Ethnobotanical survey of Hypolipidemic medicinal plants in Ghardaia Region, Algeria

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Research

Abstract

Background: Hyperlipidemia (HL) constitutes a significant risk factor for cardiovascular diseases. This lipid disorder has become a primary focus for researchers because of its high prevalence worldwide, prompting increased efforts to discover new treatment options originating from natural alternatives to synthetic medications that can have serious adverse effects. Ethnopharmacological and ethnobotanical approaches have played a key role in documenting and identifying medicinal and aromatic plants. This survey aims to document Algerian medicinal plants (MPs) reported by local populations in the Ghardaïa region (Southern Algeria) as effective for the management of HL.

Methods: The survey was conducted from February 2023 to February 2024. Data were collected via semi-structured interviews with 184 participants and analyzed using Relative Frequency of Citation (RFC), Use Value (UV), and Informant Consensus Factor (ICF). Additionally, for each identified plant species, ethnobotanical characteristics were documented, including the plant parts used and preparation methods.

Results: The investigation documented 48 species distributed across 28 families, with Lamiaceae and Apiaceae emerging as the dominant families. Additionally, several plants were documented for the first time in the management of HL, including *Pituranthos chlorantus* (Coss. and Dur.), *Echinops spinosus* L., and *Fagonia glutinosa* Del. Aerial parts were the most frequently used (30%), while infusion was the predominant preparation technique (40%). Quantitative analysis identified the species with the highest UVs as *Pituranthos chlorantus* (1.75), *Mentha spicata* L. (1.50), and *Moringa oleifera* Lam. (1.42). However, the highest Relative Frequency of Citation (RFC) values were for *Citrus limon* L. (RFC = 0.86), *Pituranthos chlorantus*, *Solanum melongena* L., *Olea europaea* L., and *Camellia sinensis* L. (each with RFC = 0.652). The highest agreement of diseases was hyperlipidemia and hyperglycemia (ICF = 0.98), followed by obesity and hypertension (ICF = 0.97).

Conclusions: The documented medicinal flora provides valuable baseline data for researchers working in phytotherapy for cardiovascular diseases, obesity, hyperglycemia, hypertension, and hyperlipidemia. These species represent promising sources of novel bioactive compounds that may be developed into therapeutic agents.

Keywords: Medicinal plants, traditional medicine, Hyperlipidemia, Ghardaia, Algeria

Background

Medicinal and aromatic plants significantly contribute to the development of modern plant-based drugs (Jangpangi *et al.* 2025). Minerals, vitamins, fiber, secondary metabolites (SMs), and natural antioxidants are all abundant in plant-based goods (Karageçili & Gülçin 2025). Due to significant differences in plant life cycles, many SMs often occur at specific stages of plant growth. A comprehensive understanding of taxonomy and field botany is crucial for effectively communicating research findings across various scientific disciplines (Kunhikannan *et al.* 2025; Thombare *et al.* 2025).

Prominent plant families associated with many medicinal plants (MPs) include Lamiaceae, Apiaceae, Asteraceae, Fabaceae, Roseaceae, Rutaceae, Solanaceae, Liliaceae, and Zingiberaceae (Alamgir 2017). For instance, the Lamiaceae encompasses a diverse array of shrubs and herbs, including mint, rosemary, and lavender (Uikey 2024; Karageçili & Gülçin 2025). Similarly, the Apiaceae family includes various vegetables, herbs, and spices, such as carrots, coriander, parsley, and fennel, which serve as important sources of botanical flavors and fragrances (Kozhanova et al. 2025) due to their essential oils. All these species are rich in terpenes, phenolic compounds, and alkaloids. These compounds contribute to biodiversity and ecosystem functionality and hold significant potential for pharmaceutical applications (Izzat *et al.* 2025).

Hyperlipidemia is characterized by imbalances in blood lipids, including total cholesterol (CL), triglycerides (TG), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), and high-density lipoprotein (HDL) (Brunham *et al*. 2024). These are considered major contributing factors to the development of heart disease and atherosclerosis (Berberich & Hegele, 2022; Iyanda *et al*. 2025). These disorders are often associated with other risk factors, such as obesity and diabetes mellitus. The global number of obese individuals surpassed one billion (Abdelhamid *et al*. 2024), while diabetes continues to spread rapidly, leading to structural changes in tissues of organ systems of the body, especially the vascular system (Shareef *et al*. 2025).

Hydroxy-3-methylglutaryl-coenzyme A reductase (HMGCR) is the first rate-limiting enzyme in the de novo synthesis of CL, critically determining CL levels in our bodies. HMGCR inhibitors, commonly known as statins (ST), are currently the most effective and widely used oral CL-lowering medications. Adverse effects of ST have been reported, mainly including risk of diabetes mellitus, hepatic enzyme elevations, muscle toxicity, gastrointestinal reactions, and some other symptoms (Shi & Han 2025; Elhwuegi & Elfakhri 2025).

Ethnopharmacological and ethnobotanical approaches have played a key role in documenting and identifying MPs (Bitwell *et al.* 2023). The oldest available medicinal records date back to 5000–3000 B.C., written by the Sumerians. Herbal medicines are classified into four typologies: traditional Chinese herbalism, the conventional Hindu system of medicine, Western herbalism, and traditional Arabic and Islamic medicine (Pergola *et al.* 2025). Approximately 80% of the world's population still relies on traditional medicine, recognizing the empirical wisdom of their ancestors (De Oliveira *et al.* 2024; Bensizerara *et al.* 2025). A comprehensive ethnopharmacological literature survey on MPs used for treating cardiovascular diseases and associated risk factors across 41 sub-Saharan African countries (1982–2021) identified 1,085 MPs from 218 botanical families (Odukoya *et al.* 2022). Furthermore, between 2001 and 2020, 174 surveys documented folk MPs for HL management. Secondary metabolites exhibit a variety of mechanisms that act on HL (Alcover *et al.* 2025).

Alkaloids upregulate LDL receptor expression in the liver, inhibit CL synthesis, and improve insulin sensitivity. Sterols, which are structurally similar to CL, reduce CL absorption and increase fecal sterol excretion (Jacobo-Velázquez 2025). Polyphenols and flavonoids inhibit HMGCR, upregulate LDL receptors (Azevedo *et al*. 2025), and downregulate transcription factors involved in lipid biosynthesis (Mao *et al.* 2024). These compounds also suppress adipogenesis, modulate lipid, energy, and amino acid metabolism, and lower blood glucose levels (Bermudes-Contreras *et al.* 2025; Zamany *et al.* 2025).

In Algeria alone, over 14,000 deaths annually are attributed to HL-induced atherosclerosis, accounting for more than 20% of total mortality in the country (Mediene *et al*. 1997). Whereas only 4 studies were done from Algeria (Aumeeruddy & Mahomoodally 2022). The Sahara Desert in Algeria, one of the world's largest deserts, exhibits a rich plant biodiversity (Ould EL hadj *et al*. 2003; Telli *et al.* 2024; Ikram *et al.* 2024; Riah *et al.* 2025; Zemmouli *et al.* 2025), including species from the northern Algerian Sahara (Ghardaia region) (Kemassi *et al*. 2014; Kemassi *et al*. 2019; Zatout *et al.* 2025; Oulad *et al.* 2025), shaped by both the anatomical structure of the plants and their environmental conditions. To our knowledge, no studies have been conducted in the Ghardaïa region on the use of MPs to treat HL. The lack of documented scientific evidence impedes the effective utilization of this medicinal heritage and delays the integration of traditional medicine into official treatment protocols (Nouri *et al.* 2025).

The study aims to address the lack of scientific documentation in Algeria on the traditional use of MPs to manage metabolic disorders in the Ghardaïa region. It aims to identify commonly used plants with lipid-lowering properties using a structured ethnobotanical approach. Additionally, the study promotes the development of safe, natural therapeutic strategies that combine traditional knowledge with modern scientific research.

