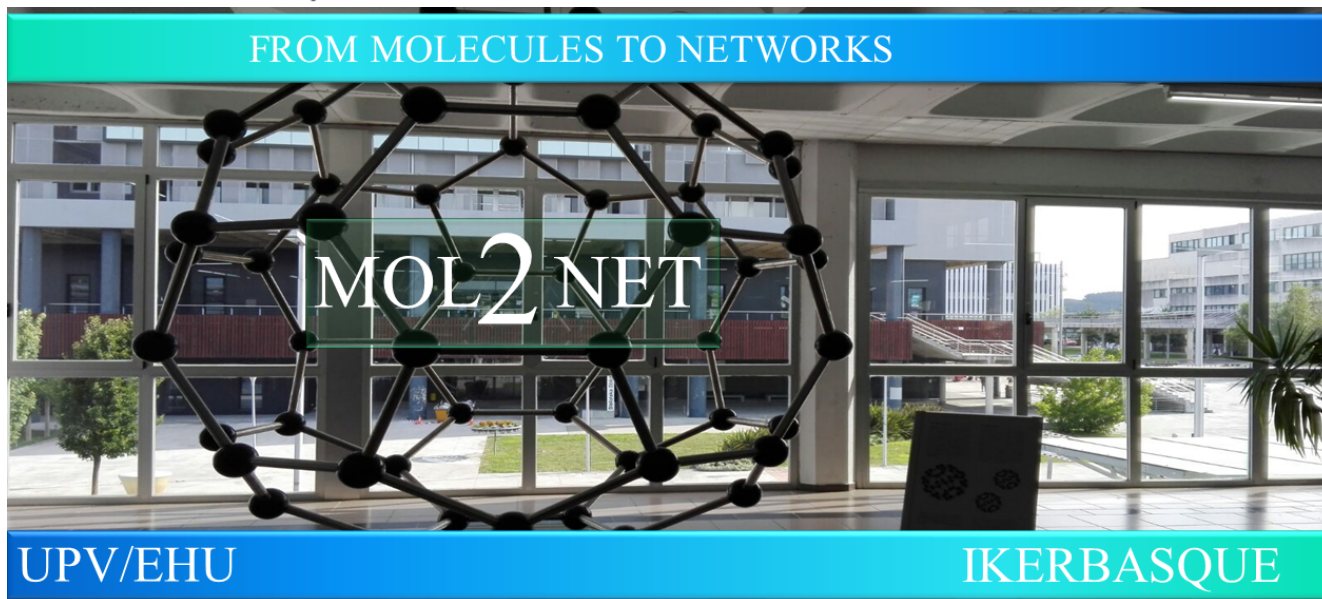




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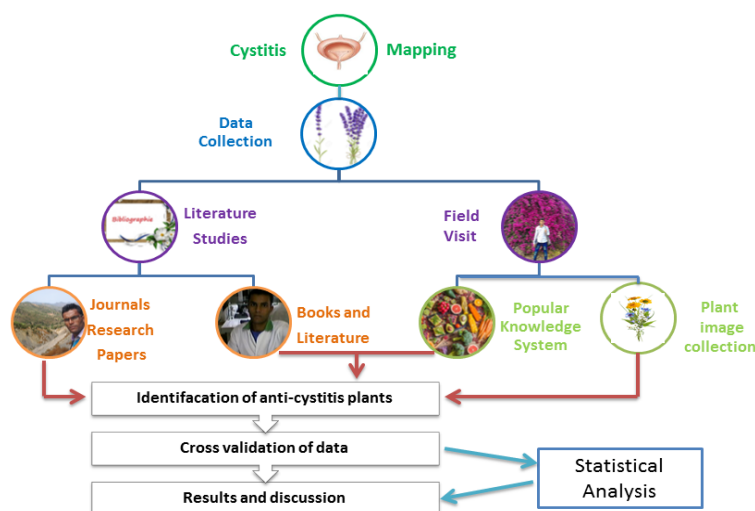
Ethnomedicinal Study of Medicinal Plants Used Traditionally for Cystitis Treatment by the Rural People of Rif, Northern Morocco

Noureddine Chaachouay ^{a,*}, Lahcen Zidane ^b.

