their multifunctional ecological role in arid ecosystems (Flowers et al., 2010; Ragab et al., 2023).

3.5 Ethnobotanical significance of *Lycium* L.

Lycium shawii holds documented ethnobotanical relevance within arid regions of the Arabian Peninsula and neighboring desert ecosystems. The species produces edible berries, which contribute to its role as a locally utilized wild food resource in harsh desert environments (Ahmed and Al-Dousari, 2017). In

traditional medicinal practices, various plant parts, particularly leaves and stems, have been employed in the management of conditions such as jaundice, colic, and vision-related disorders, reflecting its integration into indigenous healthcare knowledge systems (Ahmed and Al-Dousari, 2017). *Lycium shawii* produces edible berries traditionally consumed in arid regions and has been used in folk medicine for digestive support (laxative and diuretic effects), vision enhancement, and skin/mucosal applications in local ethnobotanical contexts; additional regional reports indicate use of roots and leaves for respiratory conditions and livestock forage, though systematic ethnobotanical documentation remains limited (Table 1). Beyond direct nutritional and medicinal uses, *L. shawii* provides important ecosystem-related services that intersect with ethnobotanical value. The species is used as a wind-break and for soil stabilization, particularly through its capacity to form sand nabkhas, thereby contributing to land protection and habitat structuring in arid landscapes (Ahmed and Al-Dousari, 2017). Such multifunctional roles enhance its practical importance in desert communities where ecological resilience and resource sustainability are closely linked.

Although other species within the genus *Lycium* have broader documentation in global nutraceutical or traditional medicine systems (Poggioni et al., 2025; Ghazanfar, 1994; Mandaville, 1990; Bosch, 2008), Ethnobotanical evidence specific to *Lycium shawii* remains limited and largely confined to certain regions within its native range. This geographic and documentation gap highlights the need for systematic and quantitative ethnobotanical investigations. Moreover, most reported uses rely primarily on traditional knowledge, with minimal standardized pharmacological validation, emphasizing the importance of rigorous experimental studies to substantiate its claimed therapeutic potential.

TABLE 1 Verified traditional uses of *Lycium shawii*.

Use category	Plant part(s)	Traditional application (as reported)	Region reported	Source type	References
Food	Berries (fruits)	Edible; consumed as traditional food source	UAE	Government medicinal plants encyclopedia	Belhouala and Benarba (2021)
Digestive / tonic	Fruit; juice	Laxative; diuretic; general tonic	UAE	Government medicinal plants encyclopedia	Ali et al. (2020)
Vision support	Fruit; leaves (juice)	Traditionally used to improve vision	UAE	Government medicinal plants encyclopedia	Belhouala and Benarba (2021)
Skin conditions	Leaves; fruit juice	Applied for skin problems / sores	UAE	Government medicinal plants encyclopedia	Ali et al. (2020)
Eye ailment remedy	Leaves (pounded)	Used traditionally for eye disorders	Yemen (Arabian Peninsula)	Tertiary compilation (encyclopedic source)	Belhouala and Benarba (2021)
Respiratory/wound-related	Roots; leaves	Used for coughs and sores	Tropical Africa	PROTA handbook (monograph)	Schmelzer et al. (2008)
Oral conditions	Roots	Decoction used for mouth sores	East Africa	PROTA handbook (monograph)	Schmelzer et al. (2008)
Livestock feed	Branches; leaves	Browsed/grazed as animal feed	Dhofar (Southern Oman)	Regional flora / ethnobotany book	Miller and Morris (1988)
Green vegetable use	Leaves	Consumed as leafy vegetable	Africa (regional reports)	Botanical ethnobotanical record	Schmelzer et al. (2008)
Tobacco substitute	Leaves	Used as tobacco substitute in some communities	Africa (regional reports)	Botanical ethnobotanical record	Schmelzer et al. (2008)

4 Nutritional composition and phytochemistry

4.1 Nutritional profile of the berries

The berries represent the primary edible part of *Lycium shawii* and constitute a wild edible resource within arid ecosystems. Available studies indicate that the fruits and vegetative tissues of *Lycium shawii* contain a combination of carbohydrates, amino acids, lipids, and bioactive secondary metabolites, with seasonal variability influencing quantitative composition (Ahmed et al., 2017). The nutritional characterization of *Lycium shawii* berries remains comparatively limited relative to extensively cultivated congeners such as *Lycium barbarum*. Available peer-reviewed data indicate that the fruits are moisture-rich (approximately 76% fresh weight) with an acidic pH (~4.3–4.4), consistent with fleshy berries adapted to arid environments (Dahech et al., 2013). The same study reports a carbohydrate-dominant profile, with total sugars representing the major macronutrient fraction, alongside measurable protein and lipid contents, supporting the classification of the berries as an energy-providing wild fruit resource. Mineral analysis on a fresh-weight basis further confirms the presence of essential elements, although comprehensive multi-location datasets and standardized proximate analyses remain scarce (Dahech et al., 2013). In contrast, *L. barbarum* berries have been extensively profiled for carbohydrates, amino acids, carotenoids, vitamins, and mineral composition, allowing robust nutritional benchmarking and quality standardization (Pires et al., 2018; Yao et al., 2018). At present, while *L. shawii* berries are confirmed to be edible and nutritionally relevant, the limited number of compositional studies and the absence of

standardized vitamin C and micronutrient quantification highlight a clear analytical gap that warrants systematic food-chemistry investigation. The available compositional data describing the proximate and mineral characteristics of *Lycium shawii* berries are summarized in Figure 3.

4.2 Phytochemical contents

In general, recent studies demonstrate that *Lycium shawii* is characterized primarily by a phenolic-rich phytochemical profile in aerial tissues, accompanied by sterols, triterpenoids, nitrogenous metabolites, and seed-associated lipophilic compounds (Table 2). However, despite the growing application of untargeted metabolomics platforms, quantitative standardization and compound confirmation using authentic standards for this desert plant remain scarce and limited.

