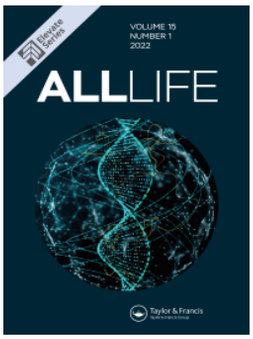

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REVIEW ARTICLE

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Roles of Lamiaceae plants from the arid and desert rangelands of Tunisia in human health and therapy

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ABSTRACT

The arid rangelands, abundant with diverse flora, play a pivotal role as sanctuaries for essential medicinal herbs. Despite their limited species diversity, Lamiaceae plants hold multifaceted significance in medicine, aromatics, and cuisine. With diverse biological activities such as anti-inflammatory, antimicrobial, antiviral, anticancer, antifungal, antiseptic, antirheumatic, and antidiabetic properties, they serve as valuable antioxidants for treating various ailments. This review delves into the latent utility and intricate biological properties of Lamiaceae species in Tunisia's arid rangelands, emphasizing their pivotal role in traditional and modern medicine. Focused on the medicinal properties of Lamiaceae species, the review not only highlights their latent utility but also addresses a crucial aspect of meeting local and global needs. Stressing their significance in traditional and contemporary medicine, the review underscores their potential contribution to biodiversity preservation. Aligned with the United Nations' Sustainable Development Goals, particularly SDG 3 on good health and wellbeing, and SDG 15 on biodiversity conservation, the study advocates collaborative efforts to address environmental challenges in Tunisian desert rangelands. A holistic approach, considering social, economic, and environmental dimensions, is deemed essential for achieving these goals and ensuring the sustainable utilization of valuable resources in arid lands.

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Lamiaceae; drylands; biological activities; medicine

Highlights

- Prioritizing biodiversity preservation in arid rangelands is vital, safeguarding medicinal herbs and preventing plant species loss.
- Recognizing the role of medicinal plants in healthcare, especially in underserved rural areas, is essential. They offer cost-effective remedies and should be integrated into mainstream healthcare systems for better access and health outcomes.
- Supporting responsible medicinal plant use offers economic opportunities. Encouraging local investment in these resources can foster economic development in arid regions while preserving fragile ecosystems.

Introduction

Native rangelands provide a diverse array of goods and services (Tanaka et al. 2011). In recent decades, there has been a growing emphasis on utilizing medicinal herbs from these natural landscapes. It is a well-established fact that the majority of medicinal plants thrive within these native rangelands, as confirmed by Cole (1996). Globally, a remarkable 80% of the world's population relies on medicinal herbs for primary healthcare, with a significant proportion originating from South Asia, accounting for 12% (Woo and Cho 2012). For instance, China's untamed pastures serve as a primary source, contributing to about 80% of herbs used for medicinal purposes, as extensively demonstrated by Xiao (1991) and affirmed by Shanan and Sheng (1997). Moreover, the critical significance of herbs in medicine, coupled with the surging demand for ethnopharmacology, prompted the establishment of a Ministry of Indigenous Medicine in Sri Lanka since 1980 (Heywood 1999).

The significance of biodiversity and the utilization of medicinal herbs is crucial for achieving sustainable development within the framework of the Sustainable Development Goals (SDGs) (Kumar et al. 2021).

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Starting in 2015, a comprehensive set of 17 SDGs was established as part of a 15-year sustainable development strategy aimed for realization by 2030. These goals encompass diverse aims, including ensuring healthy lives and well-being (SDG3), promoting sustainable use of terrestrial ecosystems (SDG15), and maintaining biodiversity, all of which are vital components within this global endeavor (Sayer et al. 2019; Dandabathula et al. 2021).

Arid environments host a diverse array of unique medicinal plant species (Gintzburger et al. 2003). Despite facing diverse biotic and abiotic stresses, these resilient arid rangelands consistently yield numerous medicinal plants, highly valued in both traditional and modern medicine, significantly contributing to the annual incomes of many residents within these rangelands (Rasul et al. 2012; Hasan et al. 2013; Sher et al. 2014). However, the excessive and unsustainable large-scale harvesting of these medicinal plants has been identified as a significant factor contributing to rangeland degradation and the potential extinction of certain species (Miththapala 2006).

Within the realm of medicinal plants, the Lamiaceae family stands out as particularly noteworthy, despite its relatively modest species diversity. These plants possess significant biological and medicinal applications, as highlighted by Phumthum et al. (2019). Globally, they are valued for aromatic and pain therapy, thanks to their intricate blend of bioactive compounds, as elucidated by Uritu et al. (2018). The multifaceted biological potential of Lamiaceae, encompassing antioxidant, anti-inflammatory, antimicrobial, antiviral, and anticancer properties, underscores their profound importance, as indicated by Stankovic (2020). Moreover, the allure of the Lamiaceae family for modern medicine is further amplified by recent technological advancements, primarily due to its rich collection of bioactive components. Notably, many species within the Lamiaceae family find utility in diverse areas such as perfumery, cosmetics, pharmaceuticals, food, flavoring, and even as pesticides, significantly enhancing their value across various domains, as recognized by Raja (2012) and Stankovic (2020).