Materials and Methods

Study area

The Ghardaïa region is situated 600 km south of the capital, Algiers (32°29'N, 3°40'W, 450 m above sea level) (Figure 1), and is in a hyper-arid bioclimatic zone. The average annual precipitation is around 50 mm, and the maximum annual temperatures can reach 50°C, and the minimums are between 2 and 3°C (winter season) (Sebihi *et al.* 2024). It covers an area of about 86,560 square kilometers and has an estimated population of 387,880, distributed across 13 municipalities, resulting in a low population density of 4.48 inhabitants per square kilometer (Kreri *et al.* 2023). It serves as an important center for traditional medical practices, where herbal markets and folk healing methods are widespread (Telli *et al.* 2016).

Ghardaïa was selected as the study region due to its rich plant diversity within a harsh desert environment, the prevalence of traditional healing practices, the strong adherence of its inhabitants to ancestral knowledge (Kemassi *et al.* 2014), and its Arab-Muslim medicine heritage (Zatout *et al.* 2025). These factors make it an ideal model for conducting an ethnobotanical study to document the medicinal uses of plants, particularly for treating metabolic disorders such as HL and obesity.

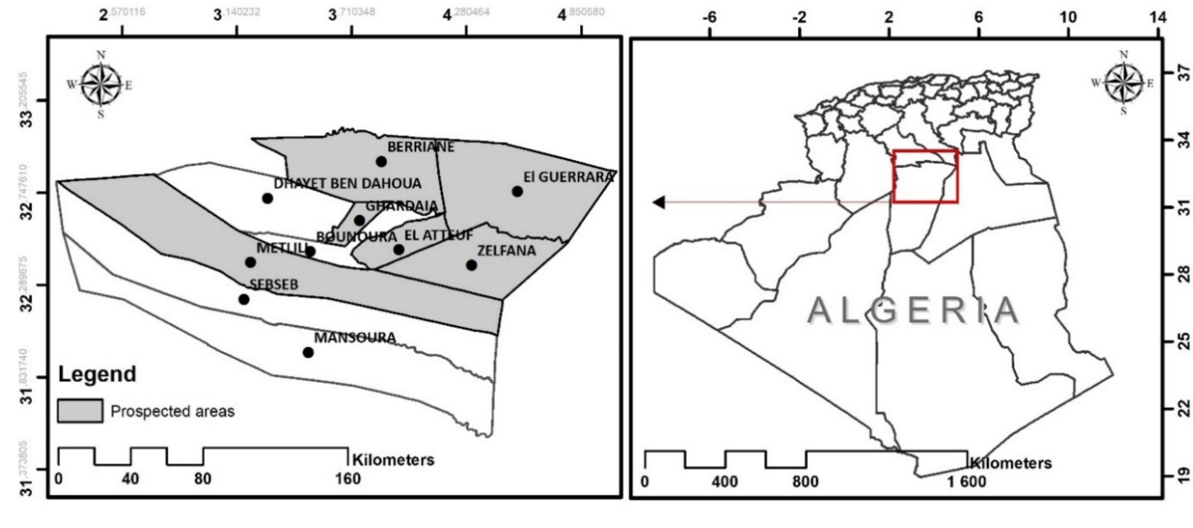

Figure 1. Map of Ghardaïa region, Algeria, showing the study area (Original)

Ethnobotanical survey

An ethnobotanical survey was conducted from February 2023 to February 2024 to document traditional knowledge on the use of MPs to manage HL. Data was collected through direct interviews with local residents, herbalists, and healers. These individuals were selected based on their personal experience with the recipe or their knowledge of a family member who had used and benefited from plant-based remedies. The interviews took place in areas known for strong traditional medicine practices aimed at treating HL. Some therapeutic uses are transmitted directly from religious texts as phytotherapy (Zatout *et al.* 2025).

The survey was conducted in several locations across the Ghardaïa Region, including the city center (M'zab Valley) and surrounding villages such as Metlili, Zelfana, El Guerrara, Berriane, and El Atteuf (Figure 1). To standardize data collection, a structured questionnaire was designed based on the methodology recommended by Eddouks *et al*. (2017). The questionnaire gathered socio-demographic information about the participants, including age, gender, educational background, and social status (Appendix). It also collected detailed ethnobotanical data, including vernacular plant names, parts used, and preparation methods.

Data Analysis

To ensure a robust interpretation of the collected ethnobotanical data, three quantitative indices were employed: Use Value (UV), Informant Consensus Factor (ICF), and Relative Frequency of Citation (RFC). The collected data were subjected to advanced statistical analysis to identify patterns and correlations.

A multivariate generalized linear model (MGLM) with logistic regression was fitted in R version 4.3.2. Additionally, a similarity index method was applied in PAST version 4.0.3 to cluster plant species by their reported uses, enhancing our understanding of the relationships between species and therapeutic applications.

Use Value

Use Value is a quantitative index that reflects the relative importance of each plant species based on the frequency with which informants cite it. It provides insight into how commonly a particular species is used within the community. The UV was calculated according to the formula proposed by Rossato *et al*. (1999):

$$UV= \sum Uis/ns$$

Where, Uis is the number of use-reports for a given plant species; ns is the total number of informants interviewed.

Informant Consensus Factor

The Informant Consensus Factor index evaluates the degree of agreement among informants regarding the use of plants for specific ailment categories. A high ICF value indicates a well-defined selection of species for treating a particular condition, suggesting a strong traditional consensus. The ICF was calculated using the method described by Andrade-Cetto & Heinrich (2011):

$$ICF= Nur - Nt/ Nur - 1$$

Where, Nur is the number of use-reports for a specific ailment category; Nt is the number of taxa used for that ailment category.

Relative Frequency of Citation

The Relative Frequency of Citation measures the local importance of each plant species by evaluating how frequently it is mentioned, regardless of use category. The RFC is calculated following Tardío & Pardo-de-Santayana's (2008) formula:

$$RFC= FC/N$$

Where, FC is the number of informants who mentioned the species; N is the total number of informants interviewed.

Results

Socio-demographic characteristics of the study population

Socio-demographic data of the respondents were collected during the field survey. Participants were selected based on their personal use of the recipes or their knowledge of family members who had successfully used them to treat HL. The results are summarized in Table 1. A total of 184 individuals participated in the study, including 66 men (36%) and 118 women (64%). The 20–40 age group accounted for 38.58% of the sample, followed by individuals over 60 (41.85%), reflecting balanced representation of active adults and older adults. However, participants aged 40–60 years comprised only 19.57% of the total sample. The findings revealed that most respondents (80.98%) had a high level of education (secondary or university level). The interviews included 165 members of the local population (53 men and 112 women), 9 traditional healers (3 men and 6 women), and 10 herbalists (all men) (Table 1).

Table 1. Socio-demographic information of respondents using plants

	Number	Percentage (%)
Region		
Ghardaïa center	66	35.9
El Gherrara	48	26.08
Metlili	24	13.04
Beriane	22	11.95
Zelfana	12	6.52
El Atteuf	12	6.52
Total	**184**	100
Sex ratio		
Men	66	35.87
Women	118	64.13
Age ranges (years)		
20 - 40	71	38.58
40 - 60	36	19.57
> 60	77	41.85
Educational level		
Illiterate	13	7.06
Middle	22	11.96
High school	95	51.63
University	54	29.35
Occupations		
Local population	165	89.68
Healers	9	4.89
Herbalists	10	5.43

The Ghardaïa Region is known for its ethnic and cultural diversity. This ethnic diversity contributes to the richness and variety of traditional therapeutic practices and knowledge. It is home to several Arab tribes (such as the Chaamba, Mdabih, Swaeh, Saaid, and Chorfa) and the Mozabite community. These groups inhabit various regions, including Ghardaïa city center, Metlili, Zelfana, El Guerrara, Berriane, and El Atteuf (Ruffié *et al.* 1962; Bensalah *et al.* 2018). Ghardaïa city, with 93,423 inhabitants, had the highest participation rate (35.9%), followed by El Gherrara (59,514, 26.08%), Metlili (40,576, 13.04%), and Berriane (30,200, 11.95%). In contrast, Zelfana (10.161; 6.52%) and El Atteuf (14.752; 6.52%) recorded the lowest numbers of interviewers (ONS 2018).