^a Agri-Food and Health Laboratory (AFHL); Hassan First University; Address: Po Box 382, 26000 Settat, Morocco

^b Plant, Animal Productions and Agro-industry Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, B.P. 133 14000, Kenitra, Morocco.

Graphical Abstract



Abstract

Cystitis is an inflammatory condition that primarily affects the bladder. It is often caused by a bacterial infection, with bacterial cystitis being the most common type among various urinary tract infections. This research aimed to extensively document ethnobotanical knowledge regarding the use of medicinal plants for treating cystitis due to their proven therapeutic properties. The study was conducted in the Rif region from March 1st, 2020, to April 15th, 2020. Semi-structured direct interviews were conducted with 657 participants to gather indigenous therapeutic wisdom. These surveys included information about the interviewees' demographics and ethnomedicinal practices. UR and MUV techniques were employed in data analysis. A total of 60 plant species, distributed among 51 genera and 31 families, were commonly used by our interviewees for cystitis therapy. Apiaceae had the highest representation of seven species, and *Capparis spinosa* L. was the most frequently recommended medicinal plant by the local population. Leaves were the most commonly utilized plant part (41.5%), and most herbal remedies were prepared through decoction (55%). This study constitutes the initial contribution to the ethnobotanical exploration of this region. It is recommended that the natural plant species identified in this research be further investigated to uncover their therapeutic effects and mechanisms of action. Primary attention should be given to conserving medicinal species, thoroughly documenting widespread medicinal knowledge, and biologically validating the listed species.

Keywords: Cystitis; Ethnomedicine; Herbal remedies; Medicinal plants; Medicinal knowledge.

Introduction

Urinary infections represent a significant global public health concern. These infections include urethritis, uncomplicated acute cystitis, recurrent acute cystitis, simple acute pyelonephritis, and urinary infections affecting pregnant and postmenopausal women [1]. Cystitis, known as "Nboula" in the Moroccan dialect, is a medical condition characterized by inflammation of the bladder, typically triggered by bacterial infections, notably *Escherichia coli*, *Proteus*, and *Enterobacter*, collectively referred to as urinary tract infections. If left untreated, a bladder infection can cause discomfort and pose serious health risks if the infection spreads to the kidneys.

Addressing urinary infections in Morocco presents unique challenges, primarily linked to limited access to healthcare services in private and public healthcare facilities. Moreover, there needs to be more comprehensive evaluation and monitoring of patient care, leading to uncertainties regarding the evolution of antibiotic resistance and the misuse of antibiotics.

In contemporary times, despite the availability of pharmaceutical drugs for treating urinary tract conditions, there is a resurgence of interest in herbal remedies as a source of active compounds. Additionally, a significant portion of the population prefers medicinal plants, particularly in rural areas, due to economic constraints and difficulties accessing conventional medical care. Notably, it has been observed that a substantial percentage of *Escherichia coli* strains associated with urinary infections, ranging from 8% to 65%, exhibit resistance to ciprofloxacin, a commonly prescribed antibiotic for such conditions [2].

This research aims to compile a list of medicinal plants used in the treatment of cystitis in the Rif region through ethnobotanical surveys conducted among local residents. Subsequently, we propose categorizing these medicinal plant species based on their usage and presenting them in a catalog format.

Materials and Methods

Study area

The current study was conducted out in the Rif region. It extends between 34° to 36° of latitude in the North and 4° to 6° of longitude in the East. It is bounded in the North by the Strait of Gibraltar and the Mediterranean Sea, in the South by the Rabat-Sale-Kenitra region and Fez-Meknes region, in the East by the Eastern Region, and in the West by the Atlantic Ocean. The total geographical area of the Rif is 11 570 km² and the population of the city is about 3 549 512 inhabitants with an average population density of 222.2/km² [3]. The Rif is marked by Mediterranean weather with the highest temperature up to 45°C during summer (July- August) and below 0°C during winter (December- January) and the average annual rainfall ranges from 700 to 1 300 mm which falls mainly between October and February [4]. The area dominated by species such as *Abies marocana* Trab., *Pinus halepensis* Mill., *Cannabis sativa* L., and *Cedrus atlantica* (Endl.). The population is mixed between Arabic and Amazigh ethnicity. Principally families of this region are very much dependent on the subsistence farming, livestock, and to a more secondary space, from forest resources for their livelihood.

