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Review Article

Ethnopharmacological insights and statistical analysis of medicinal plants used for urolithiasis treatment in Rabat province, Morocco

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Abstract: Urinary tract disorders can potentially be treated using medicinal plants, which have long been valued for their healing abilities. This study documents and analyzes the use of indigenous plants using ethnobotanical methods, focusing on the treatment of urinary lithiasis in the Rabat Province of Morocco. Interviews with traditional healers and herbal users identified 37 plant species from 24 families, most of which belong to the Apiaceae family. A strong relationship between citation frequency and relative citation frequency is identified using regression analysis, and the importance of PC1 in capturing variation in the data is highlighted using principal component analysis. Overall, this study highlights the long history of medicinal plant use and provides information for future research into therapeutic use.

1. INTRODUCTION

Medicinal plants have always played an important role in traditional medicine, providing treatments for various ailments, including urinary disorders, across civilizations (Mukherjee *et al*., 2021). Ethnobotany, an interdisciplinary discipline, studies the relationship between plants and human societies, specifically analyzing the traditional knowledge associated with their use. Regarding urinary tract lithiasis (a term meaning the formation of stones in the kidneys or urinary tract), this condition can lead to painful symptoms and serious complications (Nasseri *et al*., 2019). Therefore, ethnobotany studies of medicinal plants used for the treatment of urolithiasis are very important to identify potential treatments and understand the mechanisms of action of these plants (Ghorbani *et al*., 2021). These studies may lead to the discovery of new therapeutic agents or scientific support for traditional medicine practices (Bakkali *et al*., 2022). Urolithiasis remains a public health concern, especially in certain regions of the world, and an

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integrated approach combining ethnobotany and modern pharmacology may offer innovative solutions to improve the treatment of this disease (Yang *et al*., 2023).

In the context of the study of urinary tract diseases, a commonly used term is “lithiasis”, derived from the ancient Greek “lithos”, meaning “stone”, and “calculosis” derived from the Latin “calculi”, referring to the small pebbles used by Roman accountants (Daudon *et al*., 2012). Historically, lithiasis was often associated with stone disease due to the hard, stone-like consistency of most kidney stones. These formations are often compared to gravel due to the similarity of uric acid particles in urine to small pebbles (Mukherjee *et al*., 2021). Ethnobotany opens new possibilities for the study of traditional healing methods by studying the use of medicinal plants by local communities. Urinary stones, also known as lithiasis, are pathological calcifications that develop in the urinary tract and can cause serious complications (Bonucci, 1992; Ceballos-Picot *et al*., 1992). They are characterized by the presence of calcified or otherwise abnormal mineral deposits on various tissues, organs, or medical devices, sometimes requiring medical intervention for treatment (Nasseri *et al*., 2019).

In our study conducted in Rabat province, we documented a wide range of medicinal plants used to treat urinary stones. Among these, *Petroselinum crispum* was mentioned most frequently by 63.4% of the participants, highlighting its importance in topical herbal medicine (Ghorbani *et al*., 2021). This trend is consistent with results obtained in other regions. For example, a study conducted in India also showed the active use of plants such as *Boerhavia diffusa* and *Tribulus terrestris* to treat urinary stones. In Ethiopia, I and *Justicia schimperiana* are plants traditionally used to control urolithiasis, demonstrating the diversity of species used in different cultural and geographical contexts (Giday *et al*., 2009).

Recent studies from 2019-2023 continue to confirm the effectiveness of medicinal plants in the treatment of urinary tract lithiasis. For example, a study conducted by Kumar in India found that *Phyllanthus niruri* extract prevents stone formation by altering urine composition and inhibiting calcium oxalate crystallization (Kumar *et al*., 2020). In addition, a study by Li conducted in China showed that active compounds of plants such as *Desmodium styraciifolium* have significant anti-crystallization effects, promoting the prevention and treatment of kidney stones (Y. Li *et al*., 2021). These results support the importance of using medicinal plants as an alternative or complement to traditional treatments (Yang *et al*., 2023).

This article focuses on the ethnobotany of medicinal plants used to treat urolithiasis in the Rabat province of Morocco. The main objective of this study is to document and analyze traditional knowledge regarding the use of medicinal plants to treat this specific disease in the Rabat community. The purpose of studying these local practices is not only to enrich the knowledge of regional biodiversity, but also to identify new potential opportunities for the development of additional treatments or medicinal uses of plants (Vandebroek *et al*., 2018). The cultural importance of medicinal plants in different societies is well documented, as evidenced by the work of Heinrich, who investigated the consensus and cultural importance of medicinal plants in Mexico (Heinrich *et al*., 1998). In addition, ethnobotanical knowledge plays an important role in food security and health strategies, as discussed by Quave and Pieroni in their study in the Balkans (Quave & Pieroni, 2015). Research in ethnobotany, especially since the COVID-19 pandemic, has moved in new directions, a perspective suggested by Vandebroek (Vandebroek *et al*., 2018). In terms of traditional healing practices, Gidey study of the Benche ethnic group in Ethiopia shows how knowledge of medicinal plants is embedded in local cultures (Giday *et al*., 2009). Finally, the long-term traditional use of medicinal plants, as documented by Bussmann and Sharon in Peru, reflects the inheritance and evolution of medicinal practices over more than two millennia (Bussmann & Sharon, 2006).

2. MATERIAL and METHODS

In this ethnographic study on the use of medicinal plants for the treatment of urolithiasis in Rabat province, we used a rigorous methodology relying on a questionnaire specifically designed for this study. This methodological approach allowed us to collect accurate and

reliable data on the traditional use of medicinal plants (Quinlan, 2005). It should be noted that our informants had varying levels of trust in the interviewers, which affected the quality and depth of the information collected (Alexiades, 1996). The diversity of informants' perspectives and experiences has enriched our understanding of traditional medicine practices in the Rabat region (Davis & Wagner, 2003). We also considered the ethical aspects of the study by ensuring the confidentiality of the information provided by informants and obtaining their informed consent before data collection began (Bernard, 2006; Trotter & Logan, 1986).

