Trop J Nat Prod Res, January 2026; 10(1): 6526 - 6531
ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

Ethnobotanical Assessment of Herbal Medicine Use in Diabetes Management among Patients and Herbal Practitioners in Azilal Province, Morocco

Maria Mahzoune[1], Driss Ousaaid[2]*, Samir Benjelloun[1], Badiaa Lyoussi[3]

[1]*Laboratory of Biotechnology, Conservation, and Valorization of Bioresources (LBCVB), Faculty of Sciences Dhar El Mahraz, University Sidi Mohamed Ben Abdellah, Fez 30000, Morocco*
[2]*Laboratory of Drug Sciences, Faculty of Medicine, Pharmacy and Dental Medicine, Sidi Mohamed Ben Abdellah University, Fez, Morocco*
[3]*Laboratory of Natural Substances, Pharmacology, Environment, Modeling, Health and Quality of Life (SNAMOPEQ), Faculty of Sciences Dhar El Mahraz, Sidi Mohamed Ben Abdellah University, Fez 30000, Morocco*

ARTICLE INFO

Article history:
Received 14 November 2025
Revised 26 December 2025
Accepted 07 January 2026
Published online 01 February 2026

ABSTRACT

Diabetes mellitus is an increasingly prevalent metabolic disorder in Morocco, placing a substantial burden on healthcare systems. Traditional medicinal plants offer a culturally rooted, cost-effective alternative for diabetes management, yet knowledge regarding their use in Azilal province remains limited. This study aimed to document the ethnobotanical practices of diabetic patients and local herbalists in Azilal, focusing on plant species, preparation methods, usage frequency, and potential adverse effects. A total of 300 diabetic patients and 15 herbalists participated in structured questionnaires and semi-structured interviews. Quantitative ethnobotanical indices, including relative frequency of citation (RFC), fidelity level (FL), family importance value (FIV), and plant part value (PPV), were calculated. The results revealed that 38.3% of patients used medicinal plants as a complement to their medical treatment. Twenty-six medicinal plants were employed for diabetes management, with *Olea europaea*, *Pastinaca sativa*, and *Prunus amygdalus* being the most cited (FL = 100%). Leaves were the predominant plant part used (PPV = 0.314), primarily administered as decoctions or infusions. Approximately 36% of users reported side effects, including digestive discomfort, hypoglycaemia, and fatigue. Thirty percent of medicinal plant users reported glycated haemoglobin (HbA1c) levels. Comparative analysis indicated better glycaemic control among phytotherapy users, suggesting a potential protective effect against microangiopathic complications. This study highlights the rich ethnobotanical knowledge in Azilal and underscores the need for pharmacological validation, toxicological assessment, and clinical trials to integrate traditional remedies safely into modern diabetes care. Preserving local knowledge may enhance holistic management strategies while maintaining cultural heritage.

Keywords: Traditional knowledge, Medicinal plants, Ethnobotanical practices, Diabetes, Microangipathy, Azilal province.

Introduction

Metabolic disorders are known as serious health concerns that are becoming more common worldwide, particularly in Morocco.[1] The prevalence of diabetes has increased markedly over the past decades, placing a growing burden on both society and healthcare systems.[2] Lifestyle changes have been implicated in diabetes instances as the main risk factor.[3] The increase in the prevalence of diabetes is associated with the demographic shift of populations from marginal zones to urban areas, which is frequently accompanied by changes in lifestyle, environment, and exposure to obesogenic foods.[3] Traditional foods are rich and diverse, providing essential nutrients and antioxidants, in contrast to modern calorie-dense diets that are strongly associated with various chronic diseases.[4] Mounting evidence demonstrated that hypercaloric diets induce metabolic disorders, such as diabetes.[5,6] Despite technological advancements and the discovery of various chemical antidiabetic agents, harmful consequences are gradually are gradually becoming recognized. Due to these negative consequences, traditional therapeutic approaches that emphasize natural resources are beginning to emerge.[7] Medicinal plants and their preparations are increasingly popular due to their perceived efficiency, safety, and natural origin in the management of various chronic diseases, including diabetes, inflammation, and cardiovascular disorders.[8,9] Traditional knowledge of medicinal plants and their formulations for the management of chronic diseases, such as diabetes, is deeply rooted in the cultures of populations across different regions of Morocco.

