Diversity of plant species with ethnomedicinal potential for treating arterial hypertension and gastric ulcers, two chronic diseases: an ethnobotanical assessment in Benin

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Ethnobotany Research and Applications 29:18 (2024) - http://dx.doi.org/10.32859/era.29.18.1-22
Manuscript received: 13/01/2024 – Revised manuscript received: 06/06/2024 - Published: 07/06/2024

Research

Abstract

Background: The high prevalence of chronic diseases, including arterial hypertension (AHT) and gastric ulcers, in Africa highlights a severe health problem. Many patients resort to medicinal plants due to the high cost of medications and an inadequate healthcare system. This study aimed to dertermine plant species used in remedies for AHT and gastric ulcers, their ethnomedicine features and users' perceptions of threat and conservation strategies in Benin.

Methods: Ethnobotanical data by structured interviews were collected from 504 individuals (traditional therapists, plant consumers and sellers) from different sociocultural groups, identified by the snowball technique. Data relating to different medicinal plants used to treat AHT and gastric ulcers were collected. The relative frequencies of citation (RFC) of the species mentioned were calculated, then factorial correspondence analysis was used to determine the relationship between socio-cultural groups and plants.

Results: A total of 193 plant species belonging to 63 botanical families were determined as used to cure AHT and gastric ulcers. The most represented families were: Fabaceae (33 species), Malvaceae (9 species) and Asteraceae (8 species). Herbs (45%) and leaves (60%) were the most used life form and plant par, respectively. Decoction and infusion were the most common extraction methods of water-soluble drug substances in leaves while maceration was common for bark and roots.

Conclusion: Our study revealed an adaptive relationship between sociocultural groups and indigenous flora. Pharmacological and toxicological investigations must be conducted to confirm the effectiveness of reported plants, in order to contribute to the development of new or improved medicines.

Keywords: Ethnobotany, medicinal plants, chronic diseases, traditional therapy, Benin.

Background

In recent years, the rapid increase in Non-Communicable Diseases (NCDs), such as cardiovascular and digestive diseases, linked to globalization and economic developments, has placed an additional burden on African healthcare systems according to World Health Organization (WHO 2022). These NCDs, known as chronic diseases, kill 41 million people each year, which represents 71% of deaths worldwide (WHO 2022). Among the major risk factors, AHT is by far the most triggering factor for cardiovascular diseases and its co-morbidity with other risk factors is even more influential (Al Disi *et al.* 2016, WHO 2013). Gastric ulcers is the most recurrent chronic condition of digestive diseases (Kéïta 2005) affecting nearly 50% of the population in developing countries (Bentahar 2017). Whether they occur together or separately, AHT and gastric ulcers require long-term monitoring and expensive treatment (Al Disi *et al.* 2016, Bentahar 2017, Bio *et al.* 2015, Diop *et al.* 2022, WHO 2013). In addition to the economic and side effects implications of modern drugs (Al Disi *et al.* 2016, Susalit *et al.* 2011), the preference for medicinal plant therapy can be justified by the low compliance of patients who find it difficult to take the recommended dose of modern drugs because of side effects. In Benin, as in several African countries, healthcare systems were less developed (infrastructure and staff issues). Despite the advent of generic drugs, many treatments still remain financially inaccessible to economically deprived populations.

Thus, people suffering from chronic diseases search for alternative medications, such as herbal remedies for the treatment necessary to relieve symptoms. Literature is full of studies on herbal medication (Adomou *et al.* 2006, Adomou *et al.* 2012, Bio *et al.* 2015, Dassekpo *et al.* 2017, Dossou *et al.* 2021). Obviously, the use of herbal remedies is not astonishing, given that they contain active ingredients with known therapeutic properties (Al Disi *et al.* 2016, Pan *et al.* 2013). These studies also show that the choice of plants by populations is often not made at random but is rather a function of cultural traditions, acquired knowledge and the richness of their secondary metabolites (Albuquerque *et al.* 2011, Gaoue *et al.* 2017). However, despite the similarity of certain plant species in the treatment of AHT and gastric ulcers, as well as the concordance of risk factors, the use of medicinal plants in the treatment of AHT and gastric ulcers has never been investigated previously. Therefore, this study can be seen as the first in which ethnobotany and ethnomedicine are used to evaluate the contribution of plant biodiversity to the treatments of these chronic diseases.

It's becoming necessary to return to the fact that nature hold an interesting and diversified ethnopharmacology potential which can be an excellent site of experimentation for the development and implementation of new plant-based remedies. This study aimed to determine the diversity of plant species used for managing AHT and gastric ulcers, their ethnomedicine features, and users' perceptions of threat and conservation strategies in Benin.

Materials and Methods

Study area

The present study was carried out in the Republic of Benin, a country located in West Africa between 6°10'N and 12°25'N latitudes and 0°45'E and 3°55'E longitudes with an area of 114.760 km^2 ;Institut National de la Statistique et de l'Analyse Economique (INSAE 2016). The country borders Niger to the north, Burkina Faso to the northwest, the Atlantic Ocean to the south, Togo to the west and Nigeria to the east. In 2013, Benin's population was estimated to be more than 10 million inhabitants with 51.2% females and 48.8% males. The demography is characterized by their youth, with almost half, or 49%, being under 15 years old (INSAE 2016). Benin's cultural diversity reflects the richness of its landscape and is largely influenced by traditions ingrained in religious values.

Benin's climate is hot and humid, with alternating wet and dry seasons and an annual rainfall of around 1300 mm in the Southern region and around 700 to 900 mm in the Northern region. Average annual temperatures are 26° to 28°C and can sometimes reach 35° to 40°C (Adomou *et al.* 2006) in the Upper North regions such as Banikoara, Kandi, Karimama, Malanville. Benin is characterized by three ecological zones, namely: the Guinean zone, the Sudano-Guinean transition zone and the Sudanian zone. The edaphic conditions of the country are deep and not very fertile ferralitic soils, alluvial soils and heavy clay soils. The indigenous flora of Benin is composed of fallows, woodlands, semi-deciduous and dry forests, and savannahs and gallery forests in the Guinean and Sudano-Guinean zones (Adomou *et al.* 2006, Sinsin *et al.* 2004). The main economic activities are agriculture, livestock, crafts and informal trade. The minimum wage is 40,000 CFA francs (around 80 dollars). Benin has more than fifty local languages, which are easily grouped according to sociocultural group or geographical area (INSAE 2016).

Sampling and socio-demographic characteristics of the respondents

Ethnobotanical surveys were conducted from February to July 2023 across 8 municipalities in the three ecological zones of Benin (Figure1). Respondents were chosen through the snowball technique (N'Danikou *et al.* 2015) which allowed us to gather data from respondents with real knowledge of the use of plants as remedies against AHT and gastric ulcers. The consent of a respondent to participate in the survey was expressed by their agreement to reveal their identity, phone number and geographic coordinates. Ethical approval was obtained from the local ethics committee for biomedical research at the University of Parakou (CLERB-UP) on 8 january 2023.