Total phenolic content (TPC), measured by the Folin–Ciocalteu assay, shows clear solvent- and provenance-dependent variability in *Lycium shawii*. In a multi-platform metabolomics study of *L. shawii* leaf extracts from Palestine prepared using different solvents, TPC ranged from 15.65 to 26.27 mg GAE/g extract (Al-Nemi et al., 2025). By comparison, a study of *L. shawii* hydroalcoholic extracts from aerial parts collected in the Qassim region (Saudi Arabia) reported a higher TPC of 52.72 ± 3.17 mg GAE/g dry extract, together with a total flavonoid content (TFC) of 13.01 ± 0.63 mg QE/g dry extract (Mohammed et al., 2021). Across these datasets, flavonoid signals are largely represented by flavonol aglycones and glycosides (e.g., quercetin/kaempferol-type features and multiple quercetin-glycoside annotations), whereas compound confirmation remains predominantly putative/tentative unless supported by

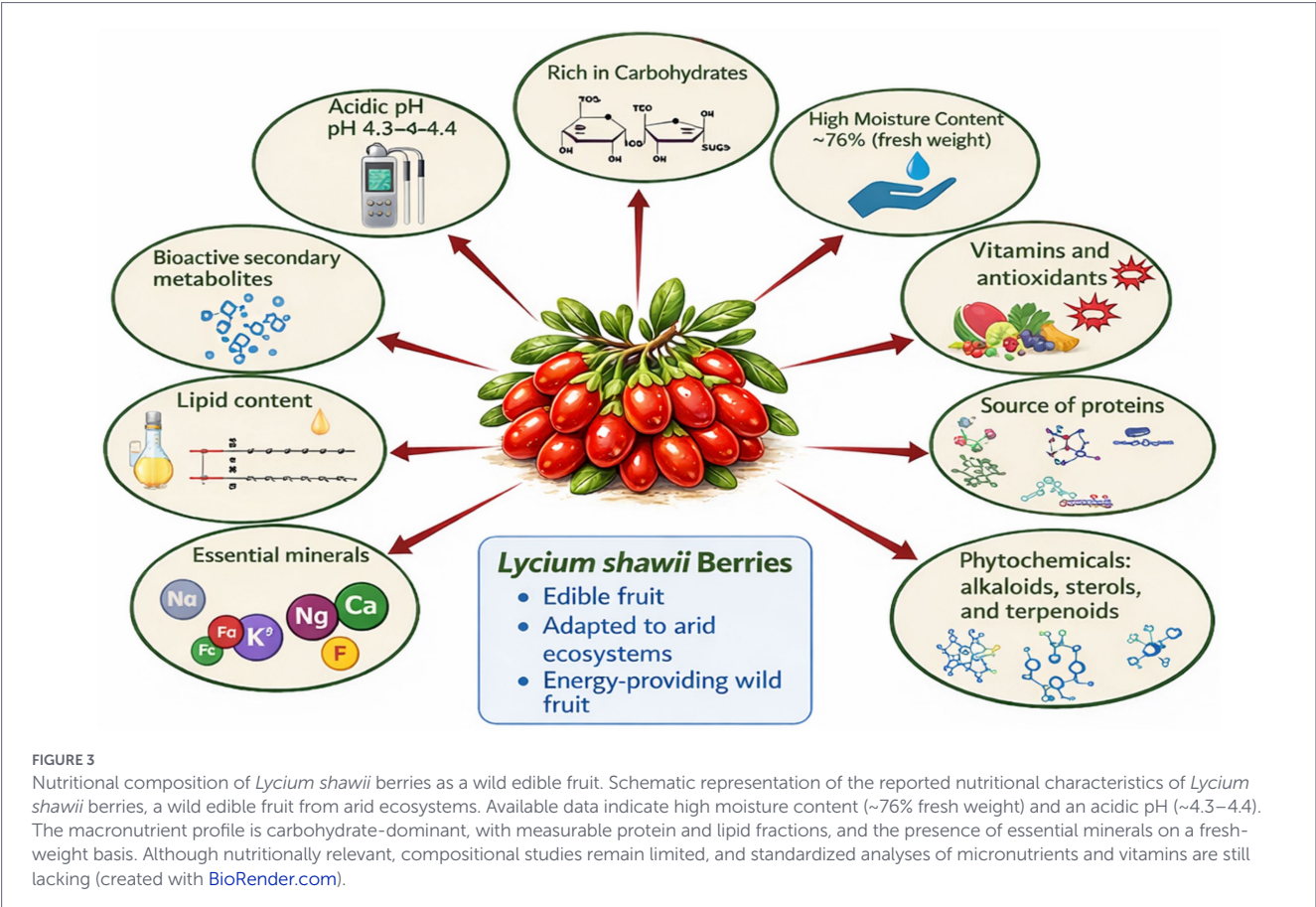


TABLE 2 Phytochemical constituents reported in *Lycium shawii* across different plant parts and their corresponding level of analytical evidence.

Plant part	Compound class	Representative compounds (Reported)	Analytical platform	Confirmation status*	References
Leaves	Phenolic acids	Chlorogenic acid, caffeic acid, ferulic acid, p-coumaric acid	UHPLC-Orbitrap HRMS; GC-Orbitrap MS	Tentative annotation based on high-resolution MS	Al-Nemi et al. (2025)
Leaves	Flavonols	Quercetin, rutin, quercitrin, kaempferol derivatives	UHPLC-Orbitrap HRMS (ESI±)	Tentative annotation	Al-Nemi et al. (2025)
Leaves	Total phenolics	Total phenolic content (15.65–26.27 mg GAE/g extract)	Folin–Ciocalteu assay	Bulk quantitative class measurement	Al-Nemi et al. (2025)
Aerial parts	Flavonoids	Total flavonoid content (13.01 ± 0.63 mg QE/g dry extract)	Colorimetric assay	Bulk quantitative class measurement	Mohammed et al. (2021)
Aerial parts	Flavonoid glycosides	Quercetin-type glycosides	UPLC-ESI-QTOF	Semi-quantitative annotation	Mohammed et al. (2021)
Leaves	Nitrogen-containing small molecules	Tryptamine (annotation), quinoline-type features	LC-HRMS	Putative annotation only	Al-Nemi et al. (2025)
Seeds	Fatty acid derivatives	9,12-Octadecadienoic acid (Z, Z), methyl ester	GC/MS	Identified by spectral matching	Nasr et al. (2025)
Seeds	Triterpenoids	Lupenone, betulin, lupeol acetate	GC/MS + isolation	Structurally confirmed isolated compounds	Nasr et al. (2025)
Seeds	Sterols	Stigmasterol, β-sitosterol-D-glucoside	GC/MS + isolation	Structurally confirmed isolated compounds	Nasr et al. (2025)
Berries	Total phenolics	TPC reported (bulk measurement)	Folin–Ciocalteu assay	Bulk quantitative class measurement	Dahech et al. (2013)

*Confirmation status reflects the degree of analytical validation reported in the original studies and does not imply biological efficacy.