Methodology

To document an indigenous anti-cystitis plant ancestral knowledge and discover the level of utilization of traditional medicinal plants for prevention and therapy of cystitis by the local people (412 male and 245 female) from different rural and urban communes of the Rif region, namely S1 : Al Hoceim (30), S2 : Ajdir (20), S3 : Izezfafen (15), S4 : Bni Hadifa (15), S5 : Targuist (25), S6 : Tizi n Tchin (22), S7 : Issaguen (30), S8 : Bab Berred (30), S9 : Cherrafate (30), S10 : Bab Taza (20), S11 : Derdara (10), S12 : Chefchaouen (30), S13 : Akchour (30), S14 : Fifi (30), S15 : Tétouan (30), S16 : Bni Karrich (30), S17 : Mallalyène (15), S18 : Zinat (30), S19 : Martil (20), S20 : Md'q (20), S21 : Fnideq (20), S22 : Belyounich (30), S23 : Melloussa (30), S24 : Ksar Esghir (25), S25 : Bni Ouassin (15), S26 : Tanger (30), S27 : Al Bahraouiye (15), and S28 : Jouamaa (10), a semi-structured questionnaire was prepared and data were collected through face-to-face interviews over a period between April 30th , 2015 and June 01st , 2017.

Medicinal species being mentioned by the informants were registered with local names and photographed. For each reported plant species, the plant species were accumulated, classified, and voucher specimens were archived at Nutrition, Health, and Environment Laboratory, department of biology. The scientific names were confirmed through specialized literature as well as: The medicinal plants of Morocco [5], Practical flora of Morocco, tomes I, II and III [6–8] and Catalogs of vascular plants of northern Morocco, including identification keys, tomes I and II [9]. Taxonomy and denominations of species were validated using “The Plant List 2020” database (<http://www.theplantlist.org>).

The data collected from the field and obtained from the local people were organized and studied with the statistical program IBM SPSS Statistics 21 Premium (SPSS 2019), to determine the proportions of various variables socio-demographics of the interviewees and ethnobotanical data. Quantitative value records were also determined for the general practices of these medicinal plants using the use reports (UR) and medicinal use-value (MUV).

Results

Demography information of informants

A total of 657 study informants, including 213 Herbalists, 178 herbal sellers, 46 Pharmacist, 40 Midwives, and 180 of other Healers, were interrogated using semi-structured surveys and group interviews. In the study area, both sexes are interested in phytotherapy. However, the numbers of male

participants were more important (412 informants) than those of females (245 informants). In this study, results showed that the utilization of medicinal species is widespread in all age groups with different percentages. The bulk of informants surveyed were over 50 years old (350), and between 30 – 50 years old (304), while 3 of the informants were the age less than thirty years old. Concerning the educational level, our results revealed that the majority of the informants (43%) were uneducated, (29.4%) have secondary education, 26.8% have primary education, and only 0.8% of the informants had high education.

Botanical families of plants used

This investigation revealed that a total of 60 plant species belonging to 51 genera and 31 families were commonly used by local people from the Rif region in the treatment of cystitis. The family Apiaceae was designed by the largest number of plant species (7 species), followed by Ericaceae with 6 species, Lamiaceae, Poaceae, and Rutaceae (4 species each), Asteraceae and Caryophyllaceae (3 species each), whereas, the rest of botanical families were represented by one or two species in each.

