Ethnobotanical study of medicinal plants traditionally used for osteoporosis treatments in Boumerdes region of Algeria

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Research

Abstract

Background: Osteoporosis is a serious health problem, especially among the elderly. Characterized by progressive bone loss, it increases the risk of fractures, which contribute to significant morbidity, mortality, and healthcare costs. Many medicinal plants used in traditional medicine contain bioactive compounds with potential skeletal benefits. This study aims to identify and document the medicinal plants traditionally used to manage osteoporosis in Algeria.

Methods: Ethnomedicinal data were collected through face-to-face interviews with 48 traditional herbalists in Boumerdes Province in Algeria, using semi-structured questionnaires. Information gathered included vernacular plant names, parts used, and preparation methods. The data were analyzed using quantitative ethnobotanical indices, the relative frequency of citation (RFC).

Results: The study recorded that the local population uses 54 plant species from 32 botanical families. The most common families are Fabaceae (5 taxa), Lamiaceae (5 taxa), and Poaceae (5 taxa). Lepidium sativum and Eleusine coracana emerged as the most frequently cited species. Seeds were the most commonly used plant part (31%), followed by leaves (20%) and leafy stems (14%). Remedies were primarily administered orally, with powders being the most common preparation method (25.37%), followed by decoctions (19.4%) and infusions (17.91%). Additionally, the literature shows that several experimental studies confirm the role of 48 plants from this list in treating osteoporosis.

Conclusions: This study provides a comprehensive ethnobotanical record of traditional treatments for osteoporosis in Boumerdes and offers a foundation for future interdisciplinary research involving ethnobotany, pharmacology, and clinical sciences. The findings highlight the potential of several plant species for phytochemical and pharmacological investigation, with the prospect of developing novel natural therapies for bone health with fewer adverse effects.

Keywords: Ethnobotany, Osteoporosis; Medicinal plant, Relative frequency of citation, Boumerdes City, Algeria

Background

Medicinal plants continue to play a vital role in the healthcare systems of rural African communities, with estimates indicating that over 80% of the population relies on these natural remedies as a primary source of treatment (World Health Organization, 2002). Globally, interest in natural products has grown significantly, particularly as alternative or complementary approaches for managing chronic diseases such as osteoporosis and other bone-related conditions (Belkhadir, 2012; Kouassi *et al.* 2017).

Osteoporosis is a systemic, progressive disease characterized by reduced bone mineral density and the deterioration of bone microarchitecture. Often referred to as a “silent disease,” it typically remains asymptomatic until a fracture occurs. Osteoporotic fractures affect nearly 8.9 million individuals worldwide each year and are associated with substantial morbidity, mortality, and healthcare costs (Delmas *et al.* 2005). With the global population aging, the incidence of osteoporosis is expected to rise, highlighting the need for effective, safe, and affordable treatment options.

Modern pharmacological treatments for osteoporosis primarily follow two strategies: inhibiting bone resorption or stimulating bone formation. Hormone replacement therapy (HRT) using estrogens, with or without progestins, effectively reduces bone resorption but is associated with increased risks of cardiovascular events, breast and endometrial cancers, and thromboembolic complications (Rossouw et al.,2002). Bisphosphonates (such as alendronate, risedronate, ibandronate, zoledronic acid, and pamidronate) act on osteoclasts to slow down bone resorption and are frequently linked to gastrointestinal disorders, hypocalcemia, post-infusion fever, osteonecrosis of the jaw, and atypical femoral fractures. Selective estrogen receptor modulators (SERMs), such as raloxifene, share antiresorptive properties with estrogens and have a more favorable profile regarding breast cancer risk, but commonly induce hot flashes, leg cramps, and increased thrombotic risk. Anabolic agents (e.g., teriparatide) stimulate osteoblast activity and bone formation but may cause nausea, hypercalcemia, injection site reactions, and—rarely—a theoretical risk of osteosarcoma. Finally, the monoclonal antibody denosumab (anti-RANKL) effectively inhibits bone resorption, though it may lead to hypocalcemia, musculoskeletal pain, urinary or respiratory infections, skin reactions, constipation, osteonecrosis of the jaw, and atypical fractures (Khosla et al.,2017).

Given the limitations and potential adverse effects associated with conventional pharmacological treatments, there is growing scientific interest in exploring alternative therapeutic strategies. Among these, traditional ethnomedicinal remedies are gaining renewed attention, as they may offer safer, culturally appropriate, and cost-effective alternatives or adjuncts for the management of osteoporosis ((Kouassi *et al.* 2017; Zhang *et al.* 2006). In countries like Algeria, initiatives aimed at developing and standardizing herbal medicine are increasingly supported by national policies and by the World Health Organization's efforts to promote the integration of traditional medicine into modern healthcare systems

Ethnobotany, which investigates the dynamic relationships between people and plants, provides a crucial framework for understanding traditional healing systems and identifying novel bioactive compounds. However, much of this traditional knowledge is orally transmitted and remains poorly documented, putting it at risk of disappearing without systematic research and scientific validation (Heinrich *et al.* 2006). In Algeria, traditional medicine continues to play an important role in primary healthcare, with numerous herbal remedies used—often in combination—to support bone health and alleviate symptoms related to osteoporosis (Bouziane, 2020).

Despite Algeria’s rich ethnobotanical heritage, no comprehensive study has yet been conducted to specifically explore the traditional use of medicinal plants in osteoporosis management. To address this gap, the present study aims to document the medicinal species traditionally employed by herbalists in the town of Boumerdes, with a focus on their local therapeutic uses against osteoporosis. This research not only contributes to the preservation of valuable cultural and medicinal knowledge but also lays a foundation for future pharmacological, toxicological, and clinical investigations.

Materials and Methods

Study area

This ethnobotanical study was carried out in Boumerdes Province, located in northern Algeria (Fig. 1) along the Mediterranean coast (Latitude: 36° 45' 59.00" N, Longitude: 3° 28' 37.81" E). The region is characterized by a Mediterranean climate, with mild, rainy winters and hot, dry summers. Boumerdes encompasses a variety of ecological zones, including coastal plains, agricultural valleys, and forested hills. The area supports rich plant biodiversity and a strong tradition of herbal medicine, particularly in rural and peri-urban communities. Six localities within the Boumerdes region: Boumerdes, Issers, Baghlia, Thénia, Khmis El-Khechna, and Boudouaou (Fig.1)

Figure 1. Map of the study area in Boumerdes regions, Algeria.