authentic standards and orthogonal evidence (Al-Nemi et al., 2025; Mohammed et al., 2021). Importantly, catechin cannot be dismissed for *L. shawii*: it has been reported among purified isolates from *L. shawii* in an isolation/NMR-based phytochemical study (Rehman et al., 2018). Therefore, rather than claiming “absence,” it is more accurate to state that catechin is not consistently highlighted as a dominant feature in the recent untargeted profiling outputs, and any claim of “catechin-rich” composition should be reserved for studies providing targeted quantification (Al-Nemi et al., 2025; Rehman et al., 2018). Untargeted profiling has also reported nitrogen-containing metabolites (including annotations such as tryptamine- and quinoline-type signals), but these remain putative without standard-based confirmation (Al-Nemi et al., 2025). With respect to lipophilic chemistry, *L. shawii* seeds extracted with petroleum ether showed GC/MS major constituents including 9,12-octadecadienoic acid, methyl ester, and the same work reported isolation/identification of lupenone, betulin, lupeol acetate, stigmasterol, and β -sitosterol-D-glucoside (Nasr et al., 2025). For volatiles, an essential-oil study reported antimicrobial outcomes (zone

diameters 14–44 mm; MIC 3.12–25 mg mL⁻¹) alongside GC–MS analysis, though the record emphasizes bioactivity more than standardized quantitative composition (Torabi et al., 2025). Finally, regarding carotenoids and high-molecular-weight polysaccharides, the currently cited *L. shawii*-specific profiling literature above focuses mainly on small-molecule metabolite/phenolic measurements and GC/LC–MS features, and does not provide targeted carotenoid quantification (e.g., C30-HPLC carotenoid workflows) or polysaccharide isolation/structural elucidation (e.g., HPSEC-MALS, linkage analysis, 2D-NMR), which can be framed as clear evidence gaps within the referenced *L. shawii* dataset (Al-Nemi et al., 2025; Mohammed et al., 2021). Although progressively more researchers are interested in *Lycium shawii*, there aren't enough quantitative pharmacological studies that show standardized concentration–activity relationships (like IC₅₀ and MIC). Most of the studies that are available only provide information about the total phenolic/flavonoid contents or the dose-dependent extract activities, not the concentrations of specific compounds on individual basis (Table 3).

TABLE 3 Bioactive constituents of *Lycium shawii*, their concentrations, and therapeutic activities.

Bioactive constituent/extract	Concentration/Quantitative value	Therapeutic activity	Experimental model/assay	References
Methanolic leaf extract (phenolics, flavonoids)	IC ₅₀ = 0.06 mg/mL (DPPH); 0.007 mg/mL (ABTS)	Strong antioxidant activity	DPPH and ABTS radical scavenging assays	Ali et al. (2020)
Total phenolic content	100–377 mg GAE/g DW	Antioxidant potential (positive correlation)	Folin–Ciocalteu assay	Dahech et al. (2013)
Total flavonoid content	3.3–110.6 mg QE/g DW	Antioxidant and antimicrobial activity	Spectrophotometric quantification	Dahech et al. (2013)
Identified phenolic/flavonoid compounds (e.g., p-coumaric acid, apigenin, fisetin)	Identified via GC–MS (no individual quantification)	Antioxidant, antimicrobial	GC–MS profiling + bioactivity assays	Ali et al. (2020)
Crude fruit extracts (various solvent fractions)	Variable (no uniform IC ₅₀ reported)	Antioxidant, antibacterial, antifungal	β -carotene bleaching, antimicrobial assays	Dahech et al. (2013)
Leaf extracts (various solvents)	Qualitative (MIC not consistently reported)	Antimicrobial against MDR pathogens	Clinical bacterial isolates	Ali et al. (2020)
Isolated bioactive compounds	IC ₅₀ = 31–60 μ M (active compounds)	Cytotoxic (anticancer potential)	MDA-MB-231 breast cancer cells	Ur Rehman et al. (2020)
Extract (various concentrations)	Dose-dependent (no fixed IC ₅₀)	Cytotoxic and anti-inflammatory effects	In vitro assays	Ur Rehman et al. (2020)
Methanolic extract (topical formulation)	2% (w/w) formulation → 88.63% wound closure	Wound healing, tissue regeneration	In vivo rat model	Moustafa et al. (2025)
Metabolite-rich extract (62 compounds identified)	Not individually quantified	Wound healing and antioxidant potential	LC–MS/MS metabolomics + in vivo study	Moustafa et al. (2025)
Secondary metabolites (various classes)	Identified via LC–MS	Drug-likeness, enzyme interaction potential	In silico pharmacology	Mohammed et al. (2022)
Crude extract metabolites	Dose-dependent (not standardized)	Antimalarial activity	In vitro bioassay + metabolomics	Al-Nemi et al. (2025)
Extract compounds (unspecified)	Not quantified	Melanogenesis stimulation	Human melanocyte model	Alghamdi et al. (2023)
Secondary metabolites (terpenes, fatty acids, phenolics)	Identified (multi-compound profile)	Multi-target therapeutic potential	Metabolomics profiling	Moustafa et al. (2025)

5 Biological activities of *Lycium shawii*

Although *Lycium shawii* has long been used traditionally across arid and semi-arid regions for diverse therapeutic purposes, its biological profile has only recently begun to be systematically characterized using modern phytochemical and pharmacological methodologies. Current data suggest that the reported activities of *L. shawii* are associated with a chemically diverse polar–non-polar metabolome, including phenolics, flavonoids, terpenoids, fatty acids, and related small bioactive molecules. However, unless otherwise specified, the majority of documented biological effects originate from *in vitro* assays or controlled experimental models and should therefore be interpreted as preliminary rather than clinically validated outcomes. At present, the most consistently supported domains include antioxidant and antimicrobial activities of aerial parts and leaves, the presence of small molecules with antiproliferative potential, and more recent experimental observations such as wound-healing effects and inhibition of heme biocrystallization linked to antimalarial relevance (Ali et al., 2020). A schematic overview summarizing reported and putative biological activities of *L. shawii* is provided in Figure 4.

5.1 Antioxidant activity

Multiple extract types (notably methanolic/ethyl acetate fractions) demonstrate antioxidant capacity using standard chemical assays (DPPH/ABTS) and phenolic–activity correlations. A key strength in the *L. shawii* leaf literature is that antioxidant activity was not only quantified but also linked to phenolics/flavonoids abundance and supported by microscopy-based evidence of microbial cell damage in the same experimental framework (supporting a broader redox–membrane disruptive bioactivity theme) (Ali et al., 2020).

Beyond crude extracts, fractionation work shows that antioxidant potency varies substantially by solvent polarity: ethyl acetate/butanol fractions can outperform crude methanol extract, consistent with enrichment of mid-polarity phenolics and related redox-active constituents (Ur Rehman et al., 2020). A more recent applied study on

L. shawii leaves evaluated antioxidant performance using DPPH and FRAP, positioning the plant as a candidate for “drug resistance + oxidative stress” contexts (still screening-level, but adds assay diversity and a different dataset) (Alruways and Khan, 2022). At present, *L. shawii* antioxidant evidence is strongest at the level of direct radical scavenging/reducing power and enrichment of phenolic pools; cellular antioxidant signaling (e.g., Nrf2/HO-1) remains under-validated for most extract types and should be framed as a priority rather than a settled mechanism.