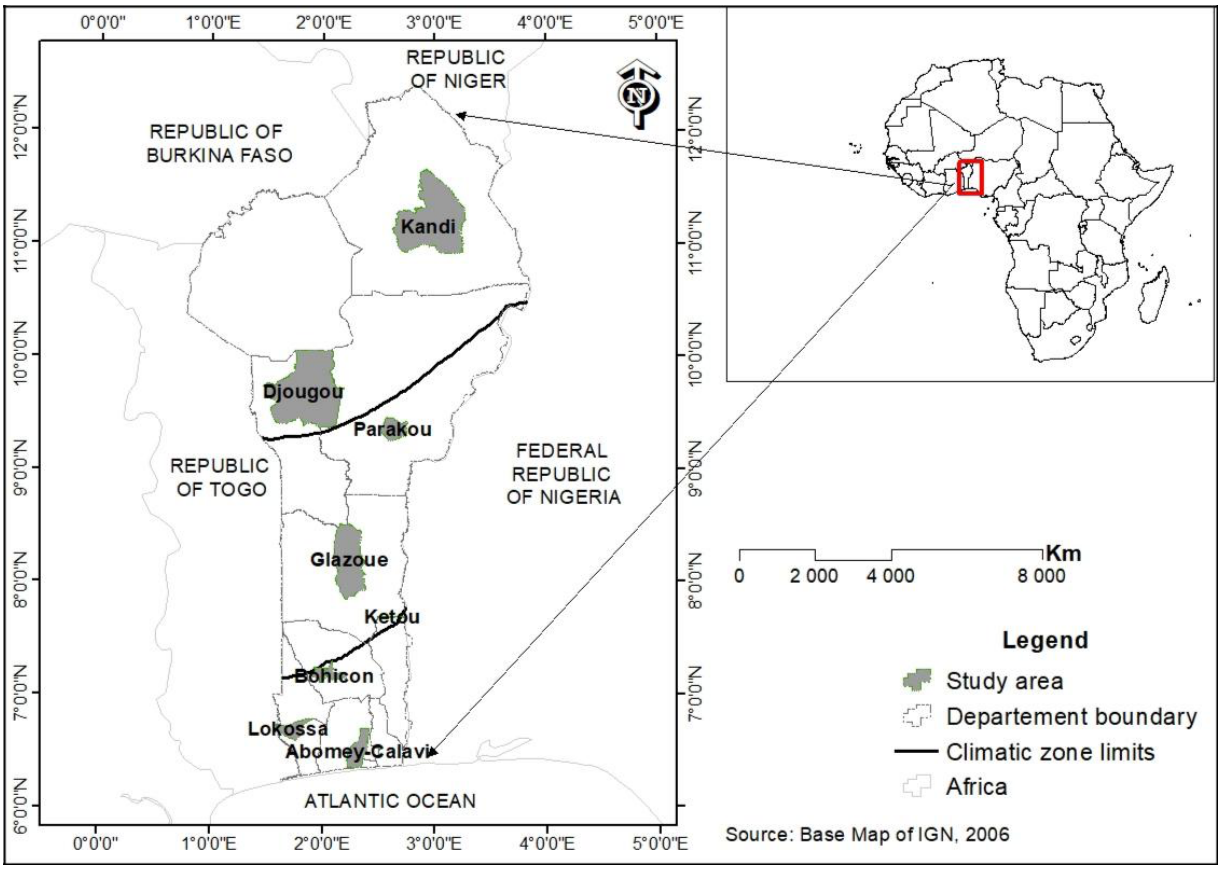


Figure 1. Study area showing the prospected communes, Benin

Patients suffering from AHT or gastric ulcers were met at the herbalist markets and the traditional therapist's houses, while they bought plants to prepare remedies or received healthcare treatments.

Herbalists and traditional therapists were adults with at least ten years of experience in traditional medical practices. The first respondents identified had been asked to indicate any other respondent with relevant experience in traditional medicine. The number of respondents was considered representative once the saturation limit was reached. This limit was defined as the point at which there were no new respondents identified by the last person interviewed.

Data collection and analysis

Data collection was carried out through a structured interview using a survey questionnaire recorded digitally in the KoboCollect application with consumers, herbalist and traditional therapists (table 1), with proven knowledge in the treatment of AHT and gastric ulcers. The questionnaire collected information on the various species used to prevent and cure AHT and gastric ulcers, the parts of the plant used, the preparation methods, the dosage, the accessibility and availability of the species, the mode of acquisition and the state conservation (threats and conservation strategies) on the monitoring of the species in the wild.

Samples of the plants mentioned were collected or purchased for their identification using reference documents on the region (de Souza 2008, Akoègninou *et al.* 2006). Verification of scientific names and species families was carried out using the international biodiversity information network site, Global Biodiversity Information Facility (GBIF; https://

www.gbif.org/) and the National Herbarium of (http:// publish.plantnet-project.org/project/herbierbenin) for species not included in the aforementioned documents. All named species have been listed and identified (Table 3).

The Relative Frequencies of Citation (RFC) of plants used in remedies for AHT and gastric ulcers were calculated according to the formula: (Dossou *et al.* 2021, Vitalini *et al.* 2013);

$$\text{RFC} = \frac{\textit{Number of citations for the plant}}{\textit{Total number of citations for all plants}} \; x \; 100$$

This index was also used to assess knowledge of the plant parts used, morphological types, places of collection, potential threats and conservation strategies.

To appreciate the relationship between sociocultural groups and plant species identified correspondence factor analysis (CFA) was performed out on the citation frequency for the ten (10) most cited plants.

Results

A total of 504 respondents, including 42 herbalists, 136 traditional therapists and 326 patients were interviewed as part of this study. Among the respondents women were 30.36% and men 69.64%, ranging from 17 to 100 years old. Five respondents under 21 years old were included because of their reputation in the use of medicinal plants for AHT and gastric ulcers. People aged between 30 and 50 years have a more diversified knowledge of plant species in the management of chronic diseases, including AHT and gastric ulcers (table1). The population studied was diverse with 23 sociocultural groups structured into 7 large groups. The most proportionate are Fon (41.67%), Yoruba (18.45%), Adja (13.69%), Baatombu (11.31%) and Yoa-lokpa (11.77%).

Table 1. Sociodemographic characteristics of respondents

Variables		Number of respondents	Proportions (%)
Groups of repondents	Herbalists	42	8.33
	Traditional therapists	136	26.99
	Consumers	326	64.68
	Total	504	100
Sex	Female	153	30.36
	Male	351	69.64
Age [17-100]	[≤ 25]	20	3.97
	[26-50]	297	58.93
	[51-75]	161	31.94
	[76-100]	26	5.16
Sociocultural groups	Adja	69	13.69
	Fon	210	41.67
	Baatombu	57	11.31
	Dendi	10	1.98
	YoaL	59	11.77
	Peulh	6	1.19
	Yoruba	93	18.45

Diversity of plant species used in remedies for AHT and gastric ulcers

Hundred and ninety-three (193) plant species grouped into 63 families were used as medicinal plants in remedies for arterial hypertension (AHT) and gastric ulcers in the study area. Among these species, 134 species (69.43%) belonging to 53 families were cited as antihypertensives and 142 species (73.58%) belonging to 54 families were cited as antiulcerants (table 3). It should be noted that 83 of the 193 plant species identified were used to treat both the AHT and gastric ulcers.

In the category of antihypertensive plants, the most represented families were Fabaceae with 16 species, Annonaceae, Apocynaceae, and Asteraceae with 6 species each (Figure2a). The most important species based on RFC were *Moringa oleifera* Lam. (42.14%), *Mangifera indica* L. (27.14%), *Persea americana* Mill. (26.43%), *Heliotropium indicum* L. (24.28%), *Parkia biglobosa* (Jacq.) R.Br. ex G.Don (22.86%) and *Newbouldia laevis* (P.Beauv.) Seem. ex Bureau (23.57%). These species were mainly trees (59.88%), and herbaceous (45.23%) (Figure 2b). These medicinal plants were purchased at herbal markets (68.46%), or harvested from gardens (63.81%), and fallow lands (35.61%) (Figure 2c).

Regarding the antiulcer plants cited, the most represented families were Fabaceae (28 species), Lamiaceae (7 species), Apocynaceae and Malvaceae (with 6 species each), Poaceae and Asteraceae (with 5 species each). The most cited species were among others *Ocimum gratissimum* L. (36.11%), *Khaya senegalensis* (Desr.) A.Juss. (33.33%), *Crateva adansonii* DC. (29.86%), *Vachellia nilotica* (L.) P.J.H.Hurter & Mabb. (22.91%), *M. oleifera* (21.51%), *Vitellaria paradoxa* C.F.Gaertn. (16.66%) (Figure 3a). These plants mentioned were trees (53.16%) and herbaceous plants (44.74%) (Figure 3b). These plants were purchased at herbal markets (73.56%) or harvested at home gardens (52.04%) and farms (48.24%) (Figure 3c).