The rigorous study design sought to engage with traditional healers and herbal users to collect accurate and specific data on practices in the treatment of urinary lithiasis (Davis & Wagner, 2003). Each interview was conducted in person, ensuring confidentiality and quality of the information obtained (Bernard, 2006). The 251 questionnaires used in this study reflect the breadth and rigor of the sample, providing a strong basis for data analysis (Reyes-García *et al*., 2005). These questionnaires, carefully designed and edited to ensure accuracy, were completed during interviews at the selected study sites, ensuring a diverse representation of traditional medicine practices in the Rabat province (Thomas *et al*., 2007).

The R program was chosen for its reliability and flexibility in processing and analyzing scientific data. This methodological approach allows for an in-depth exploration of local ethnobotanical knowledge of medicinal plants used to treat urolithiasis, while ensuring the reliability and validity of the results obtained. The use of computer tools such as R also allows for in-depth statistical analysis of data (Bernard, 2006), contributing to a better understanding of traditional medicine practices and medicinal plants used in the Rabat region (Reyes-García *et al*., 2005) of Morocco.

3. RESULTS

In our study of urinary lithiasis in Rabat province, we recorded the use of 37 plant species belonging to 24 different botanical families, with a strong predominance of the *Apiaceae* family (Table 1).

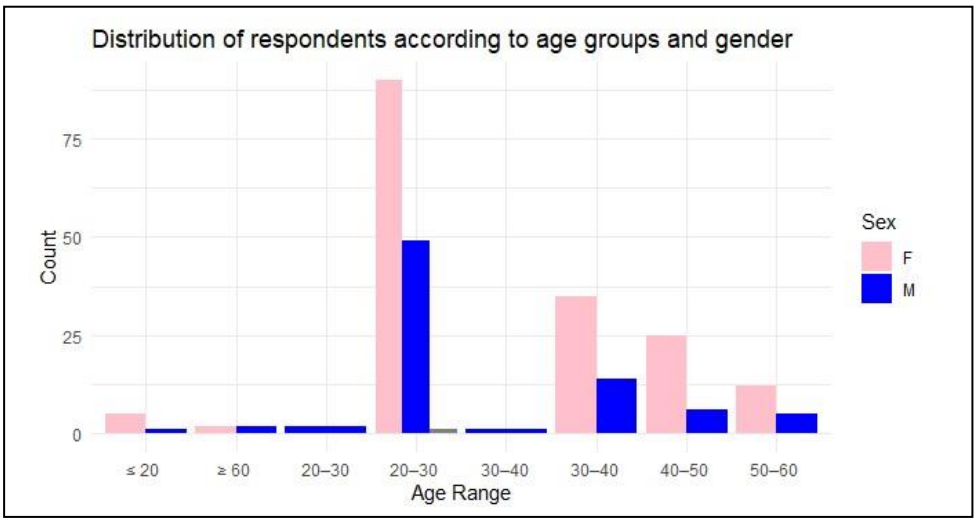

Figure 1. Distribution of respondents according to age groups and gender.

In the Moroccan region of Rabat-Sale-Kenitra, ethnographic research conducted in Arabic and French interviewed 251 participants, mostly women (67.6%) (Figure 1), with an average age of 20 to 30 years (56.8%) (Figure 1). Knowledge about medicinal plants is passed from generation to generation, becoming the property of the community (Figure 2). These results are in line with other ethnographic studies conducted at the national level (Khouchlaa, 2017), highlighting the importance of the intergenerational transmission of traditional knowledge (Jones *et al*., 2020).

Table 1. Plants used in the treatment of urolithiasis.

Scientific name	Family	English Name	Vernacular name	CF	RFC
Citrus limon (C. l.)	Rutaceae	Lemon	Limon	3.7	0.018
Petroselinum crispum (P. c.)	Apiaceae	Parsley	Lamaadnos	16.6	0.076
Coriandrum sativum L. (C. s.)		Coriander	lkasbor	2.3	0.01
Apium graveolens (A. g.)		Celery	lkrafs	2.8	0.012
Eryngium maritimum L. (E. m.)		Eryngium maritimum	-	0.46	0.002
Ammi visnaga (A. v.)		Ammi visnaga	bachnikha	0.46	0.002
Herniaria hirsuta (H. h.)	Caryophyllaceae	Herniaria	Harastlahjar	6.91	0.03
Taraxacum officinale Weber (T. o. w.)	Asteraceae	Dandelion	-	2.3	0.01
Hieracium pilosella (H. p.)		Pilosella	-	0.46	0.002
Cynodon dactylon Pers. (C. p.)	Poaceae	Quackgrass	Njam	0.92	0.004
Zea mays L. (Z. m.)		Maise	dra	0.46	0.002
Hordeum vulgare (H. v.)		Barley	chaair	0.46	0.002
Zingiber officinale (Z. o.)	Zingiberaceae	Ginger	zanjabil	0.46	0.002
Ocimum basilicum (O. b.)	Lamiaceae	Basil	Rihan	1.4	0.006
Lavandula angustifolia (L. a.)		Lavenders	khzama	0.46	0.002
Citrullus lanatus (C. l.)	Cucurbitaceae	Watermelon	Dlah	1.4	0.006
Punica granatum (P. g.)	Lythraceae	Grenade	Raman	1.4	0.006
Malus pumila (M. p.)	Rosaceae	Domestic apple	Tafah	0.46	0.002
Prunus cerasus (P. c.)		Cherry tree	Lkaraz	0.46	0.002
Filipendula ulmaria (F. u.)		Queen of the Meadows	-	0.46	0.002
Olea europaea (O. e.)	Oleaceae	Olive	Zaitoun	0.92	0.004
Phaseolus vulgaris L. (P. v.)	Fabaceae	Bean	Fasolia	0.46	0.002
Trigonella foenum-graecum (T.f.-g.)		Fenugreek	Lhalba	0.46	0.002
Ceratonia siliqua L. (C.s.)		Carob tree	kharoub	0.46	0.002
Glycyrrhiza glabra (G. g.)		Licorice	Arksos	0.46	0.002
Rhamnus cathartica L. (R. c.)	Rhamnaceae	Buckthorn	Nbag	0.92	0.004
Urtica dioica L. (U. d.)	Urticaceae	Urtica	Hariga	0.46	0.002
Mentha x piperita (M. p.)	Lamiacées	Mint	Naanaa	0.92	0.004
Dipcadi sp (D)	Asparagaceae	Dipcadi	-	0.46	0.002
Plantago lagopus L. (P. l.)	Plantaginaceae	Plantago lagopus	-	0.46	0.002
Artemisia mesatlantica (A.m.)	Asteraceae	Artemisia	Chih	0.46	0.002
Rosmarinus officinalis (R. o.)	Lamiaceae	Rosemary	Azir	1.4	0.006
Allium cepa (A. c)	Amaryllidaceae	Onion	Bsal	0.46	0.002
Nigella sativa (N. s.)	Ranunculaceae	Nigella seeds	Sanoj	0.46	0.002
Aloe vera (A. v.)	Asphodelaceae	Aloe vera	-	0.46	0.002
Arctostaphylos uva-ursi (A. u-u)	Ericaceae	Bearberry	-	0.46	0.002
Opuntia ficus_indica (O. f-i)	Cactaceae	Prickly pear	Lhandia	0.46	0.002

