

Gastrointestinal Ulcers Treatment: Plants and Recipes Used by Herbalists of Abomey-Calavi and Cotonou Districts, Southern Benin

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Abstract

This study set out to identify plants and recipes used by herbalists in the municipalities of Abomey-Calavi and Cotonou to treat gastrointestinal ulcers and to characterize the distribution of their knowledge. An ethno-pharmacological survey was carried out in which informants who agreed freely were interviewed using a semi-structured questionnaire. A total of 85 herbalists were surveyed. The data were processed with Microsoft Excel to calculate the relative frequencies of citation of the various species mentioned by the herbalists and various indices including Simpson's Index were adapted to test the distribution of their knowledge. Multiple regression and correspondence analysis were performed using R studio. Our results revealed that the Dendi, Ifè and Mina, all equitable in their knowledge of anti-ulcer plants, are likely to know more than the other ethnic groups. On the other hand, respondents practicing Islam are more likely to know many antiulcer plants than those practicing Vodoun and Christianity. This constant distribution of knowledge of anti-ulcer plants among the Dendi, Ifè and Mina, three different ethnic groups seems normal and attests to the fusion between these different ethnic groups in view of this knowledge. A total of 70 anti-ulcer recipes, made from 71 species of medicinal plants or non-floristic resources were recorded. *Vitellaria paradoxa*, *Parkia biglobosa* and *Ocimum gratissimum* were the top 03 most frequently

cited in descending order of frequency. All the species cited are grouped into 44 botanical families among which the Fabaceae, *Lamiaceae* and *Sapotaceae* were strongly represented. Benin's flora abounds in a diversity of medicinal plant species known to herbalists in Abomey-Calavi and Cotonou for the treatment of gastrointestinal ulcers. The results of this study constitute a good archive for the selection of plant species for in-depth studies with a view to formulating improved traditional medicines for gastrointestinal ulcers.

Keywords

Gastrointestinal Ulcer, Ethnomedicine, Herbalist, Nature, Plant Material

1. Introduction

Gastrointestinal ulcers are one of the major gastrointestinal pathologies affecting more than 10% of the world's population each year [1]-[3]. It is a pathology frequently engendered by chronic consumption of alcoholic beverages, smoking, non-steroidal anti-inflammatory drugs, stress and *H. pylori* infection [4]. It may also be due to *Salmonella enterica* infection. Indeed, complications of typhoid or paratyphoid fever have led to cases of ulcer [5] [6]. While colonic ulcer due to *Salmonella enteritidis* infection is less common in children, a recent case was reported in a 32-month-old child [7]. In detail, infection with *Salmonella enterica* (*Salmonella typhimurium*, *Salmonella paratyphi*, and *Salmonella enteritidis*) causes gastric oxidative stress and disruption of gastrointestinal mucosal barriers, resulting in bleeding ulcerations [8]. Anticholinergics and antibiotic agents against ulcerogenic bacteria are the main classes of drugs used to treat this disease [9].

However, the incidence of relapses and adverse effects generally associated with synthetic therapies cripple peptic ulcer control programs. By way of result, resistance to antibiotic therapy involved in the control of this pathology is a growing and persistent phenomenon as the deaths associated with bacterial AMR was estimated to be 4.95 million in 2019, including 1.27 million deaths attributable to bacterial AMR and the all-age death rate attributable to resistance was estimated to be highest in western sub-Saharan Africa, at 27.3 deaths per 100,000 [10]. *H. pylori* is one of the multidrug-resistant bacteria reported and resistance to clarithromycin, levofloxacin, and metronidazole has risen alarmingly [11] [12]. The WHO has classified *Helicobacter pylori* and *Salmonella* as priority pathogens for research and development of new antibiotics [13] [14]. In addition, studies have reported a high prevalence of *Salmonella enterica* multidrug resistance to antibiotics and resistance determinants that indicate an increased public health risk associated with *Salmonella enterica* infection [15] [16]. It is therefore urgent to find new molecules capable of replacing the anti-inflammatories, antioxidants, wound-healers and antimicrobials currently in use and failing, in particular those used to treat gastrointestinal ulcers. The therapeutic or dietary use of plant resources by anthropological groups has long provided a basis for the discovery of

new active principles [17]. Herbal medicines continue to play an essential role in healthcare and their use by different cultures has been widely documented [18] [19]. The World Health Organization (WHO) estimated in 1985 that around 65% of the world's population relied primarily on traditional plant-derived medicines for their primary health care [20]. Even though, plants-based metabolites could play a crucial role in the treatment of *H. pylori* infections [21].

The medicinal richness of African flora has been documented by several scientific studies. An ethnobotanical study conducted by Tesfaye *et al.* in Ethiopia identified 53 plant species belonging to 30 families traditionally used in cancer treatment, the most frequently mentioned being *Acmella caulirhiza* Del (*Asteraceae*), *Clematis simensis* Fresen (*Ranunculaceae*), *Croton macrostachyus* Del (*Euphorbiaceae*) and *Dorstenia barnimiana* Schweinf (*Moraceae*) [22]. The ethnopharmacology of cancer in Togo includes 70 plants from 39 families, the most frequently mentioned being *Rubiaceae*, *Caesalpiniaceae*, *Fabaceae* and *Annonaceae*, with the ten most frequently cited species being *Xylopiya aethiopica*, *Aframomum melegueta*, *Khaya senegalensis*, *Parkia biglobosa*, *Piliostigma thonningii*, *Blighia sapida*, *Vitellaria paradoxa*, *Adansonia digitata*, *Annona muricata* and *Parinari curatellifolia* [23]. 14 plants commonly used and often endangered used by communities and traditional medical practitioners for treating sexually transmitted diseases from 5-selected districts of Zimbabwe were investigated for toxicity by Brine shrimp lethality test (BSLT), by 50% Cytopathic effect on VERO cultured cells, for antiviral activity and were found to be toxic and to have efficient antiviral activity [24].

Benin, like other countries, boasts a wealth of ethno-medical resources. In particular, Akoegninou *et al.* listed nearly 30,700 specimens with therapeutic properties in Benin's flora [25]. In the ethnobotanical study carried by Adomou *et al.*, a total of 205 plant species used in the formulation of 41 recipes to treat 37 illnesses and symptoms, grouped into 181 genera and 74 families were identified [26], the most represented families in terms of specific richness were *Leguminosae*, *Rubiaceae* and *Euphorbiaceae*. A recent study reported by Dougnon *et al.* identified 57 species sold by Beninese herbalists for the treatment of typhoid fever, including *Senna siamea*, *Phyllanthus amarus*, *Uvaria chamae*, *Vachellia sieberiana*, *Heterotis rotundifolia*, *Crateva adansonii*, *Citrus aurantiifolia*, *Acanthospermum hispidum*, *Corchorus olitorius* [27]. There's no doubt that Benin's flora overflows in plants probably with anti-ulcer properties. To help meet the challenges posed by the ineffectiveness of the anti-ulcer molecules currently in use and the antimicrobial resistance of ulcer-causing bacteria, this study set out to explore the Beninese pharmacopoeia to identify and characterize plants and recipes used by the herbalists of Abomey-Calavi and Cotonou to treat gastrointestinal ulcers.

2. Materials and Methods

2.1. Study Area

This study was carried out in the communes of Abomey-Calavi (**Figure 1**) and Cotonou (**Figure 2**) from April to May 2022, both in southern Benin. This region

is characterized by strong ethnic and culture diversity. Indeed, each people has its own relationship with its animal and plant environment, which it exploits to satisfy its basic needs, particularly health [28].

Southern Benin lies between 6°25'N and 7°30'N and covers an area of 17.109 km². Its climate is sub-equatorial and characterized by a bimodal rainfall regime with two rainy seasons alternating with two dry seasons. The average annual temperature is 28 °C and air humidity varies between 69% and 97%. Ferralitic soils on clayey sediments, hydromorphic soils in valleys, lowlands and alluvial plains, Vertisols in the Lama depression and tropical eutrophic brown soils are found. Its vegetation comprises a mosaic of dense rainforest islands, savannahs, grasslands, mangroves and fallows. The total flora of southern Benin comprises 1170 plant species [26]. The dominant ethnic groups are Fon and related cultures (39.2%), Adja and related cultures (15.2%) and Yoruba and related cultures (14.5%) [29] [30].

2.2. Data Collection

To carry out the ethno-pharmacological survey, we explained the purpose of our study to herbalists and sought their consent to the capitalization of their