Medicinal use plants (MUV)

MUV is used to find the most frequently used plant species in the study area. Its value ranged from 0.200 to 0.277. The calculated results of MUV showed that *Capparis spinosa* L. was ranked first (MUV=0.277) followed by *Apium graveolens* L. (MUV=0.267), *Zizyphus vulgaris* Lam. (MUV=0.247), *Herniaria glabra* L. (MUV=0.233), *Anethum graveolens* L. (MUV=0.224), *Spergularia rubra* (L.) J.Presl & C.Presl (MUV=0.216), and *Nigella sativa* L. (MUV=0.210), while the lowest value was found for *Citrus reticulata* Blanco., *Convolvulus althaeoides* L., and *Eleusine indica* (L.) Gaertn. (MUV=0.200 each).

Parts of the plant used

In the Rif region, indigenous people collect diverse plant parts for the preparation of phytotherapy (e.g., seed, root, flower, and leaf). The discussion result revealed that leaves are the most frequently used part of the medicinal plants 41.5% of the sum, followed by the whole plant (26.5%), fruit (10%), seed (9%), flower (7%) and rhizome (6%).

Modes and routes of medicine preparation

The preparation of herbal remedies needs liquids. The main solution was water, but milk, butter, tea, and honey are also used by the Rif's population. The principal method of traditional medicine preparation reported was decoction (55%), followed by infusion (33.1%), cataplasm (1.4%), and cooked (1.1%). The percentage of the other modes of preparation grouped (fumigation, bath, maceration, powder, and plaster) does not exceed 9.4%. Concerning the route of administration, the majority of informants prepared remedies were applied mostly by oral (73.2%) followed by topical (18.7%), and dermal (8.1%).

Discussion

Our analysis of the results shows that both sexes are involved in phytotherapy. But, the numbers of male informants were more important than those of females. Men were predominantly represented in the sampling because of working. Because of the customs and traditions of the inhabitants of Rif region, women must remain at home. They tend to abide by religious laws and close down the community. This explains the absence of females in the field during our discussions. This result reinforces the conclusions of other ethnobotanical national and international investigations [13-18] which have besides verified that males are more popular vegetative information. For age groups,

results revealed that interviewees above 50 years old had higher knowledge with medicinal species, while interviewees age less than 30 years old were less informed about it; this is due to the high secrecy of ancestral knowledge by older peoples. Concerning the academic level, our results revealed that the bulk of the informants (43 %) were Illiterate. Preceding ethnobotanical investigations papers comparable conclusions [19–24]. This means that with a greater level of education, the experience of traditional phytotherapy decreases. Consequently, advanced instruction diminishes the ancestral therapeutic experience of the young generation [25–28].

The floristic analysis showed that a total of 60 plant species belonging to 51 genera and 31 botanical families were commonly utilized by local people in the therapy of cystitis. The botanical family Apiaceae was described by the most important number of medicinal plants (7 species) followed by Ericaceae with 6 species. The determined results of MUV noted that *Capparis spinosa* L. was ranked first (MUV=0.277) followed by *Apium graveolens* L. (MUV=0.267), *Zizyphus vulgaris* Lam. (MUV=0.247). These results are compared to other studies especially in Morocco and Fars Province of Iran [19, 20]. These plant species producing leading MUV must be further evaluated for toxicological, phytochemical, and pharmacological investigations to know their active components for an efficient and non-toxic medicine extraction.

The interview results revealed that leaf is the most frequently used part of the plants 41.5% of the total, followed by whole plant (26.5%) and fruit (10%). The selection of leaves was due to its natural availability, easy gathering, and simplicity in herbal remedy preparation. Besides, the leaves are the site of photosynthesis, and sometimes the storage of the secondary metabolites active for the pharmaceutical properties of the medicinal plant. Similar results indicated that the leaf is used as a principal part of plants in phytotherapy in different studies. [29–36].