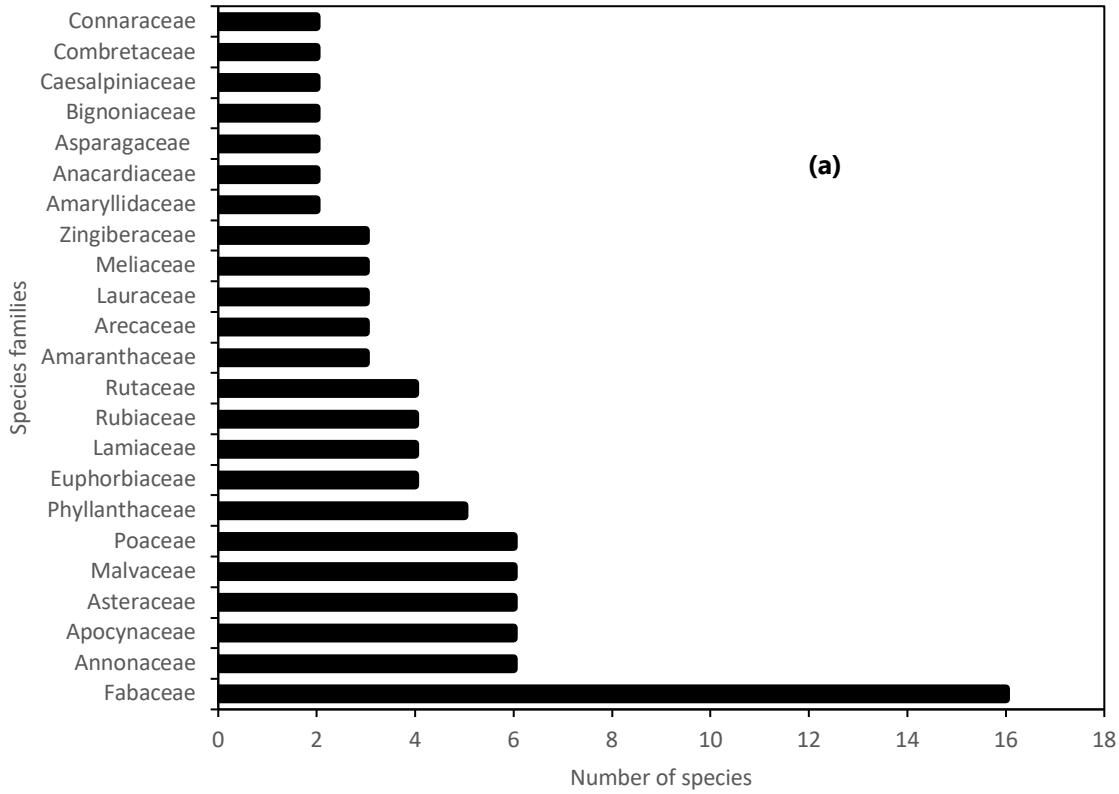
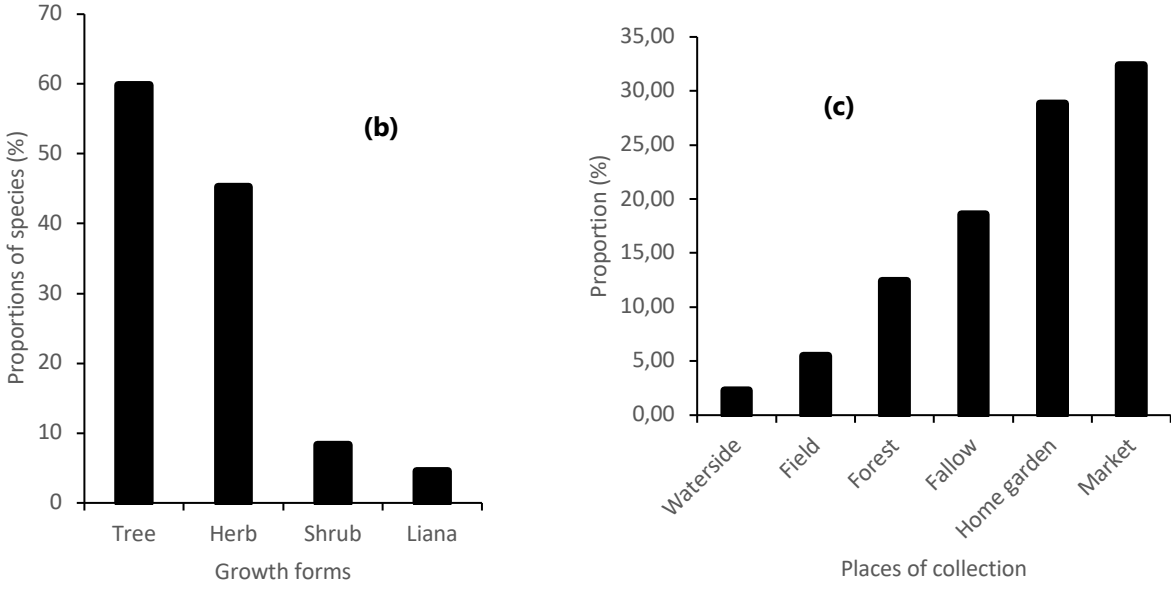


Figure 2. Distribution of plant species used in remedies for AHT following: (a) dominant families, (b) growth forms, (c) places of collection.



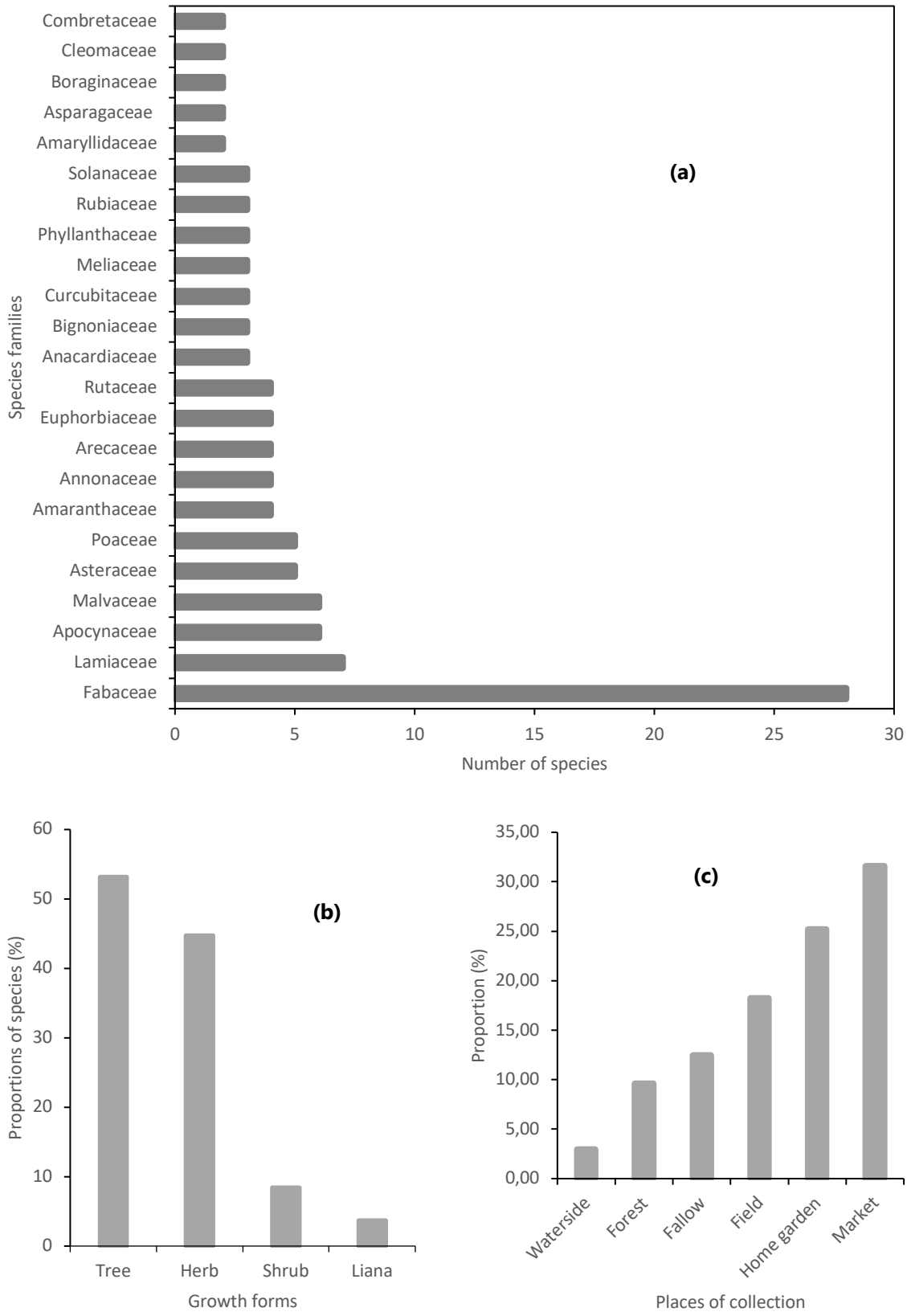


Figure 3. Distribution of plant species used in remedies for gastric ulcers following: (a) dominant families, (b) growth forms, (c) places of collection.