5.2 Antibacterial and antifungal effects

The most compelling antimicrobial dataset for *L. shawii* is the leaf-extract study targeting MDR/PDR wound/burn pathogens, where antimicrobial activity was supported not only by inhibition outcomes but also by TEM evidence consistent with membrane/cell envelope injury in *Pseudomonas aeruginosa* and *Staphylococcus aureus*, and activity against fungal species including *Candida albicans* and *Aspergillus niger*. This moves the evidence beyond “zones of inhibition” and supports a plausible membrane-disruption mechanism for at least some extract fractions (Ali et al., 2020). Recent work also investigated *L. shawii* essential oil chemistry with antimicrobial screening (supporting the idea that volatile/lipophilic constituents may contribute to activity), although detailed mechanistic validation remains limited in the public abstract-level view (Torabi, et al., 2025). Based on microscopy evidence and the typical behavior of lipophilic fractions/essential oils, the most defensible mechanistic framing is cell-envelope perturbation (permeabilization, structural damage), with possible additive contributions from phenolic-mediated protein/enzyme interference. Claims about efflux inhibition or quorum-sensing disruption should be labeled exploratory unless backed by dedicated assays.

5.3 Antidiabetic properties

Evidence for antidiabetic activity in *L. shawii* is stronger than simple enzyme-inhibition claims because an animal-model study reported blood glucose reduction in normal and glucose-loaded rats, and a significant effect in streptozotocin (STZ) diabetic rats. Importantly, the same work included acute and 90-day toxicity evaluation, which is unusual for early ethnopharmacology papers and should be highlighted as a strength (even though spermatotoxic signals were reported and must be handled transparently) (Sher and Alyemeni, 2011). Earlier investigations have associated the phytochemical richness of *L. shawii*, including flavonoids, terpenoids, glycosides, polysaccharides, and saponins with its reported antidiabetic activity (Malviya et al., 2010). In general, published information supports a real hypoglycemic effect *in vivo*, but mechanistic depth is still limited. In this section, it is scientifically safer to frame mechanisms as plausible pathways requiring confirmation: improved peripheral glucose handling, oxidative-stress reduction, and/or modulation of hepatic glucose output. Until insulin signaling/GLUT4/AMPK or pancreatic histology data are shown, avoid over-claiming.

5.4 Hepatoprotective activity

Hepatoprotective evidence exists but is methodologically uneven across the literature base. A study on aerial parts grown in Egypt reported hepatoprotective activity in a CCl₄-induced hepatotoxicity

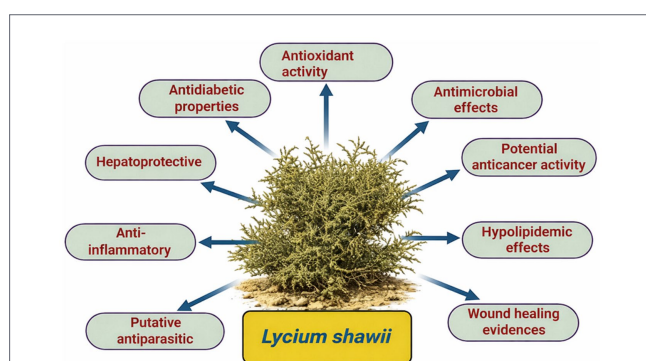


FIGURE 4

Overview of the reported and putative biological activities of *Lycium shawii*. Schematic representation summarizing the reported and putative biological activities of *Lycium shawii*. The figure highlights research evidence of antioxidant, antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, wound-healing, possible cardioprotective, potential anticancer, and putative antiparasitic effects attributed to different parts of the plant, as documented in the scientific literature. The biological activities are supported mainly by preliminary to moderate evidence, with wound healing being the most robustly validated activity based on experimental and histological findings (created with BioRender.com).

model, with the ethyl acetate fraction described as most active and compared against silymarin. However, the outlet and accessibility of the paper mean it should be cited with caution and its results treated as preliminary until independently replicated in a higher-visibility pharmacology journal (Gaweesh et al., 2015). However, studies on this issue are scarce. The best defensible mechanistic linkage is that hepatoprotection (if real) likely tracks with antioxidant/anti-inflammatory capacity of mid-polarity fractions (phenolics + related constituents). Reviewers will expect you to explicitly state that robust multi-marker liver panels and pathway validation remain limited for *L. shawii*.

5.5 Anti-inflammatory activity

Anti-inflammatory activity of *Lycium shawii* has recently been examined in standardized *in vitro* bioassays as part of broader metabolomic and biological profiling studies. In a comprehensive investigation by Al-Nemi et al. (2025), crude extracts of *L. shawii* prepared using water, ethanol, methanol, and acetone were assessed for a range of biological effects including anti-inflammatory potential. In this study, the water extract of *L. shawii* was tested for its ability to modulate inflammation-related endpoints in cell-based screening systems as part of a multiparameter bioactivity panel, and showed measurable suppression of pro-inflammatory responses at extract concentrations consistent with traditional consumption methods. Although this study incorporated anti-inflammatory assays alongside antibacterial and antimalarial screening, it did not include detailed mechanistic characterization such as cytokine profiling (e.g., TNF- α , IL-6, IL-1 β), quantification of key inflammatory enzymes (such as COX-2 or iNOS) at protein level, or *in vivo* models of acute or chronic inflammation (Lawrence, 2009). Consequently, while the findings provide preliminary evidence that *L. shawii* extracts can attenuate inflammatory processes *in vitro*, the molecular pathways and specific targets underlying this activity remain to be defined. Future work using standard inflammatory models (e.g., LPS-stimulated macrophages with full cytokine panels and enzyme expression analysis, or rodent models of inflammation) will be required to determine whether the observed effects reflect inhibition of NF- κ B signaling, modulation of eicosanoid synthesis, or other pathways relevant to human inflammatory disease. Therefore, *Lycium shawii* exhibits emerging anti-inflammatory activity in extract-level bioassays, but the current evidence does not yet include mechanistic depth or validated molecular endpoints that are typically required to support claims of specific anti-inflammatory action in peer-reviewed pharmacological literature (Al-Nemi et al., 2025).

5.6 Potential anticancer

The anticancer potential of *Lycium shawii* has been investigated primarily through compound-level and nanomaterial-mediated *in vitro* studies rather than crude extract screening alone. A bioassay-guided fractionation study isolated structurally defined constituents from *L. shawii* and evaluated their antiproliferative activity against the human breast cancer cell line MDA-MB-231. Several isolated compounds demonstrated measurable cytotoxicity with reported IC₅₀ values, and the study additionally assessed carbonic anhydrase II (CA-II) inhibition, providing a defined biochemical target context rather than nonspecific viability reduction (Ur Rehman et al., 2020). This work represents one of the more mechanistically structured anticancer

investigations for *L. shawii*, as it links chemical identity to functional cellular outcomes.