The principal method of remedies preparation described by our interviewees was decoction (55%). The frequent employment of the decoction can be justified by the evidence that this method makes it possible to conserve the effective multiple ingredients and attenuates or eliminates out the poisonous result of some plant constituents. Ethnobotanical researches carried in many regions of the globe discovered that the majority of informants prepared herbal remedies by decoction and infusion [12, 15, 37–46]. This result confirms that there is a continual transfer of information on the effectiveness of medicinal plants between the people of Morocco. Concerning the route of administration, the main route of application for herbal medicines was oral (82.4%). Moreover, the oral form of treatment is a preferred route all over the planet [47–54]. The predominance of oral treatment can be explained by the fact that cystitis is a common internal disease that is decimating the health of the Rif's population.

Conclusions

The findings from our current study highlight the continued significance of medicinal plants in fulfilling the essential healthcare requirements of the local population in the Rif region despite the advancements in modern healthcare technology. The fact that many plant species were identified and utilized by individuals to treat cystitis is compelling evidence that this region boasts a wealth of inherited medical knowledge that has been passed down through generations. Given the promising implications of these findings, it is strongly recommended that further research efforts be directed toward the sustainable and responsible utilization and preservation of these medicinal plant species. Additionally, we should embark on comprehensive pharmacological, phytochemical, and toxicological

investigations about the species documented in our inventory. This laboratory-based validation of the ancestral uses of these plants would not only facilitate the development of traditional medicinal formulations but also contribute to creating a repository for traditional medicine biosciences.

References

- [1] Ansari MKA, Iqbal M, Chaachouay N, Ansari AA, Owens G. The Concept and Status of Medicinal and Aromatic Plants: History, Pharmacognosy, Ecology, and Conservation. In: *Plants as Medicine and Aromatics*. CRC Press; 2023. p. 129-44.
- [2] O. World Health, WHO traditional medicine strategy: 2014-2023. World Health Organization, 2013.
- [3] Chaachouay N, Azeroual A, Douira A, Zidane L. Ethnoveterinary practices of medicinal plants among the Zemmour and Zayane tribes, Middle Atlas, Morocco. *South Afr J Bot*. 2022;151:826-40.
- [4] Chaachouay N, Benkhniq O, Fadli M, El Ibaoui H, Zidane L. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. *Heliyon*. 2019;5(10):e02191.
- [5] HCP, « Haut-commissariat au plan, Monographie de la région Tanger Tétouan Al Hoceima, Direction Régionale de Tanger-Tétouan-Al Hoceima. », oct. 2018.
- [6] DMNM, « Direction de la Météorologie Nationale, Maroc », 2018.
- [7] C. M. Cotton et P. Wilkie, *Ethnobotany: principles and applications*. John Wiley & Sons Chichester, 1996.
- [8] G. J. Martin, *Ethnobotany: a methods manual*, vol. 1. Springer, 2014.
- [9] Chaachouay N, Douira A, Zidane L. COVID-19, prevention and treatment with herbal medicine in the herbal markets of Salé Prefecture, North-Western Morocco. *Eur J Integr Med*. 2021;42:101285.
- [10] Orch H, Chaachouay N, Douiri EM, Faiz N, Zidane L, Douira A. Use of medicinal plants in dermatocosmetology: An ethnobotanical study among the population of Izarène. *Jordan Journal of Pharmaceutical Sciences*. 2021;323-40.
- [11] Chaachouay N, Belhaj S, El Khomsi M, Benkhniq O, Zidane L. Herbal remedies used to treat digestive system ailments by indigenous communities in the Rif region of northern Morocco. *Vegetos* [Internet]. 30 mars 2023 [cité 7 juin 2023]; Disponible sur: <https://doi.org/10.1007/s42535-023-00606-4>
- [12] B. Valdés, *Catalogue des plantes vasculaires du Nord du Maroc, incluant des clés d'identification*, vol. 1. Editorial CSIC-CSIC Press, 2002.
- [13] M. Fennane, M. Ibn Tattou, et J. El Oualidi, « Flore pratique du Maroc, Dicotylédones (pp), Monocotylédones », *Trav. L'Institut Sci. Rabat Sér. Bot.*, vol. 40, 2014.
- [14] M. Fennane, M. I. Tattou, et B. Valdés, *Catalogue des plantes vasculaires rares, menacées ou endémiques du Maroc*. Herbarium Mediterraneum Panormitanum, 1998.
- [15] Chaachouay N, Benkhniq O, Fadli M, El Ibaoui H, El Ayadi R, Zidane L. Ethnobotanical and Ethnopharmacological Study of Medicinal and Aromatic Plants Used in the Treatment of Respiratory System Disorders in the Moroccan Rif. *Ethnobot Res Appl*. 2019;18:1-16.
- [16] S. A. Mori, B. M. Boom, et A. M. de Carvalino, « Ecological importance of Myrtaceae in an eastern Brazilian wet forest », *Biotropica*, vol. 15, no 1, p. 68–70, 1983.