Multiple ethnobotanical surveys have been conducted in different regions to document the traditional knowledge of Moroccan populations.[10–15] Therefore, further investigations are required to elucidate the medicinal and therapeutic potential of medicinal plants, with the aim of integrating these natural products as therapeutic agents or complementary options to modern medicines. Several medicinal plants were initially utilized as holistic remedies, including *Allium cepa, Trigonella foenum-graecum*, *Olea europaea*, *Artemesia herba-alba*, *Nigella sativa, and Marrubium vulgare.*[16,17] These plants have attracted growing attention from the scientific communities due to their various health-promoting potentials. Different parts of these plants have been administered using different routes to treat and prevent different diseases and disorders.[18–20] The complex chemical composition of medicinal plants is closely associated with the virtually limitless potential combinations of their bioactive compounds. Traditional knowledge serves as a cornerstone for understanding the management of critical health conditions and for identifying effective sources of bioactive compounds. This knowledge is poorly documented in many regions, putting it at risk of extinction in the absence of systematic research and scientific validation.[11]

*Corresponding author. Email: driss.ousaaid@usmba.ac.ma
Tel: +212-6-14 40 07 62

Citation: Mahzoune M, Ousaaid D*, Benjelloun S, Lyoussi B. Ethnobotanical Assessment of Herbal Medicine Use in Diabetes Management among Patients and Herbal Practitioners in Azilal Province, Morocco. Trop J Nat Prod Res. 2026; 10(1): 6526 – 6531 https://doi.org/10.26538/tjnpr/v10i1.14

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

 ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

The present study integrates the traditional knowledge and perspectives of both diabetic patients and local herbalists to provide a comprehensive understanding of antidiabetic herbal medicine practices in the Azilal region, Morocco. To the best of our knowledge, this is the first ethnobotanical study in Azilal province to document these dual perspectives. This study provides new insights about the identification, preparation methods, and usage frequency of medicinal plants for diabetes management in this largely unexplored region of Morocco. Thus, future pharmaceutical research will be supported, and local knowledge will be preserved.

Materials and Methods

Study location and population

The survey was carried out in the Moroccan province of Azilal, which is located in the central Atlas region (31°56'47" N, 6°33'35" W), as indicated in Figure 1. Azilal is known for its harsh natural conditions, which have resulted in extremely remote rural areas and, consequently, a strong reliance on traditional herbal remedies. The study was carried out between December 2024 and July 2025). The study population involved 300 diabetic patients recruited from various public health centers across the province of Azilal, the majority of whom were women (68%), with an age range between 16 and 82 years. Fifteen herbalists from the aforementioned region were recruited to collect plant samples and document various recipes and herbal preparations recommended for diabetes management.

Ethical approval

Ethical approval for this study was obtained from the Ethical Review Committee of the Department of Biology, University of Sidi Mohamed Ben Abdellah, Morocco, with the approval number USMBA-SNAMOPEQ 2019–05. All participants provided informed consent prior to their inclusion in the study, and confidentiality and anonymity were strictly maintained throughout the research process.

Inclusion and exclusion criteria

Participants eligible for this study included individuals diagnosed with either Type 1 or Type 2 diabetes by a healthcare professional, aged 16 years and above, and residing in Azilal Province, Morocco. Eligible participants were those willing to provide informed consent, regularly attending public health centers, or actively using traditional medicinal plants for diabetes management. Additionally, herbalists practicing in Azilal with experience in preparing and recommending antidiabetic plants were included. Excluded from the study were individuals with acute or terminal illnesses, non-residents of the province, those unable or unwilling to provide consent, diabetic patients unfamiliar with medicinal plant use, and herbalists lacking practical experience with antidiabetic plant preparations. These criteria ensured the study captured relevant experiences while maintaining participant safety and data reliability.

Data collection

Data were collected using two complementary tools. First, a structured questionnaire was administered to diabetic patients, covering their sociodemographic characteristics, type of diabetes, ongoing treatment, use of medicinal plants, modes of use, and reported side effects. Secondly, a semi-structured interview guide was conducted with 15 traditional herbalists practicing in the region. The aim was to gather detailed information on the plants they use, including the parts utilized, methods of preparation and administration, therapeutic indications, frequency of use, observed effects, potential side effects, dosage, and duration of treatment. Feedback from users was also collected. Additionally, socio-demographic information of the herbalists was recorded, including age, years of experience, and training.