Arid rangelands in Tunisia play an essential role in the utilization of medicinal plants, particularly in challenging environmental regions. Encompassing approximately 5.5 million hectares, with 87% classified as arid (Gamoun et al. 2018), the Tataouine governorate emerges as a significant contributor, occupying a substantial portion, around 1.5 million hectares, of these rangelands (Gamoun and Louhaichi 2021). Despite the adversities imposed by these harsh conditions, these rangelands persist in sustaining a rich diversity of medicinal plants, thanks to the diverse array of ecological habitats they provide (You et al. 2016; Neffati et al. 2017). Notably, a local community survey in Tataouine revealed that a significant 70% of these plants find traditional use in treating specific diseases (Karous et al. 2021). According to the findings by Gamoun and Louhaichi (2021), approximately 13% of the total plant species are commonly used in both traditional and modern medicine, with a remarkable 35% of these medicinal plant species belonging to the Lamiaceae family.

The goal of this review was to document the importance and the potential sustainable use of Lamiaceae plants species, arising from arid rangelands of the Tataouine Governorate in southern Tunisia, in human health and therapy.

Materials and methods

Beforehand, we documented the botanical composition and species diversity of arid and desert rangelands in southern Tunisia's Tataouine region (Gamoun and Louhaichi 2021). A comprehensive survey in 2018 meticulously documented a diverse assemblage of over 270 plant species, distributed across 58 distinct families (Gamoun et al. 2018; Gamoun and Louhaichi 2021). These findings strikingly spotlight the notable prominence of ten specific families, which collectively account for nearly 65% of the region's botanical composition. These significant botanical families encompass Asteraceae, Poaceae, Fabaceae, Amaranthaceae, Brassicaceae, Boraginaceae, Caryophyllaceae, Lamiaceae, Apiaceae, and Cistaceae, serving as the foundational underpinnings of the region's botanical diversity.

Notably, the Lamiaceae family, with a substantial representation of 12 species, and the Apiaceae family, represented by 4 species, emerge as pivotal contributors to the region's medicinal flora, as illustrated in Figure 1. Therefore, our findings revealed a collection of 12 plant species belonging to the Lamiaceae family, all possessing significant aromatic and medicinal qualities. These plants have been utilized by various communities to treat a wide array of illnesses. Numerous studies have further validated these species as a

source of biologically active compounds that exhibit therapeutic benefits. Therefore, in this review, our aim is to present a comprehensive overview of the phytochemical composition, as well as the medicinal and pharmacological applications of the 12 plant species of the Lamiaceae family found in the arid and desert rangelands of Tataouine, located in southern Tunisia. The variation in the composition of essential oils in plants can be attributed to differences in where they grow and environmental conditions like sunlight, temperature, rainfall, and humidity (Jaouadi et al. 2023). For instance, Jaouadi et al. (2023) demonstrated that *Thymus algeriensis* exhibited optimal activities in the driest regions of Tunisia, distinguished by its high carvacrol content. Moreover, the connection between the essential oil content of these medicinal plants and environmental factors hasn't been extensively documented.

The present study extensively utilized various electronic databases, including well-established platforms such as ScienceDirect, PubMed, Scopus, Google Scholar, and authoritative scientific websites, to meticulously compile a comprehensive body of knowledge. The exhaustive search strategy employed the precise botanical nomenclature of the 12 specific species, ensuring the inclusion of relevant and accurate literature. Our reference list encompasses publications from different countries, spanning a substantial timeframe from 1981 to 2023, covering a wide spectrum of critical research and findings. Additionally, we focused on research that incorporates the specified keywords in their textual content: *Ajuga iva, Lavandula multifida, Marrubium deserti, Marrubium vulgare, Prasium majus, Rosmarinus officinalis, Salvia aegyptiaca, Salvia verbenaca, Teucrium alopecurus, Teucrium polium, Thymbra capitata*, and *Thymus algeriensis*. This approach ensures a robust foundation for our review, providing readers with a thorough and up-to-date understanding of the subject matter.

Results and discussion

Most plants contain multiple compounds with pharmacological abilities that are utilized in treating various human ailments. Numerous authors have explored the Lamiaceae family due to its numerous aromatic plant species used in traditional medicine, pharmaceuticals, and the food industry for their diverse biological properties. Members of the Lamiaceae family produce significant quantities of secondary metabolites, including compounds found in essential plant oils that exhibit biological effects and therapeutic promise. The array of bioactive elements found in Lamiaceae provides attributes such as antioxidants, insecticides, fungicides, and bactericides, offering collective potential economic and pharmacological value. The 12 plant species of the Lamiaceae family found in the arid and desert rangelands of Tataouine include *Ajuga iva* (L.) Schreb, *Lavandula multifida* L., *Marrubium deserti* (de Noé) Coss., *Marrubium vulgare* L., *Prasium majus* L., *Rosmarinus officinalis* L., *Salvia aegyptiaca* L., *Salvia verbenaca* L., *Teucrium alopecurus* de Noé, *Teucrium polium* L., *Thymbra capitata* (L.) Cav., and *Thymus algeriensis* Boiss. & Reut. The scientific name, botanical family, common name, and biological activities of the major compound of medicinal plants from the Lamiaceae family are provided in Table 1.

