Ethnobotanical survey on threatened medicinal plants in Togo

K. M. L. AGBODAN[1*], A. AKODEWOU[2], K. B. AMEGNAGLO[1], A. BAWA[3], S. AKPAVI[1], K.AKPAGANA[1]

[1] *Laboratory of Botany and Plant Ecology, University of Lomé, Togo*

[2] *Forests and Societies Research Unit, CIRAD, Montpellier, France*

[3] *Laboratory of Applied Agronomic and Biological Sciences, University of Kara, Togo*

[*] *Corresponding author agbodana@gmail.com*

Received 09/11/2023
Accepted 20/12/2023

Abstract

Local communities heavily rely on the use of plants for disease treatment, notwithstanding modern medicine's progress. However, climate change and anthropic actions exacerbate threat to these medicinal plant's survival. This study aims to list Threatened Medicinal Plants (TMP) in the Guinean Zone of Togo and to access community's traditional knowledge about them. For this purpose, 31 localities were investigated and ethno-medicinal data was collected through semi-structured methods, including individual interviews and focus groups. A total, of 124 TMP were recorded, belonging to 118 genera and 47 families. The top five plant taxa were *Khaya senegalensis* (49.4%), *Sarcocephalus latifolius* (35.5%), *Zanthoxylum zanthoxyloides* (26.1%), *Flueggea virosa* (19.3%) and *Caesalpinia bonduc* (19.0%). The plant parts and mode of preparation most used were respectively leaves (64.8%) and decoction (76.6%). The high Informant Consensus Factor (IFC) (0.79) calculated shows strong agreement on TMP usage according to the disease categories identified. TMP such as *K. grandifoliola*, *K. senegalensis, A. africana, G. afzelii, V. paradoxa, P. erinaceus* and *M. excelsa* are vulnerable worldwide according to IUCN criteria. Safeguarding these TMP through their domestication and culture will help to safeguarding TMP and the traditional knowledge about them.

Keywords: Threatened medicinal plant, ethnobotany, conservation, Togo

INTRODUCTION

Plant genetic resources provide a multitude services for all human-being across the world (Thiombiano *et al.*, 2022). They are still used in numerous fields, and their medicinal use is highly valued (Sofowora, 2010; Chukwuma *et al.*, 2015). Despite the progress of modern medicine (Motto *et al.*, 2021), plant drugs are gaining in popularity among populations (Gadikou *et al.*, 2022), especially in these post Covid-19 times (Haidara *et al.*, 2020), because plant drugs are considered to be less toxic and milder than pharmaceutical product (Briki, 2019; Delhami *et al.*, 2022). As result, 70–95% African people use plants for the treatment of primary symptoms. The plants knowledge (Atakpama *et al.*, 2021), the trust and the medicinal efficacy of plant recipes (Kpoyizoun *et al.*, 2019), and the populations impoverishment (Ouro-Djeri *et al.*, 2022) explain this high increase in plant use (Agbodan, 2023). These reasons have increased anthropic action on medicinal resources, leading to the scarcity of some medicinal phytogenetic resources (Ouro-Djeri *et al.*, 2022). In addition, climate change (Elith *et al.*, 2011; Cain and Douzet, 2022) combined with ecosystem fragility (Adjossou *et al.*, 2022) hampers the chances of survival and perpetuation of medicinal plant species, which are a cultural legacy for various populations (Salako *et al.*, 2021; Favi *et al.*, 2022; Xu *et al.*, 2022). Plants that were once highly prized for treating diseases are seeing their habitat reduced and threatened (Gadikou *et al.*, 2022). There is a need to survey scarce and threatened medicinal plants and their related local knowledge for their conservation to next generations. This study contributes to the conservation of threatened medicinal plants (TMP) with their local knowledge. To the best author's knowledge, the available information on TMP in the Guinean zone is far from exhaustive. Although previous ethnobotanical surveys of medicinal plants have been conducted in the study area (Agody, 2007; Gnondoli *et al.*, 2015; Holaly *et al.*, 2015; Kpodar *et al.*, 2015; Agbodeka *et al.*, 2016; Kpodar *et al.*, 2016; Agbodeka *et al.*, 2017; Gbekley *et al.*, 2017; Effoe *et al.*, 2020; Atakpama *et al.*, 2021; Gadikou *et al.*, 2022; Ouro-Djeri *et al.*, 2022), few investigations have focused on TMP. Consequently, this work would provide a useful update to a database for the preservation and promotion of ancestral TMP knowledge. Knowledge about diversity and local knowledge of TMP will allow for giving a priority on their conservation. This study aims to (i) list threatened medicinal plants in the Guinean zone of Togo, and (ii) inventory the medicinal uses of these TMP.

MATERIAL ET METHODS

Study area

The choice of the Guinean zone is based on its abundant plant diversity and the pressures from agricultural and urban expansion on the local ecosystem. The study area can be divided into three ecological zones (Ern, 1979). The plains zone situated in the northeast is characterized by savannas interwoven with dry forests dominated by *Anogeissus leiocarpus*. These savannas exhibit diverse flora, with Combretaceae and Andropogonae being the prominent species. Amid these savannas, are pockets of semi-deciduous forests and gallery forests featuring primary species like *Cynometra megalophylla, Parinari congensis*, and *Pterocarpus santalinoides*. The mountainous zone (ecological zone IV) in the northwest consists of semi-deciduous humid forests (Akpagana,

1989). Species found here include *Hidelgardia barteri, Khaya grandifoliola, Milicia excelsa, Morus mesozygia, Parkia filicoidea, Musanga cecropioides, Triplochiton scleroxylon*, and *Pterocarpus midbraedii*. These forests are interspersed with savannas containing species such as *Lophira lanceolata, Pterocarpus erinaceus, Hymenocardia acida, Crossopteryx febrifuga, Faurea speciosa*, and *Vitex doniana*. This region also harbors 110 locally threatened species and 16 globally vulnerable species, as per the IUCN criteria, highlighting its ecological significance (Adjossou, 2009).

The coastal plain (ecological zone V) to the south showcases a diverse landscape including croplands, fallow areas, thickets, bushes, and grassy savannas, along with sacred and community forests (Folega *et al.*, 2023). Mangroves, flooded meadows, and savannas also thrive in the extreme southeast. This study holds particular importance in mitigating human-induced impacts on these ecosystems, reinforcing the conservation of threatened medicinal plants (TMP), promoting sustainable management practices, and safeguarding the valuable indigenous knowledge pertaining to TMP.

Ethnobotanical survey and data collection

The localities to be investigated were chosen on a stratified sampling basis (Akpavi *et al.*, 2007). Strata selected were ecological zones (Ern, 1979) and the spread of ethnocultural groups (Gayibor, 1997) (Figure 1). An explorative survey was carried out to evaluate the understanding of the questionnaire and to determine the size of sample to be survey.