In parallel, *L. shawii* has been used in green synthesis approaches to generate silver nanoparticles (AgNPs), which were subsequently evaluated for cytotoxic activity against cancer cell lines including HCT116 and MDA-MB-231. Plant-mediated AgNPs exhibited dose-dependent reduction in cancer cell viability, with comparative testing against non-malignant cells to estimate selectivity (Mohammed et al., 2022). Importantly, Comprehensive anticancer characterization requires mechanistic validation beyond simple cytotoxicity metrics, including detailed apoptosis pathway analysis, cell-cycle profiling, mitochondrial integrity assessment, and confirmation in relevant *in vivo* tumor models. Moreover, translational relevance depends on pharmacokinetic and exposure evaluation to determine clinical feasibility (Day et al., 2015), and *in vivo* tumor models have not been systematically conducted for *L. shawii* extracts or isolated compounds. Furthermore, pharmacokinetic characterization and clinically relevant exposure assessments are lacking. Collectively, available data support that *Lycium shawii* derived constituents and plant-mediated nanomaterials possess *in vitro* antiproliferative activity; however, the evidence remains preclinical and exploratory, with no validated *in vivo* oncological models or translational studies currently available.

5.7 Hypolipidemic effects

Evidence related to lipid modulation derives from a carbon tetrachloride (CCl₄)-induced hepatotoxicity study in rats, in which methanolic extracts of *L. shawii* were administered and serum lipid parameters were measured as secondary outcomes rather than primary endpoints. In that study, total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were quantified. The authors reported modest and statistically non-significant trends toward reductions in TC, TG, and LDL-C, alongside slight increases in HDL-C compared with toxic controls (Alharbi et al., 2017). Accordingly, while these findings suggest that *L. shawii* may exert limited lipid-modulating effects under conditions of hepatic oxidative stress, the current evidence remains secondary and preliminary. Robust evaluation in validated hyperlipidemia models is required before any claims can be substantiated.

5.8 Emerging antiparasitic activity

Antimalarial-relevant activity of *Lycium shawii* has been examined in a recent metabolomics-guided study using a β -hematin (heme biocrystallization) inhibition assay, a widely used *in vitro* proxy for screening compounds that interfere with the parasite heme detoxification pathway. In this work, water extracts of *L. shawii* leaves, stems, and seeds were tested alongside negative (water) and positive controls (chloroquine, 0.1 mg/mL), with inhibition inferred from reduced absorbance of dissolved β -hematin measured at 405 nm. The leaf water extract showed marked inhibition of β -hematin formation, whereas the stem and seed water extracts were inactive under the tested conditions, and activity for the leaf extract was further evaluated across dilutions (Al-Nemi et al., 2025). The same study complemented screening with untargeted metabolomics (RP-HPLC-QTOF-MS/MS) and reported tentative annotation of phytochemicals detected in the active leaf extract. However, the work did not include parasite-based assays (e.g.,

Plasmodium falciparum culture growth inhibition with IC_{50}), in vivo murine malaria models, or target-engagement validation in parasite systems. Therefore, the β -hematin inhibition findings should be interpreted as preliminary and hypothesis-generating, requiring confirmation in standardized parasite assays and in vivo models before any antimalarial efficacy claims can be considered robust.

5.9 Wound healing and tissue regeneration

Among the reported bioactivities of *Lycium shawii*, wound healing is currently the best supported by direct experimental evidence. The most rigorous study to date combined chemical profiling with in vivo efficacy testing using a rat excision wound model. In this work, a topical formulation containing 2% *L. shawii* extract cream significantly accelerated wound closure and improved multiple histological indices of repair, including re-epithelialization and collagen deposition, alongside increased VEGF expression within wound tissue (Moustafa et al., 2025). Importantly, this study did not rely solely on gross wound contraction; it incorporated tissue-level endpoints that are directly relevant to regeneration (collagen organization and angiogenesis-related signaling via VEGF), supporting a biologically coherent repair phenotype rather than a purely cosmetic closure effect. In the same paper, the authors performed RP-HPLC-QTOF-MS/MS metabolite profiling and complemented the biological data with molecular docking and in silico ADMET-style predictions for selected constituents, which may help prioritize candidate compounds for future target-validated mechanistic studies; however, these computational findings should be interpreted as hypothesis-supporting rather than definitive evidence of target engagement *in vivo* (Moustafa et al., 2025).

A second, clinically relevant component of “wound healing” is control of wound microbial burden, particularly in burns and chronic wounds where biofilms and antimicrobial resistance delay healing. While this does not constitute regeneration per se, it provides mechanistic support for *L. shawii* as an adjunct in wound care contexts. In a study focused on pathogens isolated from wound/burn infections, *L. shawii* leaf extracts showed *in vitro* antibacterial activity against multidrug- and pandrug-resistant strains and provided ultrastructural evidence of bacterial damage by electron microscopy (Ali et al., 2020); These findings support a plausible “indirect pro-healing” pathway by limiting pathogen-driven inflammation and tissue degradation though they do not replace direct regenerative endpoints. At the cellular level, *L. shawii* has also been tested *in vitro* in a scratch (wound) migration assay within a melanocyte-focused study, where low extract concentrations modulated cell migration and proliferation (Alghamdi et al., 2023); This indicates that *L. shawii* extract can modulate cellular migration dynamics *in vitro*; however, these assays were not designed as dermal wound-healing models and therefore cannot be considered direct evidence of tissue regeneration.

Despite those evidences, important gaps remain before translational claims can be considered robust. Current studies have not yet delivered a standardized, widely replicated evidence base across multiple wound models (e.g., diabetic wounds, infected wounds, ischemic wounds), nor have they comprehensively quantified canonical repair mediators. Accordingly, *L. shawii* has its strongest species-specific support for wound healing, supported by *in vivo* excision data showing enhanced regeneration and angiogenesis (VEGF upregulation), although mechanistic validation and independent replication are still required.

5.10 Biological significance and translational relevance

While *L. shawii* possesses a broad spectrum of biological activities, most of the available scientific data is sourced from *in vitro* assays and animal models, demonstrating its direct clinical applicability still in its preliminary stages. But the inclusion of antioxidant, antimicrobial, anti-inflammatory, and wound-healing attributes indicates multiple prospective medicinal applications in which *L. shawii* may possess translational significance.

The most promising clinical use is in wound care, where a 2% topical formulation significantly improved wound closure, collagen deposition, and angiogenesis *in vivo*. This suggests that it could be suggested as a plant-based topical treatment for skin repair and chronic wounds (Moustafa et al., 2025). Moreover, its documented antimicrobial efficacy against multidrug-resistant pathogens underscores its potential as an adjunct therapy for infected wounds, especially in conditions characterized by increasing resistance to antibiotics (Ali et al., 2020).