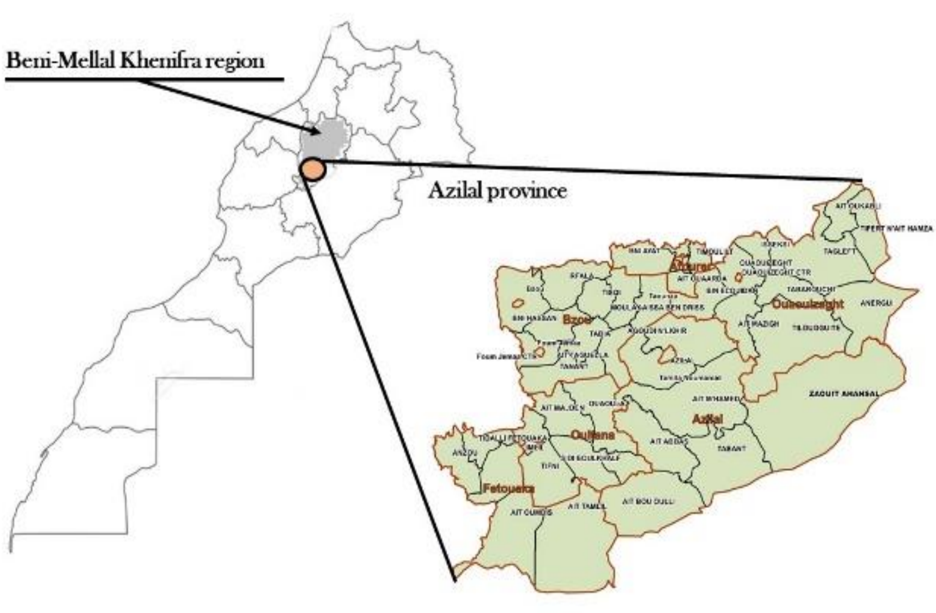

Figure 1: Geographical location of the study area, Azilal, Morocco (31°56'47" N, 6°33'35" W).

Relative frequency of citation

The relative frequency of citation (RFC) of each medicinal plant used for diabetes management by the population of Azilal was calculated by dividing the number of informants who cited a given species (FC) by the total number of informants interviewed (N). The formula (Equation 1) developed by [21] was used to calculate this parameter.

$$RFC = \frac{FC}{N} \quad \text{……………………………………………………(1)}$$

where $0 < RFC < 1$

 ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Family importance value
The family importance value (FIV) is an important ethnobotanical index used to evaluate the significance of plant families in traditional medicine. The formula (Equation 2), developed by,[21] was used to determine the FIV.

$$FIV = \frac{FC\ family}{Ns} \quad \ldots\ldots(2)$$

Where FC family is the number of informants who cited at least one species belonging to that family, and Ns is the total number of species recorded within the same family.

Fidelity level
Fidelity level (FL) describes the beneficial potential of each species against a given ailment. It was calculated based on the number of participants confirming the utility of a particular plant against a particular disease in the studied region and expressed as a percentage, as presented in Equation 3.

$$FL = \frac{lp}{Lu} \quad \ldots\ldots(3)$$

Where Ip is the number of participants reporting the same plant against a specific disease, Lu is the number of participants confirming the utility of the same herb.

Plant part value
Plant part value (PPV) was determined on the basis of the frequency of specific plant parts used by the population to manage diabetes. Equation 4 was adopted to determine PPV.

$$PPV = \frac{RU\ plant\ part}{RU} \quad \ldots\ldots(4)$$

Where RU plant part represents the sum of uses of a particular plant part, and RU is the total of uses of all plant parts.

Statistical analysis
The collected data were processed and statistically analyzed using Microsoft Office Excel (2016) and GraphPad Prism 6 software. The various parameters were analyzed using basic descriptive statistics.

Results and Discussion

Respondent profile
In the region of Azilal, medicinal and aromatic plants play a pivotal role in the management of various diseases, including diabetes. The utility of medicinal plants to manage diabetes in the abovementioned region exceeds 90%, which confirms the wide use of the natural resources as the first line of treatment of diabetes. Analysis of the results showed that women accounted for 68% of the respondents, while men accounted for 32%. The mean age of all participants was estimated at 49 years with an age range of 16-82 years (Table 1). It was observed that the majority of plant-based alternative medicine (PAM) users belonged to the older generation, reflecting their extensive knowledge of medicinal plants and their use in managing various diseases. Concerning educational level, the majority of respondents had low educational attainment. For multiple reasons, married individuals preferred to use medicinal plants as an affordable healthcare option, which may explain the high proportion of married participants in this study (Table 1).