Ethnomedicinal characteristics of remedies for AHT and gastic ulcers and mode of preparation

Several parts of plants (leaves, fruit, root, bark, flower, stem, seed, bulb, pod, sap, rhizome and the whole plant) were used in the preparation of remedies for AHT and gastric ulcers. Leaves (84.01% and 74.12%), fruit (21.80% and 18.85%), bark (17.88% and 26.86%), and roots (14.53% and 16.74%) were the most cited parts used respectively of remedies for AHT and gastric ulcers (Figure 4a and 5a).

The method of preparation and administration of the remedies varied. However, decoction (67.63% and 32%), infusion (35.90% and 26%) and maceration (15.41% and 19%) were the preparation methods most used respectively in the preparation of recipes against AHT and gastric ulcers, respectively (Figure4b and 5b). Oral use was the common method of administration. Other methods of preparation, notably crushing, chewing, calcination and oil extraction, were infrequently used by local communities. The main solvents or liquid extractors of the bioactive compounds of the plants used were water, alcohol (distilled palm wine), coconut water and corn starch Ttable 2).

These plant parts were often used individually or in combination with compounds. Recipes for AHT and gastric ulcers are prepared from one part of a plant or the mixture of several parts of the plant or sometimes a combination of two or more different plant species. In addition to plant organs, other elements such as animal parts (ox flesh, viper head), kaolin were associated in the preparation of these remedies Ttable 2).

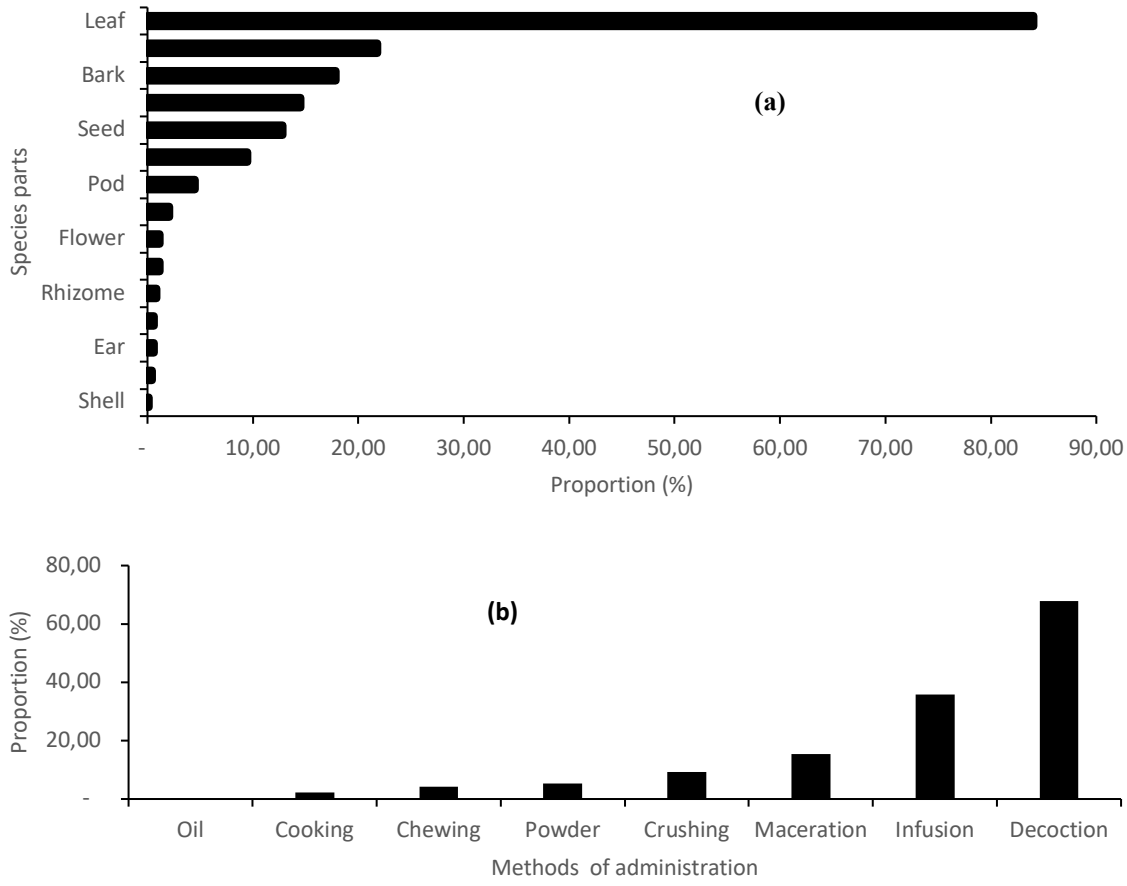


Figure 4. Ethnomedicinal characteristics of remedies for AHT, (a) parts of species, (b) Methods of administration.

Table 2 Complementary ingredients in remedies for AHT and gastric ulcers

Animal parts	Viper's head, ox's viscera and hooves, pig's blood, dog's liver
Food supplements	Lemon juice, honey, shea butter, red oil, palm wine, palm kernel oil, cassava starch, coconut water
Mineral additives	Red salt, kaolin

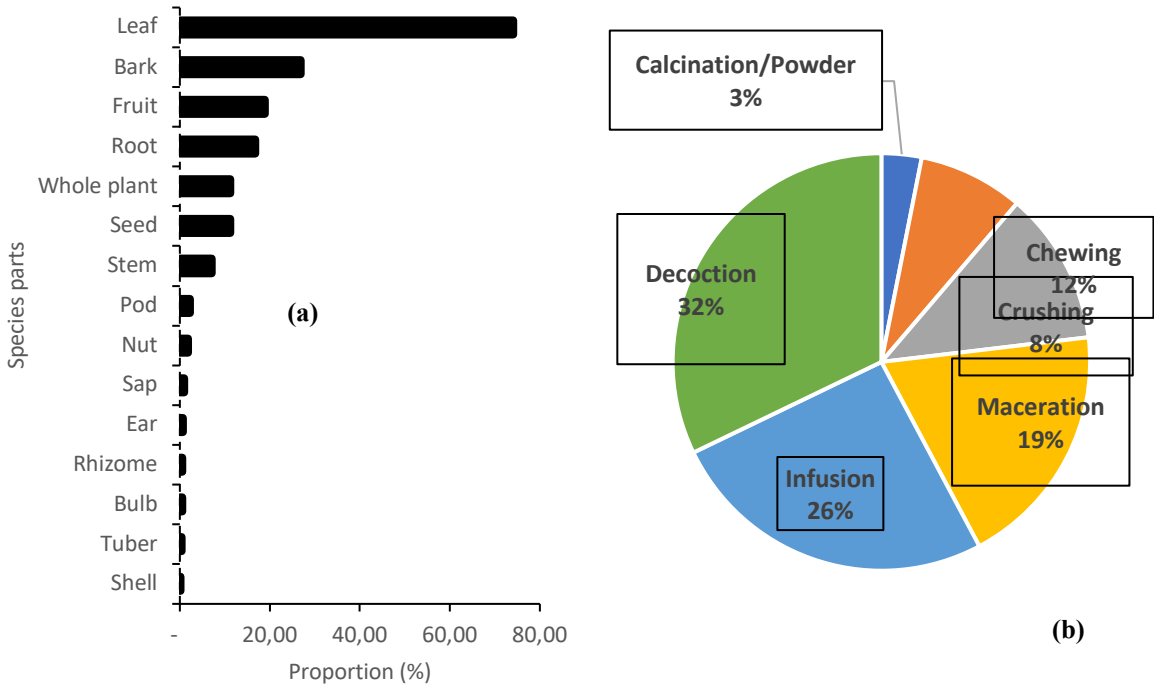


Figure 5. Ethnomedicinal characteristics of remedies for gastric ulcers, (a) parts of species, (b) Methods of administration.