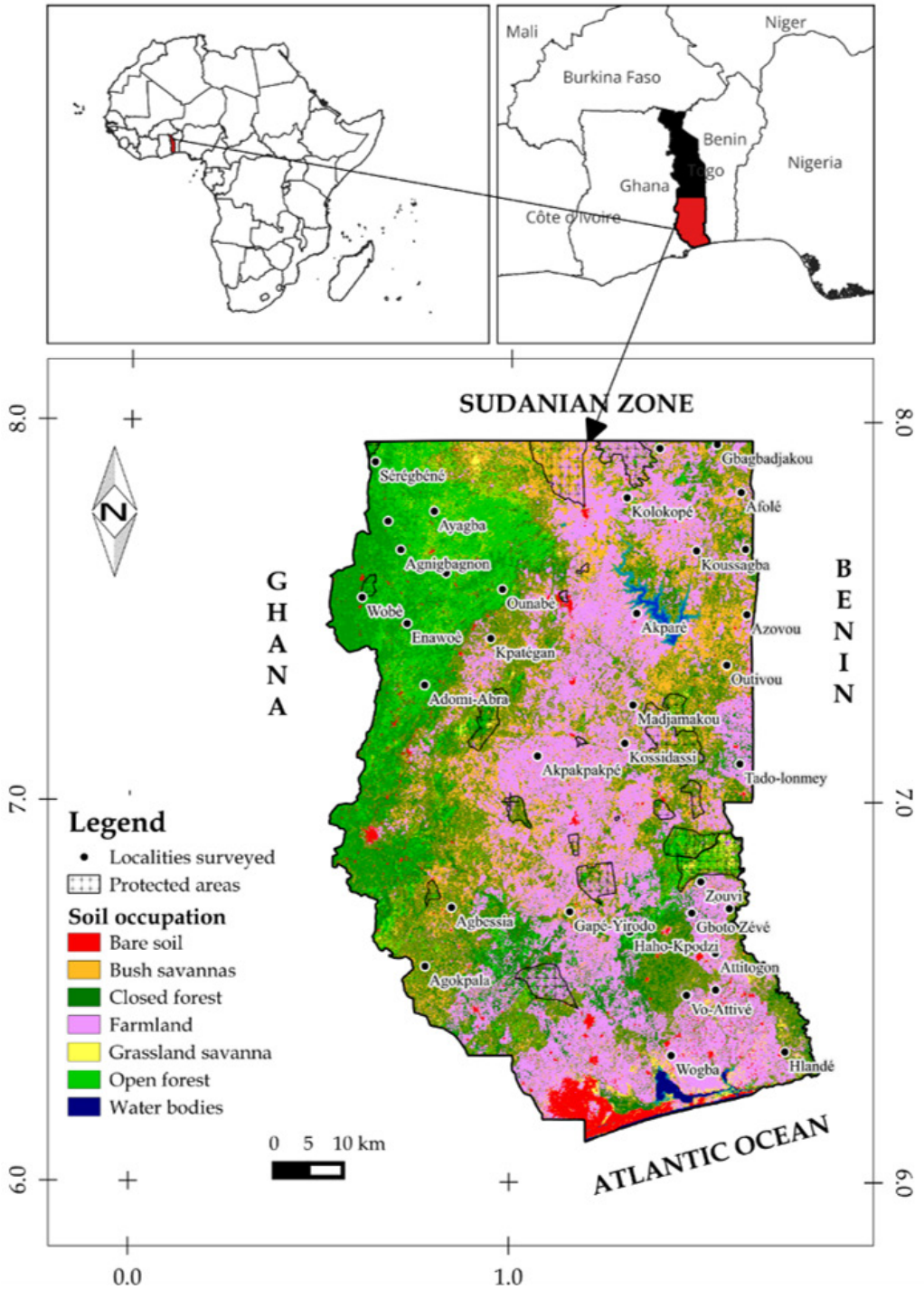

Figure 1: Prospecting points

The sample was determined by Dagnelie's formula (Dagnelie, 1998) $N = \frac{U^2_{1-\alpha/2} \times p(1-p)}{d^2}$, where N is the sample size to be determined; p is the proportion (relative frequency) of respondents with knowledge about TMP; $U_{1-\alpha/2}$ is the standard value of confidence level (interval); and d is the margin of error set at 5% for this study. This formula provides a theoretical sample of person to be surveyed. It has been used by several authors to determine the size of the surveyed sampling (Agbodan *et al.*, 2020; Awo *et al.*, 2020; Bi *et al.*, 2020). Thus, several householders were surveyed in each locality with the goal to obtain a maximum and redundancy in information on TMP and their related local knowledge. Given the specificity of the information searched, adults (30-60 years) and older people (> 60 years) were favored. In each locality, resource people were selected with the help of local leaders. After explanation of the objectives, the local leaders and agricultural managers assembled people who fulfilled the criteria of the investigation. This approach has the advantage to build a mutual climate of trust and enables the collection of reliable and accurate information on a highly sensitive topic of medicinal plant. The ethics code was carefully followed, and an oral agreement "agreeing to be interviewed" from the community authorities and each interviewee, in accordance with the principles of the ethics ISE code was received. So, 352 interviewees from 31 localities and 10 cultural groups were surveyed from April to September 2022 throughout the study area. The Ewe, Adja, and Kabyè communities were investigated more, because of their widespread geographic distribution (Gayibor, 1997). Data were collected through semi structured individual and focus group (Akpavi *et al.*, 2013). The questions are focused on medicinal plants, which were used in the past but no longer exists in the area, local knowledge related to these medicinal plants, plant organs, preparation, administration method, and diseases treated.

Classification of medicinal uses

The various diseases and symptoms were grouped into categories defined by the International Classification of Primary Care, Second Edition (Jamoulle *et al.*, 2000). This classification has been used in several research related to medicinal plants (Gumisiriza *et al.*, 2019; Lee *et al.*, 2019; Miara *et al.*, 2019; Anywar *et al.*, 2020). These are general and unspecified diseases (A), blood and immunological system diseases (B), digestive system diseases (D), cardiovascular diseases (K), osteoarticular diseases (L), neurological diseases (N), psychological diseases (P), pregnancy and childbirth diseases (W), respiratory diseases (R), skin diseases (S), endocrine metabolism diseases (T), female genital system diseases (X), and male genital system diseases (Y).

Statut IUCN et statut local des TMP

The TMP identified was compared to the IUCN Red List (List, 2015) and local red lists (Radji, 2008; Adjossou, 2009; Atsri *et al.*, 2018). The red list allows us to know the risk of extinction of species, and to monitor changes in the status of species (Kaky & Gilbert, 2019). The classes defined are Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), and Least Concern (LC). According to the latest categorization, species considered threatened include those that are critically endangered, endangered and vulnerable. The R software, via rredlist package, was used to establish the status of TMP identified (Whitney, 2022).

Data Analysis

The collected data are inputted and encoded in the Excel for analysis. The Ethnobotany package of Rstudio software was used to generate basic quantitative indices in ethnobotany (Table 1). These are the reported uses (UR), the index of cultural importance (IC), and the consensus factor index (CFI).

RESULTS AND DISCUSSION

Respondents' profile

The largest numbers of respondents were native people (84.4%), given the specific nature of the topic (Table 2). The sex ratio was 0.87, indicating a nearly equal distribution of interviewees by gender. Adults and elderly people (over 35 years old) were the most investigated age groups. The number of dependents (children) was low (0–5) in 42.0% of households investigated. The respondents were occasional users (77.0%), traditional practitioners (19.6%), and resellers (3.4%), and 40.1% of these categories were illiterate. The results indicate that a low level of education does not hamper the acquisition

Table 1: Indices used to describe threatened medicinal plant knowledge

Calculated index	Method	Interpretation
Reported uses (RU) $RU = \sum_{u=u1}^{uNC} \sum_{i=i1}^{iN} URui$	Calculates the total uses for the species by all informants (from i_1 to ^iN) within each use-category for that species (i)	Calculates the cultural importance index (CI) for each TMP among ethnocultural group prospected (Prance *et al.*, 1987).
Consensus Factor Index (CFI) **CFI = (Nur - Nt)/(Nur - 1)**	Nur, the number of times a disease category was mentioned; and Nt, the number of PMTs used in the treatment of that disease category	This index makes it possible to evaluate the degree of homogeneity of the information received from the respondents (Tardío & Pardo-de-Santayana, 2008).
Cultural Importance Index (CI) **IC = Na /NT**	Na, number of people who cited the medicinal plant for a given disease divided by NT, the number of people who cited the plant	Nur, the number of times a disease category was mentioned; and Nt, the number of PMTs used in the treatment of that disease category (Reyes-García *et al.*, 2019).

of medicinal plant practices. Our results support those of Kpodar *et al.*, (2015, 2016) in Togo. The number of threatened medicinal plants did not vary significantly according to respondent age, education level or household size. However, a significant difference at the 5% threshold was observed for the variables gender, type of respondent and distance of the locality from the nearest hospital (Table 1). Results are similar to those of work of Kébenzikato *et al.*, (2015) in Togo, on the influence of socio-economic parameters on local knowledge about *Adansonia digitata*.

Medicinal plant diversity

Semi-structured interview helped to identify 124 TMP belonging to 118 genera and 47 families (Table 3). This rich diversity of TMP indicates a good knowledge of medicinal plants that are becoming rare, disappearing, or difficult to access (Gaur and Sharma, 2011), an area rich in highly anthropized ecosystems (Adjossou, 2009; Koda *et al.*, 2019), a poor economic status of the residents, and an attachment to plants for the diseases treatment (Ouro-Djeri *et al.*, 2022). Fabaceae (21 species), Euphorbiaceae (12 species), Apocynaceae (7 species), Compositae (5 species), and Rutaceae (5 species) are the most abundant botanical families identified (Figure 2). More than half-botanical families are represented by one or two species. The most frequently cited TMP are *Khaya senegalensis* (49.4%), *Sarcocephalus latifolius* (35.5%), *Zanthoxylum zanthoxyloides* (26.1%), *Flueggea virosa* (19.3%), *Caesalpinia bonduc* (19.0%), *Bridelia ferruginea* (16.19%), *Acanthospermum hispidum* (15.63%), *Uvaria chamae* (14.8%), *Morinda lucida* (13.7%), and *Alstonia boonei* (12.2%). Our results reinforce those of Gadikou *et al.*, (2022) working on vulnerable medicinal plants in the maritime region of Togo. Seventy-eight (78) species are similar between the two studies. Seven (07) TMP are involved in the treatment of more than five (05) diseases. These plants, qualified as versatile, offer a wide range of recipes for the treatment of diseases. It is about *A. hispidum, A. floribunda, C. bonduc, Jatropha curcas, K. senegalensis, M. lucida,* and *Vitex doniana.* According to Schulz *et al.*, (2001), for a given therapeutic indication, the traditherapist can cite several plants to hide the one containing the active ingredient. Sanon *et al.* (2003) showed significant inhibitory activity of *A. hispidum* (IC 50 =5.02 µg/mL) on *Plasmodium falciparum* isolates from children between 4 and 10 years old in Burkina Faso. In addition, Ram *et al* (Ram *et al.*, 2004) proved the efficacy of *A. hispidum* (5000 µg/mL) against *Pseudomonas aeruginosa* and *Candida albicans*. These results can explain the folk utilization of *A. hispidum* in malaria and sinusitis treatment.