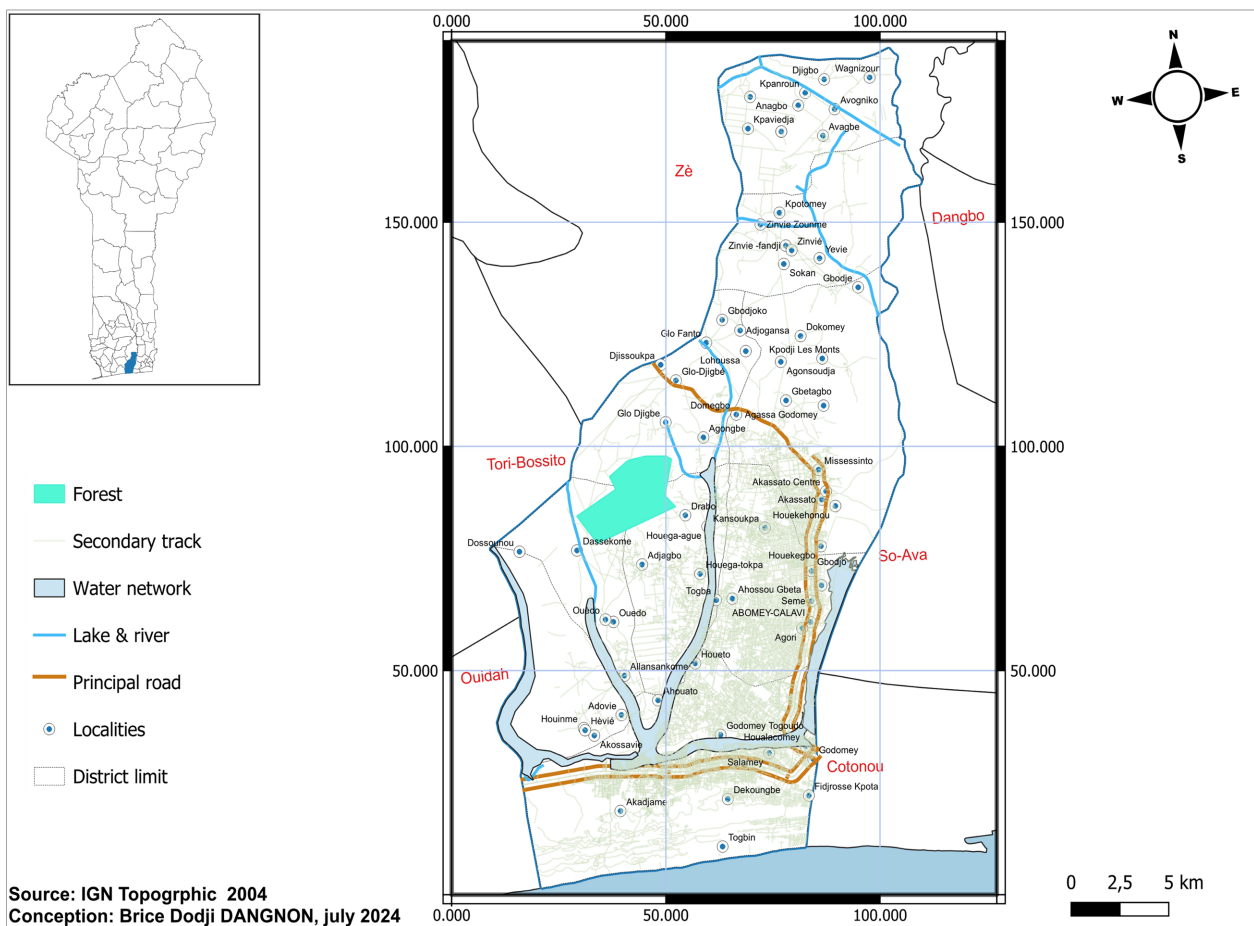


Figure 1. Abomey-Calavi municipality map.

$$\lambda = \sum_{i=1}^S (P_i)^2 \quad (1)$$

where, P_i = proportion of citations for species i (2), S = total or cardinal number of species cited.

$$P_i = \frac{n_i}{N} \quad (2)$$

where, n_i = number of citations of species I , N = total number of citations. The closer this index is to 1, the more evenly distributed the knowledge is.

The Diversity index (3) and the Equitability index (4), were calculated to measure respectively the diversity of plant species cited and the dominance of plants cited.

$$D = 1 - \lambda \quad (3)$$

where, λ = Index of Simpson, $D = 1$: Case where an infinite number of species are cited. Probability approximately equal to zero: Case where very few species are cited.

$$ED = D/D_{\max} \quad (4)$$

where, D = Diversity of citation, D_{\max} = maximal Diversity. Simpson's equitability index is used to express the dominance of one species (ED tends towards 0) or the codominance of several species (ED tends towards 1).

In addition, the data were subjected to multivariate statistical analysis, including multiple regression and factorial correspondence analysis.

3. Results

3.1. Characteristics of the Herbalists Prospected

Figure 1 shows the socio-demographic characteristics of the survey population. This includes information on ethnicity, religion, education level and seniority.

The populations surveyed are made up of 50%, 14.28%, 10.71%, 7.14%, 3.57%, 3.57%, 3.57%, 3.57%, 3.57% respectively Fon, Aizo, Mina, Goun, Dendi, Hloua, Houagonou, Ifè and Mahi (**Figure 3(a)**). Even if other ethnic groups are represented, it is clear that the herbalists surveyed in this study are dominated by fons speakers. We recorded the representation of Christianity, Vodoun and Islam (**Figure 3(b)**). In fact, 71.42% of the herbalists surveyed were Christians, 25% were followers of Vodoun and 3.57% were Muslims. It should be noted that the majority of herbalists surveyed were Christians. The herbalists surveyed are categorized into three levels of education: primary, secondary and higher (**Figure 3(c)**). The primary education was the most represented with 82.75%, followed by the secondary level with 13.79% and the higher level with 3.44%.

Herbalists' seniority was represented in four ranges: [1;10[, [10;20[, [20;30[and [30;40] (**Figure 3(d)**). The [20;30[seniority was the most representative with 32.14%. It is followed by the [1;10[and [10;20[each with a percentage of 25%. In addition, 17.85% of herbalists have exerted the profession since 30 to 40 years.

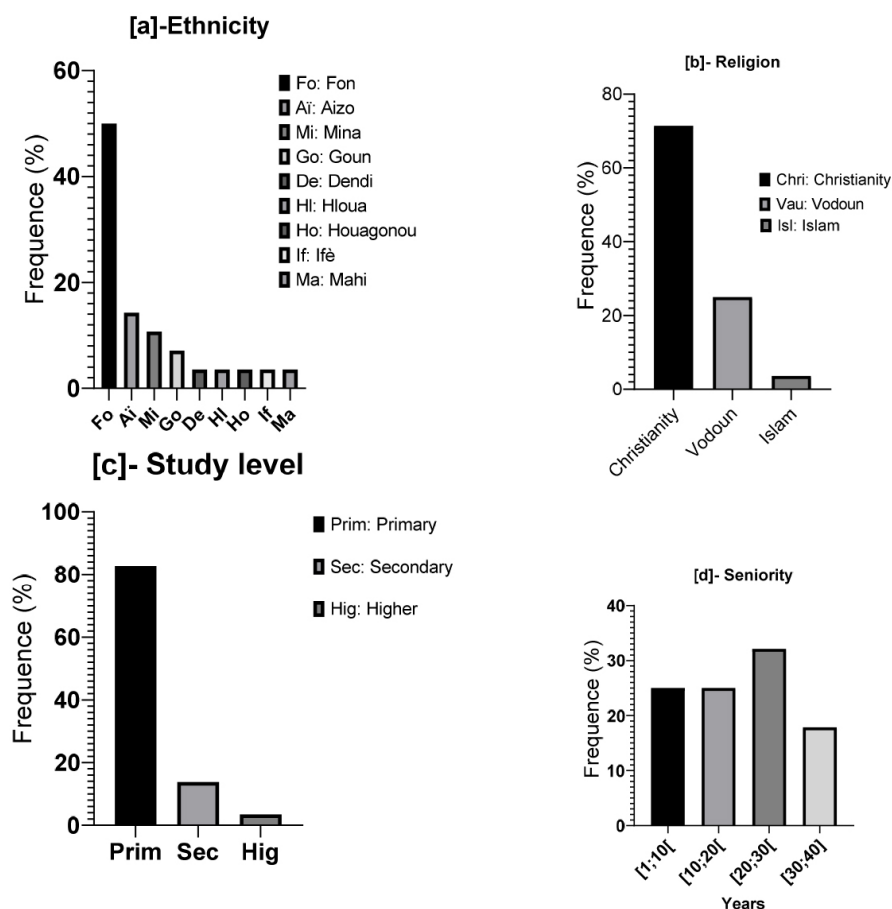


Figure 3. Characteristics of informants.

3.2. Distribution of Knowledge on Plant Used for Treatment of Gastrointestinal Ulcer

The parameters of repartition on plant used for treatment of gastrointestinal ulcer are summarized in **Table 1** and **Table 2**. The interviewee diversity index calculated shows that Dendi (0.0697), Ifè (0.0697) and Mina (0.0593) ethnic groups are susceptible to knowing more antiulcer plants than the other ethnic groups. In addition. The Equitability Index was evaluated for the populations surveyed, where the averages by ethnic group are summarized in. A comparison of the equitability index between ethnic groups shows that the Dendi (0.8991), Ifè (0.8991) and Mina (0.7657) groups have equal knowledge of anti-ulcer plants. The same statement applies to the Aizonnou, Fon, Goun and Mahi ethnics groups.

We also note that respondents practicing Islam are more likely to know many anti-ulcer plants than those practicing Vodou and Christianity. We also note from the comparison of the average equitability index of religious groups that respondents practicing Vodou and those practicing Christianity tend to have the same level of knowledge of anti-ulcer plants. All these explanations are confirmed by correspondence analysis summarized in **Figure 4**, where ethnic and religious groups are defined by their level of knowledge of anti-ulcer plants. However, the

multiple regression analysis performed has demonstrated that none of ethnicity, education and religion whether or not combined did not predict the distribution of knowledge on plants used to treat gastro-intestinal ulcer (**Table 3**).

Table 1. Distribution of ethnic groups represented according to average diversity and equitability indices.

Ethnic Group	Average Diversity index (ID = Ex/Et)	Equitability index (IE = ID/IDmax)
Aizonnou	0.0271	0.3498
Dendi	0.0697	0.8991
Fon	0.0320	0.4128
Goun	0.0232	0.2992
Hloua	0.0077	0.0993
Houagonou	0.0155	0.1999
Ifè	0.0697	0.8991
Mahi	0.0232	0.2992
Mina	0.0593	0.7657

Table 2. Average diversity and equitability indexes defined by religious groups.