Our study noted a growing demand for CL-lowering and weight-loss herbal remedies. This may be linked to improved socioeconomic status and heightened awareness of health and body image, particularly among women. Bio-social factors such as gender, age, socioeconomic status, and access to health education significantly shape individuals' perceptions of body image (Akliman *et al*. 2023). This trend corresponds with global findings showing a rise in obesity and overweight prevalence (Rousseau-Ralliard *et al*. 2023). Previous studies (Errahmani & Zahi 2024; Soleimani & Asham 2025) have highlighted the importance of local knowledge in managing HL through MPs.

Women play a central role in the study region by gathering MPs and preparing traditional remedies for their families, thereby preserving ethnobotanical knowledge, a pattern also noted by Telli *et al.* (2024) and other regional studies (Kemassi *et al.* 2019; Oulad *et al.* 2025; Zatout *et al.* 2025) on traditional plant use.

The observed sex imbalance (61% females, 36% males) accurately reflects regional ethnobotanical realities, in which women dominate herbal recipe preparation as primary knowledge custodians. This strong female involvement likely stems from their socioeconomic background and heightened vulnerability to HL, exacerbated by chronic psychosocial stress from balancing multiple family-supporting roles (Kyalwazi *et al.* 2024).

The significant proportion of elderly participants (41.85%) suggests an abundance of traditional knowledge, as older individuals typically possess greater experience with medicinal herbs. Encouragingly, individuals aged 20–40 (38.58%) expressed interest in traditional medicine, thereby facilitating the intergenerational transmission and sustainability of ethnobotanical knowledge. Young people in Saharan communities were more aware of phytotherapy because of their experiences with COVID-19, changes in their diets, the influence of social media, and health problems related to stress. The 40–60 age group (19.57%) was underrepresented due to cultural reluctance to disclose illnesses, time constraints from professional obligations, hesitance to engage, reflecting local attitudes, and their historical dependence on chemical treatments from an era of insufficient awareness regarding chemical hazards, necessitating a distinction from herbal effects to prevent confounding variables. This age disparity in mindset and uptake of phytotherapy is rational rather than indicative of methodological bias. Statistical analyses indicated no age-related variation in effective responses.

Phytotherapy has significant clinical implications, especially given its potential to cause side effects and interact with conventional medications (Lacerda *et al.* 2024). e.g., polyphenols, key bioactive compounds in MPs, may, depending on dosage and individual responses, exert harmful effects such as reduced iron absorption, interference with digestive enzymes, disruption of gut microbiota, drug interactions, hormonal imbalances, and even mutagenic, carcinogenic, or genotoxic effects (Duda-Chodak & Tarko 2023).

Despite the widespread availability of phytotherapy and the diversity of traditional practices in the study region, many herbal treatments are administered without proper training. Some participants and herbalists reported cases of intoxication, coma, and even death due to incorrect dosage or preparation methods, such as using decoction instead of infusion. This issue is particularly critical when phytotherapy is practiced without formal training.

Concerns about the safety, efficacy, and standardization of herbal remedies are increasing, particularly amid weak regulatory frameworks (Usure et al. 2024).

Comorbid conditions and dietary patterns associated with hyperlipidemia in the study population

During the survey, it was observed that many patients diagnosed with HL also suffered from comorbid conditions, including hypertension, obesity, cardiovascular diseases, and diabetes. Zhao *et al*. (2025) noted that these conditions were potential risk factors for the development of HL or emerged as consequences of lipid disorders. To better understand these associations, a statistical analysis was conducted to examine the frequency of these comorbidities in relation to variables such as gender, age, geographical location, and obesity status.

The typical diet in the study region is characterized by the frequent consumption of traditional high-fat dishes, fast food, and high-calorie beverages. This dietary pattern significantly contributes to the rising prevalence of HL and its associated conditions, notably obesity, hyperglycemia, hypertension, atherosclerosis, and coronary artery disease (Singh & Vellapandian 2023; Giles 2024; Shareef *et al*. 2025).

Figure 2 illustrates the distribution of diabetes prevalence among males and females. In both groups, the majority of individuals do not have diabetes. However, the proportion of diabetic cases relative to group size appears slightly higher among males than among females. Figure 3 presents the distribution of diabetes cases by gender across different geographic locations in the study region. While raw frequency data suggest patterns in the distribution of diabetes by location, such data can be misleading when used in isolation to assess risk.

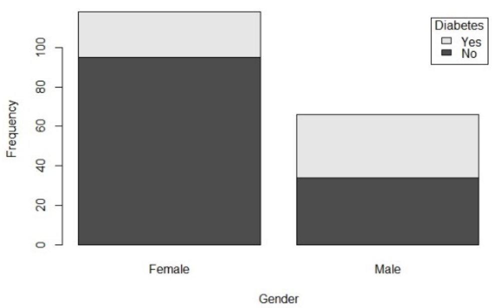

Figure 2. Frequency of diabetes by gender.

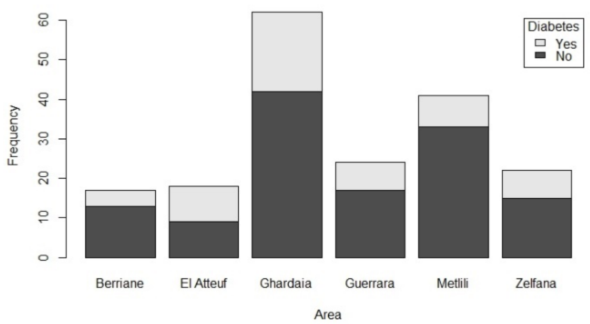

Figure 3. Frequency of diabetes by region.

To address this limitation, Table 2 presents the results of a statistical analysis, including odds ratios (OR), confidence intervals (CI), and p-values for various factors associated with diabetes. This approach provides a more accurate interpretation by quantifying the strength and significance of each association. The results indicate that male gender is significantly associated with a higher risk of diabetes (OR = 4.31, 95% CI: 2.11–9.12, $p < 0.001$). This suggests that, after adjusting for other variables, men are over four times more likely to develop diabetes compared to women. In contrast, other factors such as age, geographic location, and obesity status were not significantly associated with diabetes in this sample, as evidenced by wide confidence intervals and p-values exceeding the 0.05 threshold. These findings are consistent with epidemiological evidence suggesting that men often exhibit a higher risk or earlier onset of type 2 diabetes than women, particularly before the age of 60, although prevalence may vary across populations and age groups (Kautzky-Willer *et al.* 2023).

Table 2. Diabetes Prevalence by Gender, Age, Region, and Obesity

Characteristic	Category	OR	95% CI	p-value
Gender	Female	—	—	—
	Male	4.31	2.11,9.12	**<0.001**
Age (years)	20–40	—	—	—
	40–60	0.84	0.40,1.76	0.6
	60–100	1.17	0.36,3.59	0.8
Area	Berriane	—	—	—
	El Atteuf	4.04	0.91,20.6	0.075
	Ghardaia	2.56	0.73,10.8	0.2
	El Guerrara	1.55	0.36,7.42	0.6
	Metlili	1.35	0.33,6.28	0.7
	Zelfana	2.07	0.47,10.1	0.3
Obesity	No	—	—	—
	Yes	0.79	0.20,2.60	0.7

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

Figure 4 illustrates the distribution of hypertension cases by gender. Although the total number of female participants exceeds that of males (likely reflecting a larger female sample size), the relative frequency of hypertension appears higher among males. Figure 5 shows the geographic distribution of hypertension cases across the study regions. While the raw frequency data suggest regional disparities, frequency alone can be misleading in assessing risk without accounting for sample size and other variables.