Alchornea floribunda inhibit *Bacillus cereus, Enterococcus faecalis*, *Escherichia coli*, which are responsible of gastrointestinal disease, and, *Klebsiella pneumonia* and *Moraxella catarrhalis,* responsible of respiratory disease (Noundou *et al.*, 2014). These results confirm the traditional use of *A. floribunda* for respiratory and gastrointestinal (diarrhea) disease collected. Afolabi and Abejide (2020) reported in vitro activity of *Alstonia bonei* leaf extract against *P. falciparum.* The biological properties presented by plant extracts give credit to their indigenous uses. However, twelve plants have not been studied to show the safety and toxicity of TMP. It's

Table 2: TMP collected according to respondents' profile

Caterory	Variable (Number)	Mean ± SD	Statistical analyses
Sex	Woman (163)	8.75 ± 4.28 a	Pr (> F) = 0.000593
	Man (189)	7.29 ± 3.67 b	
Type of respondent	Herbalist (69)	8.64 ± 4.29 a	Pr (> F) = 7.97e-10
	Resellers (12)	14.7 ± 0.87 b	
	Occasional user (271)	7.49 ± 3.74 a	
Respondant age	20 - 30 (54)	7.2 ± 3.19 a	Pr (> F) = 0.0283
	31 - 40 (88)	7.48 ± 3.63 a	
	41 - 50 (86)	8.69 ± 4.22 a	
	51 - 60 (56)	9.11± 4.86 a	
	61 - 70 (44)	7.14 ± 4.2 a	
	sup 71 (24)	7.75 ± 3.15 a	
Education level	Illiterate (141)	8.04 ± 3.79 a	Pr (> F) = 0.44
	College (73)	8.38 ± 4.05 a	
	High school (15)	8 ± 4.14 a	
	Primary (120)	7.71 ± 4.29 a	
	University (3)	4.33 ± 2.31 a	
Household size	0 - 5 (148)	8.09 ± 4.22 a	Pr (> F) = 0.112
	6 - 10 (170)	7.76 ± 3.72 a	
	11 - 15 (23)	9.48 ± 5.15 a	
	16 - 20 (11)	6.18 ± 1.99 a	
Distance from hospital	< 5 km (200)	8.4 ± 4.28 a	Pr (> F) = 0.00000589
	10 à 15 km (21)	10.9 ± 5.95 b	
	5 à 10 km (131)	6.84 ± 2.71 c	

about *A. hispidum, A. floribunda, A. albida, C. bonduc, C. viscosa, D. mespiliformis, J. curcas, L. taraxacifolia, M. lucida, N. latifolia, P. foetida,* and *X. aethiopica*.

Launaea taraxacifolia has antimalarial, antiviral against the measles virus, antiarthritic, anti-inflammatory and bactericidal activities (Bello *et al.*, 2018; Owolabi *et al.*, 2020). *Milicia excelsa* is anticonvulsant, antiamnesic, antipsychotic, antihypoxic activities (Adebayo *et al.*, 2019; Akinpelu *et al.*, 2020). These pharmacological proprieties can explain traditional uses in malaria and female sterility treatment.

Securidaca longipedunculata has antiparasitic, antibacterial, antifungal, antiplasmodial, antiinflammatory, anticonvulsant, histopathologic activities (Alitonou *et al.*, 2012; Mongalo *et al.*, 2015). These proprieties can explain traditional uses against snakebite, sinusitis and head wounds. However, there is a need to study the toxicity of these plants to ensure safe and effective use in populations.

IUCN Statut vs. local Statut of TMP

Different conservation statuses of TMP were determined (Figure 3). These include vulnerable species (VU) with 2.21% and are represented by species such as *K. grandifoliola, K. senegalensis, A. africana, G. afzelii*, and *V. paradoxa*. Threatened species (EN) with 0.74% are represented by *P. erinaceus*, while *M. excelsa* is the representative of the near-threatened species (NT) with 0.74%. Nearly 87 plant species are not evaluated (NE) by the IUCN. These results corroborate work which reports that, the IUCN Red List, although providing threat levels at the global level, has limitations because only 5.5% of plant species are assessed (List, 2015; Heywood, 2017). Thus, the threat status of plants varies more at local level than the international level, and several species may be threatened at the local level but not be evaluated at international level. In addition, the level of threat may differ by locality, region, or even continent. Among the 124 TMP identified, twenty-five (25) are classified as vulnerable according to the GBIF-Togo, the national herbarium, and the Togolese flora developed by Radji (2008). It's about *A. africana, A. adianthifolia, A. floribunda, A. nobilis, A. vogelii, B. aethiopum, C. edulis, C. pentandra, D. senegalensis, D. mespiliformis, E. angolense, G. afzelii, G. kola, H. floribunda, K. anthotheca, K. grandifoliola, K. senegalensis, M. altissima, M. lutea, M. excelsa, P. excelsa, P. erinaceus, P. santalinoides, T. scleroxylon* and *V. paradoxa.*

This study is in line with the one conducted by Adjossou (2009) in the forest zone (ecological zone IV) of Togo. Thus, 23 TMP were cited as threatened in the forest present in ecological zone IV of Togo. These are A. *digitata, A. africana, A. adianthifolia, A. floribunda, A. nobilis, A. vogelii, B. aethiopum, C. edulis, C. pentandra, D. senegalense, D. mespiliformis, G. afzelii, G. kola, H. floribunda, K. senegalensis, M. lutea, M. excelsa, P. excelsa, P. erinaceus, P. santalinoides, T. scleroxylon, V. paradoxa* and *X. aethiopica.* In comparison with the red list of Benin (Neuenschwander *et al.*, 2011), twenty-one (21) TMP are classified as vulnerable. This study has the merit of identifying 35 other TMP (not cited in previous work in Togo) which becoming threatened in study area.

Table 3: Species of TMP with information on their families. plants parts and medicinal use. ecological zone. ethnobotanical indices (UR. IVI. and CI). local names. and IUCN status

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Acacia dudgeoni	Diarrhea / baby's tummy ache / constipation / snakebite	Bark / leaves / root	Decoction / trituration	I, II	27	0.143	0.081	Kabétumbé/Peu	LC
Acanthospermum hispidum	Abscess / wounds / hematoma / hypertension / jaundice / anemia / headache / scorpion bite / malaria / typhoid fever / sinusitis	Leaves / whole plant	Decoction / maceration / trituration	I, II, III, IV, V	55	0.429	0.164	Lan gbanisoè/Ka	NE
Adansonia digitata	Anemia	Root	Decoction	I, II, III, V	4	0.071	0.012	Adzidotsi/Ew	NE
Afraegle paniculata	Intestinal wound	Root	Food	II, III, V	9	0.071	0.027	Ngoné/Ka	NE
Aframomum melegueta	Abdominal and intestinal wound/ vomiting	Fruit / grain	Maceration	III, IV, V	26	0.214	0.078	Colombo/Ka	NE
Afzelia africana	Whooping cough / sexual dysfunction	Root	Decoction	I, II, III, V	7	0.143	0.021	Wéré/Ka	VU
Albizia adianthifolia	Asthma / stomach ache	Leaves	Decoction / maceration	III, IV, V	14	0.143	0.042	Ziwa/Adj	LC
Alchornea cordifolia	Wounds / constipation	Root	Decoction	II, III, IV, V	2	0.071	0.006	Zowou/Ka	LC
Alchornea floribunda	Colic / dysentery / toothache / respiratory problems / urinary problems / ulcers	Leaves / root / stem	Decoction	IV	32	0.214	0.096	Ayraba/Ew	LC