Relationships between socio-cultural groups and medicinal plants used in the treatment of AHT and gastric ulcers

Correspondence Factor Analysis performed on the citation frequencies of the most cited species according to socio-cultural groups indicated that first two dimensions brought together 77.24% (Figure6) and 80.56% (Figure7) of information about the relationships between socio-cultural groups and the preference of medicinal plants used in remedies for AHT and gastric ulcers, respectively. Therefore, both axes were considered to reveal the relationships between socio-cultural groups and medicinal plants. Thus, we noted that to treat AHT, the socio-cultural groups Adja then Fon used *P. americana*, *Gmelina arborea* Roxb. ex Sm., *H. indicum*, *N. laevis* and *Allium sativum* L. while the socio-cultural groups Yoruba, Dendi, Peulh, Yoa-lokpa used *M. indica*, *Combretum micranthum* G.Don., *K. senegalensis* and *M. oleifera* and the socio-cultural group Baatombu used *P. biglobosa*.

Concerning remedies for gastric ulcers, the sociocultural groups Adja then Fon used *Momordica charantia* L., *O. gratissimum*, *H. indicum* L., *C. adansonii*, while the socio-cultural groups Yoa-lokpa used *M. oleifera* and the Yoruba, Dendi, Baatombu used *V. paradoxa*, *V. nilotica*, *K. senegalensis*.

User perception of endogenous threats and approaches to conservation

Users of medicinal plants in remedies for AHT and gastric ulcers perceived the existence of threats to plant species that could reduce their capacity for survival and contribute to the degradation and loss of medicinal plant for treatment of chronic diseases. They cite, among other threats, the abusive collection (62%) of certain organs (bark, roots), uncontrolled logging (45%) (felling of trees), vegetation fires (34%), climate change and overgrazing (Figure 8a).

To cope with these threats, local communities imposed a variety of restrictions to ensure long-term conservation of medicinal plant species. This concerns the establishment of home gardens (46%), species access restrictions (32%) and enhancement of local species in plantations (Figure 8b). Most traditional therapists had home gardens where various medicinal plant species grown.

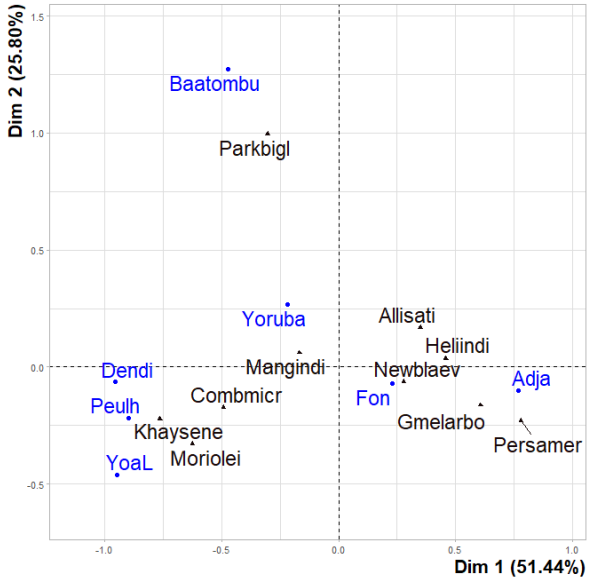


Figure 6. Projection of the most cited plant species for AHT to according to the sociocultural groups.
Legend: YoaL = Yoa-lokpa, Allisativ = *Allium sativum*, Combmicr= *Combretum micranthum*, Gmelarbo= *Gmelina arborea*, Hellindi= *Heliotropium indicum*, Khaysene= *Khaya senegalensis*, Mangindi= *Mangifera indica*, Moriolei= *Moringa oleifera*, Newblaev= *Newbouldia laevis*, Parkbigl= *Parkia biglobosa*, Persamer= *Persea americana*

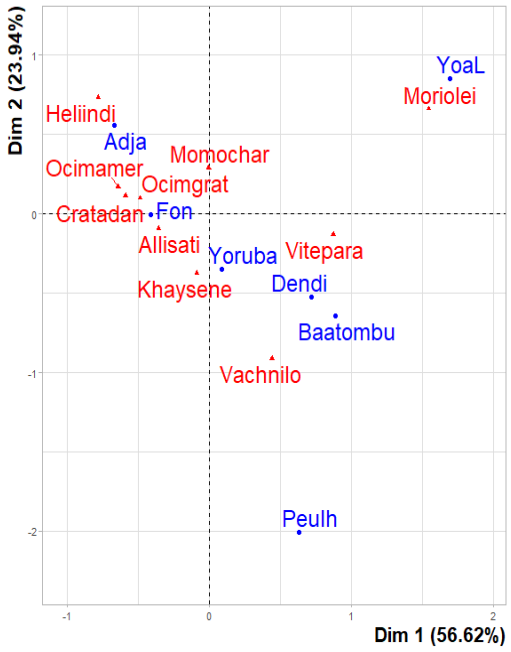


Figure 7. Projection of the most cited plant species for gastric ulcers to according to the sociocultural groups.
Legend: YoaL = Yoa-lokpa, Allisativ = *Allium sativum*, Vachnilo= *Vachellia nilotica*, Cratadan= *Crateva adansonii*, Hellindi= *Heliotropium indicum*, Khaysene= *Khaya senegalensis*, Momochar= *Momordica charantia*, Moriolei= *Moringa oleifera*, Ocimamer= *Ocimum americanum*, Ocimgrat= *Ocimum gratissimum*, Vitepara= *Vitellaria paradoxa*.

Discussion

The harvesting of medicinal plants is a frequent and constant practice that requires a thorough understanding of the principles governing exploitation and sustainable preservation on the part of traders and consumers (Dibong *et al.* 2011). The present study highlighted the knowledge of different sociocultural groups regarding therapy involving the use of medicinal plants in the prevention and treatment of chronic diseases such as arterial hypertension (AHT) and gastric ulcers.

Gender differences in medicinal plant use

The high number of male respondents may have to do with the dominance of men in traditional therapy. Even though gender does not appear to have a strong influence on traditional knowledge (Pila Cando & Hernández Maqueda 2023), this gender imbalance could be due to the reluctance of women in traditional therapy, even if women have proven knowledge of medicinal plants. On the other hand, this may be because of the inheritance of traditional knowledge which grants priority to the masculine gender (Albuquerque *et al.* 2011, Bio *et al.* 2015, Voeks 2004, Gaoue *et al.* 2017). Nonetheless, it should be noted that the study focused on specific chronic diseases with very specific respondents, which may have conditioned this gender imbalance. To understand whether gender influences knowledge of medicinal plants used in remedies for AHT and gastric ulcers, additional investigations with a greater diversity of respondents are recommended.