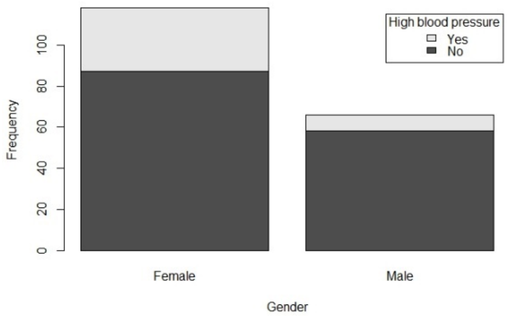

Figure 4. Frequency of hypertension by gender

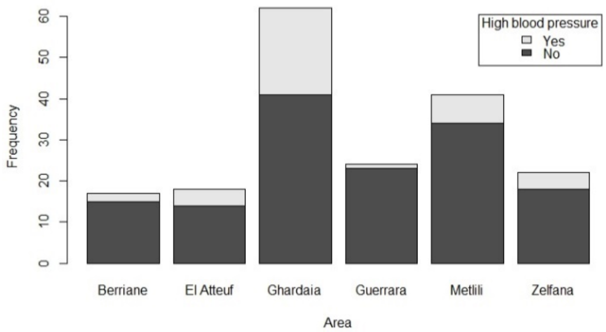

Figure 5. Frequency of hypertension by region

To provide a more accurate interpretation, Table 3 presents the OR, CI, and p-values for various factors associated with hypertension. The analysis reveals that male participants have significantly higher odds of hypertension than females (OR = 0.37, 95% CI: 0.14–0.88, p = 0.031), indicating that females are less likely to develop hypertension in this sample.

Other variables, including age, geographic location, and obesity, did not demonstrate statistically significant associations with hypertension, as indicated by their wide confidence intervals and non-significant p-values. These findings align with existing literature suggesting that men are more likely to develop hypertension at younger ages, potentially due to hormonal and physiological differences (Appiah *et al.* 2025). However, this gender gap tends to narrow with advancing age, with postmenopausal women eventually matching or exceeding men in hypertension prevalence (Yeo *et al.* 2024).

Table 3. Prevalence of hypertension by Gender, Age, Region, and Obesity

Characteristic	Category	OR	95% CI	p-alue
Gender	Female	—	—	—
	Male	0.37	0.14,0.88	**0.031**
Age (years)	20–40	—	—	—
	40–60	1.77	0.77,4.18	0.20
	60–100	0.69	0.17,2.37	0.60
Area	Berriane	—	—	—
	El Atteuf	1.91	0.31,15.8	0.50
	Ghardaia	3.30	0.77,22.9	0.15
	El Guerrara	0.33	0.01,3.89	0.40
	Metlili	1.08	0.21–8.25	>0.9
	Zelfana	1.49	0.24–12.4	0.70
Obesity	No	—	—	—
	Yes	0.00	—	>0.9

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

Geographical and multivariate analysis of hyperlipidemia risk factors

Figure 6 presents the distribution of HL cases across different study regions. While the data reveal notable geographic patterns, raw frequency figures alone may not accurately reflect risk levels due to variations in population sizes and confounding variables.

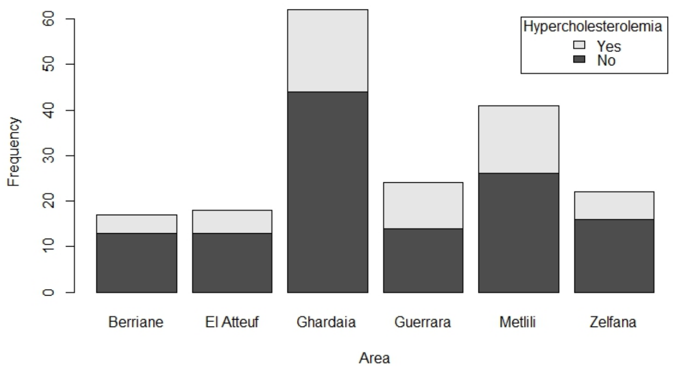

Figure 6. Frequency of hyperlipidemia by region

To provide a more refined analysis, Table 4 displays OR, CI, and p-values for several factors potentially associated with HL. The results indicate that gender, age, geographic location, and obesity were not statistically significant predictors of hyperlipidemia in this dataset, as evidenced by wide confidence intervals and p-values exceeding the 0.05 threshold.

Table 4. Prevalence of hyperlipidemia with Gender, Age, Region and Obesity

Characteristic	Category	OR	95% CI	p-value
Gender	Female	—	—	—
	Male	1.03	0.51,2.06	>0.9
Age (years)	20–40	—	—	—
	40–60	1.08	0.53,2.19	0.8
	60–100	0.89	0.29,2.53	0.8
Area	Berriane	—	—	—
	El Atteuf	1.32	0.28,6.51	0.7
	Ghardaia	1.37	0.41,5.48	0.6
	El Guerrara	2.29	0.59,10.1	0.2
	Metlili	1.95	0.54,8.22	0.3
	Zelfana	1.21	0.28,5.67	0.8
Obesity	No	—		

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

These non-significant associations may stem from sample size limitations and the influence of unmeasured confounders, such as ethnicity, dietary patterns, and physical inactivity (Edwards *et al.* 2024). Additionally, oxidative stress, known for its role in DNA damage, has been implicated in the pathogenesis of hyperlipidemia (Woźniak *et al.* 2024). Moreover, hypertriglyceridemia frequently co-occurs in individuals with diabetes due to both excessive hepatic production of VLDL and impaired clearance of TG-rich lipoproteins. This metabolic imbalance is exacerbated by insulin resistance and weight gain (Santos *et al.* 2022).

Our findings are consistent with previous literature (Sparks *et al.* 2024; Koh *et al.* 2024), which suggests that obesity contributes to HL through increased CL synthesis, enhanced biliary CL secretion, and bile supersaturation. Elevated levels of LDL and TG are strongly associated with a heightened risk of atherosclerotic cardiovascular disease. Atherosclerosis, or coronary artery disease, remains the most prevalent form of cardiovascular disease globally (Balling *et al.* 2023). These results underscore the importance of multivariate analysis in epidemiological research, as it allows for a more accurate and comprehensive identification of risk factors beyond what univariate statistics can reveal.

Cataloguing medicinal plants for hyperlipidemia in the study region

Table 5 presents a comprehensive summary of species classification, plant parts utilized, preparation methods, citation frequency, and ethnobotanical indices (UV, RFC, and ICF), with plant species organized alphabetically by family. These families have been consistently reported in ethnobotanical surveys investigating MPs' utilization for treating various diseases (Kemassi *et al.* 2014; Telli *et al.* 2016; Yasser *et al.* 2018). The findings underscore the significance of traditional phytotherapy in the Ghardaïa region. Medicinal plants are abundant in bioactive compounds that provide therapeutic and preventive benefits against various diseases. These compounds modulate physiological processes and influence organ function, thereby contributing to overall health maintenance (Riaz *et al.* 2023). Additionally, functional foods, spices, and herbal remedies have been proposed as innovative strategies for managing metabolic disorders (Eknath *et al.* 2025).

This investigation identified 28 families and 48 species of MPs, with Lamiaceae the most prevalent, accounting for 6 species (21.42%), followed by Apiaceae with 4 species (14.28%). Asteraceae, Fabaceae, and Rutaceae were represented by three species each (10.71%), while Amaryllidaceae, Brassicaceae, Poaceae, Rosaceae, Rutaceae, Zingiberaceae, and Zygophyllaceae had two species each (7.14%). The other families were represented by one species each (3.57%) (Figure 7).