Table 3: Continued

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Allophylus africanus	Migraine / wounds	Leaves	Maceration / trituration	I, II, III, IV, V	11	0.143	0.033	Assiviaton/ Mi	LC
Aloe buettneri	Stomach ache	Sap	Leaves juice	I, II, IV	3	0.071	0.009	Aloes/Ew	NE
Alstonia boonei	Abdominal wounds / malaria	Bark	Decoction	IV	43	0.143	0.128	Nyamidua/ Ew	LC
Annona muricata	Diabetes / cancer / blood pressure	Leaves / grain	Decoction	I, II, III, IV, V	11	0.214	0.033	Agnigli/Ew	LC
Anogeissus leiocarpa	Sexual dysfunction/ mental disorder/malaria	Bark / leaves	Decoction	I, II, III, IV, V	10	0.143	0.03	Tchininga/Te	LC
Anthocleista djalonensis	Cough / hernia / aphrodisiac / intestinal wounds	Leaves / root / stem	Decoction / trituration	I, II	26	0.286	0.078	Gboloba/Ew	LC
Anthocleista nobilis	Headaches / wounds	Bark / root	Decoction / trituration	IV	14	0.143	0.042	Gboloba/ Ew	LC
Anthocleista vogelii	Epilepsy	Root	Decoction	IV	13	0.143	0.039	Gboloba/Ew	LC
Aristolochia albida	Snakebite	Leaves	Maceration	II, III	35	0.071	0.104	Gadagali/Ew	NE
Bidens pilosa	Snakebite	Leaves	Cataplasm	II, IV, V	7	0.071	0.021	Dzany-ipipi/Ew	NE
Blighia sapida	Good shape / guinea worm / athlete's foot	Bark / leaves	Maceration	II, III, IV, V	12	0.143	0.036	Kpizou/Ka	LC
Boerhavia diffusa	Smallpox	Root	Maceration	I, III, V	2	0.143	0.006	Avhaxasa/Ew	NE
Borassus aethiopum	Sore throat	Root	Decoction	I, II, III, V	13	0.071	0.039	Agoti/Ew	LC
Bridelia ferruginea	Dysentery / constipation / ulcers / deworming	Bark / leaves / root	Decoction	I, II, III, IV, V	57	0.214	0.17	Akamati/ Ew	LC
Burkea africana	Epilepsy / toothache	root / stem	Decoction	I, II, III, IV	24	0.143	0.072	Tchingli/Ka	LC
Caesalpinia bonduc	Diuretic / headache / stomach ache /malaria/ wounds/cough/vomiting	Leaves / grain / seed / root	Decoction / piler	III, V	67	0.5	0.2	Adikou/Ew	NE
Cardiospermum halicacabum	Antiviral	Leaves	Decoction / roasting / trituration	III, V	1	0.071	0.003	Gbatog-bato/Ew	LC
Carissa edulis	Sexual dysfunction	Root / stem	Decoction	II, III, V	9	0.071	0.027	Boetso/Ew	LC
Cassia alata	Dermatosis	Leaves	Decoction / maceration	I, II, III, IV, V	8	0.071	0.024	Madonso-homè/Ew	LC
Catharanthus roseus	Dysmenorrhea / tension	Flower / root	Decoction	I, II, III, IV, V	11	0.143	0.033	Flawavig-bé/Ew	NE
Ceiba pentandra	Fracture / wounds	Leaves	Maceration	I, II, III, IV, V	12	0.143	0.036	Komoulé/ Ag	LC
Chenopodium ambrosioides	Dermatosis / edema / chickenpox	Bark/ leaves/stem	Decoction / maceration	III, IV, V	16	0.143	0.048	Emigbe/ Ew	NE
Chrysobalanus icaco	Laxative	Grain	Trituration	V	3	0.071	0.009		NE
Cissus populnea	Edema / wounds	Leaves / root	Decoction / maceration	I, II, III, IV, V	14	0.143	0.042	Mènè/Ka	NE
Clausena anisata	Aphrodisiac / measles	Root / stem	Roasting	II, IV, V	5	0.143	0.015	Idenug-bata/Akp	LC
Cleome viscosa	Fever / hemorrhoid / earache / malaria	Leaves	Decoction	I, II, V	34	0.214	0.101	Pepelugbe/ Ew	NE
Cnestis ferruginea	Snakebite	Root	Decoction / maceration	II, III, IV, V	4	0.071	0.012	Tsoade/Ew	NE
Cola gigantea	Against stuttering / leprosy	Leaves	Decoction	II, III, V	7	0.143	0.021		LC
Cola nitida	Incurable wounds	Leaves	Infusion / maceration / trituration	III, IV	4	0.071	0.012	Coroo/Te	LC

Table 3: Continued

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Combretum micranthum	Fever	Leaves	Decoction	II, III, IV, V	4	0.071	0.012	Bessikaku/ Ew	LC
Conyza aegyptiaca	Eczema	Leaves	Maceration / dew water in the leaves	I, II, III, IV, V	9	0.071	0.027		NE
Costus spectabilis	Malaria	Leaves	Powder	II, III	8	0.071	0.024	Tetegugu/ Ew	NE
Crateva adansonii	Icterus / sterility	Leaves	Maceration	I, II, III, IV, V	5	0.143	0.015	Watayizan/ Ew	LC
Curcuma longa	Malaria	Root	Maceration	I, II, III, IV, V	7	0.071	0.021	Wissikoyè/ Ka	DD
Dichrostachys cinerea	Snakebite / measles	Root / stem	Trituration	II, III, V	9	0.143	0.027	Sozossi/Te	LC
Diospyros mespiliformis	Dermatosis / headaches / stomach aches / female infertility	Bark / leaves / root	Decoction	I, II, III, V	34	0.214	0.101	Tigbado/ Te	LC
Entandrophragma angolense	Malaria	Bark	Decoction	IV	3	0.071	0.009		NT
Erythrina senegalensis	Aphrodisiac / dysuria	Root / stem	Decoction	I, II, III, IV, V	22	0.143	0.066	Gbengben tchikoloka/ Te	LC
Euphorbia hirta	Tension	Leaves	Decoction / infusion / maceration	I, II, III, IV, V	13	0.143	0.039	Notsigbe/ Ew	NE
Euphorbia poissonii	Constipation	Leaves	Decoction	II, III	7	0.071	0.021	Adikpui/ Ew	NE
Flacourtia flavescens	Dermatitis / diarrhea	Leaves	Cataplasm / decoction	III, V	13	0.143	0.039	Dêgogo/ Ew	NE
Garcinia afzelii	Sexual dysfunction	Root	Decoction	IV	2	0.071	0.006		VU
Garcinia kola	Sexual dysfunction / snakebite / shingles	Fruit / grain / seed	Decoction	IV	15	0.214	0.045	Ahowe/Ew	VU
Gliricidia sepium	Fever / malaria	Leaves	Roasting	I, II, III, IV, V	1	0.071	0.003		NE
Harrisonia abyssinica	Diabetes / wounds	Leaves	Decoction	III, V	12	0.143	0.036	Xedza/Ew	LC
Heliotropium indicum	Dermatitis / hypertension / canker sores / tension	Leaves/ flower/fruit /whole plant / stem	Decoction	III, IV, V	31	0.286	0.093	Koklota-doe/Ew	NE
Holarrhena floribunda	Diarrhea / fever / sexual impotence	Bark / leaves / root	Decoction	I, II, III, IV, V	10	0.214	0.03	Sesewu/Ew	LC
Imperata cylindrica	Good shape	Root	Decoction / trituration	I, II, III, IV, V	4	0.071	0.012	Bedje/Ew	NE
Jatropha curcas	Diabetes / malaria / wounds / female sterility / tetanus / cough	Leaves/root / sap/stem	Decoction / maceration	I, II, III, IV, V	40	0.429	0.119	Babatihé/ Ew	LC
Jatropha gossypiifolia	sexual asthenia / fever / malaria	Leaves / stem	Decoction	I, II, III, IV, V	13	0.214	0.039	Babatidjin/ Ew	LC
Jatropha multifida	Wounds	Leaves	Decoction	I, II, III, IV, V	4	0.071	0.012	Têtwima/Ew	NE
Kalanchoe crenata	Epilepsy / vomiting	Sap	Decoction / maceration	IV	24	0.214	0.072	Aflatogan/ Ew	NE
Khaya anthotheca	Antiseptic	Stem	Decoction	IV	1	0.071	0.003	Mahogen/ Ew	VU
Khaya grandifoliola	Anemia / malaria / abdominal pain / malaria	Bark	Trituration	II, IV	29	0.143	0.087	Mahogen/ Ew	VU
Khaya senegalensis	Anemia / anthelmintic / hemorrhoid / headache / edema / malaria / abdominal and intestinal wounds	Bark / leaves / root	Decoction / maceration / trituration	I, II, III	170	0.429	0.507	Mahogen/ Ew	VU