***Ajuga iva* (L.) Schreb**, commonly known as herb ivy or locally as chandgoura, is a small herbaceous perennial native to the Mediterranean region. This plant holds a prominent place in traditional medicine. Ethnobotanical investigations on *A. iva* indicate its potential medicinal uses across various disorders. It exhibits properties such as carminative, anti-allergic, stomachic, anti-diabetic, anti-cancer, antiseptic, antirheumatic, antidiarrheal agent, and antihypertensive effects. Additionally, it demonstrates protective activities against cardiovascular, metabolic, digestive, renal, and respiratory disorders (You et al. 2016; Neffati et al. 2017; Bouyahya et al. 2020a; Karous et al. 2021). Notably, it possesses a diverse range of medicinal properties, including antioxidant, antimicrobial, anti-inflammatory, antifungal, anti-hypercholesterolemia, antifebrile, analgesic, and anthelmintic effects (Taleb-Senouci et al. 2009; Baghiani et al. 2011; Boudjelal et al. 2015; Miara et al. 2019). Studies have also identified various bioactive compounds in *A. iva,* such as steroids (Bondi et al. 2000), flavonoids (Miara et al. 2019), neo-clerodane diterpenoids (Makni et al. 2013), phytoecdysteroids (Bouyahya et al. 2020a), tannins (Aly et al. 2011), and iridoids (Coll and Tandrón 2008).

Like many lavender species, *Lavandula multifida* is valued for its aromatic properties. The fragrant essential oil extracted from its flowers and leaves is used in perfumery, aromatherapy, and the production of scented products. While not as commonly used in culinary applications as some other lavender species, the flowers of *Lavandula multifida* can be used to add

Table 1. Scientific name, botanical family, common name and biological activities of the major compound of medicinal plants from Lamiaceae family.

Species	Common name	Biological Activities	Phytochemicals'	Animal/cell models
Ajuga iva (L.) Schreb	Southern Bugle	Antioxidant, antimicrobial, anti-inflammatory, antifungal, anti-hypercholesterolemia, antifebrile, analgesic, anthelmintic, anti-diabetic (Taleb-Senouci et al. 2009; Baghiani et al. 2011; Boudjelal et al. 2015; Miara et al. 2019).	Steroids, flavonoids, neo-clerodane diterpenoids, phytoecdysteroids, tanninsand iridoids (Bondi et al. 2000; Coll and Tandrón 2008; Aly et al. 2011; Makni et al. 2013; Miara et al. 2019; Bouyahya et al. 2020a).	Rats β cells
Lavandula multifida L.	Fern leaf lavender	Hypoglycemic, anti-inflammatory, antimicrobial, antioxidant and antifungal (Sosa et al. 2005; Benbelaid et al. 2012; Zuzarte et al. 2012; Molina-Tijeras et al., 2013; Sellam et al. 2013).	Carvacrol, bisabolene, linalool, linalyl acetate, bornyl acetate, β-caryophyllene, nerol, α-thujene, terpinolene, and camphene (Chograni et al. 2010; Msaada et al. 2012; Saadi et al. 2016; Salehi et al. 2018).	Mice
Marrubium deserti (de Noé) Coss.	Horehound	Antioxidant, antiviral, antigenotoxic, antinociceptive and antimicrobial (Edziri et al. 2007; Laouer et al. 2009; Zaabat et al. 2011; Edziri et al. 2012).	Labdane diterpenes, flavones, flavonols, germacrene-D, tetracosane, δ-cadinene, α-cadinol, t-cadinol, bicyclogermacrene, and β-caryophyllene (Msaada et al. 2012; Chemsa et al. 2016; Saadi et al. 2016).	Microorganisms, Rats *Escherichia coli* PQ37 cells Human and Animal Cells
Marrubium vulgare L.	White Horehound	Antioxidant, insecticide, hypotensive, antidiabetic, antibacterial, neurosedative anti-inflammatory, antispasmodic analgesic, hepatoprotective, anticancer, antinociceptive and antiviral (Duke 2002; Sahpaz et al. 2002; Sahpaz et al. 2002; VanderJagt et al. 2002; Herrera-Arellano et al. 2004; Pavela 2004; Meyre-Silva et al. 2005; Benedum et al. 2006; Kadri et al. 2011; Kanyonga et al. 2011; Zarai et al. 2011; Boudjelal et al. 2012; Salama et al. 2012; Akther et al. 2013; El Abbouyi et al. 2013; Bokaeian et al. 2014; Boulila et al. 2015; Elberry et al. 2015; Bouterfas et al. 2016; Bouterfas et al. 2016; Ettaya et al. 2016; Rodríguez Villanueva and Martín Esteban 2016; Amri et al. 2017; Béjaoui et al. 2017; Rodríguez Villanueva et al. 2017; Yabrir 2019; Aćimović et al. 2020; Dar et al. 2020; Rezgui et al. 2020).	Marrubin, eugenol, terpenoids, phenolics, flavonoids, and phenylethanoids (Chouaieb et al. 2012; Amessis-Ouchemoukh et al. 2014).	Mice and rats Cell lines
Prasium majus L.	White Hedge-Nettle	Gastrointestinal, analgesic and antioxidants (Hammami et al. 2007; Ben Ismail 2013; Chaouche et al. 2013).	Polyphenols, flavonoids, tannins, 1-Octen-3-ol, α-Pinene, and linalool (Basta et al. 2007).	Human, Rodents Liver, kidney
Rosmarinus officinalis L.	Rosemary	Antioxidant, anticancer, antibacterial Antifungal, pulmonary antiseptic, antidiarrheal and antihypertensive (Özcan and Chalchat 2008; Bernardes et al. 2010; Hussain et al. 2010; Jarrar et al. 2010; Moore et al. 2016; Gezici et al. 2017; Jardak et al. 2017; Neffati et al. 2017; da Silva Bomfim et al. 2020; Moumni et al. 2020).	Carnosol, rosmarinic acid and carnosic acid (Andrade et al. 2018).	Mice, Rats, Rabbits Human cell culture
Salvia aegyptiaca L.	Egyptian sage	Carnosol, rosmarinic acid and carnosic acid (Firuzi et al. 2013; Pourhosseini and Asgarpanah 2015; Ben Farhat et al. 2019; El-Bondkly et al. 2020).	Phenols, flavonoids, steroids, saponins, tannins, terpenoids, quinones, coumarins, anthraquinone metabolites methyl carnosate, rosmarinic acid, and apigenin-7-glucoside (Ben Farhat et al. 2019; El-Bondkly et al. 2020).	Humans, mice, microbes Cell Culture
Salvia verbenaca L.	Wild Clary	Antiseptic, antioxidant, antifungal, anti-inflammatory and analgesic (Khlifi et al. 2006; Tepe et al. 2008; Ben Taarit et al. 2010; Canzoneri et al. 2011; Canzoneri et al. 2011; Ben Farhat et al. 2013; Al-Zereini et al. 2017; Belkhiri et al. 2017; Khouchlaa et al. 2021).	Viridiflorol, camphene, and methyl eugenol (Ben Taarit et al. 2010)	Humans, mice, microbes Human cell lines