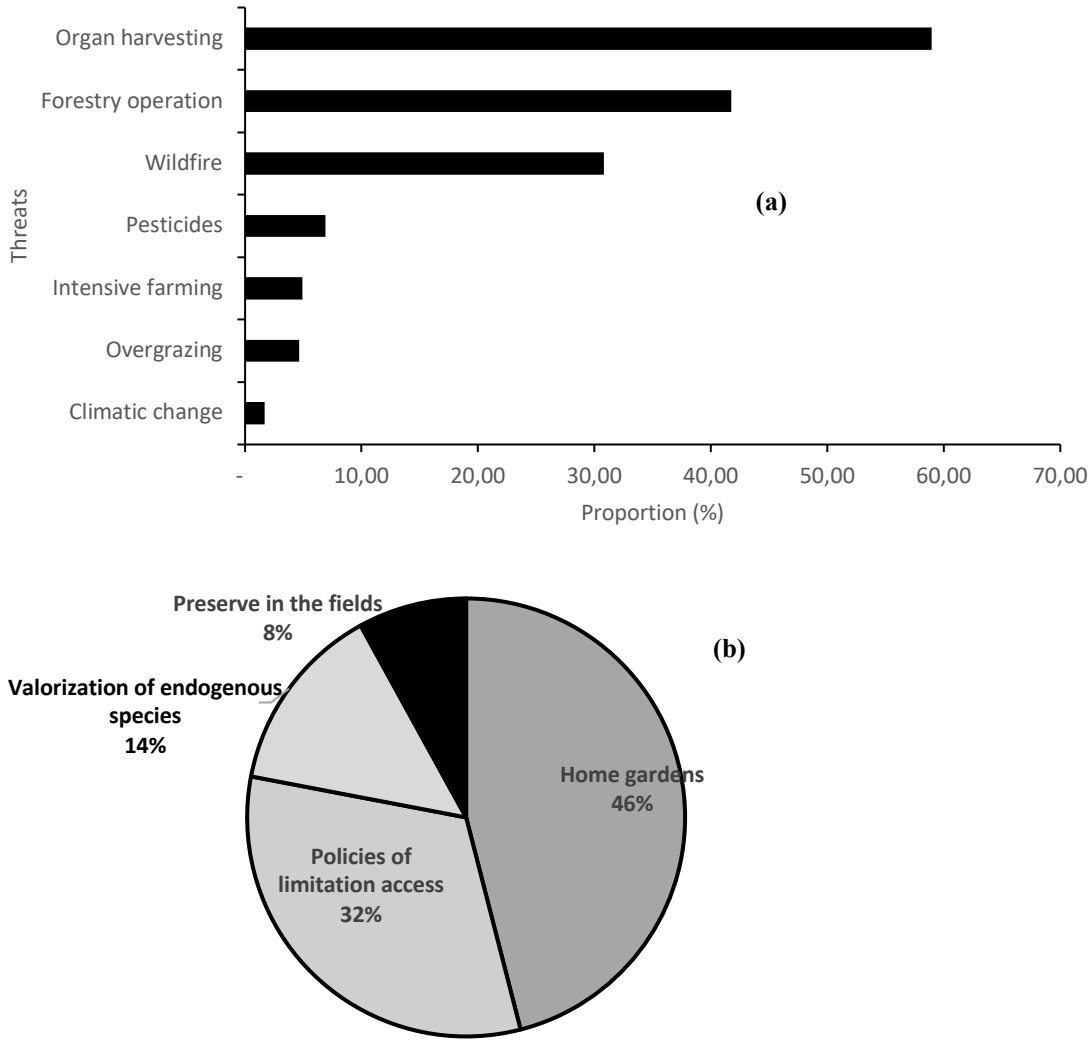


Figure 8. Threats (a) and Conservation (b) strategies of medicinal plants used in remedies for AHT and gastric ulcers

Diversity of medicinal plants

This study made it possible to identify a large number of cultivated or planted species used for the treatment of AHT and gastric ulcers, the number of which *M. oleifera*, *H. indicum*, *P. biglobosa*, *O. gratissimum*, *K. senegalensis*, *C. adansonii* and *V. nilotica* were most cited while Fabaceae, Caesalpiniaceae, Apocynaceae and Asteraceae were the most represented botanical families. However, Fabaceae was most cited by communities may be because this family is quite diverse in terms of plant species and reveals an impressive medicinal plant diversity with a large distribution range which would explain species availability and accessibility reported by the local communities (Albuquerque *et al.* 2006). These species and families have also been known and used as medicinal plants in remedies for AHT and gastric ulcers, particularly South Africa (Engwa *et al.* 2022), Algeria (Aouamri *et al.* 2020), Cameroon (Dibong *et al.* 2011), Ethiopia (Asfaw & Abebe 2022), Morocco (Orch *et al.* 2015), Nigeria (Bello *et al.* 2022) and Senegal (Gueye *et al.* 2012). This could be explained by their large distribution range and abundance as well as the diversity of their active ingredients. Most of the medicinal plants identified in this study are herbaceous. Previous work has also listed a large number of herbaceous used in remedies for AHT and gastric ulcers (Adomou *et al.* 2012, Dassekpo *et al.* 2017, Sewani-Rusike & Mammen 2014). This finding indicates that herbaceous are important components of medicinal plant diversity and contribute significantly to global biodiversity and the treatment of many chronic diseases all over the world. The frequent use of herbs by local communities to treat illness may have to do with the large diversity and economic availability of herbaceous plants they harvest from their immediate environment (Albuquerque *et al.* 2006). Herbs, which primarily occur in home gardens, fallows, farms, watersides, and all over disturbance landscapes, may be dominant because they are easy to access in nature. These results are consistent with the availability hypothesis which states that the use of plants to remedy a health problem depends on their accessibility and local abundance (Gaoue *et al.* 2017, Voeks 2004).

Table 3. Plant species used in remedies for AHT and gastric ulcers

Family	Species name	Part used	Methods of administration	Treated disease (AHT/GU)	Growth form
Acanthaceae	*Dianthera secunda* (Lam.) Griseb.	Leaves	Watery decoction, Alcoholic maceration	GU	Herb
Amaranthaceae	*Pupalia lappacea* (L.) Juss.	Leaves	Infusion, Decoction Soup, Crushing	AHT+ GU	Herb
	Celosia argentea L.	Leaves, Fruit	Infusion, Soup, Crushing	AHT+GU	Herb
	Dysphania ambrosioides (L.) Mosyakin & Clemants	Leaves, Whole plant	Infusion	GU	Herb
	Amaranthus tricolor L.	Leaves, Fruit	Infusion, Soup, Crushing	AHT+GU	Herb
Amaryllidaceae	*Allium cepa* L.	Bulbe, Leaves	Infusion, Decoction, Chewing, Soup	AHT+GU	Herb
	Allium sativum L.	Leaves, Pod	Decoction, Maceration, Infusion, Chewing	AHT+GU	Herb
Anacardiaceae	*Anacardium occidentale* L.	Leaves, Bark	Decoction, Maceration, Chewing	AHT+GU	Tree
	Mangifera indica L.	Leaves, Bark, Roots	Decoction, Powder, Infusion	AHT+GU	Tree
	Sclerocarya birrea (A.Rich) Hochst.	Leaves, Baie, Seeds	Decoction, Infusion, Chewing	GU	Tree
	Spondias mombin L.	Leaves	Decoction	AHT	Tree
Annonaceae	*Annona senegalensis* Pers.	Leaves, Fruit, Roots	Decoction, Infusion, Maceration, Tea	AHT+GU	Tree
	Annona muricata L.	Leaves	Decoction	AHT	Tree
	Annona squamosa L.	Leaves, Fruit, Bark	Decoction, Infusion, Chewing	AHT+GU	Tree
	Monodora myristica (Gaertn.) Dunal	Leaves, Fruit, Seeds, Bark	Decoction, Maceration	AHT+GU	Shrub
	Xylopia aethiopica (Dunal) A.Rich.	Leaves, Fruit, Seeds, Stem, Roots	Maceration, Infusion, Decoction	AHT+GU	Tree
	Uvaria chamae P.Beauv.	Leaves, Fruit, Roots	Decoction	AHT	Shrub
Apiaceae	*Daucus carota* L.	Stem	Chewing	AHT+GU	Herb
Apocynaceae	*Calotropis procera* (Aiton) W.T.Aiton	Leaves	Decoction, Infusion	AHT+GU	Shrub
	Baissea zygodioides (K.Schum.) Stapf	Leaves, Flower	Decoction, Infusion	GU	Herb
	Carissa spinarum L.	Leaves, Fruit	Maceration, Infusion, Decoction	AHT+GU	Tree
	Catharanthus roseus (L.) G.Don	Whole plant	Decoction, Infusion, Crushing	AHT+GU	Herb