Table 3: Continued

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Kigelia africana	Abdominal wounds	Bark / leaves	Decoction	II, III, IV, V	26	0.214	0.078	Gnak-pekpe/Ew	LC
Lannea acida	Anemia	Bark	Decoction	I, II, III, IV, V	1	0.071	0.003	Kèlo/Te	NE
Lannea barteri	Anemia / fracture / wounds	Bark	Decoction / maceration / infusion	II, III, IV, V	25	0.214	0.075	Kisan/Ka	NE
Lannea kerstingii	Anemia	Bark	Decoction / infusion	I, II, IV, V	23	0.071	0.069		NE
Launaea taraxacifolia	Teething / intestinal wounds / anemia / blood pressure / vision problems	Leaves / whole plant	Decoction	I, V	31	0.429	0.093	Anonto/ Ew	NE
Leptadenia hastata	Cough / ulcer	Whole plant / root	Decoction / infusion	I, II, III, V	26	0.143	0.078	Sopotoriyi/ Peu	NE
Lippia multiflora	Anemia	Bark	Decoction	II, IV	2	0.071	0.006	Avudatsi/ Ew	NE
Lonchocarpus sericeus	Headache / malaria	Leaves	Decoction / maceration / trituration	II, III, IV, V	8	0.143	0.024	Lonba/Ad	NE
Mallotus oppositifolius	Headache	Leaves	Decoction / maceration	I, II, III, IV, V	4	0.071	0.012	Nyativi/Ew	LC
Markhamia lutea	Scabies	Leaves	Decoction / maceration	II	8	0.071	0.024		LC
Mezoneuron benthamianum	Antiseptic / sexual dysfunction	Leaves / stem	Maceration	III, IV, V	11	0.143	0.033	Gbigbova/ Ew	NE
Milicia excelsa	Madness / edema / malaria / female sterility	Bark / leaves	Decoction	II, IV, V	28	0.286	0.084	Odoum/ Akp	NT
Monodora myristica	Sores / sexual dysfunction / stomach ache	Fruit	Trituration	II, IV, V	10	0.143	0.03	Asioti/Mi	LC
Morinda lucida	Fever / hypertension / icterus / stomach ache / malaria /taenia	Leaves / root	Decoction / maceration	I, III, IV, V	46	0.357	0.137	Dadakla-lan/Ew	LC
Newbouldia laevis	Malaria / wounds	Leaves	Decoction / maceration / trituration	II, IV, V	27	0.214	0.081	Kpatima/ Ew	NE
Ocimum americanum	Fever / headache / malaria / felon	Leaves / stem	Decoction / infusion / maceration	I, II, III, IV, V	31	0.214	0.093	Defetsui/ Ew	NE
Ocimum basilicum	Stomach ache	Leaves	Decoction / maceration / trituration	I, II, III, IV, V	9	0.071	0.027	Esrou/Ew	NE
Ocimum canum	Stomach ache / wound	Leaves	Decoction / maceration	I, II, III, IV, V	4	0.071	0.012	Aswoeloo/ Ka	LC
Ocimum gratissimum	Constipation / diarrhea / stomach ache / sores	Leaves	Decoction / maceration	IV, V	27	0.214	0.081	Hetchagni/ Ag	NE
Opilia amentacea	Malaria / fatigue	Leaves	Crush	I, II, III, V	8	0.071	0.024	Kalibinou/ Ka	NE
Parinari excelsa	Diarrhea	Stem	Decoction / maceration	IV	9	0.071	0.027	Kura/Peu	LC
Parkia biglobosa	Abdominal wounds / malaria	Bark	Decoction / trituration	I, II, III, IV, V	17	0.071	0.051	Wotsi/Ew	NE
Passiflora foetida	Anemia / malaria	Leaves	Decoction	I, IV, V	30	0.214	0.09	Gbanto gbantwe/ Adj	NE
Pergularia daemia	Vertigo	Leaves	Decoction	I, II, IV, V	1	0.071	0.003	Halbodo/ Ka	LC
Phyllanthus amarus	Hip and stomach pain / malaria	Leaves / fruit / whole plant / root	Decoction	I, II, III, V	38	0.286	0.113	Hlinvi/Ew	NE
Piliostigma thonningii	Bleeding / stomach ache / malaria / body wounds	Leaves / whole plant	Maceration	I, II, III, IV, V	19	0.286	0.057	Boboou/ Ka	NE

Table 3: Continued

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Piper guineense	Stomach ache / abdominal wounds	Fruit / root	Decoction / maceration	IV	17	0.143	0.051	Kouleboe/ Aké	LC
Piper nigrum	Wounds / sexual dysfunction	Fruit / root	Decoction / maceration	IV	4	0.071	0.012	Akposso/ Adj	
Portulaca oleracea	Dermatosis / snakebite	Leaves / stem	Decoction / crush and put in sauce	I, II, IV, V	9	0.143	0.027	Ebouatcho/Akp	LC
Prosopis africana	Cavity / dermatosis / hemoroids	Bark / leaves	Decoction	I, II, III	16	0.214	0.048	Balo/Ka	LC
Psidium guajava	Diarrhea / laxative	Root / stem	Decoction / maceration	I, II, III, IV, V	21	0.071	0.063	Alelo/La	NE
Pteleopsis suberosa	Intestinal and skin wounds	Leaves	Decoction	II	3	0.071	0.009	Kizisina/ Ka	LC
Pterocarpus erinaceus	Dysentery / sexual dysfunction / deworming	Bark / leaves / root	Decoction / maceration	I, II, III	21	0.143	0.063	Ntem/Ka	EN
Pterocarpus santalinoides	Dysentery	Leaves	Decoction	III, V	3	0.071	0.009	Kpesna/ Mb	LC
Pupalia lappacea	Wounds	Leaves	Decoction	III, V	4	0.071	0.012	Tetemalima/Ew	LC
Raphia vinifera	Wounds	Leaves	Decoction	III, V	4	0.071	0.012	Alati/Ew	LC
Rauvolfia vomitoria	Aphrodisiac / hemoroids / malaria	Leaves / root	Decoction	III, IV, V	13	0.214	0.039	Dodemakpowoè/Ew	LC
Sarcocephalus latifolius	Malaria / stomach ache / abdominal and intestinal wounds	Bark / leaves / root	Decoction	I, II, III, IV, V	104	0.357	0.31	Nyimon/ Ew	LC
Securidaca longipedunculata	Snakebite / sinusitis / head wounds	Leaves / root	Decoction	I, II, III, IV, V	34	0.143	0.101	Tritou/Ew	NE
Securinega virosa	Malaria / head and stomach aches	Leaves / whole plant / root	Decoction	III, V	68	0.357	0.203	Hesre/Ew	LC
Sida acuta	Complication of childbirth	Leaves	Decoction	I, II, III, V	20	0.071	0.06	Afidémè/ Adj	NE
Spathodea campanulata	Wounds / infertility / anemia / malaria	Bark	Chew / cataplasm / maceration / powder	III, IV, V	20	0.143	0.06	Adatsigolo/Ew	LC
Spondias mombin	Candidiasis/ leprosy / postpartum bleeding	Leaves / root	Decoction	I, II, III, IV, V	22	0.286	0.066	Akikonti/ Ew	LC
Strophanthus hispidus	Malaria / skin wounds	Leaves	Maceration	I, III, IV, V	16	0.143	0.048	Pitombayi/ Ew	LC
Tapinanthus bangwensis	Cough	Leaves / root	Decoction	II, III, IV, V	12	0.143	0.036	Gui/Ew	NE
Terminalia superba	Anemia / vomiting	Bark	Maceration	IV	2	0.071	0.006	Donko/Ew	NE
Tetrapleura tetraptera	Abscess / gonorrhea	Leaves / root	Decoction / maceration	III, IV	15	0.286	0.045	Ledza/Ew	LC
Thevetia peruviana	Abscess / gonorrhea / ulcer	Leaves / root / sap	Infusion / decoction	I, II, III, IV, V	12	0.214	0.036	Thevetia/ Ew	LC
Triplochiton scleroxylon	Wounds	Bark	Decoction	III, IV	9	0.071	0.027	Atiyhe/Ew	LC
Uvaria chamae	Anemia /wounds / female sterility / cough	Leaves / root	Decoction / maceration	II, III, V	52	0.286	0.155	Agbana/ Ew	LC
Vernonia amygdalina	Stomach ache/malaria /abdominal sores	Leaves	Decoction	I, IV, V	8	0.214	0.024	Aloma/Ew	NE
Vernonia cinerea	Fever / toothache / female sterility	Leaves / stem	Trituration	I, II, IV, V	12	0.143	0.036	Hunsikonou/Adj	NE
Vitellaria paradoxa	Icterus / sexual dysfunction / head ache / sores / colds	Almond/ bark/leaves / latex	Decoction / trituration	I, II, III, IV, V	29	0.286	0.087	Yokuti/Ew	VU
Vitex doniana	Diuretic/ frigidity/ icterus/body wounds/ liver problems/ strengthens teeth	Bark / leaves / root	Food / decoction / trituration	I, II, III, IV, V	27	0.357	0.081	Otitikpe/ Aké	NE