(*continued*).

Table 1. Continued.

Species	Common name	Biological Activities	Phytochemicals'	Animal/cell models
Teucrium alopecurus de Noé	Fox-Tail Germander	Anti-inflammatory and anticancer (Guesmi et al. 2021a; Guesmi et al. 2021b).	Sesquiterpene hydrocarbons and δ-cadinene (Hachicha et al. 2007; Guesmi et al. 2018).	Rats Human cell lines
Teucrium polium L.	Felty germander	Anti-inflammatory, antibacterial, anti-hypertensive, hypoglycemic, hypolipidemic, anorectic, antioxidant, antinociceptive, and even anticancer (Abdollahi et al. 2003; Bruno et al. 2003; Couladis et al. 2003; Corea et al. 2004; Esmaeili and Yazdanparast 2004; Kabouche et al. 2007).	β-pinene, germacrene, and α-pinene (Boulila et al. 2008).	Mice and rats Cell cultures
Thymbra capitata (L.) Cav.	Conehead thyme	Antioxidant, anti-inflammatory, antimicrobial, antimycotic, anticancer and antiproliferative (Bounatirou et al. 2007; Albano and Miguel 2011; Palmeira-de-Oliveira et al. 2013; Miguel et al. 2015; Aazza et al. 2016; Delgado-Adámez et al. 2017; Elmi et al. 2017; Carrasco et al. 2016; Merino et al. 2019; Moumni et al. 2020).	Carvacrol, thymol, and β-caryophyllene (Carrasco et al. 2016; Moumni et al. 2020).	Mice and rats Human clinical studies Cell cultures
Thymus algeriensis Boiss. & Reut.	Mougecha	Antioxidant, antimicrobial, anti-inflammatory, antispasmodic, Antifungal, antitumor, anticancer, parasiticidal, sedative and gastrointestinal (Salgueiro et al. 2004; Babaei et al. 2008; Al-Qura'n 2009; El Abed et al. 2014; Guesmi et al. 2014; Ben El Hadj Ali et al. 2015; Bendjabeur et al. 2018; Jaouadi et al. 2018; Jayari et al. 2018; Merino et al. 2019; Messaoudi et al. 2019; Righi et al. 2020; Sobeh et al. 2020; Ouakouak et al. 2021; Mahdi et al. 2022).	Camphor, 4-terpineol, α-pinene and carvacrol (Kouache et al. 2017; Jaouadi et al. 2023).	Mice and rats Human cell lines

Figure 1. Twelve species of Lamiaceae family found in arid and desert areas of southern Tunisia. Photos: Mouldi Gamoun.