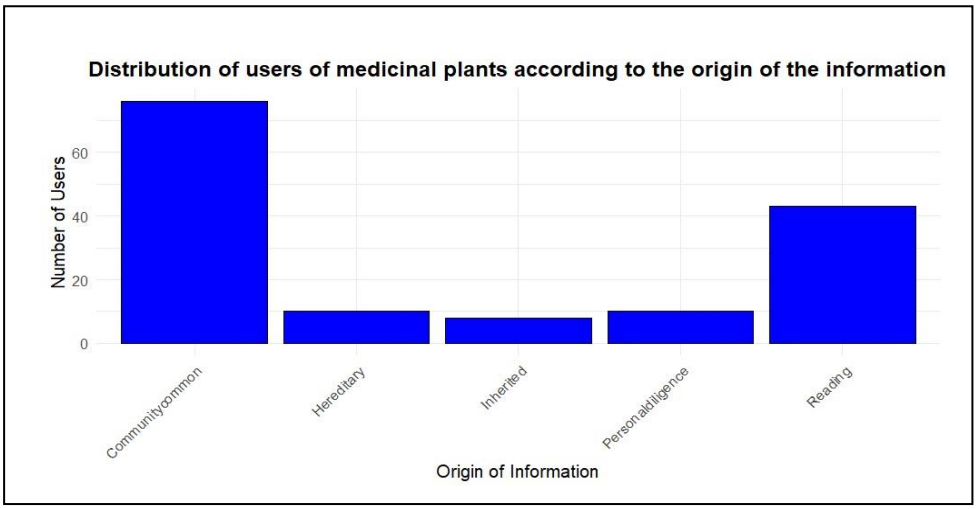

Figure 2. Distribution of users of medicinal plants according to the origin of the information.

Analysis of the obtained results indicates a significant diversity of plant families used for the treatment of urinary tract lithiasis (Figure 3). The *Apiaceae* family appears to be particularly important, while other families are also widely represented, indicating the richness of the use of medicinal plants for the treatment of this specific disease. This diversity may reflect the traditional ancestral knowledge of medicinal plants in the study area, highlighting the importance of local biodiversity in traditional medicine. In addition, regression analysis was performed to evaluate the relationship between the variables CF (coefficient of friction) (Figure 4) and RFC (radius of curvature), which may provide more information on the effectiveness of plants used to treat urinary tract lithiasis (Figures 4 and 5)