Table 3: Continued

TMP/Family	Medicinal use TMP	Plant parts	Preparation method	Ecological zone	UR	Ivi	CI	Local name	Statut IUCN
Ximenia americana	Diarrhea / eczema	Leaves	Decoction	I, V	19	0.143	0.057	Roumou-loung/Na	LC
Xylopia aethiopica	Dysmenorrhea / fever / malaria / sexual dysfunction	Leaves / fruit / root / stem	Decoction / maceration / trituration	I, II, III, IV, V	41	0.286	0.122	Etso/Ew	LC
Zanthoxylum leprieurii	Abdominal wounds	Bark	Decoction / maceration	IV	5	0.071	0.015	Xéti/Ew	NE
Zanthoxylum macrophylla	Stomach ache / abdominal pain / malaria	Bark	Decoction / trituration	IV	16	0.286	0.048	Xéti/Ew	NE
Zanthoxylum zanthoxyloides	Aphrodisiac / post-delivery wounds / internal wounds for nursing mothers / malaria	Bark / leaves / whole plant / root	Decoction / dry and crush	I, III, V	74	0.5	0.221	Xéti/Ew	LC

Ad: Adja; Ag: Agnanga; Aké: Akébou; Akp: Akposso; Ew: Ewé; Ka: Kabyè; La: Lamba; Mb: Moba; Mi: Mina; Na: Nawdba; Peu: Peulh and Te: Tem

Plant parts and medicinal recipe preparation methods

The interviewees use different plant parts, alone or in combination, for the preparation of medicinal recipes. In this study, eleven (11) plant parts were identified (Figure 2): leaves (64.8%) remained the most commonly used, followed by roots (37.5%), bark (22.7%), and stem (14.8%). These results are similar to those obtained by Ouattara (2006) in Côte d'Ivoire and Olivier *et al.* (2012) in Burkina Faso.

Leaves are the most used for the preparation of medicinal recipes, as they are more accessible (Mounkaila *et al.*, 2017) and are a safe identification factor for users (Asase *et al.*, 2005). Also, leaves, thanks to the photosynthesis phenomenon, remain the primary production site of secondary metabolites. Depending on the nature of the disease, a specific mode of extraction is used. The surveys identified seven (07) methods of preparing medicinal recipes (Figure 3). Of these, the three most commonly used methods of preparation were decoction (76.6%), maceration (35.2%), and roasting (17.2%). These results are similar to those found by Gnagne *et al.* (2017) in Côte d'Ivoire. Indeed, these different techniques of extraction of active principles from plant organs explain the use of a plant in the treatment of several pathologies or

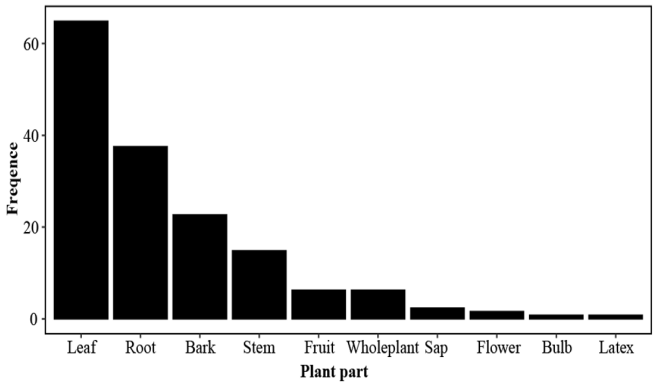

Figure 2: Plant part frequency

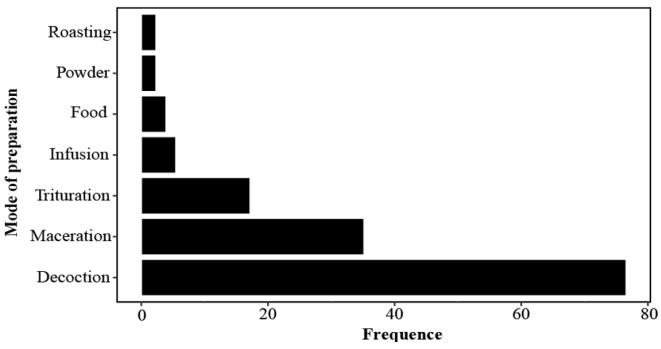

Figure 3: Frequency of use and preparation of drug recipes

Table 4: **IFC by disease category**

Disease category		Number of plant	Nur	IFC
A	General and Unspecified disease	45	346	0.87
B	Blood, Blood Forming Organs and Immune Mechanism disease	58	554	0.90
D	Digestive	33	320	0.90
K	Cardiovascular	8	49	0.85
L	Osteoarticular	21	245	0.92
N	Musculoskeletal	5	29	0.86
P	Psychological	2	9	0.88
R	Respiratory	16	112	0.86
S	Skin	62	473	0.87
T	Endocrine/Metabolic and Nutritional	2	11	0.90
W	Pregnancy, Childbearing, Family Planning	8	61	0.88
X	Female Genital	15	111	0.87
Y	Male Genital	17	76	0.79

symptoms (N'guessan *et al.*, 2009). Decoction remains the most used extraction method in the world because it allows, on the one hand, complete extraction of active principles (especially tannins) from the plant organs (Etame-Loe *et al.*, 2018), and on the other hand, because it mitigates or cancels the toxic effect of some medicinal recipes (Salhi *et al.*, 2019; Koman *et al.*, 2021). However, it should be noted that respondents have difficulties in putting differences between "decoction" and "infusion".

Informant Consensus Factor

The high consensus factor index (above 0.79) demonstrates strong agreement on the TMP used in each category of disease (Table 4). These results are similar to those obtained by Gumisiriza *et al.* (2019) and Anywar *et al.*, (2020) in Uganda. This index reflects good knowledge of PMTs due to cultural mixing during inter-ethnic marriages (Atakpama *et al.*, 2015) or fine environmental control. Skin diseases (S), those related to the immunological system (B), and those of a general and non-specific nature (A) are treated, respectively, by 62, 58, and 45 TMP. However, dermatitis, wounds, and malaria constitute important scourges in rural environments. The scarcity of these TMP makes it difficult to find a cure for these diseases, especially in poor families.

CONCLUSION

In the Guinean zone of Togo, there is a rich diversity (124) of medicinal plants that are threatened with extinction. This phytodiversity is essential for the local populations because the are used in the treatment of general and non-specific ailments, with general illnesses taking the lead. The plant parts and mode of preparation most used were leaves (64.8%) and decoction (76.6%), respectively. The pharmacological tests confirm the validity of medicinal recipes based on these TMP. This list remains threatened due to the increasing pressure on the collection of plant parts. However, a judicious use of herbal remedies is necessary to prevent resistance and public health issues. It is essential to promote domestication efforts to carry out their conservation.

Funding

This study was funded by Rufford Foundation, England (N°34986-1, 2022) and IDEA Wild (USA, 2022) to the first author.

REFERENCE

Adebayo M.A., Adedokun O.A., Akinpelu L.A., Okafor P.O. (2019). Evaluation of anti-diarrheal activity of methanol root bark extract of Milicia excelsa (Welw) C. C Berg (Moraceae) in rats. *Drug Research*, 69: 439-444.

Adjossou K. (2009). *Diversity, structure and dynamics of the vegetation in the fragments of rainforests of Togo: the challenges for biodiversity conservation.* Phd thesis, Togo: University of Lome, p.

Adjossou K., Kokou K., Deconchat M. (2022). Floristic composition and turnover analysis in Dahomey Gap and the surrounding sub-humid Togolese mountain minor forest refuges: Importance for biogeography and biodiversity conservation in sub-Saharan Africa. *Ecology and Evolution*, 12: e9304.

Afolabi O.J., Abejide A.E. (2020). Antiplasmodial activities of Morinda lucida (Benth) and Alstonia boonei (De wild) in mice infected with Plasmodium berghei. *Bulletin of the National Research Centre*, 44: 1-6.

Agbodan K.M.L. (2023). Les plantes médicinales menacées de disparition au Togo. 48p.

Agbodan K.M.L., Akpavi S., Amegnaglo K.B., Akodewou A., Diwediga B., Koda D.K., Batawila K., Akpagana K. (2020). Savoirs locaux sur les marqueurs temporels en zone guinéenne au Togo. *BASE*.

Agbodeka K., Gbekley H.E., Karou S.D., Anani K., Agbonon A., Tchacondo T., Batawila K., Simpore J., Gbeassor M. (2016). Ethnobotanical study of medicinal plants used for the treatment of malaria in the plateau region, Togo. *Pharmacognosy research*, 8: S12.

Agbodeka K., Gbekley H. E., Karou S. D., Anani K., Simpore J. (2017). Activité antiplasmodiale des plantes médicinales d'Afrique de l'Ouest: Revue de la littérature. *International Journal of Innovation and Scientific Research*: 121-129.

Agody K. (2007). *Contribution au recensement des plantes médicinales: enquête ethnobotanique dans la région maritime du Togo.* Thèse de Doctorat, pharm. Dakar.

Akinpelu L.A., Adebayo M.A., Aiyelero O.M., Alamojin R.T., Mbara C.J., Ogunwade I. (2020). Anti-amnesic effect of ethanol stem bark extract and fractions of *Milicia excelsa* (Moraceae) in mice. *Investigational Medicinal Chemistry and Pharmacology*, 3: 38.