Religious group	Average Diversity index (ID = Ex/Et)	Equitability index (IE = ID/IDmax)
Christianism	0.0356	0.4594
Vodoun	0.0271	0.3495
Islam	0.0697	0.8991

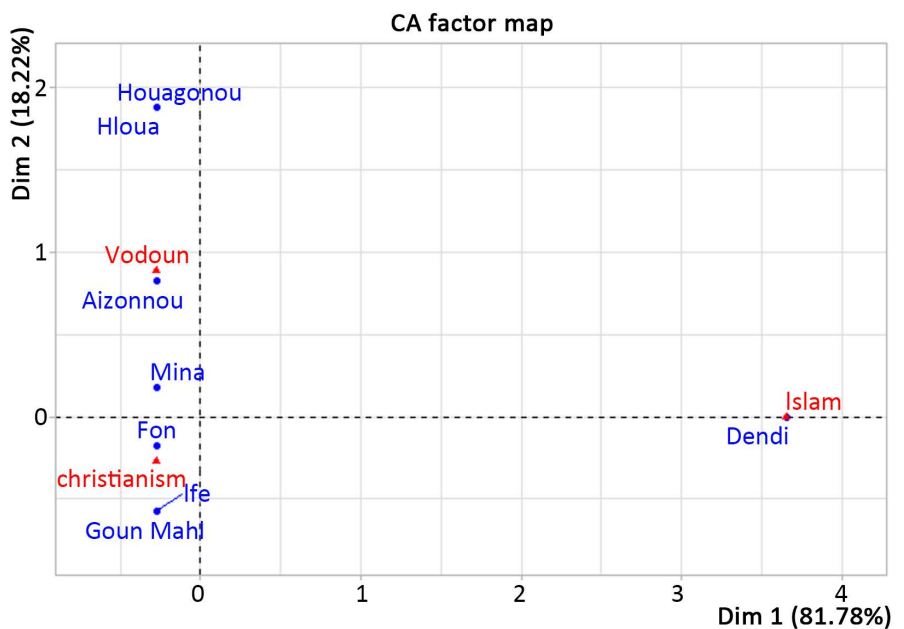


Figure 4. Projection of ethnic and religious groups defined by knowledge of anti-ulcer plants.

Table 3. Multiple regression of the distribution of antiulcer plant knowledge according to ethnicity, level of education and/or religion.

Model	Multiple R-squared	Adjusted R-squared	F-statistic	p-value
Ethnicity + Education + Religion	0.03925	-0.07604	0.3404	0.7963
Ethnicity + Education	0.0354	-0.0388	0.4771	0.6259
Ethnicity	0.003141	-0.03378	0.08508	0.7728
Education	0.03456	-0.001193	0.9666	0.3343
Religion	0.001089	-0.03591	0.02944	0.8651
Education + Religion	0.03902	-0.0349	0.5279	0.596
Ethnicity + Religion	0.005628	-0.07086	0.07357	0.9293

3.3. Plants Used by Herbalists in the Municipalities of Abomey-Calavi and Cotonou to Treat Gastrointestinal Ulcers

Table 5 shows the plant species of the Benin pharmacopoeia used by herbalists in the municipalities of Abomey-Calavi and Cotonou for the treatment of gastrointestinal ulcers. A total of 71 species were inventoried, among which the 12 most frequently cited, in decreasing order of frequency, were *Vitellaria paradoxa*, *Parkia biglobosa*, *Ocimum gratissimum*, *Khaya senegalensis*, *Citrus limon*, *ACACIA nilotica* ou *adansonii*, *Ocimum canum*, *Phyllanthus amarus*, *Senna siamea*, *Piper guineense*, *Momordica charantia*, *Pteleopsis suberosa*, *Spondias mombin*, *Sida acuta*, *Jatropha multifida*, *Heliotropium indicum*, *Eugenia aromatica* and *Crateva adansonii*. With a fair citation frequency (3.57%) and a fair probability of occurrence (0.01), 26 of the species cited for the treatment of gastrointestinal ulcers are less represented. These include: *Anchomanes difformis*, *Anacardium occidentale*, *Catharanthus roseus*, *Combretum micranthum*, *Rhaphiostylis beninensis*, *Xylopi aethiopica*, *Sansevieria liberica*, *Hyptis suaveolens*, *Pseudocedrela kotschyi*, *Rauvolfia vomitoria* Afzel, *Cassytha filiformis*, *Alium cepa*, *Newboudia leavis*, *Rourea coccinea*, *Alchornea cordifolia*, *Combretum racemosum*, *Eucalyptus globulus* (*Eucalyptus radiata*), *Zanthoxylum zanthoxyloides* (Lam.), *Rytigynia umbellulate*, *Carissa spinarum*, *Cajanus cajan*, *Passiflora foetida*, *Ceratotherca sesamoides*, *Bridelia ferruginea* Benth, *Terminalia glaucescens* and *Carica papaya*.

All the cited species are grouped into 44 taxonomic families, as shown in **Table 6**. In ascending order of frequency, *Fabaceae*, *Lamiaceae*, *Sapotaceae*, *Euphorbiaceae*, *Rutaceae*, *Annonaceae*, *Meliaceae*, *Malvaceae*, *Combretaceae* and *Boraginaceae* were the ten firstly most represented families.

The various species cited for the treatment of gastrointestinal ulcers are heterogeneously distributed as confirmed by the Simpson Index evaluated ($\lambda = 0.163$), which is inferior to 1 (**Table 4**). Furthermore, the calculated Diversity Index is $D = 0.837$, a value very close to 1, indicating a large number of species with very low probabilities (**Table 4**). In addition, the Simpson Equitability Index (ED) was

evaluated to determine the degree of equality of the species listed. Its value ED = 0.849, very close to 1, indicates the codominance of several listed species (Table 4). This codominance is noted with *Vitellaria paradoxa*, *Parkia biglobosa* and *Ocimum gratissimum* and *Khaya senegalensis*, *Citrus limon*, *Acacia nilotica* or *adansonii*, *Ocimum canum*, *Phyllanthus amarus* and *Senna siamea*. The equality of frequency and probability noted for some of the species mentioned also accounts for this codominance (Table 5).

Table 4. Indices of anti-ulcer plant distribution.

Species diversity index	Valeurs
Simpson index (λ)	0.163
Diversity Index (D)	0.837
Maximum diversity (Dmax)	0.985
Equitability Index (EI)	0.849

3.4. Characterization of Recipes Listed by Herbalists for the Treatment of Gastrointestinal Ulcer

The various recipes given by herbalists for the treatment of gastrointestinal ulcers are listed in Table 7. A total of 70 anti-ulcer recipes made from medicinal plants (leaves, stems, seeds, fruits, barks, whole plants, flowers and/or roots) and/or non-wood resources such as peak milk, white calaba and honey (recipes 7, 13, 14, 23 and 28) were given by the herbalists surveyed. On average, they consisted of 3 ± 2 phytopharmaceutical resources. Three of the recipes are made up of the largest number of phytopharmaceutical resources, i.e. recipes N°8, 11 and 21. The 8th recipe is made up of 9 resources, including *Acacia nilotica* or *adansonii*, *Momordica charantia* L., *Phyllanthus amarus*, *Ocimum gratissimum* L., *Lantana camara*, *Hyptis suaveolens*, *Piper guineense*, *Allium sativum* and *Piper guineense*; the 11th recipe is made up of 10 resources including *Tetrapleura tetraptera*, *Xylopi aethiopia*, *Acacia nilotica* or *adansonii*, *Spondias mombin*, *Alchornea cordifolia*, *Piper guineense*, *Eugenia aromatica*, *Khaya senegalensis*, *Pteleopsis suberosa*, and *Saba senegalensis*; then the 21st recipe is made up of 11 resources including *Eugenia aromatica*, *Xylopi aethiopia*, *Monodora myristica*, *Tetrapleura tetraptera*, *Momordica charantia*, *Clausena anisata*, *Caesalpinia pucherrima*, *Ocimum gratissimum* L., *Khaya senegalensis*, *Jatropha multifida*, and *Piper guineense*. Although the majority of recipes are used by decoction, some of them are used by maceration, infusion, crushing or pulverization. Most of the recipes given have no contraindications. However, some of them prohibit the consumption of certain foods during treatment. These are recipes 13 (Consumption of raw meat, gari and galette), 24 (Consumption of spicy, hot meals and gari), 38 (Consumption of spicy and fermented meals), 51 (Consumption of milk and gari) and 57 (Consumption of cold meals, sweet drinks and fruit).

Table 5. Plants used to treat gastrointestinal ulcers.

N°	Scientific names	Family	Local names	Citation Frequency	Proportional abundance (P _i)	(P _i) ²
1	<i>Vitellaria paradoxa</i>	<i>Sapotaceae</i>	Limi	46.42	0.18	0.0324
2	<i>Parkia biglobosa</i>	<i>Fabaceae</i>	Aha	39.28	0.15	0.0225
3	<i>Ocimum gratissimum L.</i>	<i>Lamiaceae</i>	Tchiayo	35.71	0.14	0.0196
4	<i>Khaya senegalensis</i>	<i>Meliaceae</i>	Zounza; Kaïlcédra	25	0.1	0.01
5	<i>Citrus limon</i>	<i>Rutaceae</i>	cle	25	0.1	0.01
6	<i>ACACIA nilotica ou adansonii</i>	<i>Fabaceae</i>	Nep nep/Bani	21.42	0.08	0.0064
7	<i>Ocimum canum</i>	<i>Lamiaceae</i>	Késsoukéssou	21.42	0.08	0.0064
8	<i>Phyllanthus amarus</i>	<i>Euphorbiaceae</i>	Hlenwé	21.42	0.08	0.0064
9	<i>Senna siamea</i>	<i>Fabaceae</i>	Acasia	17.85	0.07	0.0049
10	<i>Piper guineense</i>	<i>Piperaceae</i>	Linlinku	14.28	0.05	0.0025
11	<i>Momordica charantia L.</i>	<i>Cucurbitaceae</i>	Nyèsiken; Nyinya	14.28	0.05	0.0025
12	<i>Pteleopsis suberosa</i>	<i>Combretaceae</i>	kuilikuili	14.28	0.05	0.0025
13	<i>Spondias mombin</i>	<i>Anacardiaceae</i>	Agnougloétin ; Sam	14.28	0.05	0.0025
14	<i>Sida acuta</i>	<i>Malvaceae</i>	Azatalouga (Adonma)	14.28	0.05	0.0025
15	<i>Jatropha multifida</i>	<i>Euphorbiaceae</i>	tanti doto	14.28	0.05	0.0025
16	<i>Heliotropium indicum</i>	<i>Boraginaceae</i>	Kokloden	14.28	0.05	0.0025
17	<i>Eugenia aromatica</i>	<i>Myrtaceae</i>	Atikingbadota	14.28	0.05	0.0025
18	<i>Crateva adansonii</i>	<i>Capparaceae</i>	Wontonzouinzuin	14.28	0.05	0.0025
19	<i>Monodora myristica</i>	<i>Annonaceae</i>	Sasaliku	10.71	0.04	0.0016
20	<i>Xylopia aethiopica</i>	<i>Annonaceae</i>	Kpédjréku	10.71	0.04	0.0016
21	<i>Cola millenii</i>	<i>Malvaceae</i>	Aloviaton	10.71	0.04	0.0016
22	<i>Kigelia africana</i>	<i>Bignoniaceae</i>	Gnanblikpo	10.71	0.04	0.0016
23	<i>Capsicum frutescens</i>	<i>Solanaceae</i>	Danmè takin	10.71	0.04	0.0016
24	<i>Vernonia cinerea (L.) Less.</i> (<i>Cyanthilium cinereum (L)</i>)	<i>Asteraceae</i>	Houinssikoussè; Hussikonou	10.71	0.04	0.0016
25	<i>Dichapetalum madagascariense (DC.)</i>	<i>Dichapetalaceae</i>	Gbaglo	10.71	0.04	0.0016
26	<i>Cocos nucifera</i>	<i>Arecaceae</i>	Agonkètin	10.71	0.04	0.0016
27	<i>Chenopodium ambrosioides</i>	<i>Chenopodiaceae</i>	Amantrouzu/Gogo	10.71	0.04	0.0016
28	<i>Tetrapleura tetraptera</i>	<i>Fabaceae</i>	Linja	10.71	0.04	0.0016
29	<i>Bambusa vulgaris Schrad ex. Wendel</i>	<i>Poaceae</i>	Dawé	10.71	0.04	0.0016
30	<i>Persea americana</i>	<i>Lauraceae</i>	Avoca ma	7.14	0.02	0.0004
31	<i>Cymbopogon citratus</i>	<i>Poaceae</i>	Tea ma	7.14	0.02	0.0004