a subtle lavender flavor to certain dishes and beverages. In general, it has a history of use in traditional medicine for its purported calming and relaxing properties. While *Lavandula multifida* may not be as widely studied as some other lavender species, it is likely to share similar aromatic and potential therapeutic qualities (El-Hilaly et al. 2003; Upson and Andrews 2004; Tofah et al. 2022). Due to its attractive appearance and distinctive foliage, *Lavandula multifida* is often cultivated as an ornamental plant in gardens and landscapes. Additionally, it boasts hypoglycemic and anti-inflammatory characteristics (Sosa et al. 2005; Molina-Tijeras et al. 2023) along with antimicrobial efficacy (Benbelaid et al. 2012), antioxidant capacity (Sellam et al. 2013), and antifungal activity (Zuzarte et al. 2012). The essential oils extracted from *L. multifida* contain significant amounts of carvacrol, bisabolene, linalool, linalyl acetate, bornyl acetate, β-caryophyllene, nerol, α-thujene, terpinolene, and camphene (Chograni et al. 2010; Msaada et al. 2012; Saadi et al. 2016; Salehi et al. 2018).

***Marrubium deserti* (de Noé) Coss.,** is a resilient herbaceous perennial shrub native to the North African regions of Tunisia, Mauritania, Algeria, Libya, and Morocco. Commonly known as desert horehound and referred to as Marroubia in Arabic, *M.*

deserti thrives in the harsh conditions of arid desert gravel and sandy wadis (Benhouhou 2005). Within traditional medicine, *M. deserti* is frequently employed to address various ailments including colds, colic, fevers, coughs, asthma, digestive troubles, diabetes, acting as a diuretic, helminthiasis, nausea, allergies, and even scorpion stings (Didi et al. 2003). *M. deserti* possesses the capability to address multiple health conditions, with remedies formulated through combinations with various ingredients, including other plants like white wormwood, mint, rosemary, and henna, or non-plant additives such as olive oil, honey, milk, sugar, yogurt, or eggs (Saad et al. 2022). Pharmacological studies have illuminated the species' beneficial properties, revealing it to possess antioxidant, antiviral, antigenotoxic, and antimicrobial capabilities (Edziri et al. 2007; Laouer et al. 2009; Zaabat et al. 2011; Edziri et al. 2012). The primary components of its essential oil consist of labdane diterpenes, flavones, flavonols, germacrene-D, tetracosane, δ-cadinene, α-cadinol, t-cadinol, bicyclogermacrene, and β-caryophyllene (Msaada et al. 2012; Chemsa et al. 2016; Saadi et al. 2016).

Marrubium vulgare L., commonly known as white horehound, is a resilient herbaceous perennial shrub, standing at an approximate height of 50 cm. Its distinct features include a robust, thick, white, cottony felt covering its surface, branched at the lower part, and exhibiting a bluntly quadrangular form. Originating from northern Africa and Europe, and spanning across southwestern and central Asia, this versatile plant has made its presence known beyond its native regions. It has been introduced to various corners of the globe, including both the southern and northern parts of America. Thriving in warm climates and well-suited for growth in dry, sandy wastelands, *M. vulgare* has established itself as a staple in traditional herbal medicine, revered for its efficacy in treating an extensive array of ailments. *Marrubium vulgare* is known to possess analgesic, antidiabetic, antiplatelet, anticoagulant, antispasmodic, gastroprotective, antihypertensive, and anti-edematogenic properties (Tlili et al. 2019; Pipinis et al. 2022). It also serves as a potent anti-inflammatory and antispasmodic remedy (Ibrahim et al. 2014; Dorni et al. 2017). Furthermore, research has unveiled a diverse array of medicinal properties attributed to *M. vulgare*, including its role as an antioxidant agent (VanderJagt et al. 2002; Boulila et al. 2015; Bouterfas et al. 2016; Amri et al. 2017; Rezgui et al. 2020), an effective insecticide (Pavela 2004; Benedum et al. 2006; Salama et al. 2012), a hypotensive agent (Kadri et al. 2011), a potential antidiabetic remedy (Herrera-Arellano et al. 2004; Boudjelal et al. 2012; Elberry et al. 2015; Rodríguez Villanueva et al. 2017), and possessing antibacterial properties (Zarai et al. 2011; Bokaeian et al. 2014; Bouterfas et al. 2016; Béjaoui et al. 2017), neurosedative effects (Duke 2002; Sahpaz et al. 2002), potent anti-inflammatory traits (Sahpaz et al. 2002; Kanyonga et al. 2011; El Abbouyi et al. 2013), antispasmodic capabilities (Meyre-Silva et al. 2005), and even demonstrating analgesic properties (Rodríguez Villanueva and Martín Esteban 2016). Notably, *M. vulgare* contributes to hepatoprotective effects (Akther et al. 2013; Ettaya et al. 2016; Yabrir 2019), and exhibits potential as an anticancer and antiviral agent (Aćimović et al. 2020; Dar et al. 2020). This remarkable medicinal profile is attributed to the presence of essential compounds such as marrubin, eugenol, terpenoids, phenolics, flavonoids, and phenylethanoids, underscoring the significance of this species in the realm of herbal medicine (Chouaieb et al. 2012; Amessis-Ouchemoukh et al. 2014).