Akpagana K. (1989). Recherches sur les forêts denses du Togo: Université de Bordeaux III, Thèse de Doctorat d'Université.

Akpavi S., Banoin M., Batawila K., Vodouhe R., Akpagana K. (2007). Stratégies paysannes de conservation de quelques ressources phytogénétiques dans le Moyen-Mono au Togo. *Agronomie Africaine*, 19: 337-349.

Akpavi S., Kanda M., Odah K., Akpakpah K.E., Kossi-Titrikou K., Boutaré I., Akpagana K. (2013). Valeur socio-culturelle des plantes alimentaires: un facteur de préservation. *European Scientific Journal*, 9.

Alitonou G.A., Koudoro A.Y., Dangou J.S., Yehouenou B., Avlessi F., Adeoti S., Menut C., Sohounhloue D.C. (2012). Volatile constituents and biological activities of essential oil from *Securidaca longepedunculata* Fers. growing in Benin. *Scientific Study & Research. Chemistry & Chemical Engineering, Biotechnology, Food Industry*, 13: 33.

Anywar G., Kakudidi E., Byamukama R., Mukonzo J., Schubert A., Oryem-Origa H. (2020). Indigenous traditional knowledge of medicinal plants used by herbalists in treating opportunistic infections among people living with HIV/AIDS in Uganda. *Journal of ethnopharmacology*, 246: 112205.

Asase A., Oteng-Yeboah A.A., Odamtten G.T., Simmonds M.S. (2005). Ethnobotanical study of some Ghanaian anti-malarial plants. *Journal of ethnopharmacology*, 99: 273-279.

Atakpama W., Adoko S.A., Batawila K.A., Atakpama W. (2021). Plantes et prise en charge de la santé maternelle dans la région Maritime du Togo. *Ann. Afr. Med*, 14: e4196.

Atakpama W., Batawila K., Gnamkoulaba A., Akpagana K. (2015). Quantitative approach of *Sterculia setigera* Del.(Sterculiaceae) ethnobotanical uses among rural communities in Togo (West Africa). *Ethnobotany Research and Applications*, 14: 063-080.

Atsri H.K., Konko Y., Cuni-Sanchez A., Abotsi K.E., Kokou K. (2018). Changes in the West African forest-savanna mosaic, insights from central Togo. *PloS one*, 13: e0203999.

Awo H., Chaffra S.A., Yabi F.B., Lougbenon T.O., Djondo M., Tente B. (2020). Étude ethno-zoologique et formes d'utilisation de *Trichechus senegalensis* au Sud Bénin. *Rev. Mar. Sci. Agron. Vét.,* 8: 179-185.

Bello O.M., Abiodun O.B., Oguntoye S.O. (2018). Insight into the ethnopharmacology, phytochemistry, pharmacology of *Launaea taraxacifolia* (Willd) amin ex c. jeffrey as an underutilized vegetable from Nigeria: A review. *The Annals of the University Dunarea de Jos of Galati. Fascicle VI-Food Technology*, 42: 137-152.

Bi D.P.V.D., Koffi K.J., Yao C.Y.A. (2020). Importance sociale de Bambusa vulgaris Schrad ex. JC Wendl.(Poaceae) dans la Sous-préfecture d'Azaguié, Sud-Est de la Côte d'Ivoire. *Ethnobotany Research and Applications*, 19: 1-17.

Briki Z. (2019). *Etude Ethnobotanique des plantes médicinales de la commune de M'Sila.* Université Mohamed Boudiaf de M'Sila.

Cain B.E., Douzet F. (2022). La Californie à l'avant-garde de la lutte contre le changement climatique: un immense défi politique. *Hérodote*, 1-2: 11-21.

Chukwuma E.C., Soladoye M.O., Feyisola R.T. (2015). Traditional medicine and the future of medicinal Plants in Nigeria. *Journal of Medicinal Plants Studies*, 3: 23-29.

Dagnelie P. (1998). Statistique théorique et appliquée (Tome 2). *De Boeck & Larcier, Paris–Bruxelles*.

Delhami M., Boussaid A., Chafai B., Nebbache S. (2022). Diversité et inventaire des plantes dans la région de djebel Sidi Rghis, Wilaya d'Oum El Bouaghi.

Effoe S., Gbekley E.H., Mélila M., Aban A., Tchacondo T., Osseyi E., Karou D. S., Kokou K. (2020). Étude ethnobotanique des plantes alimentaires utilisées en médecine traditionnelle dans la région Maritime du Togo. *International Journal of Biological and Chemical Sciences*, 14: 2837-2853.

Elith J., Phillips S.J., Hastie T., Dudík M., Chee Y.E., Yates C.J. (2011). A statistical explanation of MaxEnt for ecologists. *Diversity and distributions*, 17: 43-57.

Ern H. (1979. Die vegetation togos. gliederung, gefährdung, erhaltung. *Willdenowia*: 295-312.

Etame-Loe G., Ngoule C.C., Mbome B., Pouka C.K., Ngene J.P., Yinyang J., Okalla C. (2018). Contribution à l'étude des plantes médicinales et leurs utilisations traditionnelles dans le département du Lom et Djerem (Est, Cameroun). *Journal of Animal &Plant Sciences*, 35: 5560-5578.

Favi G.A., Dassou G.H., Agoundé G., Ouachinou J.M.-A.S., Djidohokpin D., Adomou A.C., Yédomonhan H., Tossou G.M., Akoègninou A. (2022). Current and future distribution pattern of *Cochlospermum planchonii* and *Cochlospermum tinctorium* in Benin (West Africa), in response to climate change scenario. *Modeling Earth Systems and Environment*, 8: 773-786.

Folega F., Bilouktime B., Mustapha T., Kamara M., Wouyo A., Aboudoumisamilou I., Oyetunde D., Kperkouma W., Komlan B., Koffi A. (2023). Land Use Change and Structural Diversity of Affem Boussou Community Forest in Tchamba 1 Commune (Tchamba Prefecture, Togo). *Conservation*, 3: 346-362.

Gadikou K.J., Atakpama W., Egbelou H., Kombate B., Batawila K., Akpagana K. (2022). Valeur d'importance d'usage des plantes médicinales vulnérables de la région Maritime du Togo. 15.

Gaur R., Sharma J. (2011). Indigenous knowledge on the utilization of medicinal plant diversity in the Siwalik region of Garhwal Himalaya, Uttarakhand. *Journal of forest and environmental science*, 27: 23-31.

Gayibor N. (1997). Togo. *The Journal of African History*, 38: 301-358.

Gbekley H.E., Katawa G., Karou S.D., Anani K., Tchadjobo T., Ameyapoh Y., Batawila K., Simpore J. (2017). Ethnobotanical study of plants used to treat asthma in the maritime region in Togo. *African Journal of Traditional, Complementary and Alternative Medicines*, 14: 196-212.

Gnagne A.S., Camara D., Bene K., Zirihi G.N. (2017). Étude ethnobotanique des plantes médicinales utilisées dans le traitement du diabète dans le Département de Zouénoula (Côte d'Ivoire). *Journal of Applied Biosciences*, 113: 11257-11266.

Gnondoli P., Bakoma B., Batawila K., Wala K., Dourma M., Pereki H., Akpagana K. (2015). Distribution et utilités des mauvaises herbes des champs de cultures du campus Universitaire de Lomé. *Journal de la Recherche Scientifique de l'Universite de Lome*, 17: 1-19.

Gumisiriza H., Birungi G., Olet E.A., Sesaazi C.D. (2019). Medicinal plant species used by local communities around queen elizabeth national park, maramagambo central forest reserve and ihimbo central forest reserve, south western Uganda. *Journal of ethnopharmacology*, 239: 111926.

Haidara M., Diarra M.L., Doumbia S., Denou A., Dembele D., Diarra B., Sanogo R. (2020). Plantes médicinales de l'Afrique de l'Ouest pour la prise en charge des affections respiratoires pouvant se manifester au cours de la Covid-19. *International Journal of Biological and Chemical Sciences*, 14: 2941-2950.

Heywood V. H. (2017). Plant conservation in the Anthropocene–challenges and future prospects. *Plant Diversity*, 39: 314-330.

Holaly G.E., Simplice K.D., Charlemagne G., Kodjovi A., Kokou A., Tchadjobo T., Amegnona A., Komlan B., Jacques S. (2015). Étude ethnobotanique des plantes utilisées dans le traitement du diabète dans la médecine traditionnelle de la région Maritime du Togo. *The Pan African Medical Journal*, 20.

Jamoulle M., Roland M., Humbert J., Brûlet J.-F. (2000). Traitement de l'information médicale par la Classification Internationale des Soins Primaires CISP-2 Deuxième version.

Kaky E., Gilbert F. (2019). Assessment of the extinction risks of medicinal plants in Egypt under climate change by integrating species distribution models and IUCN Red List criteria. *Journal of Arid Environments*, 170: 103988.