Pituranthos chloranthus (Apiaceae), *Echinops spinosus* (Asteraceae), and *Fagonia glutinosa* Del. (Zygophyllaceae) are wild species from the northern Sahara (Chehma 2008; Chehma 2019) and are documented here for the first time as hypolipidemic plants.

Ethnobotanical literature on plants used for HL reports 7 plant families in Dastyar & Ahmadi (2022), 6 families in Ghabbour *et al*. (2023), 37 families in Errahmani & Zahir (2024), and 109 families in Aumeeruddy & Mahomoodally (2022), with Lamiaceae, Apiaceae, Asteraceae, and Fabaceae frequently highlighted for lipid-lowering effects.

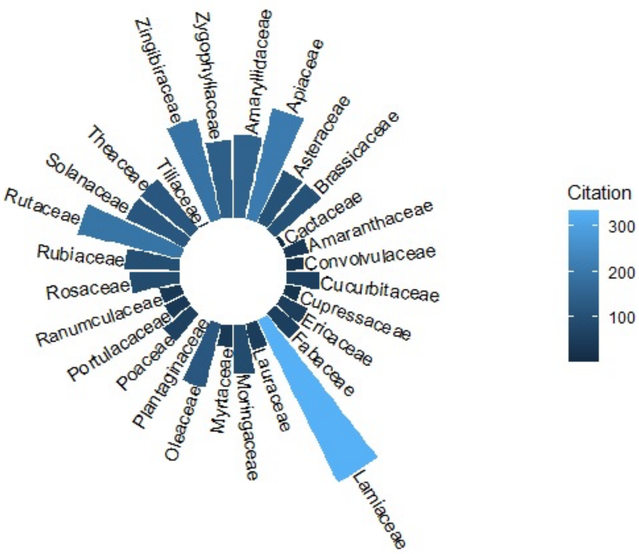

Figure 7. Number of species reported in each family (Circular barplot for citation by family)

Table 5. Medicinal plants used in the treatment of hyperlipidemia in the Ghardaïa region

Family	Species	Vernacular Name	ST	PU	PM	Number of citations	RFC	UV
Amaryllidaceae	*Allium sativum* L.	Thoum	C	BU	J	81	0.44	1
	Allium cepa L.	Bsal	C	BU	J	40	0.217	1
Amaranthaceae	*Artiplex halimus* L.	G'taf	W	AP	I	30	0.163	1
	Suaeda fruticosa Forssk. ex J.F.Gmel	Soueid	W	AP	I	43	0.233	1
Apiaceae	*Cuminum cyminum* L.	Kamoun	C	SD	I/P	30	0.163	1.33
	Foeniculum vulgare Mill.	Basbas	C	FR/SD	I/P/J	29	0.157	1.31
	Pituranthos chlorantus (Coss. and Dur.)	Gozah	W	AP	I/M	120	0.652	1.75
	Apium graveolens L.	Krafs	C	AP	I	30	0.163	1
Asteraceae	*Artemisia herba-alba* Asso.	Chih	W	AP	I/M	60	0.326	1.416
	Matricaria chamomilla L.	Babounj	W	AP	I	44	0.239	1
	Echinops spinosus L.	Chawk Ejmal	W	AP	I	4	0.0217	1
Brassicaceae	*Brassica rapa* var. *rapa* L.	Left	C	FR	J	100	0.543	1
	Brassica oleracea var capitata f. alba	Kromb	C	FR	J	10	0.054	1
Cactaceae	*Opuntia ficus-indica* (L.) Mill	Hendi	W	FR	J	8	0.043	1
Convolvulaceae	*Convulvulus supinus* L.	Boumachkoun	W	AP	I	30	0.163	1
Cucurbitaceae	*Cucumis sativus* L.	Khiar	C	FR	J	60	0.326	1
Cupressaceae	*Juniperus phoenicea* L.	Ârâar	C	LE	P	29	0.157	1
Ericaceae	*Erica cinerea* L.	Khelnej	W	AP	I	54	0.293	1
Fabaceae	*Medicago sativa* L.	Al-Fasfasa	C	AP	I	10	0.054	1
	Trigonella foenum-graecum L.	Helba	C	SD	M/P	10	0.054	1.3
	Sengalia Senegal L.	Louban Dkar	C	SD	M	40	0.217	1
Lamiaceae	*Mentha spicata* L.	Naânaâ	C	LE	I/D	80	0.434	1.5
	Rosmarinus officinalis L.	Azir	C	LE	I	69	0.375	1
	Salvia officinalis L.	Meramia	W	LE	I	50	0.271	1
	Teucrium polium L.	Jâida	W	AP	I	74	0.402	1
	Thymus vulgaris L.	Zaatar	C	AP	I	60	0.326	1
Lauraceae	*Laurus nobilis* L.	Rand	C	LE	I	50	0.271	1
Moringaceae	*Moringa oleifera* Lam.	Moringa	C	LE/SD	I/P	90	0.489	1.422
Myrtaceae	*Eucalyptus globulus* Labill.	Kalitous	C	LE	I	40	0.217	1
Oleaceae	*Olea europaea* L.	Zaytoun	C	FR/LE	O/I	120	0.652	1.25
Plantaginaceae	*Plantago lanceolata* L.	Lsan Elhamel	W	AP	I	1	0.005	1

Poaceae	*Hordeum vulgare* L.	Châir	C	SD	M/P	55	0.298	1.36
	Imperata cylindrica L.	Halfa	C	AP	I	10	0.054	1
Portulacaceae	*Portulaca oleracea* L.	Bn Drag	W	AP	I	40	0.217	1
Ranumculaceae	*Nigella sativa* L.	Sanouj	C	SD	P	40	0.217	1
Rosaceae	*Malus domestica* (Suckow) Borkh.	Teffah	C	FR	J / M	50	0.271	1.2
	Prunus armeniaca L.	Hermes	C	FR	M	40	0.217	1
Rubiaceae	*Coffea arabica* L.	Kahoua	C	SD	I/D	100	0.534	1.1
Rutaceae	*Ruta tuberculata* Forssk	Feïjel	C	AP	I	30	0.163	1
	Citrus limon (L.) Burm.F.	Kares	C	FR	J	160	0.869	1
	Citrus sinensis (L. Osbeck)	Dchin	C	FR	J	4	0.021	1
Solanaceae	*Solanum melongena* L.	Denjel	C	FR	M	120	0.652	1
Theaceae	*Camellia sinensis* L.	Atay	C	LE	I/D	120	0.652	1.33
Tiliaceae	*Corchorus olitorius L.*	Mouloukhia	C	LE	P	4	0.021	1
Zingibiraceae	*Zingiber officinale* Roscoe	Zinjabil	C	RT	M	90	0.489	1
	Curcuma longa L.	Aoudasfar	C	RT	P	99	0.538	1
Zygophyllaceae	*Peganum harmala* L.	Harmal	W	AP	I	60	0.434	1
	Fagonia glutinosa Del.	Cherraik	W	AP	P	80	0.326	1

Legend:

Status (ST): C: Cultivated, W: Wild; **Part used (PU):** AP: Regionl part, LE: Leaves, FR: Fruit, SD: Seeds, BU: Bulb, RT: Roots; **Preparation method (PM):** J: Juice, M: Maceration, I: Infusion, D: Decoction, P: Powder, O: Oil; **Quantitative indices:** RFC: Relative Frequency of Citation, UV: Use Value.

Table 6. Values of the informant consensus factor for category ailments

Diseases	Nur	Nt	ICF
Hypercholesterolemia	2598	48	0.98
Obesity	867	20	0.97
Hypertention	195	6	0.97
Hyperglycemia	328	6	0.98

Nur: Number of use-reports for a specific ailment category, **Nt:** Number of taxa used for that ailment category, **ICF:** Informant consensus factor.