Continued

32	<i>Ehretia cymosa</i> Thonn	Boraginaceae	Mignonman	7.14	0.02	0.0004
33	<i>Clausena anisata</i>	Rutaceae	Gbossoazohion	7.14	0.02	0.0004
34	<i>Acanthospermum hispidum</i> DC.	Asteraceae	Ahouanglon	7.14	0.02	0.0004
35	<i>Annona muricata</i>	Annonaceae	Chap-chap	7.14	0.02	0.0004
36	<i>Corchorus olitorius</i> L	Malvaceae	Ninouwi	7.14	0.02	0.0004
37	<i>Pupalia lappacea</i> ou <i>Achyranthes lappacea</i> L. ou <i>Pupal lappacea</i> (L.)	Amaranthaceae	Trèdoavohou; Trèdagboko; Tètèmatè	7.14	0.02	0.0004
38	<i>Lippia multiflora</i>	Verbenaceae	Agalala	7.14	0.02	0.0004
39	<i>Caesalpinia pucherrima</i>	Fabaceae	Orgueil de chine	7.14	0.02	0.0004
40	<i>Allium sativum</i>	Amaryllidaceae	Ayo	7.14	0.02	0.0004
41	<i>Lantana camara</i>	Verbenaceae	Hlachiayo	7.14	0.02	0.0004
42	<i>Erythrina senegalensis</i>	Kpakléssi	Kpakéssi	7.14	0.02	0.0004
43	<i>Maranthes polyandra</i> (Benth.)	Chrysobalanaceae	Magbèvidé	7.14	0.02	0.0004
44	<i>Cissus quadrangularis</i>	Vitaceae	Asan. Kankpe. Alinkpe. Avounga	7.14	0.02	0.0004
45	<i>Anchomanes difformis</i>	Araceae	Godoe	3.57	0.01	0.0001
46	<i>Anacardium occidentale</i>	Anacardiaceae	Cajou	3.57	0.01	0.0001
47	<i>Catharanthus roseus</i>	Apocynaceae	Bonjourbonsoir	3.57	0.01	0.0001
48	<i>Combretum micranthum</i>	Combretaceae	Kinkéliba	3.57	0.01	0.0001
49	<i>Rhaphiostylis beninensis</i>	Metteniusaceae	Kplakplakan	3.57	0.01	0.0001
50	<i>Xylopia aethiopica</i>	Annonaceae	Wakonto	3.57	0.01	0.0001
51	<i>Sansevieria liberica</i>	Agavaceae	Kpognando	3.57	0.01	0.0001
52	<i>Hyptis suaveolens</i>	Lamiaceae	Zansoukpema; Afio	3.57	0.01	0.0001
53	<i>Pseudocedrela kotschy</i>	Meliaceae	Atidohoukpédo	3.57	0.01	0.0001
54	<i>Rauvolfia vomitoria</i> Afzel	Apocynaceae	Lèwédo	3.57	0.01	0.0001
55	<i>Cassytha filiformis</i>	Lauraceae	Agbégbékan	3.57	0.01	0.0001
56	<i>Alium cepa</i>	Amaryllidaceae	Ayoma vovo	3.57	0.01	0.0001
57	<i>Newboudia leavis</i>	Bignoniaceae	Désré	3.57	0.01	0.0001
58	<i>Rourea coccinea</i>	Connaraceae	Vikplomba	3.57	0.01	0.0001
59	<i>Alchornea cordifolia</i>	Euphorbiaceae	Djéka (Dioulas); Klan Madou (g)	3.57	0.01	0.0001
60	<i>Combretum racemosum</i>	Combretaceae	Wèdo	3.57	0.01	0.0001
61	<i>Eucalyptus globulus</i> ; <i>Eucalyptus radiata</i>	Myrtaceae	Eucalyptus	3.57	0.01	0.0001
62	<i>Zanthoxylum zanthoxyloides</i> (Lam.)	Rutaceae	Hèdo	3.57	0.01	0.0001

Continued

63	<i>Rytigynia umbellulata</i>	<i>Rubiaceae</i>	Gbadéman	3.57	0.01	0.0001
64	<i>Carissa spinarum</i>	<i>Apocynaceae</i>	Ahazodo	3.57	0.01	0.0001
65	<i>Cajanus cajan</i>	<i>Fabaceae</i>	Klouékou ma	3.57	0.01	0.0001
66	<i>Passiflora foetida</i>	<i>Passifloraceae</i>	Avoun didouè	3.57	0.01	0.0001
67	<i>Ceratotheca sesamoides Endl</i>	<i>Pedaliaceae</i>	Agbo	3.57	0.01	0.0001
68	<i>Bridelia ferruginea Benth.</i>	<i>Phyllanthaceae</i>	Housoukokwé	3.57	0.01	0.0001
69	<i>Terminalia glaucescens</i>	<i>Combretaceae</i>	Anagoitin do	3.57	0.01	0.0001
70	<i>Carica papaya</i>	<i>Caricaceae</i>	kpin assou	3.57	0.01	0.0001
71	<i>Gardenia erubescens Stapf & Huteh</i>	<i>Rubiaceae</i>	Adakplaman/Hêmandjè	3.57	0.01	0.0001

Table 6. Distribution of different species families.

N°	Family	Frequencies
1	<i>Fabaceae</i>	52.27
2	<i>Lamiaceae</i>	38.63
3	<i>Sapotaceae</i>	29.54
4	<i>Euphorbiaceae</i>	22.72
5	<i>Rutaceae</i>	20.45
6	<i>Annonaceae</i>	20.45
7	<i>Meliaceae</i>	18.18
8	<i>Malvaceae</i>	15.9
9	<i>Combretaceae</i>	15.9
10	<i>Boraginaceae</i>	13.63
11	<i>Poaceae</i>	11.36
12	<i>Myrtaceae</i>	11.36
13	<i>Asteraceae</i>	11.36
14	<i>Anacardiaceae</i>	11.36
15	<i>Fabaceae</i>	11.36
16	<i>Vitaceae</i>	9.09
17	<i>Bignoniaceae</i>	9.09
18	<i>Piperaceae</i>	9.09
19	<i>Capparaceae</i>	9.09
20	<i>Verbenaceae</i>	9.09
21	<i>Cucurbitaceae</i>	9.09
22	<i>Apocynaceae</i>	6.81

Continued

23	<i>Dichapetalaceae</i>	6.81
24	<i>Solanaceae</i>	6.81
25	<i>Areaceae</i>	6.81
26	<i>Chenopodiaceae</i>	6.81
27	<i>Lauraceae</i>	6.81
28	<i>Chrysobalanaceae</i>	4.54
29	<i>Malvaceae</i>	4.54
30	<i>Amaryllidaceae</i>	4.54
31	<i>Amaranthaceae</i>	4.54
32	<i>Kpakléssi</i>	4.54
33	<i>Metteniusaceae</i>	2.27
34	<i>Euphorbiaceae</i>	2.27
35	<i>Araceae</i>	2.27
36	<i>Amaryllidaceae</i>	2.27
37	<i>Rubiaceae</i>	2.27
38	<i>Agavaceae</i>	2.27
39	<i>Caricaceae</i>	2.27
40	<i>Phyllanthaceae</i>	2.27
41	<i>Passifloraceae</i>	2.27
42	<i>Pedaliaceae</i>	2.27
43	<i>Rutaceae</i>	2.27
44	<i>Connaraceae</i>	2.27

Table 7. Recipes listed by herbalists for anti-ulcer plants.