Diversity and frequency of medicinal herbs in Azilal region
The analysis of the obtained data also revealed that twenty-six medicinal plants were recorded, eight of which were the most frequently cited (Table 2). The most represented species was *Olea europaea* (20 citations), followed by *Pastinaca sativa* (18 citations), *Amygdalus communis* var. amara (16 citations), *Artemisia herba-alba* (15 citations), *Cytinus hypocistis* (15 citations), *Euphorbia resinifera* (10 citations), *Berberis vulgaris* (8 citations), and *Trigonella foenum-graecum* (7 citations).

Table 1: Sociodemographic characteristics of diabetic patients (n = 300).

Variable	Description
Sex	68% female, 32% male
Mean age (years)	49 years
Age range	16 to 82 years
Education level	Predominantly low educational attainment
Marital status	Majority married

Table 2: Most commonly cited medicinal plants by patients.

Scientific name	Vernacular name	Number of citations
Olea europaea	Olive leaves	20
Pastinaca sativa	Parsnip	18
Amygdalus communis var. amara	Bitter almond	16
Artemisia herba-alba	White wormwood	15
Cytinus hypocistis	Cytinus	15
Euphorbia resinifera	Resin spurge	10
Berberis vulgaris	Barberry	08
Trigonella foenum-graecum	Fenugreek	07

Ethnomedicinal use and route of administration
In the treatment of diabetes among the indigenous population of the Azilal region, a wide range of medicinal plants and their formulations, prepared using various methods, were identified. Among the medicinal plants used, *Olea europaea* leaves were used in a decoction and administered orally. The same method was used to prepare *Pastinaca sativa* roots to manage diabetes. Whereas, *Artemisia herba-alba* aerial parts were used in an infusion. Regarding *Trigonella foenum-graecum*, the seeds were used in powdered form for oral administration. The preparations were mainly decoctions using leaves or roots and were administered orally (Table 3).

Occurrence of side effects
Table 4 displays different adverse effects that accompanied the use of medicinal plants to manage diabetes according to the interviewed participants in the Azilal region. The analysis of data revealed that among the users, 36% reported experiencing different adverse effects, such as digestive disorders, hypoglycaemia, and weakness. Digestive disorders ranked in the top list of side effects with a proportion of 18%, while hypoglycaemia, and weakness represented 9% and 5%, respectively. Table 5 displays the characteristics of the participants. Analysis of the data showed that 30% of medicinal plant users reported glycated haemoglobin (HbA1c) levels exceeding 7%, whereas 42% of non-users had HbA1c levels above 7%. Regarding microangiopathic complications, 35% of PAM users reported having experienced such complications, whereas 50% of non-users had experienced microangiopathic complications.

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 3: Usage methods of key antidiabetic medicinal plants.

Plant name	Part used	Preparation method	Route of administration
Olea europaea	Leaves	Decoction	Oral
Pastinaca sativa	Roots	Decoction	Oral
Artemisia herba-alba	Aerial parts	Infusion	Oral
Trigonella foenum-graecum	Seeds	Powder to swallow	Oral

Table 4: Reported side effects among users of medicinal plants.

Type of side effect	Number of cases	Percentage (%)
Digestive disorders	20	18
Hypoglycaemia	10	09
Fatigue	05	05
None	63	68

Table 5: Comparison between users and non-users of phytotherapy.

Parameter	Users of medicinal plants (30%)	Non-users (%)
HbA1c > 7%	30.0	42
Microangiopathic complications	35.0	50
Female sex	70.4	65

The majority of PAM users were female, suggesting that women's close interaction with their surrounding environment fosters traditional knowledge of natural resources for diabetes management, which is transmitted as cultural patrimony from generation to generation.