Kébenzikato A.B., Wala K., Atakpama W., Dimobé K., Dourma M., Woégan A.Y., Batawila K., Akpagana K. (2015). Connaissances ethnobotaniques du baobab (Adansonia digitata L.) au Togo. *Biotechnol. Agron. Soc. Environ*, 19: 247-261.

Koda D.K., Chérif M., Adjossou K., Amégnaglo K.B., Diwediga B., Agbodan K.M.L., Guelly A.K. (2019). Typology of coffee-based agroforestry systems in the semi-deciduous forest zone of Togo (West Africa).

Koman S.R., Kpan W.B., Yao K., Outtara D. (2021). Medicinal uses of plants by traditional birth attendants to facilitate childbirth among Djimini women in Dabakala (Center-North of Côte d'Ivoire). *Ethnobotany Research and Applications*, 21: 1-12.

Kpodar M.S., Karou S.D., Katawa G., Anani K., Gbekley H.E., Adjrah Y., Tchacondo T., Batawila K., Simpore J. (2016). An ethnobotanical study of plants used to treat liver diseases in the Maritime region of Togo. *Journal of ethnopharmacology*, 181: 263-273.

Kpodar M.S., Lawson-Evi P., Bakoma B., Eklu-Gadegbeku K., Agbonon A., Aklikokou K., Gbeassor M. (2015). Ethnopharmacological survey of plants used in the treatment of diabetes mellitus in south of Togo (Maritime Region). *Journal of Herbal Medicine*, 5: 147-152.

Kpoyizoun K., Metowogo K., Missebukpo A., Eklu-Gadegbeku K., Aklikokou K., Gbeassor M. (2019). Effect of *Maytenus senegalensis* roots on OVA-induced airway inflammation in a mouse asthma model. *African Journal of Pharmacy and Pharmacology*, 13: 49-56.

Lee C., Kim S.-Y., Eum S., Paik J.-H., Bach T.T., Darshetkar A. M., Choudhary R. K., Quang B.H., Thanh N.T., Choi S. (2019). Ethnobotanical study on medicinal plants used by local Van Kieu ethnic people of Bac Huong Hoa nature reserve, Vietnam. *Journal of ethnopharmacology*, 231: 283-294.

List I. R. (2015). The IUCN red list of threatened species. *International Union for Conservation of Nature and Natural Resources. Online at: http://www.iucnredlist. org/*.

Miara M.D., Bendif H., Rebbas K., Rabah B., Hammou M.A., Maggi F. (2019). Medicinal plants and their traditional uses in the highland region of Bordj Bou Arreridj (Northeast Algeria). *Journal of Herbal Medicine*, 16: 100262.

Mongalo N.I., McGaw L., Finnie J., Van Staden J. (2015). *Securidaca longipedunculat*a Fresen (Polygalaceae): A review of its ethnomedicinal uses, phytochemistry, pharmacological properties and toxicology. *Journal of ethnopharmacology*, 165: 215-226.

Motto A.E., Lawson-Evi P., Bakoma B., Eklu-Gadegbeku K., Aklikokou K. (2021). Antihyperlipidemic and antioxidant properties of hydro-alcoholic extracts from *Anogeissus leiocarpus* (Combretaceae). *Heliyon*, 7: e06648.

Mounkaila S., Soukaradji B., Morou B., Karim S., Issoufou H. B.-A., Mahamane A., Ikhiri K., Saadou M. (2017). Inventaire et gestion des plantes médicinales dans quatre localités du Niger. *European Scientific Journal*, 24: 498-521.

N'guessan K., Tra B., Koné M. (2009). Étude ethnopharmacologique des plantes antipaludiques utilisées en médecine traditionnelle chez les Abbey et Krobou d'Agboville (Côte-d'Ivoire). *Ethnopharmacologia*, 44: 42-50.

Neuenschwander P., Sinsin B., Goergen G.E. (2011). *Protection de la nature en Afrique de l'Ouest: une liste rouge pour le Bénin*: International Institute of Tropical Agriculture.

Noundou X.S., Krause R., Van Vuuren S., Ndinteh D.T., Olivier D. (2014). Antibacterial activity of the roots, stems and leaves of *Alchornea floribunda*. *Journal of ethnopharmacology*, 151: 1023-1027.

Olivier M., Zerbo P., Boussim J. I., Guinko S. (2012). Les plantes des galeries forestières à usage traditionnel par les tradipraticiens de santé et les chasseurs Dozo Sénoufo du Burkina Faso. *International Journal of Biological and Chemical Sciences*, 6: 2170-2191.

Ouattara D. (2006). Contribution à l'inventaire des plantes médicinales significatives utilisées dans la région de Divo (sud forestier de la Côte-d'Ivoire) et à la diagnose du poivrier de Guinée: *Xylopia aethiopica* (Dunal) A. Rich.(Annonaceae). *Rich.(Annonaceae). Thèse de Doctorat de l'Université de Cocody-Abidjan (Côte-d'Ivoire)*.

Ouro-Djeri H., Koudouvo K., Esseh K., Tchacondo T., Batawila K., Wateba M.I., Ouro-Djeri E., Gbeassor M. (2022). Etude ethnopharmacologique des plantes utilisées dans la préparation des phytomédicaments extemporanés à Tomety-Kondji, canton riverain au Parc National de Togodo-Sud du Togo. *International Journal of Biological and Chemical Sciences*, 16: 967-991.

Owolabi M.S., Ogundajo A.L., Alafia A.O., Ajelara K.O., Setzer W. N. (2020). Composition of the essential oil and insecticidal activity of *Launaea taraxacifolia* (Willd.) Amin ex C. Jeffrey growing in Nigeria. *Foods*, 9: 914.

Prance G.T., Baleé W., Boom B., Carneiro R.L. (1987). Quantitative ethnobotany and the case for conservation in Ammonia. *Conservation Biology*, 1: 296-310.

Radji P.R. (2008). Togo Plant Red List. Version 1.4. Université de Lomé. Checklist dataset. https://doi.org/10.15468/2hy4sw.

Ram A.J., Bhakshu L.M., Raju R.V. (2004). *In vitro* antimicrobial activity of certain medicinal plants from Eastern Ghats, India, used for skin diseases. *Journal of ethnopharmacology*, 90: 353-357.

Reyes-García V., García-del-Amo D., Benyei P., Fernández-Llamazares Á., Gravani K., Junqueira A.B., Labeyrie V., Li X., Matias D.M., McAlvay A. (2019). A collaborative approach to bring insights from local observations of climate change impacts into global climate change research. *Current opinion in environmental sustainability*, 39: 1-8.

Salako G., Oyebanji O.O., Olagunju T.E., Howe G.T. (2021). Potential impact of climate change on the distribution of some selected legumes in Cameroon and adjoining Nigeria border. *African Journal of Ecology*, 59: 959-975.

Salhi N., Bouyahya A., Fettach S., Zellou A., Cherrah Y. (2019). Ethnopharmacological study of medicinal plants used in the treatment of skin burns in occidental Morocco (area of Rabat). *South African Journal of Botany*, 121: 128-142.

Sanon S., Azas N., Gasquet M., Ollivier E., Mahiou V., Barro N., Cuzin-Ouattara N., Traore A., Esposito F., Balansard G. (2003). Antiplasmodial activity of alkaloid extracts from *Pavetta crassipes* (K. Schum) and *Acanthospermum hispidum* (DC), two plants used in traditional medicine in Burkina Faso. *Parasitology Research*, 90: 314-317.

Schulz V., Hänsel R., Tyler V.E. (2001). *Rational phytotherapy: a physician's guide to herbal medicine*: Psychology Press.

Sofowora A. (2010). *Plantes médicinales et médecine traditionnelle d'Afrique*: KARTHALA Editions.

Tardío J., Pardo-de-Santayana M. (2008). Cultural importance indices: a comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain) 1. *Economic botany*, 62: 24-39.

Thiombiano H.M., Bangou M.J., Nacoulma A.P., Ouoba B., Sawadogo M., Lema A., Coulidiati T.H., Ouoba H.Y., Ouedraogo G.A. (2022). Ethnobotanical survey on medicinal plants used in Burkina Faso in the treatment of breast cancer, phytochemistry and antioxidant activities: *Euphorbia poissonii* Pax and *Flueggea virosa* (Willd.) Voigt (Euphorbiaceae). *African Journal of Biology and Medical Research*, 5: 1-16.

Whitney C. (2022). EthnobotanyR: Calculate quantitative ethnobotany indices. *R package version 0.1*, 9.

Xu W., Zhu S., Yang T., Cheng J., Jin J. (2022). Maximum entropy niche-based modeling for predicting the potential suitable habitats of a traditional medicinal plant (*Rheum nanum*) in Asia under climate change conditions. *Agriculture*, 12: 610.