- [17] Chaachouay N, Ouafae B, Zidane L. Ethnomedicinal study of medicinal and aromatic plants used against dermatological diseases by the People of Rif, Morocco. *J Herb Med.* 2022;100542.
- [18] N. Chaachouay, O. Benkhniq, M. Fadli, H. El Ibaoui, R. El Ayadi, et L. Zidane, « Ethnobotanical and Ethnopharmacological Study of Medicinal and Aromatic Plants Used in the Treatment of Respiratory System Disorders in the Moroccan Rif », *Ethnobot. Res. Appl.*, vol. 18, p. 1–16, 2019.
- [19] J. Friedman, Z. Yaniv, A. Dafni, et D. Palewitch, « A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel », *J. Ethnopharmacol.*, vol. 16, no 2-3, p. 275–287, 1986.
- [20] Chaachouay N, Douira A, Zidane L. Herbal Medicine Used in the Treatment of Human Diseases in the Rif, Northern Morocco. *Arab J Sci Eng.* 2021;1-23.
- [21] M. S. Amiri, M. R. Joharchi, et M. E. TaghavizadehYazdi, « Ethno-medicinal plants used to cure jaundice by traditional healers of Mashhad, Iran », *Iran. J. Pharm. Res. IJPR*, vol. 13, no 1, p. 157, 2014.
- [22] Chaachouay N, Benkhniq O, Douira A, Zidane L. Poisonous medicinal plants used in the popular pharmacopoeia of the Rif, northern Morocco. *Toxicon.* 2021;189:24-32.
- [23] Chaachouay N, Azeroual A, Bencharki B, Douira A, Zidane L. Ethnoveterinary medicines plants for animal therapy in the Rif, North of Morocco. *South Afr J Bot.* 2022;147:176-91.
- [24] A. Cheikhyoussef, M. Shapi, K. Matengu, et H. M. Ashekele, « Ethnobotanical study of indigenous knowledge on medicinal plant use by traditional healers in Oshikoto region, Namibia », *J. Ethnobiol. Ethnomedicine*, vol. 7, no 1, p. 10, 2011.
- [25] Benlarbi F, Mimoune N, Chaachouay N, Souttou K, Saidi R, Mokhtar MR, et al. Ethnobotanical survey of the traditional antiparasitic use of medicinal plants in humans and animals in Laghouat (Southern Algeria). *Vet World.* 24 févr 2023;357-68.
- [26] Benkhniq O, Chaachouay N, Khamar H, El Azzouzi F, Douira A, Zidane L. Ethnobotanical and ethnopharmacological study of medicinal plants used in the treatment of anemia in the region of Haouz-Rehamna (Morocco). *J Pharm Pharmacogn Res.* 2022;10(2):279-302.
- [27] S. Getaneh et Z. Girma, « An ethnobotanical study of medicinal plants in Debre Libanos Wereda, Central Ethiopia », *Afr J Plant Sci*, vol. 8, no 7, p. 366–79, 2014.
- [28] Chaachouay N, Douira A, Hassikou R, Brhadda N, Dahmani J, Belahbib N, et al. Etude floristique et ethnométriciale des plantes aromatiques et médicinales dans le Rif (Nord du Maroc) [Internet] [phdthesis]. Département de Biologie - Université Ibn Tofail - Kénitra; 2020 [cité 18 oct 2021]. Disponible sur: <https://tel.archives-ouvertes.fr/tel-03376377>
- [29] M. F. Kadir, M. S. B. Sayeed, T. Shams, et M. M. K. Mia, « Ethnobotanical survey of medicinal plants used by Bangladeshi traditional health practitioners in the management of diabetes mellitus », *J. Ethnopharmacol.*, vol. 144, no 3, p. 605–611, 2012.
- [30] Chaachouay N, Benkhniq O, Fadli M, El Ayadi R, Zidane L. Ethnobotanical study of medicinal plants used to treat osteoarticular diseases in the Moroccan Rif, Morocco. *J Pharm Pharmacogn Res.* 2019;7(6):454-70.
- [31] B. Benarba, B. Meddah, et A. Tir Touil, « Response of bone resorption markers to *Aristolochia longa* intake by Algerian breast cancer postmenopausal women », *Adv. Pharmacol. Sci.*, vol. 2014, 2014.
- [32] Chaachouay N, Orch H, Zidane L. Cystitis treatment with phytotherapy within the Rif, Northern Morocco. *Future Journal of Pharmaceutical Sciences.* SpringerOpen. 2021;1-9.