	Holarrhena floribunda (G.Don) T.Durand & Schinz	Leaves, Roots	Decoction, Infusion	AHT+GU	Shrub-liana
	Landolphia owariensis P.Beauv.	Leaves	Decoction, Chewing	AHT	Liana
	Rauvolfia vomitoria Wennberg	Leaves	Decoction, Infusion	AHT	Shrub
	*Secamone afzelii (*Roem. & Schult.) K.Schum	Leaves, Roots	Decoction, Infusion	GU	Shrub
Asteraceae	*Acanthospermum hispidum* DC.	Whole plant, Leaves	Infusion, Decoction	AHT+GU	Herb
	Chromolaena odorata (L.) R.M.King & H.Rob.	Leaves, Fruit, Seeds	Infusion, Decoction, Chewing	AHT+GU	Herb
	Tridax procumbens L.	Leaves, Whole plant	Infusion, Crushing, Maceration	AHT+GU	Herb
	Gymnanthemum amygdalinum (Delile) Sch.Bip.	Leaves	Soup, Infusion Decoction	GU	Herb
	Vernonia colorata (Willd.) Drake	Leaves	Soup, Infusion Decoction	AHT	Herb
	Launaea taraxacifolia (Willd.) Amin ex C.Jeffrey	Leaves, Whole plant	Decoction, Infusion	AHT	Herb
	Aedesia glabra (Klatt) O.Hoffm.	Leaves, Whole plant	Decoction, Infusion	AHT	Shrub
	Ageratum conyzoides L.	Leaves, Whole plant	Decoction, Infusion	GU	Herb
Asparagaceae	*Sansevieria liberica* Gérôme & Labroy	Leaves	Infusion	GU	Shrub
	Furcraea foetida (L.) Haw.	Leaves, Sap, Roots	Decoction aqueuse, Powder	AHT+GU	Herb
	Dracaena arborea (Willd.) Link	Leaves	Decoction	AHT	Tree
Arecaceae	*Borassus aethiopum* Mart.	Leaves	Decoction, Infusion	AHT+GU	Tree
	Cocos nucifera L.	Leaves, Nut, Roots	Decoction, Chewing, Maceration	AHT+GU	Tree
	Elaeis guineensis Jacq.	Leaves, Roots, Bark	Decoction, Infusion, Chewing	AHT+GU	Tree
	Hyphaene thebaica (L.) Mart.	Leaves, Roots, Fruit	Decoction, Infusion, Chewing	GU	Tree
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	Leaves, Seeds, Bark	Powder, Decoction	AHT+GU	Tree
	Newbouldia laevis (P.Beauv.) Seem. ex Bureau	Leaves, Bark, Roots	Infusion, Tea, Decoction	AHT+GU	Tree

	Spathodea campanulata P.Beauv.	Leaves, Flower, Roots	Infusion, Maceration, Decoction	GU	Tree
Bixaceae	*Cochlospermum tinctorium* Perrier ex A.Rich.	Leaves, Roots	Decoction, Maceration, Powder	AHT+GU	Shrub
Boraginaceae	*Heliotropium indicum* L.	Whole plant, Leaves	Infusion, Decoction	AHT+GU	Herb
	Ehretia cymosa Thonn.	Leaves, Roots	Decoction, Maceration	GU	Tree
Brassicaceae	*Brassica oleracea* L.	Leaves	Soup, Chewing	GU	Herb
Bromeliaceae	*Ananas comosus* (L.) Merr.	Fruit	Chewing	GU	Herb
Cactaceae	*Opuntia dillenii* (Ker Gawl.) Haw.	Fruit, Flower	Decoction, Powder, Maceration	GU	Shrub
Caesalpiniaceae	*Caesalpinia benthamiana* (Baill.) Herend. & Zarucchi	Leaves, Fruit	Decoction	AHT	Tree
	Caesalpinia bonduc (L.) Roxb.	Leaves, Fruit, Seeds, Roots	Decoction, Maceration	AHT+GU	Tree
Cannaceae	*Canna indica* L.	Leaves	Infusion	GU	Herb
Cleomaceae	*Cleome viscosa* L.	Leaves, Whole plant	Infusion, Decoction	AHT+GU	Herb
	Cleome gynandra L.	Leaves, Whole plant	Infusion, Decoction	GU	Herb
Capparaceae	*Crateva adansonii* DC.	Leaves	Infusion, Decoction	GU	Tree
Caricaceae	*Carica papaya* L.	Leaves, Fruit, Seeds, Roots	Infusion, Decoction, Chewing	AHT+GU	Tree
Celastraceae	*Gymnosporia senegalensis* (Lam.) Loes.	Leaves, Bark, Fruit	Decoction, Infusion, Maceration	AHT	Shrub
Clusiaceae	*Garcinia kola* Heckel.	Fruit, Leaves,	Chewing, Decoction, Infusion, Maceration	AHT+GU	Tree
Combretaceae	*Combretum micranthum* G.Don	Leaves, Fruit, Roots	Decoction, Infusion, Chewing, Powder	AHT+GU	Tree
	Terminalia avicennioides Guill. & Perr.	Leaves, Bark, Roots	Decoction, Maceration	AHT	Tree
	Pteleopsis suberosa Engl. & Diels	Bark, Leaves, Roots	Decoction, Maceration	GU	Tree
Connaraceae	*Rourea coccinea* (Schumach. & Thonn.) Benth.	Leaves	Decoction, Infusion	AHT+GU	Shrub
	Cnestis ferruginea Vahl ex DC.	Leaves	Decoction	AHT	Tree
Convolvulaceae	*Ipomoea involucrata* P.Beauv.	Leaves, Seeds, Flower	Infusion	AHT+GU	Herb

Crassulaceae	*Bryophyllum pinnatum* (Lam.) Oken	Leaves, Whole plant	Infusion, Chewing	AHT	Shrub
	Kalanchoe crenata (Andrews) Haw.	Leaves, Whole plant	Infusion, Chewing	AHT+GU	Shrub
Curcubitaceae	*Citrullus colocynthis* (L.) Schrad.	Seeds, Fruit, Shell, Leaves	Soup, Chewing, Infusion	GU	Liana
	Luffa cylindrica (L.) M.Roem.	Leaves, Fruit, Seeds	Infusion, Maceration	AHT+GU	Liana
	Momordica charantia L.	Whole plant, Leaves	Infusion, Crushing, Maceration	AHT+GU	Liana
Dioscoreaceae	*Dioscorea alata* L.	Tubercule	Chewing, Maceration	AHT+GU	Herb
	Dioscorea bulbifera L.	Tubercule, Leaves	Decoction, Infusion	AHT	Herb
Ebenaceae	*Diospyros mespiliformis* Hochst. ex A.DC.	Leaves	Crushing, Infusion	GU	Tree
Euphorbiaceae	*Croton lobatus* L.	Leaves, Whole plant	Infusion, Decoction	AHT+GU	Herb
	Jatropha curcas L.	Leaves, Stem de Leaves	Infusion, Powder	AHT+GU	Shrub
	Jatropha multifida L.	Leaves, Stem, Sap	Infusion, Decoction	GU	Shrub
	Manihot esculenta Crantz	Leaves, Stem, Tubercule	Decoction, Infusion, Soup, Chewing	AHT+GU	Herb
	Euphorbia hirta L.	Leaves	Decoction	AHT	Herb
Fabaceae	*Abrus precatorius* L.	Leaves, Bark	Decoction, Infusion	AHT+GU	Shrub Liana
	Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	Fruit, Seeds, Leaves	Decoction, Tea, Maceration	AHT+GU	Tree
	Acacia auriculiformis A.Cunn. ex Benth.	Leaves	Tea, Infusion	AHT+GU	Tree
	Afzelia africana Sm. ex Pers.	Leaves, Bark, Roots	Decoction, Maceration	GU	Tree
	Arachis hypogaea L.	Leaves, Seeds, Shell	Infusion, Decoction, Chewing	AHT+GU	Herb
	Aganope stuhlmannii (Taub.) Adema	Leaves, Fruit	Decoction, Maceration	GU	Tree
	Albizia adianthifolia (Schumach.) W.Wight	Bark, Leaves, Roots	Maceration, Decoction, Infusion	GU	Tree
	Cajanus cajan (L.) Huth	Seeds, Leaves, Roots	Maceration, Infusion, Soup	AHT+GU	Herb
	Caesalpinia pulcherrima (L.) Sw.	Leaves, Roots	Decoction, Infusion, Chewing	AHT+GU	Shrub
	Crotalaria goreensis Guill. & Perr.	Leaves	Infusion	GU	Herb