Phytochemical profiles and therapeutic properties

Ethnopharmacological studies have confirmed the therapeutic claims associated with phytochemicals derived from medicinal and aromatic plants (Nureye et al. 2025). Factors such as origin, location, climate, variants, cultivation conditions, harvesting times, storage, and extraction methods all influence variations in chemical profiles and functional qualities (Karageçili & Gülçin 2025). Lamiaceae exhibit notable antioxidant, anti-inflammatory, liver-protective, hypoglycemic, and hypolipidemic activities, which are attributed to flavonoids, phenolic acids, terpenes, and essential oils (Karageçili & Gülçin 2025). Apiaceae are abundant in phytochemicals, including carotenoids, vitamins, minerals, terpenoids, triterpenoids, saponins, flavonoids, coumarins, and steroids, contributing to their antioxidant, anti-inflammatory, and anti-atherosclerotic effects (Sayed-Ahmad et al. 2017; Thiviya et al. 2022). Many species within Asteraceae contain bioactive compounds such as sesquiterpene lactones, flavonoids, alkaloids, terpenoids, polyacetylenes, and essential oils that demonstrate documented antimicrobial, anti-inflammatory, and antioxidant properties (Awoke & Tahir 2025). Ethnopharmacological studies have also shown that some species from Fabaceae exhibit strong antioxidant, antimicrobial, anti-inflammatory, and antidiabetic activities, due to various bioactive chemicals like phenolic acids, flavonoids, lectins, saponins, alkaloids, and carotenoids (Maroyi 2023).

The cluster analysis revealed distinct groupings of species that share similar therapeutic indications, phytochemical profiles, cultural knowledge transmission patterns across communities, or ethnogeographical variations in plant utilization (Figure 8).

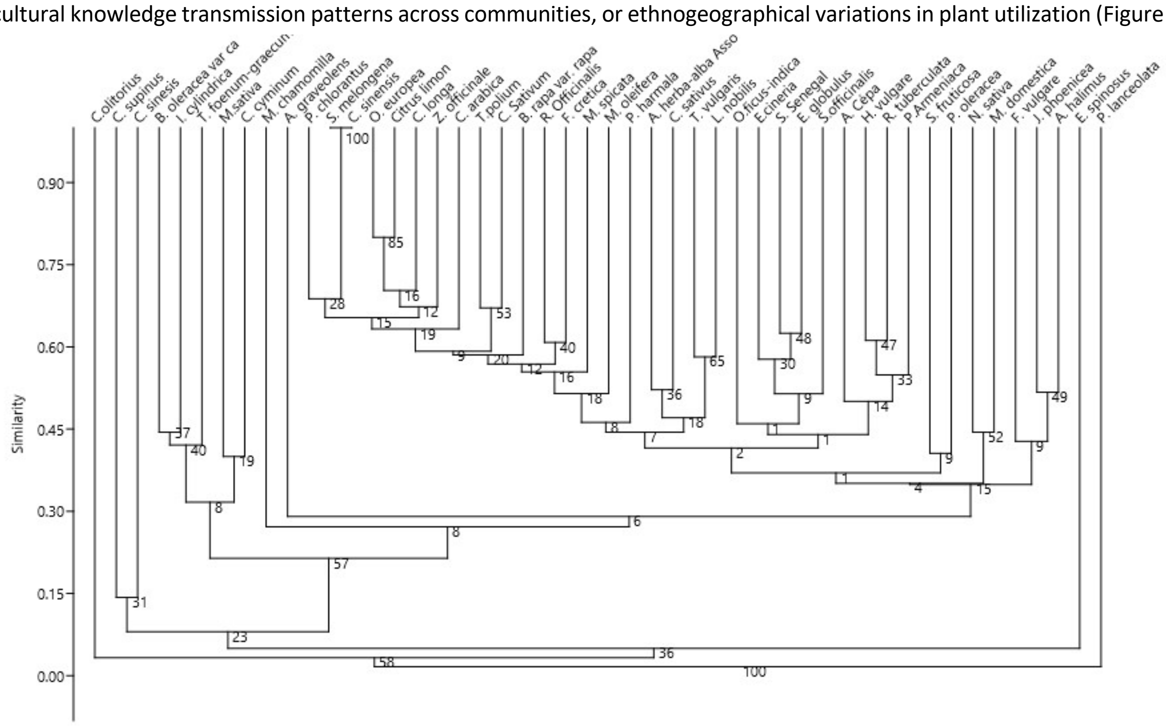

Figure 8. Dendrogram of similarity

Notably, *Moringa oleifera* (Moringaceae) clusters closely with *Matricaria chamomilla* (Asteraceae) and *Citrus sinensis* (Theaceae), indicating strong similarities in their traditional uses, preparation methods, plant parts utilized, and bioactive compounds. These plants are frequently reported in the literature to have hypolipidemic effects through antioxidant activity, regulation of lipid metabolism, and hepatoprotective mechanisms (Kashyap et al.2022; Ghorbanian et al. 2022; Hasliani 2024). Their tight clustering highlights high ethnobotanical consensus, making them promising candidates for further pharmacological validation. Additional clusters, including *Cuminum cyminum* (Apiaceae), *Thymus vulgaris* (Lamiaceae), and *Laurus nobilis* (Lauraceae), reflect the common use of aromatic and spice-derived plants rich in essential oils and flavonoids. These compounds influence lipid profiles by regulating cholesterol absorption and promoting bile secretion, as noted by Chouhan et al. (2022), Aslan et al. (2025), and Boussaoudi et al. (2024). *Curcuma longa* and *Zingiber officinale* cluster within the same broad group because they belong to the same family, Zingiberaceae.

Interestingly, *Citrus limon*, *Olea europaea*, and *Mentha spicata* cluster together despite belonging to different families. This grouping probably reflects shared ethnobotanical patterns in the Ghardaïa region rather than strict botanical relationships, as these species show overlapping therapeutic versatility and high informant consensus for hypolipidemic uses. Notably, their moderate-to-high UV values indicate diverse applications beyond lipid management, possibly driven by common phytochemicals like terpenoids and phenolics that contribute to antioxidant and metabolic effects reported in the literature (Amraoui et al. 2025; Ekissi et al. 2025; Hirata et al. 2025). Such clustering underscores the utility of UV as a quantitative measure of pharmacological potential, highlighting plants with broad traditional uses in the local context. This supports the idea that convergent evolution of medicinal use can occur across different plant families due to the presence of similar secondary metabolites (Farahnaky et al. 2018).

Ethnobotanical indices and species ranking

In the data analysis, the UV index ranged from 1.00 to 1.75, indicating different levels of ethnopharmacological significance among the documented plants (Table 5). The five species with the highest UV values were Pituranthos chloranthus, *Mentha spicata*, *Moringa oleifera*, *Artemisia herba-alba* (Asteraceae; UV=1.41), and *Hordeum vulgare* (Poaceae; UV=1). Ethnobotanical studies have previously reported the hypolipidemic activity of these plant families (Ghabbour et al. 2023; Benkhnigue et al. 2023). Errahmani & Zahir (2024) identified four plant families most frequently used in traditional phytotherapy for HL: Linaceae, Oleaceae, Zingiberaceae, and Theaceae. Soleimani & Asham (2025) recognized *Thymus vulgaris*, *Apium graveolens*, and *Mentha spicata* as the most commonly used species in Iranian ethnobotanical knowledge. Aumeeruddy & Mahomoodally (2022) listed *Allium sativum*, *Juglans regia* L., *Olea europaea*, *Rosmarinus officinalis*, *Citrus limon*, and *Linum usitatissimum* as the most reported species in a review documenting folk medicinal plants used worldwide for managing HL. This may be due to their higher diversity and abundance in the study area, their availability and affordability, and the trust that local communities place in medicinal plants (Ssenku et al. 2022).

The RFC indicates the relative importance of each MP in a certain research area at the local level.