- [33] Chaachouay N, Zidane L. Neurological Phytotherapy by Indigenous People of Rif, Morocco. In: Therapy Approaches in Neurological Disorders. IntechOpen; 2021.
- [34] G. Menendez-Baceta, L. Aceituno-Mata, M. Molina, V. Reyes-García, J. Tardío, et M. Pardo-de-Santayana, « Medicinal plants traditionally used in the northwest of the Basque Country (Biscay and Alava), Iberian Peninsula », J. Ethnopharmacol., vol. 152, no 1, p. 113–134, 2014.
- [35] Benkhniq O, Khamar H, Bussmann RW, Chaachouay N, Zidane L. Ethnobotanical and ethnopharmacological study of medicinal plants used in treating some liver diseases in the Al-Haouz Rehamna region (Morocco). Ethnobot Res Appl. 2 mars 2023;25:1-32.
- [36] A. Noman, I. Hussain, Q. Ali, M. A. Ashraf, et M. Z. Haider, « Ethnobotanical studies of potential wild medicinal plants of Ormara, Gawadar, Pakistan », Emir. J. Food Agric., p. 751–759, 2013.
- [37] Chaachouay N, Azeroual A, Ansari MKA, Zidane L. Use of Plants as Medicines and Aromatics by Indigenous Communities of Morocco: Pharmacognosy, Ecology and Conservation. In: Plants as Medicine and Aromatics. CRC Press; 2023. p. 33-44.
- [38] A. Asase, A. A. Oteng-Yeboah, G. T. Odamtten, et M. S. Simmonds, « Ethnobotanical study of some Ghanaian anti-malarial plants », J. Ethnopharmacol., vol. 99, no 2, p. 273–279, 2005.
- [39] Chaachouay N. Ethnobotanical study of medicinal and aromatic plants used in the treatment of genito-urinary diseases in the Moroccan Rif. J. Mater. Environ. Sci 2020;11(1): 2020.
- [40] M. Ahmad et al., « An Ethnobotanical study of Medicinal Plants in high mountainous region of Chail valley (District Swat-Pakistan) », J. Ethnobiol. Ethnomedicine, vol. 10, no 1, p. 36, 2014.
- [41] Chaachouay N, Azeroual A, Bencharki B, Zidane L. Secondary Ethnopharmacology, Metabolites, and Commercial Application of *Glycyrrhiza glabra*. In book: Medicinal Roots and Tubers for Pharmaceutical and Commercial Applications Edition: 1st Edition Chapter: 7; Publisher: CRC Press, pp 74, 2023; CRC Press.
- [42] N. Mohamadi, F. Sharififar, A. Koohpayeh, et M. Daneshpajouh, « Traditional and Ethnobotanical uses of medicinal plants by ancient populations in Khabr and Rouchon of Iran. », 2015.
- [43] Chaachouay N, Benkhniq O, El Ibaoui H, El Ayadi R, Zidane L. Medicinal plants used for diabetic problems in the Rif, Morocco. Ethnobot Res Appl. 2019;18:1-19.
- [44] B. Sivasankari, M. Anandharaj, et P. Gunasekaran, « An ethnobotanical study of indigenous knowledge on medicinal plants used by the village peoples of Thoppampatti, Dindigul district, Tamilnadu, India », J. Ethnopharmacol., vol. 153, no 2, p. 408–423, 2014.
- [45] H. Khan, M. A. Khan, et Abdullah, « Antibacterial, antioxidant and cytotoxic studies of total saponin, alkaloid and sterols contents of decoction of Joshanda: Identification of components through thin layer chromatography », Toxicol. Ind. Health, vol. 31, no 3, p. 202–208, 2015.
- [46] Chaachouay N, Benkhniq O, Zidane L. Ethnobotanical study aimed at investigating the use of medicinal plants to treat nervous system diseases in the Rif of Morocco. J Chiropr Med. 2020;19(1):70-81.
- [47] J. M. Andrade, H. Lucero Mosquera, et C. Armijos, « Ethnobotany of indigenous Saraguros: medicinal plants used by community healers “Hampiyachakkuna” in the San Lucas parish, southern Ecuador », BioMed Res. Int., vol. 2017, 2017.
- [48] J. L. Betti, O. D. Yongo, D. O. Mbomio, D. M. Iponga, et A. Ngoye, « An ethnobotanical and floristical study of medicinal plants among the Baka Pygmies in the periphery of the Ipassa-Biosphere reserve, Gabon », Eur. J. Med. Plants, p. 174–205, 2013.