Selection of informants and data collection

Ethnomedical data were collected between January 2020 and June 2022. A total of 48 traditional herbalists were interviewed. Informants were selected through purposive and snowball sampling techniques, based on their expertise and recognition within their communities as practitioners of traditional herbal medicine.

Prior to participation, verbal informed consent was obtained from each informant after explaining the objectives of the study. Interviews were conducted in Arabic or local dialects, depending on the participant's preference. A semi-structured interview format was used to collect information on: (i) vernacular names of medicinal plants; (ii) parts of the plant used; (iii) preparation methods; (iv) routes of administration; and.

Botanical identification and voucher specimens

A botanical sample of each mentioned plants was collected. These specimens were pressed and preserved for later identification by expert botanists of the research station on the protection of the arid regions of Tamanrasset according to the flora of Quezel and Santa. A voucher specimen (N°38) has been deposited at the herbarium of the National Institute of Agronomy, Algeria. Plant species identified were confirmed using the Plant List (https://www.theplantlist.org/) for the accepted scientific names.

Data Analysis

The ethnobotanical data were analyzed using descriptive statistical methods to identify the most frequently cited medicinal plants used in the traditional treatment of osteoporosis.

Since the study focused on a single therapeutic use (osteoporosis), the analysis primarily relied on the Relative Frequency of Citation (RFC), expressed as a percentage. It was calculated using the following formula:

$$RFC\ (\%) = \frac{FC}{N} \times 100$$

where FC is the number of informants who mentioned a particular plant species, and N is the total number of informants interviewed. Where, FC is the frequency of citation; N is the total number of respondents participating in the study, without considering use categories into account.

Results and Discussion

Demographic Characteristics of Informants

The ethnobotanical investigation carried out in the Boumerdes Province revealed a wealth of traditional knowledge regarding the use of medicinal plants for osteoporosis management. A total of 48 herbalists shared their expertise across six districts—Boumerdes, Issers, Baghlia, Thénia, Khmis El-Khechna, and Boudouaou—highlighting the continued relevance and richness of folk medicine in the region.

The sociodemographic profile of the interviewed herbalists is summarized in Table 1. Most participants were male, representing 95.83% of the total, while only 4.16% were female. The average age of the informants was 50 years, with individuals ranging in age from 30 to 67 years. Notably, more than one-third of respondents were aged 57 or older, suggesting a prevalence of older practitioners with considerable traditional knowledge.

Educational levels among the participants were generally low. A majority (85.42%) were illiterate, and 14.58% had received only basic primary education. These findings reflect a pattern of knowledge transmission rooted in oral traditions and experiential learning accumulated over time.

Regarding their place of residence, 70.83% of the informants (n = 34) lived in rural areas, while the remaining 29.17% (n = 14) were based in urban centers. This predominance of rural-based informants underscores the enduring role of traditional medicine in village communities, where herbalists continue to serve as key providers of primary healthcare.

Table 1. Demographic characteristics of the individuals interviewed

Demographic properties		**Gender ratio**		
		Female	Male	Percentages
Age	30-40	2	4	12.50
	40-50	0	8	16.67
	50-60	0	29	60.42
	>60	0	5	10.41
Study level	Illiterate	0	41	85.42
	Primary	2	5	14.58
Place of residence	City	2	12	29.17
	Village	0	34	70.83

Medicinal plants and folk osteoporosis remedies

The World Health Organization (WHO) notes that herbal medicines serve the health needs of about 80% of the world's population, particularly in rural areas of developing countries where traditional medicine is predominant. Over the last 30 years, about 50% of approved drugs have been either natural products or derived from natural products, with many important anticancer and antimicrobial drugs originating from plants.

The present study aimed to inventory the medicinal plants traditionally used to treat osteoporosis in the Boumerdes region of Algeria. To our knowledge, this is the first ethnobotanical investigation in Algeria specifically focused on osteoporosis. The field survey revealed that this region possesses a rich botanical heritage and a deep-rooted tradition of folk medicine.

A total of 54 plant species belonging to 32 botanical families were identified and are listed in Table 2, organized alphabetically by their scientific names. The widespread use of these species can be attributed to their availability, traditional efficacy, and low cost. Among the most frequently cited families were Fabaceae (5 taxa), Lamiaceae (5 taxa), and Poaceae (5 taxa), as illustrated in Figure 2. These families were also prominent in other African studies, such as Kouassi et al. (2017), although the specific taxa differed—for example, *Piliostigma thonningii, Dalbergia hostilis, Pericopsis laxiflora,* and *Pseudarthria hookeri* were reported in Côte d'Ivoire. The Fabaceae family appears promising for further investigation due to its pharmacological potential in bone health management.