***Prasium majus* L.**, commonly referred to as white hedge nettle, is a durable perennial shrub that exhibits a sarmentous growth pattern and stands at a height ranging from 0.5 to 1 m. This botanical gem finds its origins in Mediterranean regions and flourishes in soils with a rocky composition. Distinguished by its ovate to ovate-lanceolate leaves and adorned with exquisite white or lilac flowers, *P. majus* serves as a versatile resource with both medicinal and other practical applications (Bidak et al. 2015). Historically, some communities have used *Prasium majus* in traditional medicine for various purposes. The plant contains compounds that may have medicinal properties, although specific uses can vary (Rasooli 2012). In traditional medicine, its flowers and leaves are skillfully prepared into an infusion, renowned for its efficacy in addressing a range of gastrointestinal ailments (Chaouche et al. 2013) and recognized as a potent analgesic agent (Hammami et al. 2007; Ben Ismail 2013). Scientific investigations have unveiled another facet of *P. majus*, revealing its status as a valuable repository of natural antioxidants, largely due to its substantial phenolic compound content (Ben Ismail 2013). The essential oils extracted from this plant are marked by significant constituents, including polyphenols, flavonoids,

tannins, 1-Octen-3-ol, α-Pinene, and linalool (Basta et al. 2007). These findings underscore the multifaceted nature of *P. majus*, making it a compelling subject of study and an essential addition to the realm of natural remedies.

***Rosmarinus officinalis* L.,** commonly known as rosemary or Iklil in Arabic, is a woody perennial herb deeply rooted in the Mediterranean basin, serving various medicinal, aromatic, and ornamental purposes (Louhaichi and Gamoun 2020). Ethnobotanical studies indicate the prevalent use of its leaves in treating numerous ailments (Mersin and İşcan 2022). Its essential oil is a therapeutic powerhouse, notably featuring robust anti-inflammatory properties (Altinier et al. 2007; Poeckel et al. 2008; Lai et al. 2009; Benincá et al. 2011), antimutagenic effects (Marzouk et al. 2006; Ila and Istifli 2019), cytotoxic capabilities (Hussain et al. 2010; Jardak et al. 2017; Al Zuhairi et al. 2020), antiphlogistic activities (Marzouk et al. 2006; Hussain et al. 2010; Okoh et al. 2010; Jardak et al. 2017; Ila and Istifli 2019; Al Zuhairi et al. 2020), analgesic qualities (Takaki et al. 2008; Martínez et al. 2012; Lucarini et al. 2013), anti-obesity potential (Sedighi et al. 2015), and hepatoprotective attributes (Ramadan et al. 2013; Raskovic et al. 2014). It also plays a pivotal role in preventing and treating cardiovascular and diabetic ailments (Hsieh et al. 2007). The essential oil of rosemary showcases significant biological actions, including antioxidant effects (Beretta et al. 2011; Hendel et al. 2016; Takayama et al. 2016; Li Pomi et al. 2023), anticancer properties (Moore et al. 2016; Gezici et al. 2017; Jardak et al. 2017), antibacterial actions (Bernardes et al. 2010; Hussain et al. 2010; Jarrar et al. 2010; Moumni et al. 2020), and antifungal prowess (Özcan and Chalchat 2008; da Silva Bomfim et al. 2020). Furthermore, *R. officinalis* is recognized for its stomachic, pulmonary antiseptic, antidiarrheal, and anti-hypertensive attributes due to its sudorific and diuretic qualities (Neffati et al. 2017). Notably, in Southern Tunisia, local residents have used its leaves preventively against Covid-19 by soaking dried leaves in boiled water and consuming the resulting infusion after cooling (Gamoun 2021). The primary phytochemical constituents of *R. officinalis* include carnosol, rosmarinic acid, and carnosic acid, further solidifying its significance (Andrade et al. 2018).

***Salvia aegyptiaca* L.,** a diminutive perennial herb, graces the landscape with its dense branching, reaching a modest height of 20–50 cm. A profusion of petite, pale violet corolla blooms adorn this plant. *S. aegyptiaca* finds its range extending from the Cape Verde Islands to the vast realms of India. Its reputation in folk medicine has cast a wide net, drawing considerable attention. All facets of this plant, without exception, have been harnessed in traditional medicine, effectively addressing ailments such as diarrhea, gonorrhea, hemorrhoids, and eye maladies, while serving as an antiseptic, antispasmodic, and stomachic agent (Basaif 2004; Sukhdev et al. 2006). Additionally, ethnobotanically, the whole plant is used by local people to treat dizziness, trembling, diarrhea, piles, and nervous disorders (Mahmoud and Gairola 2013; Ahmad et al. 2021), proving versatile as a carminative, analgesic, and digestive aid (Pourhosseini and Asgarpanah 2015). As evidenced by the research of Ben Farhat et al. 2019, *S. aegyptia*ca's antioxidant prowess recommends it for the pharmaceutical and food industries, offering commendable health-enhancing attributes. Substantial evidence underscores its antibacterial efficacy, cytotoxic effects (Firuzi et al. 2013), and notable anticancer potential (El-Bondkly et al. 2020). The primary phenolic constituents within its methanol extracts comprise phenols, flavonoids, steroids, saponins, tannins, terpenoids, quinones, coumarins, and anthraquinone metabolites (El-Bondkly et al. 2020). Noteworthy compounds in its repertoire include methyl carnosate, rosmarinic acid, and apigenin-7-glucoside (Ben Farhat et al. 2019).