N°	Number of plants	Recipe compositions	Parts used	Forms of use	Sides effects
1	5	<i>Eucalyptus globulus; Eucalyptus radiata</i>	Stem bark	Decoction	N/A
		<i>Eugenia aromatica</i>	Dry flower		
		<i>Xylopi aethiopica</i>	Seeds		
		<i>Monodora myristica</i>	Seeds		
		<i>Acacia nilotica adansonii</i>	Seeds		
2	3	<i>Spondias mombin</i>	Leaves	Decoction	N/A
		<i>Citrus limon</i>	Leaves		
		<i>Jatropha multifida</i>	Leaves		
3	6	<i>Acacia nilotica adansonii</i>	Seeds	Decoction	N/A

Continued

		<i>Carissa spinarum</i>	Stems		
		<i>Anchomanes difformis</i>	Leaves		
3	6	<i>Ocimum canum</i>	Leaves	Decoction	N/A
		<i>Ocimum gratissimum L.</i>	Leaves		
		<i>Tetrapleura tetraptera</i>	Seeds		
		<i>Ocimum gratissimum L.</i>	Leaves		
4	3	<i>Lantana camara</i>	Leaves	Decoction	N/A
		<i>Piper guineense</i>	Seeds		
		<i>Ocimum gratissimum L.</i>	Leaves		
		<i>Passiflora foetida</i>	Leaves		
5	6	<i>Rhaphiostylis beninensis</i>	Leaves and Stems	Decoction	N/A
		<i>Kigelia africana</i>	Fruits		
		<i>Parkia biglobosa</i>	Stem bark		
		<i>Clausena anisata</i>	Roots		
		<i>Phyllanthus amarus</i>	Leaves		
6	2	<i>Momordica charantia L.</i>	Leaves and Stems	Decoction	N/A
		<i>Zea mays</i>	Fresh Seeds		
7	1	Peak milk	N/A	Piling	N/A
		<i>Acacia ilotica ou adansonii</i>	Seeds		
		<i>Momordica charantia L.</i>	Leaves and Stems		
		<i>9Phyllanthus amarus</i>	Leaves and Stems		
		<i>Ocimum gratissimum L.</i>	Leaves and Stems		
8	9	<i>Lantana camara</i>	Leaves and Stems	Decoction	N/A
		<i>Hyptis suaveolens</i>	Leaves and Stems		
		<i>Piper guineense</i>	Seeds		
		<i>Allium sativum</i>	Pods		
		<i>Piper guineense</i>	Seeds		
		<i>Khaya senegalensis</i>	Stem bark		
		<i>Terminalia glaucescens</i>	Roots		
9	5	<i>Pseudocedrela kotschyi</i>	Roots	Decoction	N/A
		<i>Combretum racemosum</i>	Roots		
		<i>Caesalpinia pucherrima</i>	Roots		
		<i>Parkia biglobosa</i>	Stem bark		
10	4	<i>Pteleopsis suberosa</i>	Stem bark	Decoction	N/A

Continued

10	4	<i>Maranthes polyandra</i>	Leaves	Decoction	N/A
		<i>Ocimum canum</i>	Leaves and Stems		
		<i>Tetrapleura tetraptera</i>	Fruits		
		<i>Xylopi aethiopia</i>	Seeds		
11	10	<i>Acacia nilotica adansonii</i>	Seeds	Decoction	N/A
		<i>Spondias mombin</i>	Leaves		
		<i>Alchornea cordifolia</i>	Leaves		
		<i>Piper guineense</i>	Seeds		
		<i>Eugenia aromatica</i>	Seeds		
		<i>Khaya senegalensis</i>	Stem bark		
		<i>Pteleopsis suberosa</i>	Stem bark		
12	3	<i>Saba senegalensis (A. DC.) Pichon</i>	Stem bark	Decoction	N/A
		<i>Ocimum gratissimum L.</i>	Leaves and Stems		
		<i>Heliotropium indicum</i>	Leaves and Stems		
13	1	<i>Acanthospermum hispidum DC.</i>	Leaves	Piling	Avoid raw meats, Gari and galette
		<i>Vitellaria paradoxa</i>	Stem bark		
14	2	<i>Calaba blanc</i>	N/A	Piling	N/A
		<i>Honney bee</i>	N/A		
15	3	<i>Khaya senegalensis</i>	Stem bark	Decoction	N/A
		<i>Honney bee</i>	Honey		
16	2	<i>Spondias mombin</i>	Leaves	Decoction	N/A
		<i>Citrus limon</i>	Leaves		
17	2	<i>Jatropha multifida</i>	Leaves	Decoction	N/A
		<i>Jatropha multifida</i>	Leaves		
		<i>Vitellaria paradoxa</i>	Stem bark		
		<i>Phyllanthus amarus</i>	Leaves and Stems		
18	7	<i>Khaya senegalensis</i>	Stem bark	Decoction	N/A
		<i>Pteleopsis suberosa</i>	Stem bark		
		<i>Parkia biglobosa</i>	Stem bark		
		<i>Vitellaria paradoxa</i>	Stem bark		
18	7	<i>Bridelia ferruginea Benth.</i>	Stem bark	Decoction	N/A
		<i>Monodora myristica</i>	Seeds		
		<i>Acacia nilotica adansonii</i>	Seeds		
		<i>Xylopi aethiopia</i>	Seeds		

Continued

19	1	<i>Vitellaria paradoxa</i>	Stem bark	Piling	N/A
20	2	<i>Cocos nucifera</i>	Juice from unripe fruit	Piling	N/A
		<i>Pupalia lappacea</i> ou <i>Achyranthes lappacea</i> L. ou <i>Pupal lappacea</i> (L.)	Leaves		
		<i>Eugenia aromatica</i>	Fruit		
		<i>Xylophia aethiopica</i>	Seeds		
		<i>Monodora myristica</i>	Seeds		
		<i>Tetrapleura tetraptera</i>	Fruit		
		<i>Momordica charantia</i> L.	Leaves		
21	11	<i>Clausena anisata</i>	Leaves	Decoction	N/A
		<i>Caesalpinia pucherrima</i>	Roots		
		<i>Ocimum gratissimum</i> L.	Leaves and stems		
		<i>Khaya senegalensis</i>	Stem bark		
		<i>Jatropha multifida</i>	Leaves		
		<i>Piper guineense</i>	Seeds		
22	1	<i>Vitellaria paradoxa</i>	Stem bark	Decoction	N/A
23	1	<i>Calaba blanc</i>	N/A	Piling	N/A
		<i>Cassytha filiformis</i>	Leaves and stem		
		<i>Pteleopsis suberosa</i>	Stem bark		
24	5	<i>Vitellaria paradoxa</i>	Stem bark	Decoction	Chilli pepper, hot meal, gari
		<i>Parkia biglobosa</i>	Stem bark		
		<i>Khaya senegalensis</i>	Stem bark		
		<i>Lippia multiflora</i>	Leaves and stem		
25	1	<i>Vernonia cinerea</i> (L.) Less. (<i>Cyanthilium cinereum</i> (L) H.Rob)	Leaves and stem	Decoction	N/A
		<i>Spondias mombin</i>	Roots, Leaves and stem		
		<i>Parkia biglobosa</i>	Stem bark		
		<i>Chenopodium ambrosioides</i>	Leaves		
		<i>Bambusa vulgaris</i> Schrad ex. Wendel	Leaves		
26	8	<i>Ocimum gratissimum</i> L.	Leaves	Decoction	N/A
		<i>Ocimum canum</i>	Leaves		
		<i>Heliotropium indicum</i>	Leaves		
		<i>Ehretia cymosa</i> Thonn	Leaves		
		<i>Vitellaria paradoxa</i>	Stem bark		
27	2	<i>Parkia biglobosa</i>	Stem bark	Decoction	N/A

Continued

28	0	<i>Calaba blanc</i>	N/A	Piling	N/A
		<i>Lait peak</i>	N/A		
29	1	<i>Persea americana</i>	Leaves	Decoction	N/A
30	3	<i>Ocimum canum</i>	Leaves and stem	Decoction	N/A
		<i>Crateva adansonii</i>	Leaves		
		<i>Dichapetalum madagascariense</i> (DC.) Keay	Leaves		
31	1	<i>Pupalia lappacea</i> ou <i>Achyranthes lappacea</i> L. ou <i>Pupal lappacea</i> (L.)	Leaves	Piling	N/A
		<i>Calaba blanc</i>	N/A		
32	5	<i>Ocimum gratissimum</i> L.	Leaves	Decoction	N/A
		<i>Momordica charantia</i> L.	Leaves		
		<i>Chenopodium ambrosioides</i>	Roots		
		<i>Jatropha multifida</i>	Leaves		
		<i>Crataeva adansonii</i> DC	Leaves		
33	4	<i>Parkia biglobosa</i>	Stem bark	Decoction	N/A
		<i>Pteleopsis suberosa</i>	Stem bark		
		<i>Maranthes polyandra</i> (Benth.), Prance	Leaves		
		<i>Ocimum canum</i>	Leaves		
34	1	<i>Parkia biglobosa</i>	Stem bark	Decoction	N/A
35	2	<i>Vitellaria paradoxa</i>	Stem bark	Decoction	N/A
		<i>Lippia multiflora</i>	Leaves and stem		
36	3	<i>Vitellaria paradoxa</i>	Stem bark	Decoction	N/A
		<i>Lippia multiflora</i>	Leaves and stem		
		<i>Justicia secunda</i> Vahl	Flowers		
37	1	<i>Jatropha multifida</i>	Leaves	Decoction	N/A
38	1	<i>Kigelia africana</i>	Fruits	Maceration	Avoid spicy or fermented foods
39	1	<i>Rourea coccinea</i>	Leaves	Piling	N/A
40	2	<i>Jatropha multifida</i>	Leaves and Roots	Decoction	N/A
		<i>Catharanthus roseus</i>	Whole plant or leaves		
41	3	<i>Ocimum canum</i>	Leaves	Decoction	N/A
		<i>Dichapetalum madagascariense</i> (DC.) Keay	Leaves		
		<i>Crateva adansonii</i>	Leaves		
42	4	<i>Parkia biglobosa</i>	Stem bark		N/A