Notably, several species recorded in this study are also reported in other Algerian ethnobotanical surveys, reinforcing both regional coherence and local specificity in traditional plant use for bone health. *Lepidium sativum*, which had the highest RFC in the Boumerdes survey, is traditionally used for osteoporosis and menopausal disorders, with its therapeutic relevance confirmed in regions such as Mostaganem and Djelfa (Batache 2020; Merazga & Ben Ayache, 2024). *Eleusine coracana*, another highly cited species, is cited in Algerian ethnobotanical studies as a medicinal and food plant used by local populations. For example, an ethnobotanical survey conducted in Adrar region reports *Eleusine coracana* among the spontaneous and cultivated plants with traditional uses (normalize the Cholesterol level) (Izri,2021). Another study from the Ghardaïa region (Metlili) includes Eleusine coracana in the inventory of medicinal plants used by Saharan populations, emphasizing its role in local pharmacopoeia and food security (Ould El Hadj *et al.* 2003).Additional ethnobotanical investigations in northeastern Algeria (Guelma, Tizi-Ouzou, Bejaia) mention *Eleusine coracana* as part of the traditional medicinal flora, highlighting its importance in treating metabolic and nutritional disorders (Messadi *et al.* 2022; [3]). These studies collectively demonstrate that *Eleusine coracana* is recognized in Algeria not only as a cereal crop but also for its ethnomedicinal properties. This last one is classified as a "nutri-cereal," is recognized for its high nutritional value, including essential dietary fiber, fatty acids, protein, B vitamins, and key minerals such as calcium, zinc, potassium, iron, and magnesium (Ramashia *et al.* 2021; Kumar, S. et al.,2021). Additionally, it exhibits antioxidant and hypolipidemic effects and has a low glycemic index, making it beneficial for chronic conditions, including osteoporosis (Chaudhary & Mudgal, 2020; Kareem *et al.* 2019). Moderately used plants like *Trigonella foenum-graecum* and *Nigella sativa* and *Thymus vulgaris* are also commonly mentioned in other Algerian regions for musculoskeletal issues, including bone pain and joint weakness (Belhouala *et al.* 2021; Benarba, 2016; Batache, 2020; Lazli *et al.* 2019). Similarly, *Urtica dioica* and *Salvia officinalis*—cited in Boumerdes for bone inflammation—have been widely used in Djelfa and northeastern Algeria to treat rheumatic and osteoarticular conditions (Lazli *et al.* 2019; Merazga & Ben Ayache, 2024). Although cited less frequently, *Ajuga iva* is locally recognized for its antioxidant and anti-inflammatory properties, supporting its relevance in bone-related therapies (Lazli *et al.* 2019). *Citrus* species, appreciated for their high vitamin C content and role in bone mineralization, are widely used across Algeria, including in Metlili, Ghardaïa, and Ain Témouchent (Ould El Hadj *et al.* 2003; Bailiche & Bailiche. 2021). The Fabaceae family, among the most represented in Boumerdes, includes species with known phytoestrogenic effects and is consistently reported across Algeria for treating hormonal and bone-related conditions (Ould El Hadj *et al.* 2003; Merazga & Ben Ayache, 2024). Although *Camellia sinensis* (green tea) had a lower RFC, it remains therapeutically significant; its antioxidant properties have been highlighted in surveys from Guelma and Yakouren, pointing to a growing interest in its use for preventing oxidative stress-related diseases, including osteoporosis (Boulmokh,2021; Lazli *et al.* 2019). Altogether, these cross-regional confirmations—especially for the most frequently cited species—underscore the cultural consistency, scientific relevance, and ethnopharmacological depth of traditional knowledge on bone health in Algeria.

Other traditional medicine systems outside Algeria. For instance, *Camellia sinensis* and *Citrus spp*. are widely used in East Asian countries such as Korea, China, and Japan for various therapeutic purposes, including bone-related conditions (Patel & Preedy. 2017). Similarly, *Urtica dioica* (stinging nettle), known for its mineral-rich composition, is frequently used in Moroccan traditional medicine for the treatment of bone and joint disorders (Chaachouay *et al.* 2019).

Table 2. List of medicinal anti-osteoporotic plants in the Boumerdes City (Algeria)

Family	**Scientific name**	**Vernacular name**	**Part used**	**Method of use**	**RFC**
Alliaceae	*Allium ampeloprasum var. porrum* (L.) J.Gay	Poireau	LS	M	0.45 %
Amaryllidaceae	*Allium sativum* L.	Ail	R	DC	0.45 %
Apiaceae	*Petroselinum crispum* (Mill.) Fuss	Persil	L	I	0.45 %
Arecaceae	*Phoenix dactylifera* L.	Palmier dattier	S, Fr	P,DC	1.80%
Arecaceae	*Cocos nucifera* L.	Noix de coco	Fr	O	0.45 %
Asteraceae	*Arctium lappa* L.	Bardane	R , L	I	0.45 %
Asteraceae	*Cichorium intybus* L.	Chicorée	L	D, P	0.45 %
Asteraceae	*Arnica montana* L.	Arnica des montagnes	Fl	D	0.45 %
Boraginaceae	*Symphytum officinale* L.	Consoude officinale	WP	D	0.45 %
Brassicaceae	*Lepidium sativum* L.	Cresson alénois	S	DC	17.57%
Brassicaceae	*Brassica juncea* (L.) Czern.	Moutarde	S	I , A.I	0.45%
Brassicaceae	*Brassica oleracea* var. *acephala DC.*	Chou pommé	L	C	0.45 %
Cactaceae	*Aloe vera* (L.) *Burm*.f.	Aloe vera	L	Oi	1.35 %
Chenopodiaceae	*Amaranthus tricolor* L.	Amarante	S	D, P	0.45 %
Cupressaceae	*Juniperus communis* L.	Genévrier	Fr	I,D	0.90 %
Cyperaceae	*Cyperus esculentus* L.	Souchet comestible	S	P	0.45%
Equisetaceae	*Equisetum arvense* L.	Préle d'hiver	LS, WP	I, P	0.90 %
Fabaceae	*Trigonella foenum-graecum* L.	Fenugrec	S	D	2.25%
Fabaceae	*Lens culinaris* Medik.	Lentille	LS	CaC	0.90%
Fabaceae	*Glycine max* (L.) Merr.	Soja	S	P	1.35 %
Fabaceae	*Coriandrum sativum* L.	Coriandre	S	D	0.90 %
Fabaceae	*Glycyrrhiza glabra* L.	Réglisse	R	P	0.45 %