The most recognized plants in HL management, with the highest RFC values, were *Citrus limonum* (0.86), *Pituranthus chlorantus, Solanum melongena, Olea europaea*, and *Camellia sinensis* with (0.652) each (Table 5). This value differs when compared to other studies, such as *Citrus limonum* in Kelechi *et al.* (2017) (0.047), *Solanum melongena* in Mohajeri (2013) (0.010), *Olea europaea* in Cheurfa *et al.* (2019) (0.084), *Camellia sinensis* in Batista *et al.* (2009) (0.031), and *Olea europaea* in Ghabbour *et al.* (2023) (0.294). In our study, the highest RFC value (0.86) remains higher than those reported by other researchers, such as El Brahimi *et al.* (2022) (0.64) and Ghanimi *et al.* (2022) (0.53), but lower than those found in Ghabbour *et al*. (2023) (0.294) and Mushtaq *et al*. (2014) (0.95).

These results clearly showed the relative importance of each species mentioned by many informants in treating a well-defined disease group. A high RFC of a MP species treating a disease warrants ethnopharmacological evaluation for potential drug development (Ghabbour *et al.* 2023). Furthermore, *Pituranthus chlorantus* and *Echinops spinosus* are predominantly recognized locally as hypolipidemic and hypoglycemic species, indicating that each region holds specific phytotherapeutic knowledge. This specificity may be attributed to factors such as local climate, culture, and ethnology (Eddouks *et al.* 2017).

The ICF index evaluates the degree of agreement among informants regarding the use of plants for specific ailment categories. In our study, the disease classes with the highest agreement among respondents were HL and Hyperglycemia (0.98), followed by Obesity and Hypertension (0.97) (Table 6). This indicates significant homogeneity of knowledge and strong consensus in the population regarding medicinal uses, contributing to a better understanding of human-plant interactions (Ghabbour *et al.* 2023). The obtained diabetes (ICF= 0.98) closely matches the value (0.98) reported by Chaachouay *et al.* (2019) from Morocco and is slightly higher than the ICF value (0.87) reported by Djahida *et al.* (2024) from Algeria. The hyperlipidemia (ICF = 0.98) surpasses that of Djahida *et al.* (2024) (0.88). Among 73 species from Morocco known for use in hypertension and cardiac diseases, 16 were also utilized for diabetes mellitus treatment (Eddouks *et al.* 2017). This therapeutic overlap may be attributed to the fiber content in plants, which interferes with carbohydrate digestion and absorption, thereby reducing blood glucose levels (Barkaoui *et al.* 2017). Furthermore, a survey among a Tunisian population of type 2 diabetics found that *fenugreek* significantly decreased TG levels (Slama 2016). Djahida *et al.* (2024) also noted the use of *Rosmarinus officinalis* for treating various metabolic disorders, including diabetes and CL management.

The close ranges of the ICF index between HL and hyperglycemia and between obesity and hypertension can be explained by interconnected mechanisms of metabolic enzyme regulation. This includes the concept of 'modification of a modification' , along with associated feedback and feedforward regulatory mechanisms, whereby modified proteins not only influence related metabolic pathways but also other signaling cascades affecting physiology and diseases (Zhang *et al.* 2025). Such crosstalk notably encompasses glucose, lipid, and nucleotide metabolism (Zhao *et al.* 2025).

Obesity has been recognized as a chronic degenerative disease that significantly predisposes individuals to disorders of glucose and lipid metabolism (Abdelhamid *et al.* 2024). Diabetes, frequently associated with hyperglycemia and weight gain, further amplifies the risk of cardiovascular complications (Ahangarpour *et al.* 2018). These metabolic disturbances are pivotal in the progression of atherosclerosis, coronary heart disease, heart failure, and stroke (Zhang *et al.* 2024).

Validation of traditional uses

These findings align with previous research investigations. Lahmar *et al*. (2021) demonstrated that *Pituranthus chlorantus* exhibits antimicrobial, anticancer, and anti-inflammatory properties attributed to its polyphenol and terpenoid content, as well as antihyperlipidemic properties attributed to its lovastatin content, as previously documented by Djeridane *et al*. (2008).

Similarly, Yellanur Konda *et al*. (2020) and Pires *et al.* (2024) reported that the aqueous leaf extract of *Mentha aquatica* demonstrates significant antidiabetic, nephroprotective, anti-inflammatory, antioxidant, antibacterial, anti-obesity, and hepatoprotective bioactivities due to various molecules, including terpenes, phenolic acids, phenols, and terpenoids.
Terpenic compounds from the Lamiaceae family, including β-pinene, promoted abdominal fat reduction in mice by acting on lipase enzymes, which facilitate fat breakdown and total cholesterol level reduction (Santos *et al.* 2022).

Moringa *oleifera* has been traditionally employed in medicine to treat anemia, diabetes, obesity, and cardiovascular diseases (El Bilali *et al.* 2024). Furthermore, Hussein *et al.* (2023) observed a statistically significant decrease in CL, TG, and LDL in rats treated with *Artemisia herba-alba* extract. Recent studies by Yan *et al.* (2022) and Boyina *et al.* (2024) revealed that *Hordeum vulgare* reduces cardiovascular disorders, suppresses obesity, mitigates organ enlargement and fat accumulation, regulates dyslipidemia, and alleviates liver function impairment.

Parts of use and potential mechanisms

Our data reveal clear and interconnected patterns in the use of medicinal plants and their preparation methods. As shown in Figure 9, leaves are the most commonly used plant parts, accounting for approximately 30% of total usage. Our findings align with Dastyar & Ahmadi (2022), Aumeeruddy & Mahomoodally (2022), Ghabbour *et al.* (2023), and Errahmani & Zahir (2024). This dominance is particularly significant given that leaves are rich in biologically active compounds such as flavonoids, specifically apigenin, quercetin, and kaempferol, which play a critical role in disease prevention and treatment (Saputra & Arjita 2024). Seeds rank second at 20% (Figure 9), likely due to their high content of essential oils and antioxidant compounds. Aerial parts account for 15% of the total, comprising stems and leaves, and offer a diverse range of therapeutic compounds, including active flavonoids.

Figure 10 highlights infusion as the most common preparation method, used in 40% of cases. This preference is strongly justified, particularly for extracting flavonoids such as apigenin. Hot water infusion is considered optimal for extracting water-soluble compounds from soft plant tissues, thereby preserving their biological activity in regulating CL and enhancing antioxidant functions (Santos *et al.* 2022). Maceration ranks second at 25% according to Figure 10 and is effective for extracting compounds such as luteolin and naringenin, which may require different solvents for optimal extraction (Saputra & Arjita 2024). Other methods, such as boiling, pressing, and grinding, are distributed more evenly, each accounting for 10-15%, reflecting the diversity of techniques depending on the compound being targeted.

Figure 11 presents a cross-analysis that reveals a logical, scientifically coherent relationship between plant part type and the chosen preparation method. Infusion, which appears most frequently in Figure 11 with over 20 occurrences, is mainly associated with leaves and aerial parts. This is ideal for extracting apigenin and other flavonoids, which facilitate CL removal by inhibiting HMGCR (Saputra & Arjita 2024).

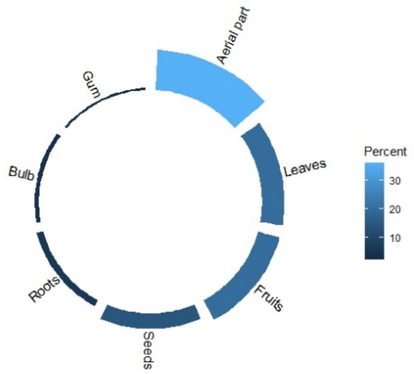

Figure 9. Part used

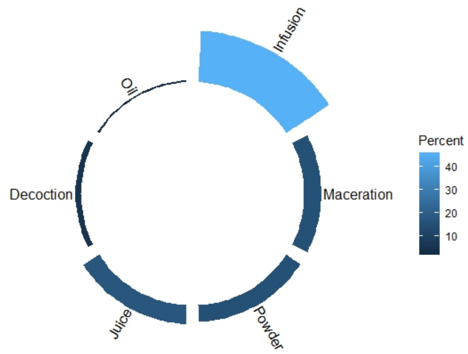

Figure 10. Preparation method

In contrast, Figure 11 also shows that boiling is primarily used with roots, though it occurs less than five times. This makes sense, as roots require higher temperatures and longer time to release their compounds, although this may reduce the effectiveness of heat-sensitive flavonoids (Ghorbani et al., 2025).