The documented antidiabetic properties in animal studies, such as blood sugar reduction in streptozotocin-induced diabetic rats, indicate the potential for controlling metabolic disorders; however, the lack of experimental and clinical validation restricts its immediate therapeutic application (Sher and Alyemeni, 2011). Antioxidant and anti-inflammatory activities suggest potential applications in oxidative stress-related and inflammatory conditions; however, these remain at the screening stage, lacking tested molecular targets or standard clinical studies.

Anticancer and antiparasitic activities, although promising, are presently confined to cell-based and biochemical assays; thus, they should be regarded as exploratory results rather than clinically viable findings. Importantly, safety data are confined to preclinical studies, and human toxicity, pharmacokinetics, and dose standardization have yet to be established, posing a significant obstacle to clinical adaptation.

In conclusion, *L. shawii* could be a source of bioactive compounds for developing novel drugs, especially for skin and antimicrobial uses. However, before it can be used in clinical practice, it needs to be tested in comprehensive clinical trials, standardized extracts, and mechanistic validation. Currently, *L. shawii* needs to be considered as a preliminary pharmacological candidate species instead of a medically verified therapeutic plant (Table 4).

6 Safety and toxicological considerations

The expanding research interest in *L. shawii* warrants comprehensive and systematic safety assessment. At present, toxicological data are insufficient, emphasizing the necessity for robust toxicity studies to ensure reliable safety characterization. Although traditional consumption of *L. shawii* berries suggests some degree of historical tolerability, traditional use alone cannot substitute for structured toxicological evaluation; preclinical safety assessment of botanical products generally requires a combination of acute, subacute, repeated-dose, and genotoxicity testing in validated animal and *in vitro* models to characterize dose–response relationships and identify potential adverse effect. It was reported that, in a preclinical safety assessment of *L. shawii*, acute (24 h) and sub-chronic (90-day) oral toxicity studies

TABLE 4 Summary of clinical implications and translational potential of *Lycium shawii*.

Pharmacological activity	Key findings	Clinical implication	Level of evidence	Limitations
Wound healing	2% topical extract → 88.63% wound closure; increased collagen & VEGF	Potential topical therapy for wound healing, burns, and tissue regeneration	In vivo (animal model)	No human trials; formulation standardization needed
Antimicrobial	Active against MDR pathogens; membrane damage observed	Adjunct treatment for infected wounds and resistant infections	In vitro + mechanistic microscopy	No clinical validation; MIC not standardized
Antioxidant	Strong DPPH/ABTS activity; phenolic correlation	Supportive role in oxidative stress-related disorders	In vitro	No in vivo/clinical biomarker validation
Anti-inflammatory	Suppression of inflammatory responses in vitro	Potential for inflammatory conditions	In vitro	No cytokine/pathway validation; no in vivo data
Antidiabetic	Reduced glucose in diabetic rat models	Possible role in diabetes management	In vivo (animal model)	Mechanism unclear; no human studies
Anticancer	Cytotoxicity (IC ₅₀ 31–60 μM); CA-II inhibition	Lead compounds for anticancer drug development	In vitro (cell lines)	No in vivo tumor models; no PK data
Antiparasitic (antimalarial)	β-hematin inhibition (heme detox pathway)	Potential antimalarial lead compounds	In vitro (biochemical assay)	No parasite culture/in vivo validation
Hepatoprotective	Activity in CCl ₄ -induced liver injury model	Possible liver-protective agent	In vivo (single study)	Limited replication; weak clinical evidence
Hypolipidemic	Non-significant lipid profile improvement	Weak potential for lipid regulation	In vivo (secondary outcome)	Not primary endpoint; inconclusive
Safety profile	No acute toxicity in animals; LD ₅₀ > 4,000 mg/kg	Suggests preliminary safety	Preclinical (animal studies)	No human safety data; long-term effects unknown

were conducted in mice across multiple dose levels. No mortality or overt clinical signs of toxicity were observed at the tested doses. Repeated administration over 90 days did not result in apparent toxic manifestations when compared with untreated controls. Comprehensive evaluations, including gross morphological examination, hematological profiling, serum biochemical analysis, and histopathological assessment of major organs were performed, and no significant treatment-related abnormalities were reported within the experimental parameters investigated (Sher and Alyemeni, 2011). The detection of di(2-ethylhexyl) phthalate in the methanolic extract of the aerial parts of *L. shawii*, together with computational toxicity class predictions (Class 3–4; predicted LD₅₀ 1,340–1,600 mg/kg), warrants cautious interpretation of the plant's safety profile and highlights the need for comprehensive toxicological validation (El-Amier et al., 2024). Although berries of *L. shawii* are edible, leaves could carry some side effects, a toxicological study of the methanolic extract of *L. shawii* leaves found that oral doses up to 4,000 mg/kg in albino rats did not cause mortality or clinical signs of toxicity, and LD₅₀ was estimated to be >4,000 mg/kg, suggesting the leaf extract may be generally nontoxic in acute exposure scenarios (Ali et al., 2020). However, Traditional uses of *L. shawii* include medicinal applications (stems, leaves, and berries), but information on toxicity of specific parts in humans is very limited.

7 Sustainable dietary potential of *Lycium shawii* in arid regions

Within the context of sustainable food systems, *L. shawii* should primarily be evaluated as a climate-resilient wild berry resource rather

than as a pharmacological commodity. The species produces edible red berries that are traditionally consumed in arid regions (Schmelzer et al., 2008), yet remain scientifically under-characterized compared with the extensively commercialized *L. barbarum*. While cultivated goji berries have undergone detailed nutritional profiling and quality standardization (Pires et al., 2018; Yao et al., 2018), available compositional data for *L. shawii* berries are limited mainly to proximate and phenolic assessments (Dahech et al., 2013), with no multi-regional nutritional benchmarking or standardized micronutrient mapping. This analytical gap currently limits its formal integration into structured value chains.

Ecologically, *L. shawii* thrives in saline and drought-prone soils and contributes to desert stabilization through nabkha formation and biomass accumulation (Ahmed and Al-Dousari, 2017; Zahran, 2010). These traits suggest that berry harvesting could theoretically be integrated with restoration-oriented agroecological systems in marginal lands. However, sustainable dietary positioning requires robust food-focused validation. Extract-based toxicological data in animal models indicate no acute mortality at tested doses (Sher and Alyemeni, 2011), yet such findings cannot be directly extrapolated to habitual human berry consumption, and human dietary exposure studies are lacking.