***Salvia verbenaca* L.,** a steadfast perennial, attains a stature of 20–50 cm, adorned with bluish-purple blossoms. Hailing from the Mediterranean expanse, it thrives across diverse soil substrates. Among the native flora, *S. verbenaca* emerges as a notable aromatic and medicinal herb. In Morocco, an ethnobotanical survey confirmed that *S. verbenaca* has been employed by the local population as antidiabetic, antispasmodic, against pimples, against stomach problems, against bad cold, against bloating, anti-acne, antiseptic, diuretic, and astringent agent (Khouchlaa et al. 2021). The distilled essential oil, extracted from its leaves, displays robust antioxidant prowess (Khlifi et al. 2006; Tepe 2008; Ben Farhat et al. 2013; Belkhiri et al. 2017). It is fortified by antibacterial attributes (Ben Taarit et al. 2010; Canzoneri et al. 2011; Al-Zereini 2017) and adeptness as an antifungal agent (Ben Taarit et al. 2010; Canzoneri et al. 2011;

Belkhiri et al. 2017). Its multifaceted qualities extend to anti-inflammatory and peripheral analgesic properties (Ben Taarit et al. 2010), with promising evidence showcasing the inhibition of cancer cell growth (Russo et al. 2015). Among its primary phytochemical constituents, viridiflorol, camphene, and methyl eugenol stand out (Ben Taarit et al. 2010).

***Teucrium alopecurus* de Noé** is a distinctive dwarf perennial herb endemic to the rocky Matmata mountain chain in southern Tunisia. The branches, with their gray and rosy hue, bear dense and reddish floral clusters evocative of a fox's tail. This plant thrives in the rugged terrain of Rocky Mountains, particularly within the Matmata region, including Matmata (Gabes), Beni Kheddache (Medenine), and Chenenni (Tataouine). Although documentation on the ethnobotanical study and biological effects of *Teucrium alopecurus* is limited, a recent investigation demonstrated its effectiveness in preventing liver cancer development (Guesmi et al. 2021a). *T. alopecurus* not only serves as a flavoring agent but also finds use as a traditional folk remedy for a wide range of ailments, either on its own or in conjunction with other medicinal herbs. Its therapeutic utility includes notable anti-inflammatory properties when the powdered leaves are applied externally to inflamed areas, effectively reducing both swelling and pain (Guesmi et al. 2021b). Remarkably, the essential oil derived from *T. alopecurus* exhibits the capacity to inhibit the growth of cancer cells. The plant's primary phytochemical components predominantly consist of sesquiterpene hydrocarbons, oxygenated sesquiterpenes, and δ-cadinene (Hachicha et al. 2007). The intriguing potential for anticancer properties in this species is likely attributed to its phenolic or sesquiterpene content, as evidenced by relevant research (Hachicha et al. 2007; Guesmi et al. 2018).

***Teucrium polium* L.,** known as both felty germander and Jaada in Arabic, is a small herbaceous perennial species with a wide distribution across the western Mediterranean countries. This plant has enjoyed a long history of use in folk medicine, dating back to ancient times, where it has been employed to address various health concerns. In an extensive study exploring ethnobotanical aspects, *T. polium* was found to be used to treat intestinal troubles and diabetes (Bahramikia et al. 2022), alleviate abdominal pain, manage common colds, and address urogenital diseases (Bukhari et al. 2015). Additionally, it has served as a valued agent for wound healing (Chabane et al. 2021). The therapeutic potential of *T. polium* extends beyond these applications, encompassing an impressive array of beneficial properties. It has been documented to possess anti-inflammatory, antibacterial, anti-hypertensive, hypoglycemic, hypolipidemic, anorectic, antioxidant, antinociceptive, and even anticancer properties (Abdollahi et al. 2003; Bruno et al. 2003; Couladis et al. 2003; Corea et al. 2004; Esmaeili and Yazdanparast 2004; Kabouche et al. 2007). The richness of its active components adds to its therapeutic allure. Key phytochemicals found within *T. polium* include β-pinene, germacrene, and α-pinene (Boulila et al. 2008).