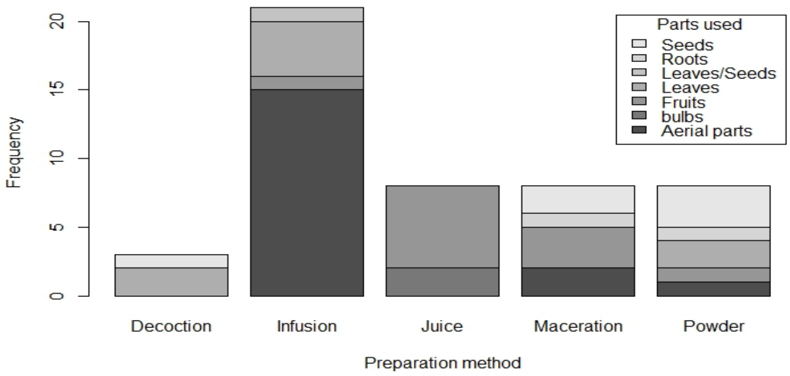

Figure 11. Frequency of the preparation method with the parts used

The patterns illustrated in Figures 9, 10, and 11 reflect centuries of accumulated traditional knowledge, remarkably aligned with modern scientific findings on the mechanisms of plant compounds. The emphasis on leaves and infusion, evident in the figures, reflects a deep traditional understanding of the best method for extracting active compounds such as apigenin, which has hypolipidemic effects (Santos et al., 2022). Furthermore, the diversity of preparation methods, as shown in Figure 11, where pressing, infusing in liquids, and grinding each have moderate and comparable frequencies of 7–8 times, indicates an advanced understanding of how to optimize the extraction of various compounds such as quercetin, kaempferol, and naringenin. All of these contribute to binding and inhibiting HMGCR (Saputra & Arjita 2024).

These findings, derived from the analysis of Figures 9, 10, and 11, provide a strong foundation for developing anti-hyperlipidemic therapies. The interplay between the choice of plant parts and preparation methods shown in Figure 11 supports the possibility of optimizing the extraction of active compounds such as apigenin and luteolin. This understanding can help researchers develop improved extraction protocols that maximize the yield of flavonoids involved in lipid breakdown, CL suppression, and CL efflux (Obakiro et al., 2021).

The integration of traditional knowledge with modern science, as reflected in the compiled data across the three figures, opens promising avenues for the development of natural anti-hyperlipidemic drugs that target specific molecular pathways while preserving the proven safety and efficacy of traditional herbal medicine (Santos *et al.* 2022; Obakiro *et al.* 2021; Saputra & Arjita 2024).

Conclusion

This survey represents the first ethnobotanical investigation to document and analyze the traditional use of medicinal plants for Hyperlipidemia management in the Algerian East Septentrional Sahara (Ghardaia region). The identification of 48 plant species belonging to 29 families, including several endemic plants documented for the first time for the management of Hyperlipidemia, demonstrates the remarkable biodiversity and extensive pharmacological potential available within this arid ecosystem. However, unregulated harvesting poses a serious threat to local plant ecotypes, potentially leading to the loss of numerous species.

The predominance of families such as Lamiaceae, Apiaceae, Asteraceae, and Fabaceae reflects traditional reliance on species rich in lipid-lowering bioactive compounds. Key species like *Pituranthus chloranthus, Citrus limon*, and *Moringa oleifera* showed high use values and citation frequencies, supporting their importance in local practices. The dominant use of leaves and the preference for infusing as a preparation method reflect an empirically grounded strategy for extracting key flavonoids with well-documented roles in lipid metabolism regulation.

Although this short-term ethnobotanical survey in a region dependent on ancestral phytotherapy, involving a limited local population, limits definitive identification of species for Hyperlipidemia management, cluster analysis revealed therapeutic similarities across diverse plants, aligning traditional knowledge with their demonstrated efficacy against Hyperlipidemia, hyperglycemia, hypertension, and obesity. These findings bridge cultural heritage with pharmacological validation, supporting preservation of indigenous practices and sustainable drug discovery informed by community knowledge. Future research should prioritize standardized preparations, toxicity assessments, and clinical validation to integrate these species into healthcare strategies.

Declarations

List of abbreviations: RFC- Relative Frequency of Citation; UV- Use value; ICF- Informant Consensus Factor; LDL-Low-density lipoprotein; HDL-High-density lipoprotein; HMG-CoA-reductase-3-hydroxy-3-methylglutaryl-coenzyme A; DNA-Deoxyribonucleic Acid; MGLM-Multivariate Generalized Linear Model; PAST-PAleontological Statistics; OR-odds ratios; CI-confidence intervals; AP-Aerial part; BU-Bulb; FL-Flower; FR-Fruit; LE-Leaves; RT-Root; SD-Seed.

Ethics approval and consent to participate: Verbal informed consent was obtained from all participants after the study's purpose was explained. Participation was voluntary, and all data were handled confidentially, in accordance with local cultural customs.

Consent for publication: Not applicable

Availability of data and materials: The datasets used in the current study are provided in the “Appendix” as supplementary information.

Competing interests: No potential conflict of interest was reported by the author(s).

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Author contributions: K.H: collected the data, analyzed, and wrote the text. T.I: supervised the investigation. K.M: Contributed significantly to data analysis. A.A: Supervised the investigation. M.A.E: participated in the theoretical background. T.A participated in the data analysis and scientific correction. I.M participated in the review and preparation of the final draft. All authors validate the paper.

Use of AI in the writing process: Artificial intelligence (AI) tools were employed as auxiliary editing instruments. These tools primarily assisted with linguistic refinement, improved logical connectivity, and enhanced academic writing style. Additionally, they aided in translation tasks and grammatical corrections. All scientific content, data interpretation, and conclusions presented in this study were independently developed by the authors. The use of AI was strictly limited to language and style improvements and did not contribute to the research's intellectual substance. The authors assume full responsibility for all scientific inputs, analyses, and conclusions drawn in this work.

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Appendix

Ethnobotanical Survey on the Use of Medicinal Plants for Hyperlipidemia Management

Question	Response Options
Do you belong to one of the following groups?	☐ Local population ☐ Herbalist ☐ Healer ☐ Other: ______
Which community or region do you come from?	____________________________
Age	_____ years
Sex	☐ Male ☐ Female ☐ Other
Level of Education	☐ Illiterate ☐ Middle ☐ High school ☐ University
Which plant(s) do you use for weight loss or lowering cholesterol?	Local name: ___________
What parts of the plant do you use?	☐ Leaves ☐ Roots ☐ Seeds ☐ Flowers ☐ Bark ☐ Areal part ☐ Gum: ______
How do you prepare the plant?	☐ Infusion ☐ Decoction ☐ Maceration ☐ Powder ☐ Other: ______
How often do you consume it?	☐ Daily ☐ Weekly ☐ Occasionally
Did you notice any effects after using the plant?	☐ Yes ☐ No
If yes, what effects did you experience?	___________________________________
Did you start using this plant based on:	☐ Family tradition ☐ Advice from herbalists ☐ Personal research ☐ Other: ______
Are you currently diagnosed with any of the following conditions?	☐ High cholesterol ☐ Obesity ☐ Hypertension ☐ Diabetes ☐ No diagnosed conditions
Would you recommend this plant to others?	☐ Yes ☐ No
Do you think this plant should be scientifically studied for its properties?	☐ Yes ☐ No