Quantitative analysis of ethnobotanical data

To further quantify the importance and traditional knowledge associated with antidiabetic medicinal plants in the province of Azilal, several ethnobotanical indices were calculated, including the RFC, FL, FIV, and PPV, as shown in Table 6. The RFC and FL values revealed that *Olea europaea, Pastinaca sativa*, and *Prunus amygdalus* were among the most cited species, each showing a FL of 100%, indicating unanimous agreement among informants regarding their use for diabetes treatment. *Olea europaea* exhibited the highest RFC (0.174), followed by *Pastinaca sativa* (0.157) and *Prunus amygdalus (*0.139), reflecting their prominence in local phytotherapeutic practices. The RFC and FL values revealed that *Olea europaea*, *Pastinaca sativa*, and *Prunus amygdalus* were among the most cited species, each showing a FL of 100%, indicating unanimous agreement among informants regarding their use for diabetes treatment (Table 6). Regarding FL analysis, the Apiaceae family recorded the highest FIV (0.191), followed by Oleaceae (0.174), Rosaceae (0.139), and Lamiaceae (0.130), highlighting the dominance of these families in traditional antidiabetic practices in the Azilal region (Table 7). As shown in Table 8, the people of Azilal region use different parts of medicinal plants with antidiabetic potential to prepare their remedies. Leaves were the most commonly used plant part in PAMs (PPV = 0.314), owing to their availability and rich chemical composition. Seeds ranked second (PPV = 0.223), followed by roots (0.179) and flowers (0.090). Ancestral knowledge of traditional medication and therapeutic approaches used by different civilizations plays a pivotal role in the management of different critical health conditions. Since ancient times, medicinal herbs and their combinations have served as the main source of biologically active compounds with high therapeutic value.

Table 6: Relative frequency of citation (RFC) and fidelity level (FL) of medicinal plants used by diabetic patients in Azilal province.

Scientific name	Family	FC	RFC	FL (%)
Olea europaea	Oleaceae	20	0.174	100.0
Pastinaca sativa	Apiaceae	18	0.157	100.0
Prunus amygdalus	Rosaceae	16	0.139	100.0
Artemisia herba-alba	Asteraceae	15	0.130	100.0
Cytinus hypocistis	Cytinaceae	15	0.130	100.0
Euphorbia resinifera	Euphorbiaceae	10	0.087	100.0
Berberis vulgaris	Berberidaceae	08	0.070	100.0
Trigonella foenum-graecum	Fabaceae	07	0.061	100.0
Capparis spinosa	Capparaceae	06	0.052	100.0
Nigella sativa	Ranunculaceae	06	0.052	100.0
Ceratonia siliqua	Fabaceae	06	0.052	100.0
Allium cepa	Amaryllidaceae	05	0.043	100.0
Allium sativum	Amaryllidaceae	05	0.043	100.0
Opuntia ficus-indica	Cactaceae	05	0.043	100.0
Citrullus colocynthis	Cucurbitaceae	04	0.035	100.0
Urtica dioica	Urticaceae	04	0.035	100.0
Punica granatum	Lythraceae	04	0.035	100.0
Origanum compactum	Lamiaceae	03	0.026	100.0
Tetraclinis articulate	Cupressaceae	03	0.026	100.0
Lavandula dentate	Lamiaceae	03	0.026	100.0
Arbutus unedo	Ericaceae	02	0.017	100.0
Teucrium polium	Lamiaceae	02	0.017	100.0
Ajuga iva	Lamiaceae	02	0.017	100.0
Chenopodium ambrosioides	Amaranthaceae	02	0.017	100.0
Salvia officinalis	Lamiaceae	02	0.017	100.0
Zingiber officinale	Zingiberaceae	02	0.017	100.0
Lavandula stoechas	Lamiaceae	02	0.017	100.0
Syzygium aromaticum	Myrtaceae	02	0.017	100.0
Petroselinum crispum	Apiaceae	01	0.009	100.0
Cinnamomum verum	Lauraceae	01	0.009	100.0
Cuminum cyminum	Apiaceae	01	0.009	100.0
Apium graveolens	Apiaceae	01	0.009	100.0
Juniperus communis	Cupressaceae	01	0.009	100.0
Foeniculum vulgare	Apiaceae	01	0.009	100.0
Lepidium sativum	Brassicaceae	01	0.009	100.0
Rosmarinus officinalis	Lamiaceae	01	0.009	100.0
Zea mays	Poaceae	01	0.009	100.0

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Table 7: Family importance value of plant families utilized in traditional phytotherapy for diabetes.