Juglandaceae	*Juglans regia* L.	Noix	Fr	DC	0.90 %
Lamiaceae	*Salvia hispanica* L.	Chia	S, L	M, D,P	6.76%
Lamiaceae	*Origanum majorana* L.	Morjolaine	LS	D	0.45%
Lamiaceae	*Thymus vulgaris* L.	Thym	LS	D, I	0.90%
Lamiaceae	*Salvia rosmarinus* Schleid.	Romarin	L	M, Oi	0.45 %
Lamiaceae	*Salvia officinalis* L.	Sauge officinale	L	D	0.45 %
Lauraceae	*Cinnamomum camphora* (L.) J.Presl	Campharier	L	C, O	0.45 %
Lauraceae	*Cinnamomum zeylanicum* Blume	Cannelle	B	I	0.90 %
Linaceae	*Linum usitatissimum* L.	Lin	S	DC	2.70%
Moraceae	*Ficus carica* L.	Figue	Fr	DC	1.35%
Moringaceae	*Moringa oleifera* Lam.	Moringa	L	M	0.45%
Oleaceae	*Olea europaea* L.	Olive	Fr	O	1.35%
Pedaliaceae	*Sesamum indicum* L.	Sésame	S	P	7.66 %
Piperaceae	*Piper nigrum* L.	Poivre noire	S	P	0.45 %
Plantaginaceae	*Plantago ovata* Forssk.	Psyllium	S	I	0.45%
Poaceae	*Eleusine coracana* (L.) Gaertn.	Eleusine	S	P	15.77%
Poaceae	*Avena sativa* L.	Avoine	S	P	2.25%
Poaceae	*Triticum aestivum* L.	Germe de blé	S	P	0.90%
Poaceae	*Pennisetum glaucum* (L.) R.Br.	Millet	S	P	0.45%
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Lemongrass	L, Fl	I	0.45 %
Ranunculaceae	*Nigella sativa* L.	Nigelle cultivée	S	M , P	3.15 %
Ranunculaceae	*Cimicifuga racemosa* (L.) Nutt.	Actée à grappe	R	P	0.45 %
Rhamnaceae	*Frangula alnus* Mill.	Nerprun	S	P	0.45 %
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	Jujubier de palestine	L	M	0.45 %
Rosaceae	*Prunus dulcis* (Mill.) D.A.Webb	Amande	Fr	DC	0.90 %
Rubiaceae	*Rubia tinctorum* L.	Garance desteinturiers	LS	M	0.45%
Rubiaceae	*Uncaria tomentosa* (Willd. ex Schult.) DC.	Liane de pérou	B	D	0.45 %
Salicaceae	*Salix pentandra* L.	Saule	B	D, I	0.45 %
Theaceae	*Camellia sinensis* (L.) Kuntze	Thé vert	LS	I, D	0.90 %
Urticaceae	*Urtica sp*	Ortie	LS, R	I, M	2.25%
Zingiberaceae	*Curcuma longa* L.	Curcuma	Rh	M,P	7.21%
Zingiberaceae	*Zingiber officinale* Roscoe	Gingembre	Rh	I	3.60 %

S: Seeds, L: Leaves, LS: Leavy steam, R: Root, Rh: Rhizome, B: Bark, F: Flowers, Fr: Fruit, WP: whole plant, D: Decoction, I : Infusion, P : Powder, Oi: Ointment, C : Compress, O: Oil, DC : Direct Consumption, C.a.c : Consumption after cooking, L A: Local Application.

Part used

The parts of the plants most commonly used in traditional remedies for osteoporosis in Boumerdes are shown in Figure 3. Seeds were the most frequently used plant part, accounting for 31% of all reported uses, followed by leaves (20%), leafy stems (14%), and fruits (12%). Other parts cited by local herbalists include roots, rhizomes, the whole plant, flowers, and bark. Taken together, leaves and leafy stems represent 34% of the plant parts used. This prevalence may be explained by the fact that leaves are not only easily accessible and simple to harvest but also serve as key organs for botanical identification (Akerreta *et al.* 2007; Hayat *et al.* 2020; Jeddi *et al.* 2021). Moreover, leaves are the main sites of photosynthesis and are known to be rich in bioactive phytochemicals, such as flavonoids, alkaloids, and phenolic compounds, which may contribute to their therapeutic efficacy (Benamar *et al.* 2024; El Hachlafi *et al.* 2020; Raterta *et al.* 2014; Xavier *et al.* 2015). Then these findings align with previous ethnobotanical studies in the Mediterranean and North African regions, where leaves and seeds are consistently among the most used parts for preparing traditional remedies.

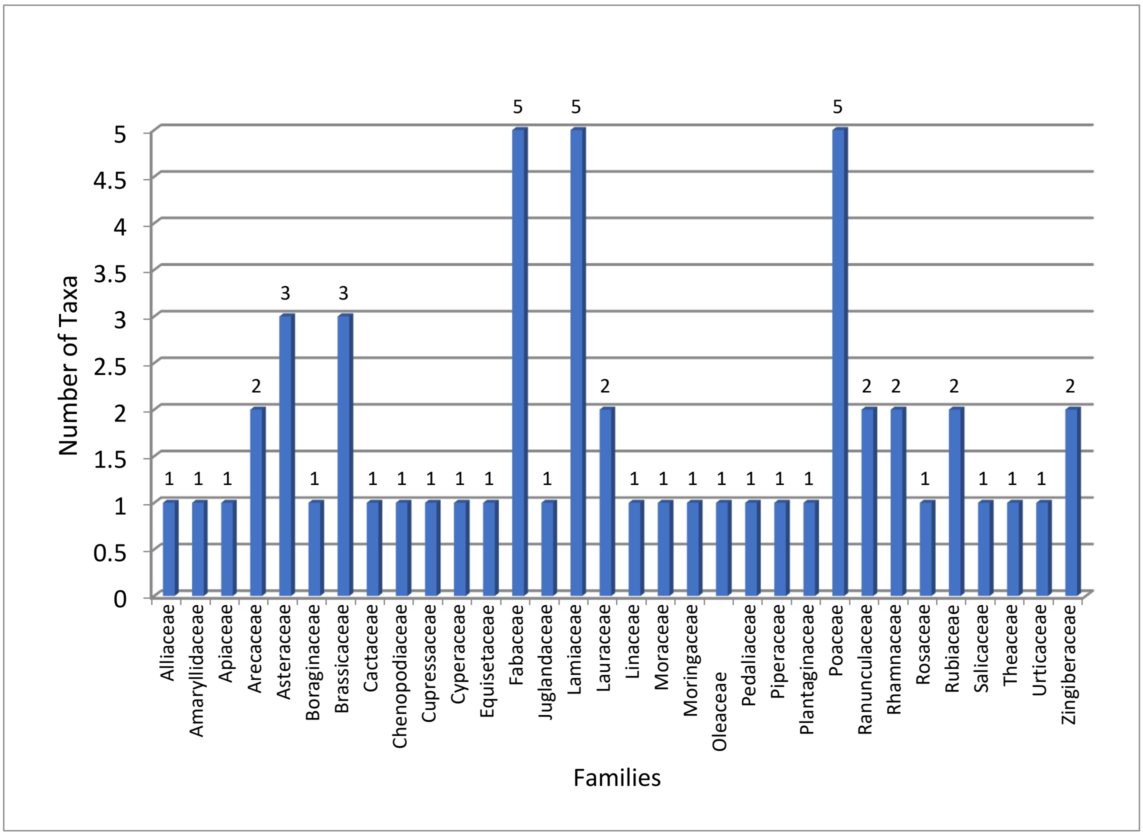

Figure 2. The most-cited plant families.