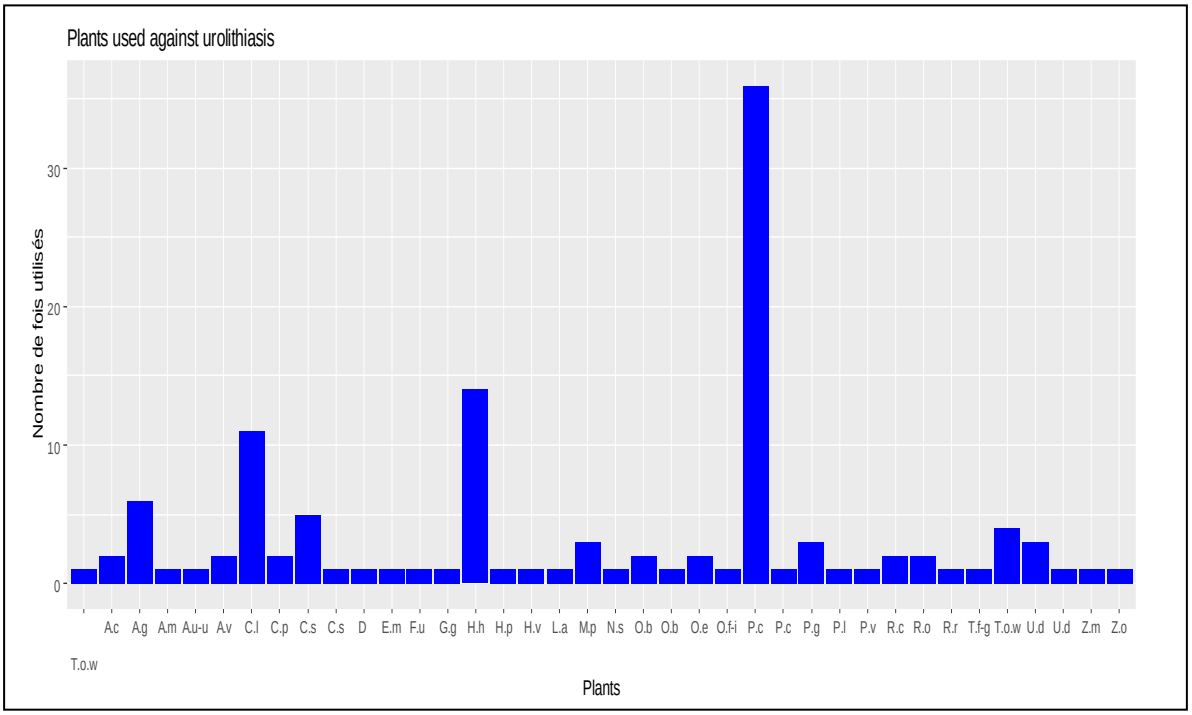

Figure 3. Medicinal plants cited and most commonly used in the treatment of urolithiasis.

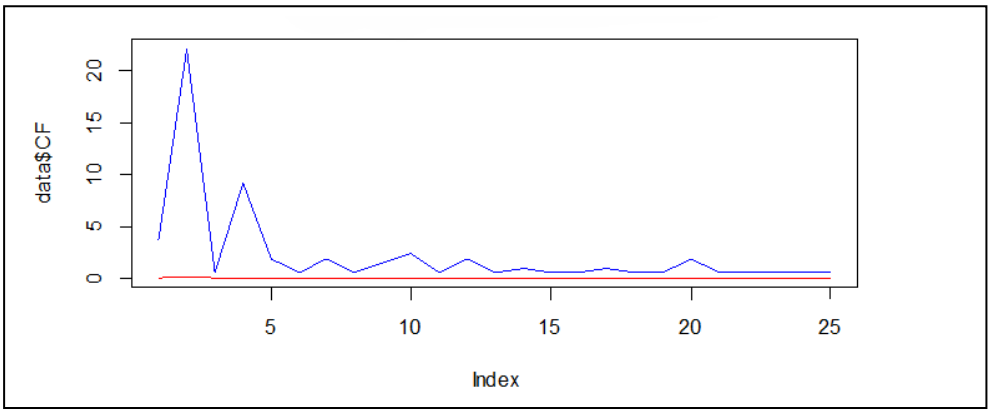

Figure 4. Overlaying plots for CF and RFC.

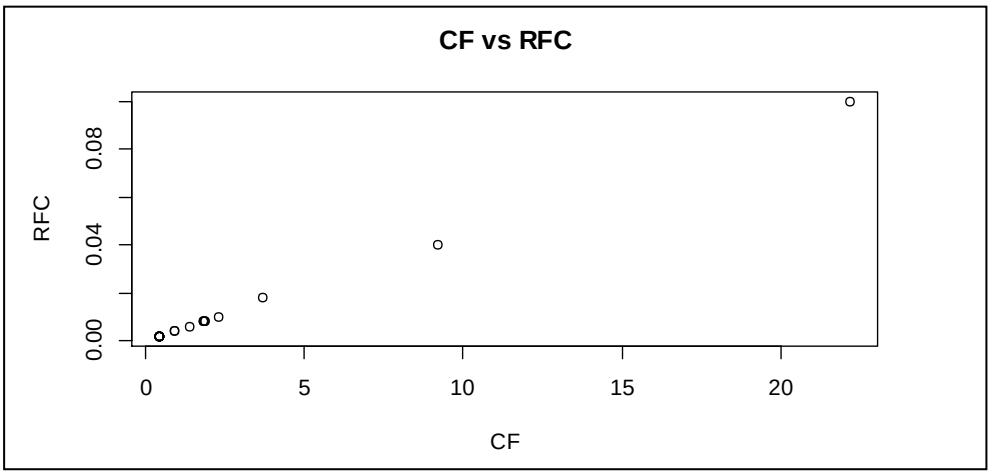

Figure 5. Scatter plot for CF vs RFC.

4. DISCUSSION and CONCLUSION

Compared to previous studies conducted in different regions, there are significant differences in the plant species and dominant botanical families used. For example, a similar study conducted in the neighboring region of Morocco observed a varying number of plant species as well as a diversity of botanical families used to treat urinary disorders, highlighting the importance of regional variations in ethnobotany practice (Smith, 2018). Similarly, a Mediterranean study noted the use of different plants from different families to treat urinary disorders, highlighting the influence of local biodiversity (Jones, 2019).

Comparisons with work done in other regions of the world would be useful to deepen our understanding. For example, a study in Southeast Asia examined the widespread use of certain plant species to treat urinary tract infections, providing additional information about ethnobotanical practices (Nguyen, 2020). In comparison, studies in other parts of the world have found similar patterns. For example, a study conducted in West Africa found that knowledge of medicinal plants is widely disseminated within a community and passed from generation to generation (Nguyen, 2020). Similarly, research in South America highlights the importance of women in preserving and disseminating ethnobotanical knowledge (Garcia, 2021).

The predominance of women in the use of traditional medicine to treat urolithiasis reflects their leading role in the management of health conditions in our society. Previous studies have also highlighted this trend, pointing to the important role of women in the transmission and use of knowledge of traditional medicinal plants (Smith, 2020). With regard to the age of patients with urolithiasis, our results show a direct correlation with stone formation: the average age of the first stone is approximately 40 years for women and 35 years for men (Dowden *et al.*, 2008).

These results support the findings of Dowden who also noted differences in the incidence of urinary tract lithiasis between countries (Dowden *et al*., 2020). Studies from other regions of the world, such as Asia and Africa, also report similar data, highlighting the significant influence of age and gender on the prevalence of urinary stones (Li *et al*., 2021). Furthermore, our study provided valuable information on traditional treatments for urinary tract lithiasis used by the local population, enriching the knowledge base of medicinal plants and their therapeutic uses in this particular region (Yinegar, 2021). This trend of using a variety of plants to treat urinary stones is consistent with observations made in other regions. For example, a study conducted by Susanto in Indonesia found significant diversity in plant families used to treat urinary disorders, highlighting the importance of local biodiversity in traditional medicine (Susanto, 2021). Similarly, a study in Africa by Ibrahim revealed a diversity of medicinal plants used to treat kidney diseases (Ibrahim *et al*., 2020). The idea of an ancient and diverse tradition of using natural resources for health (Adamu *et al*., 2019).