Continued

		<i>Lantana camara</i>	Leaves		
42	4	<i>Erythrina senegalensis</i>	Leaves		N/A
		<i>Carica papaya</i>	Flowers, Leaves and Roots		
43	1	<i>Sida acuta</i>	Whole plant	Decoction	N/A
		<i>Zanthoxylum zanthoxyloides (Lam.) Zepern. & Timler</i>	Roots		
		<i>Kigelia africana</i>	Fruit		
44	6	<i>Rauvolfia vomitoria Afzel</i>	Roots	Decoction	N/A
		<i>Heliotropium indicum</i>	Leaves		
		<i>Newbouldia leavis</i>	Stem bark and Roots		
		<i>Parkia biglobosa</i>	Stem bark		
45	1	<i>Khaya senegalensis</i>	Leaves, Roots, Stem bark	Decoction	N/A
		<i>Sida acuta</i>	Leaves and stem		
46	3	<i>Corchorus olitorius L</i>	Laves and stem	Decoction	N/A
		<i>Citrus limon</i>	Fruits		
		<i>Senna siamea</i>	Roots, Leaves, Stem bark		
47	4	<i>Ocimum gratissimum L.</i>	Leaves	Decoction	N/A
		<i>Capsicum frutescens</i>	Seeds		
		<i>Cymbopogon citratus</i>	Leaves		
		<i>Spondias mombin</i>	Leaves		
48	4	<i>Persea americana</i>	Leaves	Decoction	N/A
		<i>Citrus limon</i>	Leaves		
		<i>Cymbopogon citratus</i>	Leaves		
49	2	<i>Corchorus olitorius L</i>	Leaves and stem	Decoction	N/A
		<i>Citrus limon</i>	Fruits		
50	2	<i>Senna siamea</i>	Leaves and stem	Decoction	N/A
		<i>Sida acuta</i>	Leaves		
51	2	<i>Anacardium occidentale</i>	Stem bark	Decoction	Milk, gari
		<i>Vitellaria paradoxa</i>	Stem bark		
52	1	<i>Phyllanthus amarus</i>	Whole plant	Infusion	N/A
		<i>Sansevieria liberica</i>	Leaves		
53	2	<i>Citrus limon</i>	Leaves	Decoction	N/A
		<i>Senna siamea</i>	Leaves, Stem and Roots		
54	2	<i>Capsicum frutescens</i>	7 fruit for woman and 9 for man	Decoction	N/A

Continued

55	1	<i>Senna siamea</i>	Leaves, Stem bark, Roots	Decoction	N/A
56	2	<i>Phyllanthus amarus</i>	Whole plant	Decoction	N/A
		<i>Eugenia aromatica</i>	Flowers		
57	2	<i>Bambusa vulgaris Schrad ex. Wendel</i>	Leaves	Decoction	Cold meal, soft drink, fruit
		<i>Vitellaria paradoxa</i>	Leaves		
58	2	<i>Sida acuta</i>	Whole plant	Decoction	N/A
		<i>Citrus limon</i>	Fruits		
59	5	<i>Dichapetalum madagascariense (DC.) Keay</i>	Leaves	Decoction	N/A
		<i>Combretum micranthum</i>	Leaves		
		<i>Acanthospermum hispidum DC.</i>	Leaves		
		<i>Cissus quadrangularis</i>	Leaves		
		<i>Capsicum frutescens</i>	Fruits		
60	4	<i>Crateva adansonii</i>	Leaves	Decoction	N/A
		<i>Vitellaria paradoxa</i>	Stem bark		
		<i>Gardenia erubescens Stapf & Huteh</i>	Leaves		
		<i>Erythrina senegalensis</i>	Leaves		
61	2	<i>Ceratotheca sesamoides Endl</i>	Leaves	Decoction	N/A
		<i>Citrus limon</i>	Leaves		
62	1	<i>Alium cepa</i>	Pods	Piling	N/A
63	2	<i>Acanthospermum hispidum DC.</i>	Whole plant	Decoction	N/A
		<i>Citrus limon</i>	Fruits		
64	2	<i>Corchorus olitorius L</i>	Whole plant	Decoction	N/A
		<i>Vitellaria paradoxa</i>	Fruit		
65	2	<i>Dichapetalum madagascariense (DC.) Keay</i>	Leaves	Decoction	N/A
		<i>Cissus quadrangularis</i>	Leaves		
66	1	<i>Chap chap</i>	Leaves	Decoction	N/A
67	1	<i>Bambusa vulgaris Schrad ex. Wendel</i>	Leaves	Decoction	N/A
68	2	<i>Citrus decumana</i>	Fruits	Decoction	N/A
		<i>Moringa oleifera Lam</i>	Leaves		
69	2	<i>Corchorus olitorius L</i>	Whole plant	Decoction	N/A
		<i>Parkia biglobosa</i>	Stem bark		
70	2	<i>Cajanus cajan</i>	Leaves	Decoction	N/A
		<i>Vitellaria paradoxa</i>	Stem bark		

N/A: Not Applicable.

4. Discussion

The importance of medicinal plants became evident for all as WHO listed 21,000 plants which are extensively used for therapeutic purposes throughout the world [33]. They are known to contain Phytochemicals classified as primary (e.g. carbohydrates, lipids, amino acid derivations, etc.) or secondary (e.g. alkaloids, terpenes and terpenoids, phenolic compounds, glycosides, etc.) metabolites according to their metabolic route of origin, chemical structure and function [34]. Herbal products show a wide spectrum of biological activities and thus are efficiently harnessed for managing diseases [35].

To meet the challenge of failure in the treatment of gastrointestinal ulcers, an ethnopharmacological survey has been conducted. The populations surveyed are made up of ethnic groups including Fon, Aizo, Mina, Goun, Dendi, Hloua, Houagonou, Ifè and Mahi. This diversity of ethnic groups reflects the ethnic richness of the two research municipalities. This is also reported by Dougnon *et al.*, who found Fon, Aizo, Mahi, Oueme, Adja, Bariba, Goun, Yoruba, Toffin and Dendi groups [36]. Even if other ethnic groups are represented, it is obvious that the herbalists surveyed during this study are dominated by the Fons. From a religious point of view, we noted the representation of Christianity, Vodoun and Islam. It should be noted that the majority of herbalists surveyed are Christians. This diversity reflects the secular nature of the Republic of Benin, where the religious landscape is made up of three major religions (Vodoun, Christianity and Islam) [37].

Herbalists in the communes of Abomey-Calavi and Cotonou are categorized into three levels of education: primary, secondary and university, with primary education being the most represented. Our results on the educational level of respondents are similar to those published by Dougnon *et al.*, even though illiterates were not separated out in our case [36]. Furthermore, the seniority of herbalists is represented in four level, with intervals of 1 to 10 years, 10 to 20 years, 20 to 30 years and 30 to 40 years. The 20 to 30 years seniority was the most representative with 32.14%.

The diversity and equitability index of the interviewees calculated revealed that the Dendi, Ifè and Mina, all equitable in their knowledge of anti-ulcer plants, are likely to know more than the other ethnic groups. This steadfast distribution of knowledge of anti-ulcer plants among the Dendi, Ifè and Mina, three different ethnic groups, seems normal and attests to the fusion between these different ethnic groups in view of this knowledge. As reported, differences in language, in the cultural meaning of the plants, in the context related to cultural identities, and in social networks seem to play a fundamental role in the use, diffusion and maintenance or erosion of traditional knowledge about medicinal plants [38]. On the other hand, respondents practicing Islam are likely to know a lot about anti-ulcer plants compared to those practicing Vodou and Christianity, who tend to have the same level of knowledge of anti-ulcer plants. Indeed, a study by Abreu *et al.* similarly reported this [39]. In addition, these results could be explained by the value and symbolic efficiency accorded or granted by pre-Islamic and Muslim

cosmologies to medicinal plants [40]. Traditional societies have their own understandings of medicine as reported by Lightner *et al.*, according to whom lay people and specialists alike made extensive use of abstract concepts that were not obviously supernatural to describe how local medicines work [41]. The influences of religious background on the knowledge and distribution of medicinal plants are recognized and reported. First of all, religion and traditional medicine are so closely linked that some plants are known as religious [42]. So, Albuquerque *et al.*, reported that Religiosity/spirituality (and the dimensions of Commitment and Religious and Spiritual History, in particular) act to protect structural and functional elements of local medical systems (LMSs) and by providing protection, the LMS benefits from greater resilience, at both the individual and population levels. Based on these findings, they suggest that the socialization process resulting from the religious phenomenon has contributed to the complexity and maintenance of local medical systems (LMSs) by means of the interaction of individuals as they engage in their religious observances, thus facilitating cultural transmission [43]. By contrast, religious characteristics such as self-isolation from other cultures might be one of the reasons for such a difference [44]. However, the divergence of said ethnic groups from others in the knowledge of these plants, exhibits an indissolubility of knowledge [39]. The multiple regression analysis carried out reports that neither ethnic group, nor level of education and religion predicts the distribution of knowledge of anti-ulcer plants. Nevertheless, Pérez-Nicolás *et al.* reported that age and occupation predicted 54% variation in study populations' knowledge of medicinal plants [45]. This discrepancy between our results could be explained by the fact that our study only considered herbalists.

Plant species from the Benin pharmacopoeia used by herbalists in the communes of Abomey-Calavi and Cotonou for the treatment of gastrointestinal ulcers were reported. A total of 71 species were listed among which the 12 most frequently cited, in decreasing order of frequency, were *Vitellaria paradoxa*, *Parkia biglobosa*, *Ocimum gratissimum*, *Khaya senegalensis*, *Citrus limon*, *Acacia nilotica* or *adansonii*, *Ocimum canum*, *Phyllanthus amarus*, *Senna siamea*, *Piper guineense*, *Momordica charantia*, *Pteleopsis suberosa*, *Spondias mombin*, *Sida acuta*, *Jatropha multifida*, *Heliotropium indicum*, *Eugenia aromatica* and *Crateva adansonii*. These species were heterogeneously and co-dominantly cited. Firstly, *Vitellaria paradoxa*, *Parkia biglobosa* and *Ocimum gratissimum* are co-dominant and then *Khaya senegalensis*, *Citrus limon*, *Acacia nilotica* or *adansonii*, *Ocimum canum*, *Phyllanthus amarus* and *Senna siamea* too. These results are a kind of translation of those obtained by Ouachinou *et al.* who found 158 medicinal species belonging to 60 families whose population agreed more on the use of *Khaya senegalensis*, *Anacardium occidentale*, *Cassia sieberiana*, *Pterocarpus erinaceus* and *Vitellaria paradoxa* to treat gastrointestinal diseases in cattle in Benin [46]. Among the anti-ulcer plants we have identified, *Anacardium occidentale*, *Bambusa vulgaris*, *Khaya senegalensis*, *Ocimum gratissimum* are reported in an ethnobotanical study by Dougnon, *et al.* as used against diarrhoea [36], *Vitellaria paradoxa* and