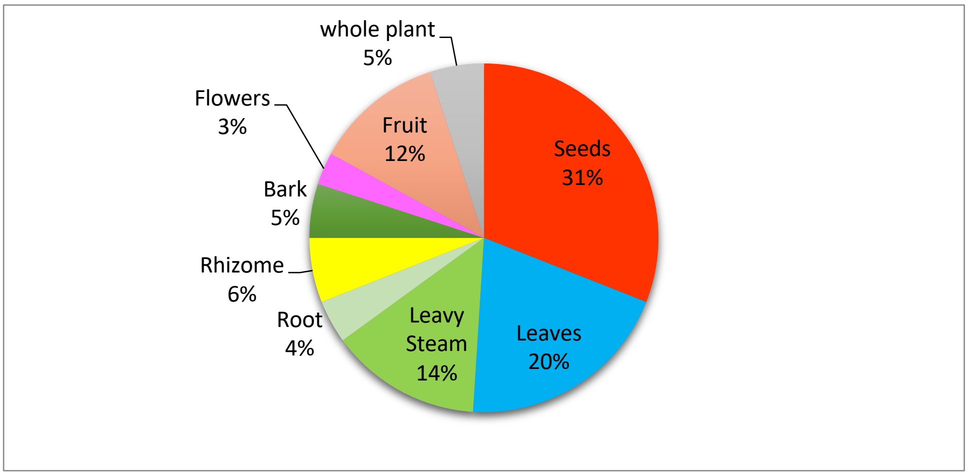

Figure 3. Plant part used in osteoporosis treatment in the study area.

Preparation mode

medicinal plants used for osteoporosis are primarily prepared for internal use via the oral route. Ten different preparation methods were recorded, reflecting a rich diversity of ethnomedicinal practices (Fig. 4).

The most commonly reported method was powder preparation, accounting for 25% of all use reports. This was followed by decoction and infusion, both cited at 19.1%, and direct consumption at 10.3%. Other preparation methods included maceration (9%), as well as external forms such as oil applications, ointments, compresses, cooking-based preparations, and local applications.

In addition, several informants indicated that specific plant preparations were combined with adjuvants such as milk, honey, or yogurt. These additions serve either to enhance the flavor of the remedy or to potentiate its therapeutic effects, particularly in long-term uses or chronic conditions like osteoporosis.

This wide range of preparation modes illustrates the depth and adaptability of traditional medicinal knowledge in Boumerdes. It also reflects the population's ability to tailor treatments according to the availability of resources, patient needs, and the perceived potency of each method.

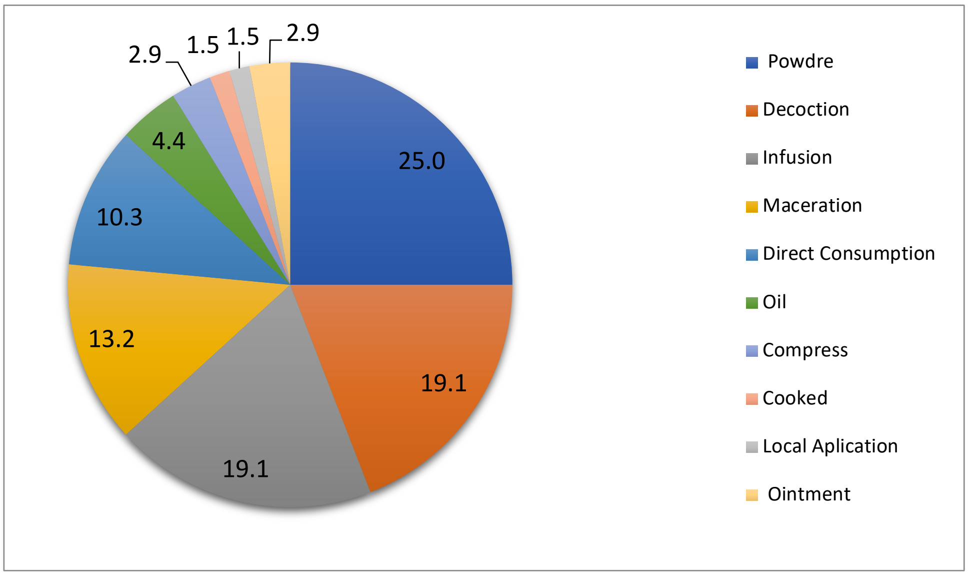

Figure 4. Frequency of different methods of preparation.

A literature review was performed on the biological anti-osteoporotic activities of cited plant species. Table 3 presents a summary of experimental findings related to each species, highlighting their effects on bone-forming osteoblasts and bone-resorbing osteoclasts. The table distinguishes whether a plant has been shown to promote osteoblast proliferation and differentiation (i.e., stimulating bone formation) or to inhibit osteoclast activity (i.e., preventing bone loss), thus contributing to overall bone health.

Remarkably, out of the 54 medicinal plant species cited by local herbalists for the treatment of osteoporosis, 47 have been previously investigated in experimental studies for their potential roles in bone metabolism. This high degree of scientific alignment with traditional knowledge underscores the cultural depth and empirical relevance of the herbal practices reported by the informants.

These findings reflect not only the rich ethnopharmacological heritage of the Boumerdes region but also the potential of traditional medicine to guide future pharmacological research. The overlap between traditional use and experimentally confirmed activity provides strong justification for the prioritization of certain species in further in vivo and clinical studies.

Table 3. Experimental evidence of anti-osteoporotic activity for medicinal plants cited in Boumerdes.