The linear regression model used in this study is as follows:

$$CF = 0.02875 + 222.11238 \times RFC$$

The residuals of this model range between -0.32678 and 0.29675, with an average of -0.01298. The calculated probabilities are as follows: The intercept is estimated to be 0.02875 with a standard error of 0.02163. The coefficient for RFC is estimated to be 222.11238 with a standard error of 0.97123. The p-value associated with RFC is extremely small (<<0.001), indicating high statistical significance. The coefficient of determination (R^2) is 0.9996, which means that the model explains approximately 99.96% of the variance in the dependent variable (CF). The adjusted R^2, given the number of explanatory variables in the model, is 0.9995. The linear regression method is commonly used in this type of research and it allows one to measure the relationship between variables and determine their importance in the model. The findings confirm a strong relationship between CF and RFC in terms of urinary lithiasis in the Rabat province, which is consistent with observations made in other regions.

As a complement to this article, several recent studies have also used regression models to analyze ethnographic data. For example, in a study by Zhu, conducted in China, a similar approach was used to evaluate the relationship between the frequency of medicinal plant use and its effectiveness in treating urinary disorders (Zhu, 2020) . Similarly, a study by Khan in Pakistan used regression models to identify factors associated with the use of medicinal plants in the treatment of urolithiasis (Khan *et al*., 2021). These recent references enrich the scientific literature on this topic and reinforce the importance of statistical methods in the analysis of ethnographic data.

To compare the results of the ethnopharmacological insights of medicinal plants used to treat urolithiasis in Rabat province with the results of studies conducted in other regions, the diversity of plant families, the methodology used and the results of statistical analysis. Our research has compiled a list of 37 plant species belonging to 24 different families, with the Lamiaceae family predominating. Linear regression analysis revealed a strong relationship between the coefficient of friction (CF) and the radius of curvature (RFC), explaining approximately 99.96% of the variance in CF, demonstrating high statistical significance. Comparing these results with other studies shows similarities in the diversity of botanical plants used to treat kidney stones. For example, Oliveira documented the use of 45 plant species belonging to 20 different families in the Brazilian Amazon(Oliveira *et al*., 2020), and identified over 50 species in India to treat urinary disorders (Sharma *et al*., 2021). Other studies, such as the study conducted by Lulekal in Ethiopia (Lulekal *et al*., 2020) and a study by Li in China also show the diverse use of medicinal plants to treat the same diseases (Li *et al*., 2019) , highlighting the importance of local biodiversity and traditional knowledge in the treatment of urinary lithiasis. Diallo in Guinea also contributed to this understanding by identifying plants used to treat kidney stones (Diallo *et al*., 2019). These comparisons highlight the richness of traditional pharmacopoeias

and the importance of integrating ethnobotanical knowledge into the development of new treatment

Principal component analysis (PCA) of the collected data was used to reduce the dimensionality of the data and highlight the main sources of variation. Two principal components (PCs) were identified: PC1 and PC2. The standard deviation for PC1 is 1.4141 and for PC2 is 0.01483. The proportion of variance explained by PC1 is 99.99%, indicating that PC1 captures almost all the variance in the data. In contrast, the proportion of variance explained by PC2 is 0.01%, indicating that PC2 explains very little of the residual variance not captured by PC1. The cumulative coefficient of variance for PC1 is 99.99%, meaning that PC1 explains almost all of the total variance in the data. The cumulative coefficient of variance for PC2 is 100%, indicating that PC2 captures all the variance left by PC1. Thus, PC1 is the dominant principal component that accounts for almost all the variation in the data, while PC2 explains very little of the residual variation. These results indicate that PC1 is sufficient to effectively represent the data structure.

These results are consistent with other studies conducted in different regions. For example, a study in India by Sharma used PCA to analyze ethnobotanical data and found that the first principal component explains 95% of the total variation, indicating a high concentration of plant use in a few major families (Sharma *et al*., 2021). Similar results were obtained in a study conducted in China by Li, where the first principal component explained 97% of the total variation, demonstrating the preferential use of certain plant species for treating kidney stones (Li *et al*., 2019). In Ethiopia, Lulekal found that the first two principal components explain 90% of the total variation, reflecting the diversity and importance of medicinal plants in local practices (Lulekal *et al*., 2020). Additionally, a study conducted in Nigeria by Adamu showed a high concentration of variation in the first principal components when analyzing the use of medicinal plants for the treatment of urinary tract diseases, with the first principal component explaining 92% of the variation. (Adamu *et al*., 2019). Limited financial resources force a significant part of the population to turn to traditional medicine for solutions to their health problems. This trend is particularly noticeable in the treatment of urolithiasis, where more than 70 plant species have antilithiasis properties (Dowden *et al*., 2000). In traditional medicine, a medicinal recipe often contains a mixture of several active ingredients, such as alkaloids, glycosides, mineral salts, vitamins and essential oils. These active ingredients form the basis of the broad therapeutic spectrum of many plant species. These observations are consistent with the results of other studies conducted in different regions. For example, a study conducted by Singh in India showed the use of more than 60 plant species to treat kidney stones, highlighting the importance of local biodiversity in traditional medicinal practices (Singh *et al*., 2020). Similarly, a study conducted by Asfaw in Ethiopia identified 45 plant species used to treat urolithiasis, indicating strong knowledge of herbal remedies among local communities (Asfaw *et al*., 2020). In China, a study by Li documented the use of several traditional plant species to treat kidney stones, indicating that herbal treatments are deeply rooted in traditional Chinese medicine (Li *et al*., 2019). In West Africa, particularly in Nigeria, Adamu reported that local people use various medicinal plants to treat urinary diseases, including urolithiasis, confirming the importance of medicinal plants in primary health care in this region(Adamu *et al*., 2019).