Parkia biglobosa have been reported for their use against gastrointestinal diseases in Benin [47]. In addition, *Xylopia aethiopica*, *Acanthospermum hispidum*, *Heliotropium indicum*, *Combretum micranthum*, *Pteleopsis suberosa*, *Acacia nolitica*, *Parkia biglobosa*, *Zanthoxylum zanthoxyloides*, *Vitellaria paradoxa*, *Bambousa vulgaris*, *Cymbopogon citratus*, *Carica papaya* were listed as antiulcer plants in an ethnopharmacological study carried out in Burkina Faso [48]. All the species cited are grouped into 44 taxonomic families, of which *Fabaceae*, *Lamiaceae*, *Sapotaceae*, *Euphorbiaceae*, *Rutaceae*, *Annonaceae*, *Meliaceae*, *Malvaceae*, *Combretaceae* and *Boraginaceae* are the most representative. Meanwhile, Ouachinou *et al.* reported Leguminosae and Combretaceae to be highly represented in addition of 31 families mentioned as heavily used and the most important are *Zygophyllaceae*, *Phytolaccaceae*, *Rubiaceae*, *Lamiaceae*, *Loranthaceae*, *Thymelaeaceae* and *Flacourtiaceae* [46]. On the other hand, Lema *et al.* recorded 113 species belonging to 48 botanical families, 18 of which are included in the families listed in our study, namely *Fabaceae*, *Lamiaceae*, *Sapotaceae*, *Euphorbiaceae*, *Rutaceae*, *Annonaceae*, *Meliaceae*, *Malvaceae*, *Combretaceae*, *Boraginaceae*, *Poaceae*, *Myrtaceae*, *Asteraceae*, *Anacardiaceae*, *Bignoniaceae*, *Apocynaceae*, *Euphorbiaceae*, *Caricaceae* [48].

A total of 70 anti-ulcer recipes made from medicinal plants and/or non-wood resources were given by the herbalists surveyed. This number validly represents more than a quarter of the 279 recipes reported by Lema *et al.* in Burkina Faso and almost 4 times the 18 recipes composed from 16 species reported by Sidio *et al.* in the Sub-Prefecture of Yopohué in the Centre-West of Côte d'Ivoire for the treatment of gastro-intestinal ulcers [48] [49].

The results of this survey constitute a database of medicinal plants used to treat gastrointestinal ulcers, which can be used for in-depth studies aimed at identifying molecules active against the disease of interest. Future studies will involve determining the chemical composition of the various species thus identified and characterizing their biological activities. Once identified, evaluated and approved, these molecules can be produced by the method of Plant Pharmaceutical Production using a synthetic biology approach, for which Plants such as alfalfa, barley, corn, duckweed, rice, safflower and tobacco are known and have received Animal and Plant Health Inspection Service (APHIS) regulatory permits for field trials [50].

5. Conclusion

Benin boasts a wealth of flora, with over 30,700 specimens with therapeutic properties listed. We carried out an ethno-pharmacological survey among herbalists in the communes of Abomey-Calavi and Cotonou to identify the medicinal plant species used to treat gastrointestinal ulcers. We determined 70 anti-ulcer recipes made up of medicinal plant species and/or non-floristic resources and composed of 71 species, of which *Vitellaria paradoxa*, *Parkia biglobosa* and *Ocimum gratissimum* were the first 03 most cited, and the *Fabaceae*, *Lamiaceae* and *Sapotaceae* families were the most strongly represented. A consistent distribution of knowledge of anti-ulcer plants was observed among the Dendi, Ifè and Mina, and respondents

practicing Islam were more likely to know many anti-ulcer plants than those practicing Vodou and Christianity. The results of this study provide a good archive for the selection of plant species for further study in the formulation of improved traditional medicines.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Katelaris, P., Hunt, R., Bazzoli, F., Cohen, H., Fock, K.M., Gemilyan, M., *et al.* (2022) Helicobacter Pylori World Gastroenterology Organization Global Guideline. *Journal of Clinical Gastroenterology*, **57**, 111-126. <https://doi.org/10.1097/mcg.0000000000001719>
- [2] Li, Y., Choi, H., Leung, K., Jiang, F., Graham, D.Y. and Leung, W.K. (2023) Global Prevalence of Helicobacter Pylori Infection between 1980 and 2022: A Systematic Review and Meta-Analysis. *The Lancet Gastroenterology & Hepatology*, **8**, 553-564. [https://doi.org/10.1016/s2468-1253\(23\)00070-5](https://doi.org/10.1016/s2468-1253(23)00070-5)
- [3] Selmi, S., Rtibi, K., Grami, D., Sebai, H. and Marzouki, L. (2017) Protective Effects of Orange (*Citrus sinensis* L.) Peel Aqueous Extract and Hesperidin on Oxidative Stress and Peptic Ulcer Induced by Alcohol in Rat. *Lipids in Health and Disease*, **16**, Article No. 152. <https://doi.org/10.1186/s12944-017-0546-y>
- [4] de Lira Mota, K.S., Dias, G.E.N., Pinto, M.E.F., Luiz-Ferreira, Â., Monteiro Souza-Brito, A.R., Hiruma-Lima, C.A., *et al.* (2009) Flavonoids with Gastroprotective Activity. *Molecules*, **14**, 979-1012. <https://doi.org/10.3390/molecules14030979>
- [5] Ezzat, R.F., Hussein, H.A., Baban, T.S., Rashid, A.T. and Abdullah, K.M. (2010) Typhoid Ulcer Causing Life-Threatening Bleeding from Dieulafoy's Lesion of the Ileum in a Seven-Year-Old Child: A Case Report. *Journal of Medical Case Reports*, **4**, Article No. 171. <https://doi.org/10.1186/1752-1947-4-171>
- [6] Sonavane, A.D., Gupta, D., Parmar, T., Sen, S., Nimavat, B., Ambekar, A., *et al.* (2020) Typhoid Ulcer Related Massive Gastrointestinal Bleeding Successfully Treated with Endoscopic Therapy. *The Egyptian Journal of Internal Medicine*, **32**, Article No. 1. <https://doi.org/10.1186/s43162-020-00004-1>
- [7] Cho, J., Seo, J., Yeom, J.S., Park, J.S., Park, C., Woo, H.O., *et al.* (2012) Diffuse Colonic Ulcer Caused by *Salmonella enteritidis* in a 32-Month-Old Female. *Pediatric Gastroenterology, Hepatology & Nutrition*, **15**, 193-196. <https://doi.org/10.5223/pghn.2012.15.3.193>
- [8] Hung, C. and Wang, P.S. (2004) Gastric Oxidative Stress and Hemorrhagic Ulcer in Salmonella Typhimurium-Infected Rats. *European Journal of Pharmacology*, **491**, 61-68. <https://doi.org/10.1016/j.ejphar.2004.03.029>
- [9] Kawade, D., Shahu, N., Bahadurkar, P., Hiradewe, P. and Dhote, N. (2020) Peptic

- Ulcer: A Review on Its Etiology, Pathogenesis and Pharmacotherapy. *World Journal of Pharmaceutical Research*, **9**, 558-583.
- [10] Murray, C.J.L., *et al.* (2022) Global Burden of Bacterial Antimicrobial Resistance in 2019: A Systematic Analysis. *The Lancet*, **399**, 629-655. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0)
- [11] Fongang, H., Mbaveng, A.T. and Kuete, V. (2023) Global Burden of Bacterial Infections and Drug Resistance. *Advances in Botanical Research*, **106**, 1-20. <https://doi.org/10.1016/bs.abr.2022.08.001>
- [12] Liou, J., Malfertheiner, P., Smith, S.I., El-Omar, E.M. and Wu, M. (2024) 40 Years after the Discovery of Helicobacter Pylori: Towards Elimination of H Pylori for Gastric Cancer Prevention. *The Lancet*, **403**, 2570-2572. [https://doi.org/10.1016/s0140-6736\(24\)01171-1](https://doi.org/10.1016/s0140-6736(24)01171-1)
- [13] WHO (2024) WHO Publishes List of Bacteria for Which New Antibiotics Are Urgently Needed. <https://www.who.int/news/item/27-02-2017-who-publishes-list-of-bacteria-for-which-new-antibiotics-are-urgently-needed>
- [14] Dang, B.N. and Graham, D.Y. (2017) Helicobacter Pylori Infection and Antibiotic Resistance: A WHO High Priority? *Nature Reviews Gastroenterology & Hepatology*, **14**, 383-384. <https://doi.org/10.1038/nrgastro.2017.57>
- [15] Jaja, I.F., Bhembe, N.L., Green, E., Oguttu, J. and Muchenje, V. (2019) Molecular Characterisation of Antibiotic-Resistant Salmonella Enterica Isolates Recovered from Meat in South Africa. *Acta Tropica*, **190**, 129-136. <https://doi.org/10.1016/j.actatropica.2018.11.003>
- [16] Onohuean, H. and Igere, B.E. (2022) Occurrence, Antibiotic Susceptibility and Genes Encoding Antibacterial Resistance of *Salmonella* Spp. and *Escherichia coli* from Milk and Meat Sold in Markets of Bushenyi District, Uganda. *Microbiology Insights*, **15**, Article 117863612210889. <https://doi.org/10.1177/1178636122108892>
- [17] Cragg, G.M. and Newman, D.J. (2013) Natural Products: A Continuing Source of Novel Drug Leads. *Biochimica et Biophysica Acta (BBA)—General Subjects*, **1830**, 3670-3695. <https://doi.org/10.1016/j.bbagen.2013.02.008>
- [18] Moerman, D.E. (1987) Medicinal Plants of Native America, Vols. 1 and 2. University of Michigan Museum of Anthropological Archaeology. <https://doi.org/10.3998/mpub.11394575>
- [19] Johnson, T. (2019) CRC Ethnobotany Desk Reference. CRC Press. <https://doi.org/10.1201/9781351070942>
- [20] Farnsworth, N., Akerele, O. and Bingel, A. (1987) Medicinal Plants in Therapy. *Journal of Ethnopharmacology*, **19**, 336. [https://doi.org/10.1016/0378-8741\(87\)90016-x](https://doi.org/10.1016/0378-8741(87)90016-x)
- [21] Deng, R., Chen, X., Zhao, S., Zhang, Q. and Shi, Y. (2024) The Effects and Mechanisms of Natural Products on Helicobacter Pylori Eradication. *Frontiers in Cellular and Infection Microbiology*, **14**, Article 1360852. <https://doi.org/10.3389/fcimb.2024.1360852>
- [22] Tesfaye, S., Belete, A., Engidawork, E., Gedif, T. and Asres, K. (2020) Ethnobotanical Study of Medicinal Plants Used by Traditional Healers to Treat Cancer-Like Symptoms in Eleven Districts, Ethiopia. *Evidence-Based Complementary and Alternative Medicine*, **2020**, 1-23. <https://doi.org/10.1155/2020/7683450>
- [23] Kola, P., Metowogo, K., Kantati, Y.T., Lawson-Evi, P., Kpemissi, M., El-Hallouty, S.M., *et al.* (2020) Ethnopharmacological Survey on Medicinal Plants Used by Traditional Healers in Central and Kara Regions of Togo for Antitumor and Chronic