Scientific name	Pharmacological Study /Biological Effect	Study Type	References
Allium ampeloprasum var. porrum (L.) J.Gay (leek)	improves bone density and strength by regulating bone metabolism, increasing markers of bone formation (by stimulating osteoblasts), and decreasing signals of bone resorption (by inhibiting osteoclasts).	*In vitro, In vivo*	(El-Shenawy *et al.* 2013)
Allium sativum L. (garlic)	helps to preserve bone integrity, strengthen bones, and stop bone loss. Furthermore, it influences the biochemical markers and supports bone formation (increase in osteoblast activity) while inhibiting resorption (decrease in osteoclast activity).	*In vivo*	(Mukherjee *et al.* 2004)
Petroselinum crispum (Mill.) Fuss (parsley)	has demonstrated osteogenic effects and inhibition of bone resorption in animals by acting through estrogen-like effects or by modulating pathways involved in bone remodeling and in silico studies, promoting overall bone strength and health.	In vivo/*In silico*	(Saeed *et al.* 2024)
Phoenix dactylifera L. (date)	*pit extract has significant potential as a therapeutic agent for preventing or reversing glucocorticoid-induced osteoporosis. Phoenix dactylifera* has shown osteoblast stimulation and osteoclast inhibition, helping maintain bone homeostasis.	*In vivo*	(Saleh *et al.* 2022)
Cocos nucifera L. (coconut)	have found that it stimulates bone formation by osteoblast and inhibits osteoclast activity, which may enhance bone structure and prevent bone loss. Coconut prevents or reduces bone loss in the rats, as evidenced by improved bone mineral density.	*In vivo*	(Hayatullina *et al.* 2012)
Arctium lappa L. (burdock)	*Arctiin* has been found in animal studies to inhibit osteoclast differentiation (Osteoclastogenesis) and significantly reduce bone resorption activity. arctiin could be a promising candidate for the development of novel therapeutics for osteoporosis and other diseases characterized by excessive bone resorption, such as rheumatoid arthritis.	*In vitro*	(Chen *et al.* 2020)
Cichorium intybus L. (chicory)	has protective effects against osteoporosis induced by dexamethasone in female rats. Histological results have revealed improved bone microstructure. It promotes osteoblast activity and inhibits osteoclast action, enhancing bone mineral density in animal models.	*In vivo*	(جوهريand ,طلعت 2022)
Arnica montana L. (arnica)	has been shown to accelerate osteogenesis (bone formation) and enhance the repair of damaged bone tissue especially in conditions like osteoporosis or postmenopausal bone loss, improving bone integrity.	*In vivo*	(Silva *et al.* 2017)
Symphytum officinale L.	The active ingredients such as allantoin and rosmarinic acid, may have worked in concert with calcium hydroxide and comfrey tincture to promote osteogenesis, or the development of new bone, by inducing the synthesis of important osteogenic indicators. It's possible that calcium hydroxide contributed to improving mineralization and creating an alkaline environment that aided in bone mending.	*In vivo*	(Kostyiuk *et al.* 2021)

Lepidium sativum L. (cress)	provides strong evidence for the osteoprotective effects, particularly in the context of postmenopausal osteoporosis by promoting osteoblast differentiation and collagen synthesis, both of which are essential for new bone matrix formation. Then it inhibits also the osteoclastogenesis	*In vivo*	(Abdallah *et al.* 2020)
Brassica juncea (L.) Czern. (mustard)	balanced, nutrient-rich bone-healthy diet due to its rich content of calcium, magnesium, and vitamin K. It can help support bone health and contribute to the prevention and management of osteoporosis.	*In vitro*	(Cartea *et al.* 2011; Gustiar *et al.* 2020)
Brassica oleracea var. acephala DC. (kale)	enhances bone mineralization and inhibits osteoclastogenesis, supporting bone structure and reducing bone loss in postmenopausal women, it increases the bone formation markers and/or decreases the resorption markers.	Clinical	(Pereira *et al.* 2006)
Aloe vera (L.) Burm.f.	*Aloe* polysaccharides have shown positive effects by enhancing osteoblast differentiation and promoting bone formation, it could serve as a natural therapeutic agent for preventing or treating osteoporosis, particularly in postmenopausal cases.	*In vitro/In vivo*	(Yao *et al.* 2022)
Amaranthus tricolor L. (amaranth)	inhibits osteoclastogenesis, plus it reduces osteoclast activity, thus reducing bone resorption activity and improving bone structure and strength.	*In vivo /In vitro*	(Jeong *et al.* 2020)
Equisetum arvense L. (horsetail)	has been shown to increase bone formation by osteoblast and remodeling, supporting overall more dense bone tissue and preventing or slowing bone loss typically. The plant's high silica content may contribute to enhanced collagen synthesis and calcium deposition in bone, which can help maintain or improve bone density	*In vivo*	(Arbabzadegan *et al.* 2019)
Trigonella foenum-graecum L. (fenugreek)	enhances osteoblast activity and inhibits osteoclasts, contributing significantly to improving bone structure and strength, effectively preventing or reducing the severity of osteopenia induced by ovariectomy (simulating menopause).	*In vivo*	(Anjaneyulu *et al.* 2018)
Glycine max (L.) Merr. (soybean)	helps to prevent or reduce bone loss in the ovariectomized rat model of osteoporosis, it has been shown to stimulate osteoblast differentiation and inhibit osteoclast activity, promoting the strength and mineral density of bone by the modulation of estrogen-related pathways that could support bone health, especially in postmenopausal conditions.	*In vivo*	(Byun and Lee, 2010)
Coriandrum sativum L. (coriander)	has been shown to enhance bone health and decrease bone loss by inhibiting osteoclastogenesis and bone resorption..	*In vitro*	(Sim *et al.* 2022)
Glycyrrhiza glabra L. (licorice)	Because of its estrogenic-like qualities, *it* protects the bone mineral density and bone health of ovariectomized rats. The extract may improve bone strength and density by promoting bone formation (by raising osteoblast activity) and limiting bone resorption (by lowering osteoclast activity).	*In vivo*	(Galanis *et al.* 2019; Tanideh *et al.* 2023)
Juglans regia L. (walnut)	has a prominent osteogenic effect on human bone marrow mesenchymal stem cells (hBMSCs) by activating two major critical signaling pathways for bone development and regeneration. Promotes osteogenic differentiation, increasing the expression of osteoblast markers and enhancing calcium deposition.	*In vitro*	(Pang *et al.* 2022)