In addition, although phenolic-rich profiles have been reported in aerial tissues (Al-Nemi et al., 2025; Mohammed et al., 2021), targeted metabolomic characterization of edible fruit tissues remains incomplete. There are no standardized data on carotenoid retention, vitamin C levels, post-harvest stability, or bioavailability of berry-derived phytochemicals. Seasonal variability documented in vegetative tissues (Ahmed et al., 2017) further suggests that fruit composition may fluctuate under environmental stress, raising important questions regarding compositional consistency and food quality control.

Therefore, before *L. shawii* can be positioned as a sustainable desert berry for wider dietary inclusion, priority research should focus on comprehensive berry-specific nutritional profiling, validated metabolomic fingerprinting using authenticated standards, food safety assessments including contaminant screening, and post-harvest processing optimization. Agronomic studies assessing yield stability under irrigation and salinity gradients would further clarify its feasibility within arid farming systems. Such interdisciplinary integration, linking plant ecology, food chemistry, nutrition science, and restoration ecology is essential to transition *L. shawii* from ethnobotanical documentation to evidence-based dietary diversification in dryland regions.

Accordingly, *L. shawii* should not be presented as a direct alternative to commercial goji production, but rather as an ecologically adapted, underexplored desert berry with confirmed edibility and preliminary nutritional relevance, whose contribution to sustainable food systems depends on rigorous food-centred validation.

8 Food use, domestication potential, and future utilization

8.1 Traditional food use and nutritional relevance

L. shawii produces edible fruits that serve as a traditional food source in arid regions of the Arabian Peninsula. Its leaves, fruits, and roots have also been used ethnobotanically for gastrointestinal complaints, vision-related conditions, dermatological applications, and other minor traditional remedies (Ahmed and Al-Dousari, 2017; Belhouala and Benarba, 2021; Bosch, 2008). Nutritionally, the fruits contain carbohydrates, proteins, lipids, and essential minerals, whereas the leaves and aerial parts are rich in phenolics and flavonoids that may contribute antioxidant and antimicrobial value (Dahech et al., 2013; Mohammed et al., 2021; Al-Nemi et al., 2025). Taken together, the available evidence supports the view that *L. shawii* has relevance not only as a traditional desert food, but also as a potentially valuable species for nutritional diversification in arid environments.

8.2 Domestication constraints and development gaps

Despite its ecological resilience and promising nutritional profile, *L. shawii* remains poorly developed as a domesticated or commercially utilized species. This pattern is consistent with many neglected and underutilized species, which often remain outside mainstream agriculture because of limited research investment, weak breeding efforts, and insufficient institutional support, even when they are well adapted to harsh environments and may offer important nutritional advantages (Li et al., 2020). For *L. shawii*, an additional limitation is the lack of practical cultivation knowledge. Wild edible plants rarely move into production systems without dependable propagation methods, clear agronomic protocols, and field-based performance data, yet such information is still very limited for this species (Polyzos et al., 2025). In particular, the lack of robust evidence on seed biology, vegetative propagation, and cultivation management currently restricts the transition from natural occurrence to reliable agricultural production.

Adoption is further constrained by weak market pathways. Underdeveloped value chains, limited post-harvest infrastructure, and low consumer awareness frequently slow the uptake of underutilized fruit crops, and these same constraints are likely relevant to *L. shawii* (Marappan et al., 2025). Thus, the challenge is not only whether the plant can grow under arid conditions, but whether it can be produced, processed, marketed, and accepted at scale.

8.3 Prospects for food-system integration

If more systematically developed, *L. shawii* could offer practical value in dryland food systems, particularly for smallholder production and local consumption in arid and semi-arid regions. Underutilized wild edible plants adapted to marginal environments are increasingly recognized as candidates for resilient food systems and dietary diversification (Heywood, 2013; Dawson et al., 2019). Because its fruits, leaves, and other parts are edible and nutritionally relevant, the species could be explored as a source of food products, traditional dietary ingredients, and selected nutraceutical applications. Similar integration of wild edible plants into local diets has been associated with improved dietary diversity and preservation of traditional food knowledge in dryland communities (Tardío et al., 2006).

Its adaptation to drought-prone environments further suggests potential suitability for low-input cultivation on marginal lands, although agronomic validation remains necessary. Plant biodiversity adapted to harsh environments has been highlighted as an important resource for climate-resilient food production and sustainable land use (Dawson et al., 2019). In parallel, the incorporation of *L. shawii*-based fruits or leaf-derived products into local diets may contribute to dietary diversification and reinforce food practices associated with desert communities.

At present, however, wider utilization appears limited beyond areas where traditional knowledge has been preserved. For many underutilized species, limited adoption reflects gaps in propagation knowledge, cultivation protocols, post-harvest handling, and food-use documentation rather than lack of biological potential (Polyzos et al., 2025). Future development will therefore require targeted research on propagation and cultivation, improved documentation of nutritional composition, evaluation of post-harvest handling, and clearer pathways for food use. Community-level dissemination, farmer demonstration trials, and integration with local food markets may further support responsible introduction of the species. Such efforts could improve the visibility of *L. shawii*, support dryland livelihoods, and strengthen the food and cultural value of desert plant resources.

9 Future research directions

Despite increasing scientific interest in *L. shawii*, the available evidence remains largely descriptive and preclinical, limiting its progression from an ethnobotanical resource to a therapeutically or nutritionally validated species. Current studies are predominantly based on crude extracts, with limited compound-specific characterization and insufficient quantitative linkage between phytochemical composition and biological activity. Future research should therefore prioritize standardized phytochemical profiling, including compound isolation and structural elucidation using advanced analytical platforms such as LC-MS/MS, NMR spectroscopy, and validated chromatographic

quantification. Establishing concentration–activity relationships for major phenolics, flavonoids, sterols, and triterpenoids would help clarify whether the reported antioxidant, antimicrobial, and anti-inflammatory effects are attributable to specific molecules or synergistic extract-level interactions. Such approaches are essential for transitioning from exploratory screening to mechanistically informed pharmacological evaluation, particularly for species where bioactivity has been reported but not mechanistically resolved (Polyzos et al., 2025). These research priorities collectively outline a stepwise pathway from phytochemical discovery to translational validation, as summarized in Figure 5.

Beyond phytochemical characterization, mechanistic pharmacology remains insufficiently explored. Most available studies on *L. shawii* report endpoint biological outcomes without defining underlying molecular pathways. Future work should therefore examine pathways commonly associated with plant-derived bioactives, including oxidative stress signaling, inflammatory modulation, and metabolic regulation, using integrated biochemical and omics-based approaches. Combining transcriptomics, proteomics, and metabolomics with targeted pathway validation would provide a more comprehensive understanding of bioactivity and reduce overinterpretation of extract-based findings. This transition from descriptive activity to mechanistic insight is widely recognized as a critical step in translating medicinal plant research into pharmacological relevance (Dawson et al., 2019).