Family	Total FC	FIV
Amaranthaceae	02	0.017
Amaryllidaceae	10	0.087
Apiaceae	22	0.191
Asteraceae	15	0.130
Berberidaceae	08	0.070
Brassicaceae	01	0.009
Cactaceae	05	0.043
Capparaceae	06	0.052
Cucurbitaceae	04	0.035
Cupressaceae	04	0.035
Cytinaceae	15	0.130
Ericaceae	02	0.017
Euphorbiaceae	10	0.087
Fabaceae	13	0.113
Lamiaceae	15	0.130
Lauraceae	01	0.009
Lythraceae	04	0.035
Myrtaceae	02	0.017
Oleaceae	20	0.174
Poaceae	01	0.009
Ranunculaceae	06	0.052
Rosaceae	16	0.139
Urticaceae	04	0.035
Zingiberaceae	02	0.017

FC: Species; FIV: Family importance value

Table 8: Plant part value distribution among various plant parts used in herbal preparations.

Plant parts	Total FC	PPV
Flower buds	02	0.011
Bulbs	10	0.053
Leaves	59	0.314
Flowers	17	0.090
Fruits	01	0.005
Seeds	42	0.223
Aerial parts	02	0.011
Roots	32	0.170
Rhizomes	02	0.011
Stigmas	01	0.005
Stems	15	0.080
Barks	05	0.027

PPV: Plant part value; FC: Species

Ethnobotanical studies integrate traditional knowledge with contemporary scientific approaches to explore the beneficial health properties of plants, owing to their safety and minimal adverse effects.[7] Several published studies provide strong evidence of traditional knowledge, documenting various recipes and therapeutic strategies for managing different chronic diseases, including diabetes.[16,22–24] Mounting evidence shows that several medicinal plants grown in Morocco, including *Pastinaca sativa*, *Amygdalus communis*, *Olea europaea*, and *Trigonella foenum-graecum*, among others, exhibit remarkable antidiabetic effects.[25] These findings are consistent with those reported in previous studies.[10,11,15,22,24] The calculation of quantitative ethnobotanical indices, such as RFC, FL, and PPV, provides additional insight into the relevance of the findings and supports the scientific rigor of the study.[11] *Trigonella foenum-graecum* and *Olea europaea* registered the highest RFC and FL values, as previously reported by several researchers.[11,26,27]

Experimental studies revealed that both medicinal plants exhibited interesting antidiabetic effects.[28,29] The study conducted by[19] demonstrated that administration of an alcoholic extract of *Olea europaea* leaves significantly reduced blood glucose levels and normalized lipid and liver profiles. The same researchers found that *Olea europaea* leaves increased serum insulin levels in diabetic streptozotocin-intoxicated rats.[19] Similarly, Yadav and Baquer (2014),[30] provided a detailed pharmacological profile of *Trigonella foenum-graecum*, emphasizing its capacity to modulate glucose metabolism and enhance insulin sensitivity. The predominance of decoction-based preparations using leaves and roots aligns with the findings of [25] who documented similar traditional practices across various Moroccan regions. This suggests a shared cultural heritage regarding the preparation and administration of medicinal plants in traditional diabetic care.

Interestingly, the side effects reported by 36% of users in this study, including digestive discomfort and hypoglycaemia, are consistent with the findings of [12] in the Taounate province. This underscores the necessity of pharmacovigilance and further toxicological assessments, despite the common perception of traditional remedies as safe. At the botanical family level, the prominence of Apiaceae, Oleaceae, and Rosaceae in terms of FIV supports previous ethnobotanical findings in southeastern Morocco.[11] The recurrent citation of these families likely reflects their phytochemical richness and cultural familiarity among rural populations. Finally, the observation that users of phytotherapy exhibited better glycaemic control than non-users suggests a potential protective effect of traditional medicinal plants, particularly against microangiopathic complications. However, this association should be interpreted cautiously in the absence of controlled clinical trials.

This study is limited by its cross-sectional, observational design and reliance on self-reported data, which may introduce recall bias. Its findings are specific to the Azilal region, with variable plant preparations and dosages and uncontrolled confounding factors. While ethnobotanical knowledge is well documented, safety and efficacy remain uncertain due to the absence of toxicological assessments and clinical trials, underscoring the need for pharmacological validation and rigorous experimental studies.