***Thymbra capitata* (L.) Cav.** is a perennial herbaceous shrub native to the Mediterranean area, commonly known as thyme and locally referred to as Zaâtar horr. In southern Tunisia, it thrives in scattered populations on sandy and rocky soils. Ethnobotanical studies have shown that *T. capitata* is utilized to address different health issues (Bouyahya et al. 2020b). The essential oil extracted from *T. capitata* has gained a notable reputation for its effectiveness and versatility in traditional medicine practices. It has been extensively employed to address a variety of health concerns, including respiratory and digestive system disorders, ulcers, arterial hypertension, diarrhea, and colic (Stahl-Biskup 2002; Ahmed et al. 2023). Remarkably, the leaves of *Thymbra capitata* are utilized by local communities for the treatment of Covid-19 (Gamoun 2021). They prepare a concoction by boiling the dried leaves in water and consuming the mixture after it cools. Additionally, a preparation of honey mixed with *T. capitata* leaves powder is applied to the chest, offering relief for colds, coughs, bronchitis, and fevers. The essential oil extracted from *T. capitata* has garnered considerable scientific interest due to its multifaceted biological properties (Ben El Hadj Ali et al. 2013; Neves et al. 2017). Notably, it demonstrates strong antioxidant activities (Bounatirou et al. 2007; Aazza et al. 2016; Delgado-Adámez et al. 2017), potent anti-inflammatory effects (Albano and Miguel 2010; Carrasco et al. 2016), and valuable antimicrobial properties (Palmeira-de-Oliveira et al. 2013; Delgado-Adámez et al. 2017; Merino et al. 2019; Moumni et al. 2020). Furthermore, it exhibits cytotoxic and antimycotic actions (Bounatirou et al. 2007; Elmi et al. 2017), along with anticancer potential (Delgado-Adámez et al. 2017) and antiproliferative activity (Miguel et al.

2015). The diverse range of properties displayed by the essential oil underscores the importance of its unique chemical composition (Ben El Hadj Ali et al. 2012; Jaouadi et al. 2018; Moukhles et al. 2020). The main active constituents within this oil include carvacrol, thymol, and β-caryophyllene (Carrasco et al. 2016; Moumni et al. 2020).

***Thymus algeriensis* Boiss. & Reut**. is a resilient North African perennial shrub, flourishing across regions including Morocco, Algeria, Tunisia, and Libya. Commonly known as thyme, it is locally referred to as Zaâtar. Thyme's aromatic qualities have led to its extensive global use both as a flavorful culinary herb and a medicinal resource. The leaves and flowers of *Thymus algeriensis* are employed in the treatment of toothache, gingivitis, mouth ulcers, and muguet (Chermat and Gharzouli 2015). The essential oil extracted from this plant boasts a wide array of pharmacological and biological properties, making it a valuable component in various applications (El Abed et al. 2014; Ben El Hadj Ali et al. 2015; Bendjabeur et al. 2018). This versatile essential oil exhibits potent antioxidant capabilities (El Abed et al. 2014; Ben El Hadj Ali et al. 2015; Bendjabeur et al. 2018), a significant antimicrobial effect (Jayari et al. 2018; Messaoudi et al. 2019; Righi et al. 2020), and robust anti-inflammatory actions (Salgueiro et al. 2004; Ben El Hadj Ali et al. 2015; Jaouadi et al. 2018; Jayari et al. 2018; Merino et al. 2019; Righi et al. 2020; Sobeh et al. 2020). Additionally, it demonstrates antispasmodic properties (Babaei et al. 2008; Al-Qura'n 2009), serves as an antifungal agent (Ouakouak et al. 2021), and exhibits antitumor and anticancer potential (Ouakouak et al. 2021). Furthermore, it holds value as a parasiticidal agent (Ben El Hadj Ali et al. 2015) and has sedative effects (Mahdi et al. 2022). *T. algeriensis* is frequently employed to address gastrointestinal issues and stomach ailments, as well as being utilized in physiotherapy (Guesmi et al. 2014) and the alleviation of neuropathic pain and related conditions (Rezq et al. 2020). The dynamic biological activities of this plant are attributed to its phenolic and volatile compounds (Boutaoui et al. 2018; Guesmi et al. 2019), notably including camphor, 4-terpineol, α-pinene, and carvacrol (Kouache et al. 2017). Jaouadi et al. (2023) demonstrated that *Thymus algeriensis* from most Tunisian arid areas, known for their abundance in carvacrol, exhibited the most favorable activities.

Conclusions

This comprehensive review illuminates the significant potential medicinal applications and diverse biological properties of prominent Lamiaceae family species found in the southern region of Tunisia. Notably, Thymus and Rosmarinus emerge as popular culinary herbs within this family. Medicinally, the Lamiaceae family is rich in volatile oils, with menthol being a prominent constituent. These oils possess warming, stimulating qualities that promote perspiration and enhance the body's natural detoxification process.

A crucial concern underscored by this review is the potential endangerment of several members of the Lamiaceae family, especially endemic species, due to over-harvesting. Users and communities must recognize the dual significance of these plants, both economically and medicinally. Swift action is imperative to ensure that these valuable species receive the protection they deserve under regulations such as the Endangered Species Act.

The distinctive biological properties of Lamiaceae species thriving in arid and desert environments present an opportunity for industrial exploration. By harnessing these properties, new drugs can be developed to contribute to both human health and the overall sustainability of the ecosystem. This convergence of economic, medicinal, and ecological aspects underscores the potential of these plants to contribute to broader societal well-being and support a more harmonious coexistence between humans and the environment.

Implementing serious steps, such as safeguarding the natural habitats of at-risk medicinal plants and exploring the cultivation of a wide array of these plants, could enhance their utilization in healthcare. This action could facilitate the spread of herbal medicine, including indigenous medicinal plants, beyond their native regions, thereby increasing access to healthcare. Ultimately, this progression aligns with achieving SDG 3 (Good health and wellbeing) and SDG 15 (Life on Land).

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Compliance with ethical standards

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Author contributions statement

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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