Equally important is the need for well-designed *in vivo* validation. Although several biological activities have been reported for *L. shawii*, systematic animal studies using standardized extracts or isolated compounds remain scarce. Carefully controlled models addressing metabolic disorders, wound healing, inflammation, and antimicrobial efficacy would help determine biological relevance under physiologically realistic conditions. Such studies should include dose–response evaluation, histopathological analysis, and reproducibility across independent experiments, which are often lacking in early-stage investigations of wild medicinal species. Without these data, extrapolation of *in vitro* findings to therapeutic potential remains premature.

Translational development also requires pharmacokinetic and bioavailability data, which are currently absent for *L. shawii*. Understanding absorption, distribution, metabolism, and excretion profiles is essential to determine whether bioactive compounds reach biologically relevant concentrations *in vivo*. In addition, stability during processing, digestion, and formulation should be evaluated, particularly if the species is to be considered for nutraceutical or functional food applications. Similar limitations have been identified as major barriers in the development of underutilized plant species with promising bioactivity but limited translational validation (Li et al., 2020).

Comprehensive toxicological assessment is another major gap. While preliminary observations suggest low acute toxicity, long-term safety, genotoxicity, reproductive toxicity, and herb–drug interaction studies have not been performed. Such evaluations are necessary before considering clinical relevance or widespread dietary use. Furthermore, regulatory advancement would require standardized extraction protocols, chemical fingerprinting, and identification of marker compounds to ensure reproducibility and quality control. These steps are particularly important for wild edible species, where phytochemical composition may vary with geography, season, and environmental stress.

Given that *L. shawii* is also consumed as a wild edible plant, nutritional research should be expanded beyond basic proximate composition. Detailed profiling of micronutrients, carotenoids, and bioactive metabolites, together with studies on post-harvest stability and food processing, would clarify its value as a functional food. Human dietary studies, although currently unavailable, would ultimately be required to confirm nutritional and health-related claims. Integration of nutritional, phytochemical, and pharmacological data would therefore provide a more realistic framework for evaluating *L. shawii* as both a food and medicinal resource.

Several limitations should be acknowledged. Most available data are derived from geographically restricted samples, limiting generalizability across populations. Reported biological activities are largely based on

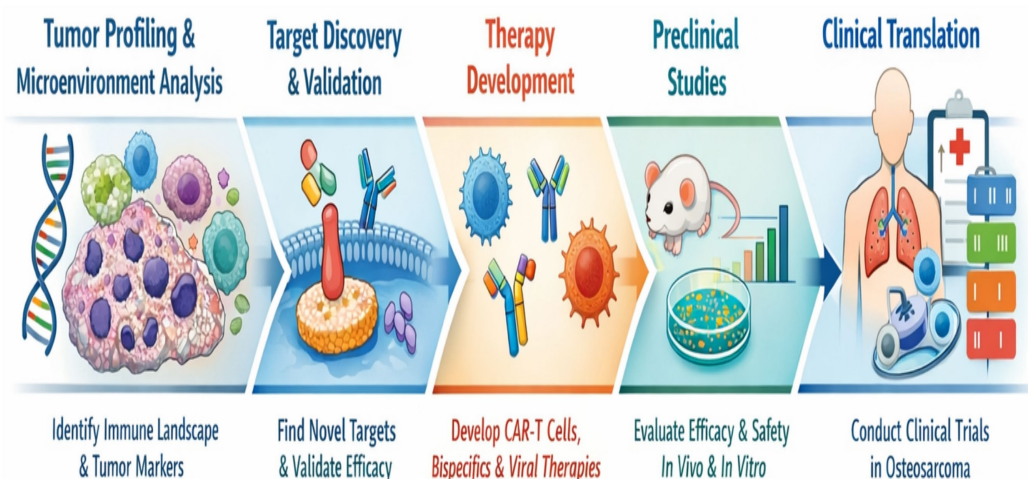


FIGURE 5

Proposed translational research pathway for the development of *Lycium shawii* from phytochemical discovery to clinical application. The schematic outlines a stepwise pathway for advancing *Lycium shawii* research from phytochemical profiling to therapeutic and nutritional validation. It begins with bioactive compound identification, followed by target discovery and mechanistic validation, then progresses through standardized extract or compound development, preclinical efficacy and safety testing, and eventual clinical evaluation. The workflow highlights the integrated research needed to move beyond descriptive bioactivity toward evidence-based therapeutic and functional food applications (created with <https://gpai.app/solver>).

crude extracts, which complicates attribution of effects to specific compounds. Mechanistic investigations, pharmacokinetic studies, and clinical evaluations are currently absent. In addition, variability in extraction methods and experimental designs reduces comparability between studies. Addressing these limitations through standardized methodologies and interdisciplinary collaboration will be essential for defining the therapeutic and nutritional relevance of *Lycium shawii* more rigorously.

10 Conclusion

This comprehensive review shows that *Lycium shawii* is a drought- and salt-tolerant desert shrub with edible berries and measurable phytochemical content. However, compared with widely commercialized species such as *Lycium barbarum*, it remains poorly studied, it remains an underexplored desert edible species that shares key characteristics with neglected and underutilized crops, including limited domestication efforts, insufficient agronomic data, and weak value-chain integration, highlighting its potential importance for climate-resilient nutrition and future food security strategies. Current evidence classifies *L. shawii* as a wild edible fruit with a carbohydrate-dominant nutritional profile and detectable levels of phenolic compounds. Extract-based studies report antioxidant, antimicrobial, antidiabetic, wound-healing, and preliminary antiparasitic activities. Among these, wound-healing activity is supported by the strongest experimental evidence. Nevertheless, most pharmacological data come from *in vitro* assays or limited animal models, and no clinical studies have been conducted.

From a sustainable food systems perspective, the ecological adaptability of *L. shawii* to arid and saline environments, together with its role in soil stabilization and desert restoration, supports its potential as a climate-resilient food resource for marginal lands. However, integration into structured food value chains requires berry-specific nutritional profiling, standardized metabolomic analysis, safety and contaminant assessment, post-harvest stability studies, and agronomic evaluation under controlled cultivation.

Therefore, *L. shawii* should not be presented as a substitute for established nutraceutical berries. Rather, it should be considered an underexplored desert edible species whose sustainable utilization depends on rigorous, food-centered scientific validation. Interdisciplinary research linking plant ecology, food chemistry, and nutrition science is essential to determine its realistic contribution to dietary resilience and to efforts aligned with the Sustainable Development Goal of Zero Hunger.

Author contributions

EA: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft. AA: Funding

acquisition, Project administration, Resources, Validation, Visualization, Writing – review & editing. HJ: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft.

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Conflict of interest

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