Conclusion

The survey highlights the richness of local ethnobotanical knowledge and its critical role in diabetes management. These findings emphasize the potential for integrating traditional medicinal practices into a holistic healthcare approach while ensuring patient safety. Future research should focus on three core areas: pharmacological validation of the most cited medicinal plants, assessment of their toxicological profiles, and clinical trials to confirm efficacy and safety. Concurrently, studies exploring the specific bioactive compounds, mechanisms of action, and potential drug-herb interactions are essential to provide a robust scientific foundation for integrating traditional remedies into modern diabetes management.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgements

The authors appreciate Mr. I.I. Ogunlowo for his assistance during plant collection.

References

1. Ahmed Chetoui KK, El Kardoudi A, Boutahar K, Chigr F, Najimi M. Epidemiology of diabetes in Morocco: review of data, analysis and perspectives. Int J Scientific Eng Res. 2018; 9:1310-1316.
2. Sluijs T, Lokkers L, Özsezen S, Veldhuis GA, Wortelboer HM. An Innovative Approach for Decision-Making on Designing Lifestyle Programs to Reduce Type 2 Diabetes on Dutch Population Level Using Dynamic Simulations. Front Public Health. 2021; 9. doi:10.3389/fpubh.2021.652694
3. Bhutta ZA, Haq ZU, Basit A. Diabetes in Pakistan: addressing the crisis. Lancet Diabetes Endocrinol. 2022;10(5):309-310. doi:10.1016/S2213-8587(22)00102-4
4. Poddar AK. Nutrition in the New Era: Bridging Cultural Traditions and Modern Health Science in Diet Choices. Food Stud Interdiscip J. 2024; 14(2). Accessed December 21, 2025. https://search.ebscohost.com/login.aspx?
5. Tapia-Martínez JA, Franco-Colín M, Blas-Valdivia V, Cano-Europa E. The joint effect of congenital hypothyroidism and hypercaloric diet consumption as triggers of type 2 diabetes mellitus. Eur Thyroid J.. 2022; 11(1). Accessed August 23, 2025. https://etj.bioscientifica.com/view/journals/etj/11/1/ETJ-21-0050.xml
6. Meléndez-Salcido CG, Ramírez-Emiliano J, Pérez-Vázquez V. Hypercaloric diet promotes metabolic disorders and impaired kidney function. Curr Pharm Des. 2022; 28(38):3127-3139. doi:10.2174/1381612829666221020162955
7. Es-Safi I, Mechchate H, Amaghnouje A, Elbouzidi A, Bouhrim M, Bencheikh N, Cheikhyouseef A. Assessment of antidepressant-like, anxiolytic effects and impact on memory of *Pimpinella anisum* L. total extract on Swiss albino mice. Plants. 2021; 10(8):1573-1589. doi:10.3390/plants10081573
8. Shayganni E, Bahmani M, Asgary S, Rafieian-Kopaei M. Inflammaging and cardiovascular disease: Management by medicinal plants. Phytomed. 2016; 23(11):1119-1126.
9. Frimpong EK, Thembane N, Hlatshwayo S, Ngcobo M, Gqaleni N. Indigenous Medicinal plants used in the management of diabetes in Africa: 5 years (2019–2024) in perspective. Plants. 2024; 13(14):1898.
10. Jouad H, Haloui M, Rhiouani H, El Hilaly J, Eddouks M. Ethnobotanical survey of medicinal plants used for the treatment of diabetes, cardiac and renal diseases in the North centre region of Morocco (Fez–Boulemane). J Ethnopharmacol. 2001; 77(2-3):175-182.
11. Eddouks M, Maghrani M, Lemhadri A, Ouahidi ML, Jouad H. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). J Ethnopharmacol. 2002; 82(2-3):97-103.
12. El-Hilaly J, Hmammouchi M, Lyoussi B. Ethnobotanical studies and economic evaluation of medicinal plants in Taounate province (Northern Morocco). J Ethnopharmacol. 2003; 86(2-3):149-158.
13. Abouri M, El Mousadik A, Msanda F, Boubaker H, Saadi B, Cherifi K. An ethnobotanical survey of medicinal plants used in the Tata Province, Morocco. Int J Med Plant Res. 2012; 1(7):99-123.