- Wound Healing Effects. *Evidence-Based Complementary and Alternative Medicine*, **2020**, 1-12. <https://doi.org/10.1155/2020/6940132>
- [24] Viol, D.I., Chagonda, L.S., Moyo, S.R. and Mericli, A.H. (2016) Toxicity and Antiviral Activities of Some Medicinal Plants Used by Traditional Medical Practitioners in Zimbabwe. *American Journal of Plant Sciences*, **7**, 1538-1544. <https://doi.org/10.4236/ajps.2016.711145>
- [25] Akoègninou, A., Van Der Burg, W.J. and Van Der Maesen, L.J.G. (2006) Flore analytique du Bénin. Wageningen Agricultural University Papers. <http://edepot.wur.nl/281595>
- [26] Adomou, A., Yedomonhan, H., Djossa, B., Legba, S., Oumorou, M. and Akoegninou, A. (2012) Etude Ethnobotanique des plantes médicinales vendues dans le marché d'Abomey-Calavi au Bénin. *International Journal of Biological and Chemical Sciences*, **6**, 745-772. <https://doi.org/10.4314/ijbcs.v6i2.18>
- [27] Dougnon, V., *et al.* (2024) Utilisation des plantes du Sud-Bénin dans le traitement de la fièvre typhoïde: Rôle des herboristes. *Ethnopharmacologia*, **11**, 64-73. <http://www.ethnopharmacologia.org/prelude2020/pdf/biblio-hd-53-dougnon.pdf>
- [28] Makponse, M. (2019) Commune d'abomey-calavi au bénin, un des milieux de prévalence écologique du *Cleome viscosa* aux usages socio-économiques multiples. *Revue Ivoirienne des Sciences et Technologie*, **34**, 309-327.
- [29] INStAD (2004) Cahier des villages et quartiers de ville, Département du LITTORAL. https://instad.bj/images/docs/insae-statistiques/enquetes-recensements/RGPH/2.RGPH_3/Cahiers-Villages-2002/LITTORAL.pdf
- [30] INStAD (2004) Cahier des villages et quartiers de ville Département de l'ATLANTIQUE. https://instad.bj/images/docs/insae-statistiques/enquetes-recensements/RGPH/2.RGPH_3/Cahiers-villages-2002/ATLANTIQUE.pdf
- [31] Yetein, M.H., Houessou, L.G., Lougbégnon, T.O., Teka, O. and Tente, B. (2013) Ethnobotanical Study of Medicinal Plants Used for the Treatment of Malaria in Plateau of Allada, Benin (West Africa). *Journal of Ethnopharmacology*, **146**, 154-163. <https://doi.org/10.1016/j.jep.2012.12.022>
- [32] Guillaume (2020) Les indices de diversité en écologie des écosystèmes. <https://louernos-nature.fr/indices-de-diversite-ecologie-ecosystemes/>
- [33] Anand, U., Jacobo-Herrera, N., Altemimi, A. and Lakhssassi, N. (2019) A Comprehensive Review on Medicinal Plants as Antimicrobial Therapeutics: Potential Avenues of Biocompatible Drug Discovery. *Metabolites*, **9**, Article 258. <https://doi.org/10.3390/metabo9110258>
- [34] Alamgir, A.N.M. (2018) Therapeutic Use of Medicinal Plants and their Extracts. Springer International Publishing.
- [35] Shils, M.E., Olson, J.A. and Shike, M. (1995) Modern Nutrition in Health and Disease. 8th Edition, Lea & Febiger. <https://www.cabidigitallibrary.org/doi/full/10.5555/19951402441>
- [36] Dougnon, V., Agbodjento, E., Hounsa, E., Legba, B.B., Deguenon, E., Bohoungbe, N., *et al.* (2021) An Ethnobotanical Survey of Seventeen Plants Species Used against Diarrhoea and Other Diseases in Southern Benin (West Africa). *Journal of Biological Research—Bollettino della Società Italiana di Biologia Sperimentale*, **94**, 34-42.
- [37] Ogouby, L.O.A.G. (2008) Les religions dans l'espace public au Bénin: Vodoun, christianisme, islam. <http://digital.casalini.it/9782296203396>
- [38] Menendez-Baceta, G., Aceituno-Mata, L., Reyes-García, V., Tardío, J., Salpeteur, M. and Pardo-de-Santayana, M. (2015) The Importance of Cultural Factors in the

- Distribution of Medicinal Plant Knowledge: A Case Study in Four Basque Regions. *Journal of Ethnopharmacology*, **161**, 116-127. <https://doi.org/10.1016/j.jep.2014.12.007>
- [39] Abreu, D.B.d.O., Santoro, F.R., Albuquerque, U.P.d., Ladio, A.H. and Medeiros, P.M.D. (2015) Medicinal Plant Knowledge in a Context of Cultural Pluralism: A Case Study in Northeastern Brazil. *Journal of Ethnopharmacology*, **175**, 124-130. <https://doi.org/10.1016/j.jep.2015.09.019>
- [40] Frazão-Moreira, A. (2016) The Symbolic Efficacy of Medicinal Plants: Practices, Knowledge, and Religious Beliefs Amongst the Nalu Healers of Guinea-Bissau. *Journal of Ethnobiology and Ethnomedicine*, **12**, Article No. 24. <https://doi.org/10.1186/s13002-016-0095-x>
- [41] Lightner, A.D., Heckelsmiller, C. and Hagen, E.H. (2021) Ethnomedical Specialists and Their Supernatural Theories of Disease. *Review of Philosophy and Psychology*, **14**, 611-646. <https://doi.org/10.1007/s13164-021-00589-8>
- [42] Sharma, U.K., Pegu, S., Hazarika, D. and Das, A. (2012) Medico-Religious Plants Used by the Hajong Community of Assam, India. *Journal of Ethnopharmacology*, **143**, 787-800. <https://doi.org/10.1016/j.jep.2012.06.053>
- [43] Albuquerque, U.P., Ferreira Júnior, W.S., Sousa, D.C.P., Reinaldo, R.C.P.S., do Nascimento, A.L.B. and Gonçalves, P.H.S. (2018) Religiosity/Spirituality Matters on Plant-Based Local Medical System. *Journal of Religion and Health*, **57**, 1948-1960. <https://doi.org/10.1007/s10943-018-0634-y>
- [44] Simanova, A., Prüse, B., Kalle, R., Kochalski, S., Prakofjewa, J., Mežaka, I., *et al.* (2020) Medicinal Plant Use at the Beginning of the 21st Century among the Religious Minority in Latgale Region, Latvia. *Ethnobotany Research and Applications*, **20**, 1-31. <https://doi.org/10.32859/era.20.21.1-31>
- [45] Pérez-Nicolás, M., Vibrans, H., Romero-Manzanares, A., Saynes-Vásquez, A., Luna-Cavazos, M., Flores-Cruz, M., *et al.* (2017) Patterns of Knowledge and Use of Medicinal Plants in Santiago Camotlán, Oaxaca, Mexico. *Economic Botany*, **71**, 209-223. <https://doi.org/10.1007/s12231-017-9384-0>
- [46] Ouachinou, J.M.-S., Dassou, G.H., Idohou, R., Adomou, A.C. and Yédomonhan, H. (2019) National Inventory and Usage of Plant-Based Medicine to Treat Gastrointestinal Disorders with Cattle in Benin (West Africa). *South African Journal of Botany*, **122**, 432-446. <https://doi.org/10.1016/j.sajb.2019.03.037>
- [47] Odounharo, O.G.R., Gnansounou, S.C., Salako, K.V., Idohou, R., Mensah, G.A., Glèlè Kakaï, R., *et al.* (2021) Medicinal Use Patterns of *Parkia biglobosa* (jacq.) Benth. and *Vitellaria paradoxa* (Gaertn. F), Two Important Traditional Agroforestry Species in Benin, West-Africa. *Advances in Traditional Medicine*, **22**, 531-545. <https://doi.org/10.1007/s13596-021-00583-6>
- [48] Armandine, L.E.M.A., Mindiériba Jean, B.A.N.G.O.U., *et al.* (2022) Medicinal Plant Recipes Used in the Management of Peptic Ulcers in Burkina Faso: Ethnobotanical Study. *International Journal of Science and Research Archive*, **6**, 263-278. <https://doi.org/10.30574/ijrsra.2022.6.1.0133>
- [49] Sidio, S.R., Wangny, A.A.S., Angaman, K.R. and N'guessan, K. (2021) Ethnomedical Inventory of Antiulcer Plants Used by the tradipraticians of Yopohué sub-prefecture in central-western Côte d'Ivoire. *Journal of Medicinal Plants Studies*, **9**, 129-135. <https://www.plantsjournal.com/archives/?year=2021&vol=9&issue=3&part=B&ArticleId=1279>
- [50] Sil, B. and Jha, S. (2014) Plants: The Future Pharmaceutical Factory. *American Journal of Plant Sciences*, **5**, 319-327.