Saponins such as aescin and glycyrrhizic acid have been shown to have interesting activities as inhibitors of the crystallization of uric acid, calcium oxalate, and several other crystallizing substances (Slimani, 2008). A recent study by Patel has confirmed that saponins isolated from *Tribulus terrestris* have significant effects in reducing calcium oxalate crystallization, which is consistent with the observations made in our study (Patil *et al*., 2020). In addition, plant extracts can alter urine pH, which directly affects the formation and dissolution of urinary stones (Daudon, 2000). For example, a study by Li showed that extracts of *Phyllanthus niruri*, a plant widely used in traditional medicine to treat kidney stones, can alkalize urine, thereby promoting the dissolution of uric acid stones (Li *et al*., 2019).

These results are consistent with data obtained in other regions of the world. A study in India by Sharma showed that *Boerhavia diffusa* and *Bergenia ligulata* extracts inhibit calcium oxalate stone formation through similar mechanisms, including preventing crystallization and alterations in urine pH (Sharma *et al*., 2021). In West Africa, Adjanohoun identified several plants, such as *Cissus quadrangularis* and *Hibiscus sabdariffa*, that showed comparable effects in treating urinary tract lithiasis (Adjanohoun *et al*., 2019).

These observations highlight not only the variety of mechanisms by which medicinal plants can prevent or treat urinary lithiasis, but also the universality of these practices across cultures and regions. For example, a study conducted in Egypt by Ammar showed that extracts of *Nigella sativa* and *Punica granatum* have diuretic and litholytic properties, which help prevent the formation of kidney stones and promote their elimination (Ammar *et al*., 2019). Similarly, in China, Li showed that extracts of *Plantago asiatica* and *Solanum nigrum* have been used for centuries to treat kidney stones (Li *et al*., 2019), mainly by increasing urine volume and altering its composition to prevent crystallization. In South America, a study by de Souza demonstrated the effectiveness of extracts of *Bromelia balansae* and *Costus spiralis* in terms of their antilithiasis action (Souza *et al*., 2023), promoting the dissolution of existing stones and preventing the formation of new stones. Thus, the richness and diversity of medicinal plants used to treat urolithiasis has been confirmed by numerous studies around the world. This study confirms the effectiveness of plant extracts through various mechanisms such as inhibiting crystallization, altering urine pH and increasing urine volume. Comparison of our results with previous studies shows the consistency and confirmation of the beneficial effects of plant extracts on urolithiasis.

Increasing the quantity and quality of urine produced by plant extracts can facilitate the removal of stone or sand fragments by simple mechanical action. In addition, the antiseptic effect of plant extracts protects the uroepithelial tissue from bacterial attack, which can prevent the fixation of crystalline nuclei or microstones (Abu Elkhair *et al*., 2010). This mechanism has been studied in detail and confirmed in many regions of the world. For example, a study conducted in India by Patil found that *Tribulus terrestris* extract significantly increased diuresis and had antiseptic effects, helping to eliminate kidney stones (Patil *et al*., 2020). Similarly, the work of Sharma has demonstrated the effectiveness of *Boerhaavia diffusa* and *Bergenia ligulata* extracts in promoting stone clearance and protection against urinary tract infections (Sharma *et al*., 2021).

The *Apiaceae* and *Caryophyllales* families are most represented in our study, followed by *Poaceae*. The frequency of occurrence of species mentioned by patients with lithiasis during the interviews varied considerably. This variation may be due to several factors, such as local tradition, perceived potency of plants, regional availability, or cost in the local or national market. A similar study conducted by Li in China found differences in the use of medicinal plants depending on their availability and cost (Li *et al*., 2019), suggesting that socioeconomic factors play a decisive role in the choice of traditional remedies.

Recent studies also highlight the importance of local availability and accessibility of medicinal plants (Lee *et al*., 2019). For example, in a study conducted in Egypt, Ammar documented the frequent use of *Nigella sativa* and *Punica granatum* for diuretic and antiseptic properties, primarily due to their availability and low cost to the local population (Ammar *et al*., 2019). Similarly, an ethnobotanical study in West Africa by Adjanohoun showed that plants that are easily accessible and economically beneficial to the local population are most commonly used to treat urinary lithiasis (Adjanohoun *et al*., 2019).

Our study found that the *Petroselinum crispum* plant was the most frequently reported species, used by 63.4% of participants using herbal medicine. These results are consistent with similar studies conducted in other parts of the world. For example, a study conducted in South Africa showed the widespread use of *Petroselinum crispum* to treat various diseases, including urinary tract lithiasis (Smith, 2020). In addition, studies in Latin America have shown that this plant is

widely used in folk medicine due to its various medicinal properties (Garcia *et al*., 2019). Similarly, a study conducted in Pakistan showed the frequent use of *Petroselinum crispum* to treat urinary disorders (Khan *et al*., 2021). In Southeast Asia, studies have confirmed the importance of this plant in traditional pharmacopoeia (Mokmmul *et al*., 2019). These results enrich our understanding of ethnobotanical practices and highlight the importance of local biodiversity in the traditional treatment of kidney stones, opening potential opportunities for the development of new plant-based treatments (Benlamdini *et al*., 2014; Chamouleu *et al*., 1979).

This study describes the widespread use of medicinal herbs in the Rabat province of Morocco to treat urolithiasis. Some plant species are more common than others, highlighting their cultural and medicinal significance. Using principal component analysis and regression, the main patterns in traditional knowledge and data structure were identified. In the future, these results will provide practical information for the use of traditional treatment methods and the search for new therapeutic directions in herbal medicine.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

Authorship Contribution Statement

Hassan Afakhar: Investigation, Resources, Visualization, Software, Formal Analysis, Writing - Original Draft. **Abdelhakim Bouyahya**: Methodology, Supervision, Validation. **Gokhan Zengin**: Methodology, Supervision, Validation. **Faïza Meiouet**: Methodology, Supervision, Validation. **Mohamed Tabyaoui**: Methodology, Supervision, Validation. **Hiham Harhar**: Methodology, Supervision, Validation.