Salvia hispanica L. (chia)	seeds have significant ameliorating effects on bone mineral density, it enhanced bone formation through increased osteoblast activity (as evidenced by biochemical markers), and reduced bone resorption (indicated by histopathological analysis showing reduced osteoclast activity).	*In vivo*	(Kadhem *et al.* 2023)
Origanum majorana L. (marjoram,)	Arbutin, a naturally occurring hydroquinone glycoside, enhances osteoblast proliferation and promotes osteoblast differentiation, as evidenced by increased biochemical markers.	*In vitro*	(Lukas *et al.* 2010; Man *et al.* 2019)
Thymus vulgaris L. (thyme)	and bee honey effectively ameliorate hydrocortisone-induced osteoporosis. It shows a restoration of bone density and improved bone turnover, with a shift toward bone formation and away from bone resorption, a reduction in oxidative stress and inflammation, which are significant contributors to the progression of osteoporosis.	*In vivo*	(Abu-Serie and Habashy, 2018)
Salvia rosmarinus Schleid. (rosemary)	Enhanced bone formation and reduced bone resorption **with thyme**, as evidenced by increased osteoblast activity and reduced osteoclast activation, thus helping to prevent bone loss and to restore bone mineral density.	*In vitro*	(Hassan and Hassan, 2023)
Salvia officinalis L. (sage)	has shown an increasing in bone mineral density and improved bone structure, by reducing oxidative stress and enhancing antioxidant enzyme activity, Thus lowering pro-inflammatory cytokines, which are involved in bone resorption, and modulating bone turnover by enhancing osteoblast activity and inhibiting osteoclast activity	*In vivo*	(Abdallah *et al.* 2010)
Cinnamomum zeylanicum Blume (cinnamon)	Increased bone formation and improved bone mineral density in ovariectomized rats , a reduction in markers of bone resorption, indicating that cinnamaldehyde might have anti-resorptive effects. It Enhanced osteoblast differentiation and bone matrix deposition in cultured osteoblasts.	*In vitro/In vivo*	(Wu *et al.* 2018b)
Linum usitatissimum L. (flaxseed)	appears to be a promising natural food source with osteoprotective properties, primarily due to its anti-inflammatory, antioxidant, estrogenic, and bone mineralization-promoting effects. Its ability to prevent bone loss, induce osteogenesis, and inhibit bone resorption makes it a promising choice for the treatment of osteoporosis and improving general bone health.	*In vivo*/ Clinical	(Batool *et al.* 2024)
Ficus carica L. (fig)	has been found to promote overall bone health and regeneration by increasing bone formation markers through osteoblast stimulation and decreasing bone resorption markers through inhibition of osteoclast activity. Ficus carica aids in reestablishing the equilibrium between bone resorption and creation.	*In vivo*	(Shamsir *et al.* 2019)
Moringa oleifera Lam. (Moringa)	has been demonstrated to increase bone density and strength by regulating bone metabolism, which promotes bone production and decreases bone resorption. A healthy microbial environment that supports bone health is also promoted by altering the gut microbiome..	*In vivo*	(Hu *et al.* 2023)
Olea europaea L. (olive)	has increased bone formation markers, indicating enhanced osteoblast activity (bone formation). This suggests that olive oil may help restore the balance between bone resorption and formation, thus combating bone loss in osteoporosis (bone mineralization and strength).	*In vivo*	(Liu *et al.* 2014)

Sesamum indicum L. (sesame)	Dietary sesame powder, particularly at higher doses, significantly diminished bone mass and bone formation indices in ovariectomized rats, confirming a negative impact on bone health in this animal model of postmenopausal osteoporosis or in estrogen-deficient conditions. But The **sesame oil** shows a moderate increase in bone mineralization and strength (~10-15%) by a reduction in bone resorption and stimulation of bone formation), it increases aromatase activity, leading to enhance the local conversion of androgens to estrogens, which further supports bone health.	*In vivo*	(Hsu *et al.* 2024; Tachibana *et al.* 2020)
Piper nigrum L. (black pepper)	Piperine interferes with important signaling pathways to prevent osteoclast development. Piperine inhibits the production of osteoclasts and, as a result, bone resorption by decreasing the activation of these pathways. This implies that piperine may be used therapeutically to treat diseases including osteoporosis, rheumatoid arthritis, and Paget's disease of the bone that are marked by excessive bone resorption.	*In vitro*	(Deepak *et al.* 2015)
Eleusine coracana (L.) Gaertn. (finger millet)	Food supplements made from *Eleusine coracana* combined with regular exercise can improve bone health, especially in premenopausal women, who are not frequently the focus of bone health therapies before menopause-related bone loss becomes noticeable.	Clinical	(Sahaya Rani *et al.* 2021)
Avena sativa L. (oats)	*promotes osteoblast development and mineralization, demonstrating encouraging osteogenic effects.*	*In vitro*	(Woo *et al.* 2020)
*Triticum aestivum.*L. (wheat)	has a protective effect on bone health in the context of glucocorticoid-induced osteoporosis. The extract appears to promote osteoblast differentiation, reduce osteoclast activity, and improve bone mineral density and bone mineral content.	*In vivo*	(Banji *et al.* 2014)
Pennisetum glaucum (L.) R.Br. (pearl millet)	could be an effective alternative or adjunct to conventional treatments like alendronate in managing bone loss (improving bone mineral density and reducing bone resorption**)** and liver dysfunction associated with glucocorticoid therapy.	*In vivo*	(Ali *et al.* 2018)
Cymbopogon citratus (DC.) Stapf. (lemongrass)	shows promise as a biocompatible and bioactive scaffold for bone tissue engineering applications. The scaffolds demonstrated enhanced osteogenic potential and antibacterial properties, making them suitable for promoting bone regeneration and reducing infection risk in bone tissue engineering.	*In vitro*	(Ali *et al.* 2022)
Nigella sativa L. (black seed)	accelerates bone healing by promoting faster callus formation and better fracture alignment, stimulating osteoblast differentiation increasing osteoblast markers, and reducing pro-inflammatory cytokines, therefore enhancing bone mineralization, resulting in improved bone mineral density at the healing site.	*In vivo*	(Ezirganli *et al.* 2016)
Cimicifuga racemosa (L.) Nutt. (black cohosh)	helps to maintain bone density, reduce bone resorption (inhibit osteoclast activity), and promote bone formation (enhanced osteoblast activity), making it a promising candidate for managing osteoporosis and bone loss associated with estrogen deficiency.	*In vivo*	(Qin *et al.* 2022)