14. Jamila F, Mostafa E. Ethnobotanical survey of medicinal plants used by people in Oriental Morocco to manage various ailments. J Ethnopharmacol. 2014; 154(1):76-87.
15. Skalli S, Hassikou R, Arahou M. An ethnobotanical survey of medicinal plants used for diabetes treatment in Rabat, Morocco. Heliyon. 2019; 5(3). Accessed August 21, 2025. https://www.cell.com/heliyon/fulltext/S2405-8440(18)35693-7
16. Bnouham M, Legssyer A, Mekhfi H, Ziyyat A. Medicinal plants used in the treatment of diabetes in Morocco. Int J Diabetes Metab. 2002; 10(1):33-50.
17. Idm'hand E, Msanda F, Cherifi K. Ethnopharmacological review of medicinal plants used to manage diabetes in Morocco. Clin Phytosci. 2020; 6(1):1-32. doi:10.1186/s40816-020-00166-z
18. Choudhury ME, Mostofa M, Awal MA. Antidiabetic effects of Azadirachta indica, Trigonella foenumgraecum, Olea europea and Glibenclamide in experimentally diabetic induced rat. J Bangladesh Agric Univ. 2005; 3(2):277-282.
19. Eidi A, Eidi M, Darzi R. Antidiabetic effect of *Olea europaea* L. in normal and diabetic rats. Phytother Res. 2009; 23(3):347-350. doi:10.1002/ptr.2629
20. Kumar P, Kale RK, Mukherjee S, Prakash K, McLean P, Baquer NZ. Antidiabetic effects of *Trigonella foenum-graecum* seed powder in a rat model. Toxicol Environ Chem. 2011; 93(10):2085-2097. doi:10.1080/02772248.2011.626418
21. Tardío J, Pardo-de-Santayana M. Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria (Northern Spain). Econ Bot. 2008; 62(1):24-39. doi:10.1007/s12231-007-9004-5
22. Bnouham M, Merhfour FZ, Ziyyat A, Aziz M, Legssyer A, Mekhfi H. Antidiabetic effect of some medicinal plants of Oriental Morocco in neonatal non-insulin-dependent diabetes mellitus rats. Hum Exp Toxicol. 2010; 29(10):865-871. doi:10.1177/0960327110362704
23. Belhaj S, Chaachouay N, Zidane L. Ethnobotanical and toxicology study of medicinal plants used for the treatment of diabetes in the High Atlas Central of Morocco. J Pharm Pharmacogn Res. 2021; 9(5):619-662.
24. Naceiri Mrabti H, Bouyahya A, Naceiri Mrabti N, Jaradat N, Doudach L, Faouzi MEA. Ethnobotanical survey of medicinal plants used by traditional healers to treat diabetes in the Taza region of Morocco. Evid-Based Complement Altern Med. 2021; 2021:1-16. doi:10.1155/2021/5515634
25. Barkaoui M, Katiri A, Boubaker H, Msanda F. Ethnobotanical survey of medicinal plants used in the traditional treatment of diabetes in Chtouka Ait Baha and Tiznit (Western Anti-Atlas), Morocco. J Ethnopharmacol. 2017; 198:338-350. doi:10.1016/j.jep.2017.01.023
26. Aouir F, Chaibi R, Benhamza AEH. An ethnobotanical inventory and therapeutic potential of medicinal plants used in traditional practices in northeastern Algeria. Ethnobot Res Appl. 2025; 31:1-19.
27. Yassara S, Jaouhar S, Zeouk I, Bekhti K. Ethnobotanical study of medicinal plants used to treat microbial infections in the Fez-Meknes region, Morocco. Ethnobot Res Appl. 2025; 31:1-19.
28. Akhtar MF, Ashraf KM, Saleem A, Sharif A, Zubair HM, Anwar F. Antidiabetic Potential and antioxidant activity of *Olea europaea* subsp. Cuspidata (Indian olive) seed extracts. Evid-Based Complement Altern Med. 2022; 2022:1-12. doi:10.1155/2022/5164985.
29. Mansour HM, Zeitoun AA, Abd-Rabou HS. Antioxidant and anti-diabetic properties of olive (*Olea europaea*) leaf extracts: *In vitro* and *in vivo* evaluation. Antioxidants. 2023; 12(6):1275.
30. Yadav UCS, Baquer NZ. Pharmacological effects of *Trigonella foenum-graecum* L. in health and disease. Pharm Biol. 2014; 52(2):243-254. doi:10.3109/13880209.2013.826247.
31. Yadav UCS, Baquer NZ. Pharmacological effects of *Trigonella foenum-graecum* L. in health and disease. Pharm Biol. 2014; 52:243–254.