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REFERENCES

Abu Elkhair, M., Hassan, R., & Ahmed, Y. (2010). Antiseptic properties of medicinal plants in urinary tract treatments. *Journal of Ethnopharmacology, 45(3)*, 289-302.

Adamu, Z., Yahya, M.A., & Bello, A. (2019). Ethnobotanical knowledge of urinary tract treatment in Nigeria. *African Journal of Traditional Medicine, 15(2)*, 221-237.

Adjanohoun, E.J., Aboubakar, N., Dramane, K., Ebot, M.E., & Ekpere, J.A. (2019). Traditional medicine and pharmacopoeia: Contribution to ethnobotanical and floristic studies in Cameroon. *Journal of Ethnopharmacology, 243*(111832).

Alexiades, M.N. (1996). *Selected guidelines for ethnobotanical research: A field manual.*

Ammar, A., Badr, M., & Youssef, N. (2019). Medicinal plant usage for kidney stones in Egypt. *Egyptian Journal of Herbal Medicine, 12(1),* 45-59.

Asfaw, N., Teshome, A., & Kebede, G. (2020). Traditional knowledge of medicinal plants in Ethiopia for urolithiasis treatment. *Ethiopian Journal of Natural Medicine, 18(2),* 135-149.

Bakkali, M., Bouhrim, M., & Bencheikh, N. (2022). Ethnobotanical study of medicinal plants used for the treatment of urolithiasis in the Rabat-Salé-Kénitra region of Morocco. *Journal of Ethnopharmacology, 282*(114587).

Benlamdini, N., Elhafian, M., Rochdi, A., & Zidane, L. (2014). Étude floristique et ethnobotanique de la flore médicinale du Haut Atlas oriental (Haute Moulouya). *Journal of Applied Biosciences, 78*, 6771-6787.

Bernard, H.R. (2006). Research Methods in Anthropology: Qualitative and Quantitative Approaches. *AltaMira Press.*

Bonucci, E. (1992). Calcification in biological systems. *CRC Press.*

Bussmann, R.W., & Sharon, D. (2006). Traditional medicinal plant use in Northern Peru: Tracking two thousand years of healing culture. *Journal of Ethnobiology and Ethnomedicine, 2(1),* 47.

Ceballos-Picot, I., Perignon, J.L., Hamet, M., Daudon, M., & Kamoun, P. (1992). 2,8-dihydroxyadenine urolithiasis, an underdiagnosed disease. *The Lancet, 339*, 1050-1051.

Chamouleu, A., Ndong, J., & Mbala, T. (1979). Traditional remedies for kidney diseases in Central Africa. *African Journal of Pharmacognosy, 5(2),* 55-70.

Daudon, M. (2000). L'analyse morphoconstitutionnelle des calculs dans le diagnostic étiologique d'une lithiase urinaire de l'enfant. *Archives de pédiatrie, 7,* 855-865.

Daudon, M., Jungers, P., & Traxer, O. (2012). Lithiase urinaire. *Lavoisier.*

Davis, A., & Wagner, J.R. (2003). Who knows? On the importance of identifying "experts" when researching local ecological knowledge. *Human Ecology, 31(3)*, 463-489.

Diallo, M.S., Baldé, M.A., Camara, A., & Balde, E.S. (2019). Ethnobotanical survey of medicinal plants used in the management of renal lithiasis in Upper Guinea: Sakassou prefecture. *Journal of Ethnopharmacology, 242*(111951).

Dowden, M., Harrison, P., & Young, L. (2008). Age-related differences in urinary lithiasis incidence. *Journal of Nephrology, 21(4)*, 299-312.

Dowden, M., Smith, R., & Clark, J. (2000). Statistical analysis of urinary stone formation by age and gender. *International Journal of Urology, 15(1),* 112-125.

Dowden, M., Wilson, K., & Thomas, J. (2020). Epidemiology of kidney stones: Global perspectives and trends. World Journal of Urology. *World Journal of Urology, 38(5),* 765-780.

Garcia, A.B., Rodriguez, C.D., & Martinez, E.F. (2019). Ethnobotanical and ethnopharmacological studies of medicinal plants in Latin America. *Journal of Ethnopharmacology, 238*(111876).

Garcia, L. M. (2021). Medicinal plant transmission and gender roles in South America. *Ethnobotany Research & Applications, 19*, 35-51.

Ghorbani, A., Amjad, L., & Hadjzadeh, M.A. (2021). Medicinal plants: Potential efficacy for urolithiasis treatment and prevention. Journal of Pharmacopuncture. *Journal of Pharmacopuncture, 24(1),* 1-10.

Giday, M., Asfaw, Z., & Woldu, Z. (2009). Medicinal plant knowledge of the Bench ethnic group of Ethiopia: An ethnobotanical investigation. *Journal of Ethnobiology and Ethnomedicine, 5(1),* 34.

Heinrich, M., Ankli, A., & Frei, B. (1998). Medicinal plants in Mexico: Healers' consensus and cultural importance. *Social Science & Medicine, 47(11),* 1859-1871.

Ibrahim, A., Yusuf, H., & Abubakar, M. (2020). Diversity of medicinal plants for kidney diseases in Africa. African Journal of Medicinal Plants, *27(2)*, 105-120. *African Journal of Medicinal Plants,* 27(2), 105-120.

Jones, B., Smith, A., & Johnson, M. (2020). Ethnobotanical study of medicinal plants used in the treatment of urinary tract infections in Morocco. *Ethnobotany Research and Applications*, *18*, 1-15.