Ziziphus spina-christi (L.) Desf. (Christ's thorn)	supplementation has a positive impact on bone metabolism in postmenopausal women with osteoporosis. The plant may offer a natural and effective option for managing osteoporosis, particularly in enhancing osteoblast activity as well as bone formation and mineralization, while potentially reducing bone resorption (significant reduction in bone resorption markers).	clinical	(Hussein *et al.* 2009)
Prunus dulcis (Mill.) D.A.Webb (almond)	promotes faster fracture healing, enhancing osteoblast activity and bone formation at the fracture site, reducing inflammation, and improving bone mineralization and strength. The findings suggest that it could be an effective natural remedy for enhancing bone repair in cases of fractures.	*In vivo*	(Anaraki *et al.* 2021)
Uncaria tomentosa (Willd. ex Schult.) DC. (cat's claw)	reduces osteoclast formation and activity, which is beneficial in preventing excessive bone resorption.	*In vivo*	(Lima *et al.* 2020)
Salix pentandra L. (willow)	salicin promotes bone formation and inhibits osteoclast differentiation and function, helping maintain bone health.	*In vitro*	(Xiao *et al.* 2022)
Camellia sinensis (L.) Kuntze (green tea)	promotes bone formation and inhibits osteoclastogenesis and osteoclastic properties.	*In vivo/ In vitro*	(Wu *et al.* 2018a)
Urtica sp (nettle)	promotes bone formation in an expanded inter-premaxillary suture, potentially through its positive effects on osteoblast activity and bone remodeling. These results suggest that nettle could have applications in orthodontic and bone healing treatments.	*In vivo.*	(Irgin *et al.* 2016)
Curcuma longa L. (turmeric)	Curcumin stimulates osteoblast differentiation and it corrects adipogenesis. These could be beneficial in osteoporosis cases and other bone-related disorders; it also reduces osteoblast apoptosis induced by glucocorticoids**.** Curcumin treatment significantly improved bone mineral density and bone microstructure in vivo.	*In vitro/ In vivo*	(Chen *et al.* 2016; Gu *et al.* 2012)
Zingiber officinale Roscoe (ginger)	stimulates osteoblast differentiation in normal physiological and inflammatory settings improving bone health. In vivo it marked anti-osteoporotic effects through mechanisms that enhance osteoblast function and reduce osteoclast activity, thus promoting bone formation and limiting bone resorption. The anti-osteoporotic effects of ginger rhizome extract are related to its anti-inflammatory and antioxidant properties, such as gingerol**.**	*In vitro/ In vivo*	(Ertanto *et al.* 2022; Fan *et al.* 2015)

While traditional knowledge provides invaluable insights into the therapeutic applications of medicinal plants, a significant limitation of the present study concerns the documentation of plant toxicity. Ethnobotanical remedies are often perceived as inherently safe; however, a rigorous scientific assessment of their safety profile remains essential, particularly for plants used in the long-term management of chronic diseases such as osteoporosis. In this study, toxicity data were primarily derived from ethnobotanical literature specific to the Maghreb region, with a focus on field-based reports by traditional healers and users.

Most of the recorded species were reported as safe under traditional conditions of use. Nevertheless, several plants have been associated with adverse effects based on field observations. For instance, *Allium sativum* and *Cichorium intybus* have been linked to digestive irritation (Djarmouni *et al.* 2023; Belhaj *et al.* 2021; Street *et al.* 2013; Bousta & Ennabili, 2011). *Petroselinum crispum* was reported to induce photosensitization reactions in some contexts (Djarmouni *et al.* 2023). Plants such as *Symphytum officinale* and *Arnica montana*, though less commonly used in the Maghreb, have been associated with toxicity when used at high doses or over extended periods (Chaachouay *et al.* 2021; Ed-dahmani *et al.* 2024). Furthermore, *Equisetum arvense* has been traditionally cited as potentially neurotoxic or nephrotoxic when misused (Chaachouay *et al.* 2021; Djarmouni *et al.* 2023; Labrighli *et al.* 2024). In addition, *Glycyrrhiza glabra* and *Juniperus communis* were identified as carrying moderate toxicity risks, such as hypertension and renal disturbances, corroborated by regional poison control data and ethnobotanical field surveys (Belhaj *et al.* 2021; Bousta & Ennabili, 2011).

Nonetheless, such reports highlight the need to interpret local knowledge with caution and emphasize the importance of toxicovigilance. Future studies should incorporate field validation, participatory risk assessments, and cross-referencing with clinical toxicology data to ensure the safe integration of medicinal plants into community health practices.

Conclusion

This ethnobotanical study conducted in the Boumerdes region of Algeria identified 54 medicinal plant species traditionally used in the management of osteoporosis. Importantly, pharmacological evidence drawn from the scientific literature supports the anti-osteoporotic potential of 47 of these species, demonstrating their effects on bone remodeling through the stimulation of osteoblast activity, inhibition of osteoclast differentiation, and improvement of bone mineral density. These findings highlight a strong correspondence between traditional uses and experimental data, underscoring the therapeutic relevance of local knowledge. However, the toxicological review—also based on regional literature from Algeria, Morocco, and Tunisia revealed that some species may pose risks when misused, especially those containing hepatotoxic, nephrotoxic, or neurotoxic compounds. This emphasizes the importance of cautious use and the need for scientific validation of safety and efficacy. Overall, this study highlights the importance of preserving local ethnomedicinal knowledge while promoting its integration into modern research. Further interdisciplinary studies—combining ethnobotany, pharmacology, and toxicology—are essential to develop safe, effective, and culturally grounded natural therapies for osteoporosis.

Declarations

Ethics approval and consent to participate: Before beginning the ethnobotanical study, we obtained verbal consent from all participants.

Consent for publication: Not applicable

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Competing interests: Not applicable

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Author contributions: MS, LR, and CN designed the overall strategy of the study and the questionnaires for the ethnobotanical survey. DR AS and LO conducted fieldwork and collected plant specimens to prepare the herbarium identification and MS, LR, and CN performed plant identifications. MS, LR, CN, DR, AS, and LO processed the survey data. MS and LR interpreted the data. MS wrote the review and edited the manuscript. All authors read, revised, and approved the final manuscript.

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