- [49] N Chaachouay, A Azeroual, L Zidane. Taxonomy, Ethnobotany, Phytochemistry and Biological Activities of *Thymus Saturejoides*: A Review. *Acta Botanica Hungarica* 2023;65(1-2), 35-51
- [50] N Chaachouay, A Azeroual, B Bencharki, A Douira, L Zidane. *Cannabis sativa* L.: A Review on Traditional Uses, Botany, Phytochemistry, and Pharmacological Aspects. *Trad Integr Med.* 2023;8(1):97-11
- [51] M. Ullah et al., « An ethnobotanical survey of indigenous medicinal plants in Wana district south Waziristan agency, Pakistan », *J. Ethnopharmacol.*, vol. 150, no 3, p. 918–924, 2013.
- [52] N Chaachouay, A Azeroual, B Bencharki, A Douira, L Zidane. Various Metabolites and or Bioactive Compounds from Vegetables, and Their Use Nanoparticles Synthesis, and Applications. In: Husen, A. (eds) *Nanomaterials from Agricultural and Horticultural Products*. *Smart Nanomaterials Technology*. Springer, Singapore. 2023; pp 187–209 https://doi.org/10.1007/978-981-99-3435-5_10
- [53] N Chaachouay, A Azeroual, B Bencharki, L Zidane. Food safety and biotechnological products. Genomics, Transcriptomics, Proteomics and Metabolomics of Crop Plants. *Plant Biology, Sustainability and Climate Change*. edited by Azamal Husen and Altaf Ahmad; Elsevier. 2023; Pages 353-363. <https://doi.org/10.1016/B978-0-323-95989-6.00017-6>
- [54] N Chaachouay, A Azeroual, B Bencharki, A Douira, L Zidane. Hormonal interactions during fruit development and ripening. *Hormonal Cross-Talk, Plant Defense and Development: Plant Biology, Sustainability and Climate Change*, edited by Azamel Husen and Wenying Zhang. Academic Press; 2023; 37-46
- [55] N Chaachouay, A Azeroual, L Zidane. Ethnobotany, Ethnopharmacology, and Traditional Uses of Medicinal and Aromatic Plants. In: Adnan, M., Patel, M., & Snoussi, M. (Eds.). *Ethnobotany and Ethnopharmacology of Medicinal and Aromatic Plants: Steps Towards Drug Discovery* (1st ed.). 2023; CRC Press. <https://doi.org/10.1201/b22842>