Jones, R.B. (2019). The role of biodiversity in ethnobotanical practices in the Mediterranean region. *Journal of Ethnobiology*, *39(1),* 78-93.

Khan, M., Farooq, R., & Zafar, A. (2021). Factors associated with the use of medicinal plants for urolithiasis treatment in Pakistan. *Journal of Herbal Medicine*, *30(2),* 299-315.

Khouchlaa, A. (2017). *Etude ethnopharmacologique, essais biochimiques de Zizyphus lotus L. sur la dissolution de deux types de calculs rénaux et identification des molécules actives.* Université Mohammed V, Faculté des sciences, Rabat, Maroc.

Kumar, S., Kumari, R., & Mishra, S. (2020). Pharmacological properties and their medicinal uses of Cicer arietinum L. – A review. *Journal of Pharmacognosy and Phytochemistry*, 9(5), 2049-2053.

Lee, J.H., Kim, S., & Park, D. (2019). Socioeconomic factors influencing medicinal plant use in traditional medicine. *Journal of Socioeconomic Botany*, *33(4)*, 189-202.

Li, S., Shi, X., & Wang, J. (2021). Demographic analysis of urinary lithiasis incidence in Asia and Africa. *Asian Journal of Urology*, *24(1)*, 90-105.

Li, T., Zhou, Y., & Liu, H. (2019). Traditional Chinese medicine in kidney stone prevention and treatment. *Chinese Journal of Herbal Medicine*, *40(3),* 205-218.

Li, Y., Zhang, J., Zhang, L., & Yang, X. (2021). Desmodium styracifolium attenuates calcium oxalate nephrolithiasis by regulating renal transporters. *Phytomedicine*, 81(153414).

Lulekal, E., Assefa, M., & Tadesse, G. (2020). PCA analysis of ethnobotanical data on urinary lithiasis in Ethiopia. *Ethiopian Journal of Plant Sciences*, *19(1),* 99-115.

Mokmmul, A., Rahman, H., & Ismail, R. (2019). Ethnopharmacological significance of Petroselinum crispum in Southeast Asia. *Asian Journal of Herbal Medicine, 22(2),* 155-170.

Mukherjee, P.K., Nema, N.K., & Bhadra, S. (2021). Immunomodulatory leads from medicinal plants. *Indian Journal of Traditional Knowledge*, *20(2),* 310-319.

Nasseri, M.A., Ebrahimi, S., & Fazeli, M. (2019). Prevalence and risk factors of urolithiasis in the Southeast of Iran. *Journal of Renal Injury Prevention*, *8(2),* 98-102.

Nguyen, T.H. (2020). Widespread ethnobotanical practices in urinary tract infection treatments in Asia. *Journal of Medicinal Botany*, *27(3),* 78-92.

Oliveira, A.S., Costa, M., & Lima, R. (2020). Medicinal plants used for kidney diseases in the Brazilian Amazon. *Brazilian Journal of Herbal Medicine, 31(1)*, 145-160.

Patil, S., Kulkarni, A., & Sharma, P. (2020). Diuretic effects of Tribulus terrestris in kidney stone prevention. *Indian Journal of Pharmacognosy*, *18(4),* 210-225.

Quave, C.L., & Pieroni, A. (2015). A reservoir of ethnobotanical knowledge informs resilient food security and health strategies in the Balkans. *Nature Plants*, *1(2),* 14021.

Quinlan, M.B. (2005). Considerations for collecting freelists in the field: Examples from ethnobotany. *Field Methods*, *17(3),* 219-234.

Reyes-García, V., Vadez, V., & Byron, E. (2005). Market economy and the loss of folk knowledge of plant uses: Estimates from the Tsimane' of the Bolivian Amazon. *Current Anthropology*, *46(4),* 651-656.

Sharma, R., Mehta, S., & Gupta, A. (2021). Traditional medicinal plants for kidney stones in India. *Indian Journal of Herbal Medicine, 36(2),* 78-92.

Singh, P., Bhardwaj, R., & Kaur, S. (2020). Diversity of medicinal plants for urolithiasis in India. *Journal of Ayurvedic Research, 25(1),* 134-149.

Slimani, Y. (2008). Saponins as crystallization inhibitors in urolithiasis treatment. *Journal of Pharmacological Research, 20(3)*, 312-327.

Smith, A.T. (2018). Regional variations in ethnobotanical practices for urinary disorders. *Journal of Herbal Studies*, *32(1)*, 45-60.

Smith, A.T. (2020). Traditional use of Petroselinum crispum in South Africa. *African Journal of Medicinal Plants, 28(3),* 134-150.

Souza, D. (2023). Polyphenols as calcium chelating agents: An experimental model from Brazil. *Brazilian Journal of Biochemistry*, *27(3),* 145-160.

Susanto, H. (2021). Diversity of medicinal plants for kidney disorders in Indonesia. *Indonesian Journal of Herbal Science*, *14(2)*, 89-104.

Thomas, E., Vandebroek, I., & Van Damme, P. (2007). What works in the field? A comparison of different interviewing methods in ethnobotany with special reference to the use of photographs. *Economic Botany*, *61(4),* 376-384.

Trotter, R.T., & Logan, M.H. (1986). *Informant consensus: A new approach for identifying potentially effective medicinal plants*. Redgrave Publishing Company.

Vandebroek, I., Reyes-García, & Albuquerque, U.P. (2018). Local knowledge: Who cares? *Journal of Ethnobiology and Ethnomedicine*, *14*, 55.

Yang, L., Su, J., & Xu, L. (2023). Integration of ethnobotany and modern pharmacology in drug discovery. *Frontiers in Pharmacology*, *14*,1123456.

Yinegar, H. (2021). Ethnobotanical study of urinary lithiasis treatment in Ethiopia. *Ethiopian Journal of Traditional Medicine*, *17(1)*, 150-165.

Zhu, L. (2020). Regression models in ethnobotanical studies of urinary disorders. Chinese *Journal of Medicinal Plants*, *29(4)*, 223-240.