	Crotalaria retusa L.	Whole plant, Leaves	Infusion, Maceration	GU	Herb
	Daniellia oliveri (Rolfe) Hutch. & Dalziel	Leaves, Bark	Decoction, Infusion, Maceration, Crushing	AHT	Tree
	Polhillides velutina (Willd.) H.Ohashi & K.Ohashi	Leaves	Infusion, Maceration	GU	Shrub
	Detarium microcarpum Guill. & Perr.	Roots, Nut	Maceration, Chewing	GU	Tree
	Dichrostachys cinera (L.) Wight & Arn.	Leaves, Stem	Infusion, Maceration, Decoction	AHT+GU	Tree
	Entada africana Guill. & Perr.	Leaves, Fruit, Seeds	Infusion, Maceration, Decoction	GU	Shrub
	Erythrina senegalensis DC.	Flower, Roots, Leaves	Infusion, Decoction, Maceration	GU	Tree
	Parkia biglobosa (Jacq.) R.Br. ex G.Don	Leaves, Seeds, Bark	Infusion, Maceration, Chewing	AHT+GU	Tree
	Pericopsis laxiflora (Benth. ex Baker) Meeuwen	Leaves, Fruit	Decoction	AHT+GU	Tree
	Phaseolus lunatus L.	Leaves, Stem	Decoction, Infusion, Maceration	AHT+GU	Herb
	Phaseolus vulgaris L.	Leaves, Stem	Decoction, Infusion, Maceration	GU	Herb
	Piliostigma thonningii (Schum.) Milne-Redh.	Leaves	Decoction	GU	Tree
	Pterocarpus erinaceus Poir.	Leaves, Bark, Roots	Infusion, Decoction, Maceration	GU	Tree
	Mimosa candollei R.Grether	Leaves	Decoction	AHT	Tree
	Senna alata (L.) Roxb.	Leaves	Decoction	AHT+GU	Herb
	Senna obtusifolia (L.) H.S.Irwin & Barneby	Leaves, Stem	Decoction, Maceration, Infusion, Soup	GU	Herb
	Senna occidentalis (L.) Link	Leaves, Whole plant	Decoction, Infusion	AHT	Herb
	Swartzia madagascariensis Desv.	Leaves, Bark, Roots	Maceration	AHT	Tree
	Vigna subterranea (L.) Verdc.	Leaves, Pod	Maceration	GU	Herb
	Uraria picta (Jacq.) Desv. ex DC.	Leaves	Decoction, Maceration	AHT	Herb
	Tamarindus indica L.	Leaves, Fruit, Seeds	Decoction, Infusion, Maceration	GU	Tree
	Tetrapleura tetraptera (Schumach. & Thonn.) Taub.	Leaves, Roots, Bark	Decoction, Infusion, Maceration	GU	Tree

	Zapoteca portoricensis (Jacq.) H.M.Hern.	Leaves, Whole plant	Decoction, Mécération	GU	Herb
Hypericaceae	*Psorospermum senegalense* Spach	Leaves	Decoction	AHT	Tree
Icacinaceae	*Icacina trichantha* Oliv.	Leaves	Infusion, Crushing	AHT	Shrub
Irvingiaceae	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.	Leaves	Infusion	AHT	Tree
Lauraceae	*Cassytha filiformis* L.	Whole plant, Leaves, Stem	Infusion, Maceration, Crushing	AHT+GU	Liana
	Laurus nobilis L.	Leaves, Bark, Roots	Decoction, Maceration, Infusion	AHT	Shrub
	Persea americana Mill.	Leaves, Fruit, Seeds	Decoction, Infusion, Maceration, Chewing	AHT+GU	Tree
Lamiaceae	*Gmelina arborea* Roxb. ex Sm.	Leaves	Decoction, Infusion	AHT+GU	Tree
	Hyssopus officinalis L.	Whole plant, Leaves	Decoction	AHT	Herb
	Hyptis sualeolens (L.) Poit.	Whole plant, Leaves	Decoction	GU	Herb
	Ocimum americanum L.	Whole plant, Leaves	Decoction, Maceration, Infusion	AHT+GU	Herb
	Ocimum basilicum L.	Whole plant, Leaves	Decoction, Maceration, Infusion	GU	Herb
	Ocimum gratissimum L.	Leaves	Decoction, Infusion	AHT+GU	Herb
	Tectona grandis L.f.	Leaves	Decoction	GU	Tree
	Vitex doniana Sweet	Leaves, Fruit	Infusion, Maceration, Soup	GU	Tree
Loganiaceae	*Strychnos spinosa* Lam.	Leaves	Decoction, Maceration	AHT+GU	Shrub
Loranthaceae	*Tapinanthus globiferus* (A.Rich.) Tiegh.	Whole plant, Leaves	Decoction	AHT	Herb
Lythraceae	*Lawsonia inermis* L.	Leaves	Infusion, Maceration, Chewing	GU	Shrub
Malvaceae	*Sida acuta* Burm.f.	Bark	Decoction	GU	Herb
	Adansonia digitata L.	Leaves, Fruit, Bark	Chewing, Soup, Infusion, Maceration	AHT+GU	Tree
	Ceiba pentandra (L.) Gaertn.	Leaves, Bark, Roots	Decoction, Infusion, Powder	AHT+GU	Tree
	Hibiscus sabdariffa L.	Leaves, Bark	Decoction, Infusion, Crushing	AHT	Herb
	Cola nitida (Vent.) Schott & Endl.	Fruit, Leaves	Maceration, Chewing	AHT+GU	Tree
	Cola acuminata (P.Beauv.) Schott & Endl.	Leaves, Bark	Maceration, Chewing	GU	Tree
	Cola millenii K.Schum.	Leaves, Fruit	Maceration	AHT	Tree
	Sterculia setigera Delile	Leaves, Bark	Decoction	AHT	Tree

	Corchorus olitorius L.	Leaves, Seeds	Decoction, Infusion, Crushing	GU	Herb
Meliaceae	*Azadirachta indica* A.Juss.	Leaves, Bark, Fruit	Decoction, Chewing	AHT+GU	Tree
	Khaya senegalensis (Desr.) A.Juss.	Bark, Leaves	Decoction, Maceration, Chewing	AHT+GU	Tree
	Pseudocedrela kotschyi (Schweinf.) Harms	Leaves, Roots, Bark	Decoction, Infusion, Crushing Chewing	GU	Tree
	Trichilia emetica Vahl	Bark	Decoction	AHT	Tree
Menispermaceae	*Cissampelos mucronata* A.Rich.	Whole plant, Stem, Leaves	Infusion, Decoction	AHT	Liana
Moraceae	*Ficus sur* Forssk.	Leaves	Decoction, Crushing	GU	Tree
	Ficus umbellata Vahl	Leaves	Decoction, Crushing, Maceration	GU	Tree
	Ficus gnapholocarpa (Miq.) Steud. ex Miq.	Leaves	Decoction	AHT	Tree
Moringaceae	*Moringa oleifera Lam.*	Leaves, Seeds, Roots	Decoction, Crushing, Maceration, Infusion	AHT+GU	Tree
Musaceae	*Musa acuminata* Colla	Fruit, Leaves	Chewing, Infusion, Decoction	AHT+GU	Herb
Myrtaceae	*Psidium guajava* L.	Leaves, Fruit	Chewing, Infusion, Decoction	AHT+GU	Tree
	Syzygium aromaticum (L.) Merr. & L.M.Perry	Fruit, Leaves	Chewing, Infusion, Maceration, Decoction	AHT+GU	Shrub
Nyctaginaceae	*Boerhavia erecta* L.	Whole plant, Leaves, Flower	Infusion	GU	Herb
	Boerhavia diffusa L.	Whole plant, Leaves	Infusion	AHT	Herb
	Boerhavia repens L.	Whole plant, Leaves	Infusion	AHT	Herb
Ochnaceae	*Lophira lanceolata* Tiegh. ex Keay	Leaves	Infusion	AHT	Tree
Papaveraceae	*Argemone mexicana* L.	Leaves, Whole plant, Roots	Infusion, Maceration, Decoction	GU	Herb
Phyllanthaceae	*Bridelia ferruginea* Benth.	Leaves, Bark	Infusion, Decoction	AHT+GU	Tree
	Bridelia scleroneura Müll.Arg.	Leaves	Infusion	AHT	Tree
	Flueggea virosa (Roxb. ex Willd.) Royle	Leaves, Stem Leaves	Decoction, Maceration, Crushing	GU	Shrub
	Phyllanthus amarus Schumach. & Thonn.	Leaves, Whole plant	Infusion, Maceration	AHT+GU	Herb
	Phyllanthus niruni L.	Leaves, Whole plant	Infusion, Maceration	AHT	Herb

	Hymenocardia acida Tul.	Nut, Bark, Flower	Chewing, Infusion, Maceration	AHT	Tree
Piperaceae	*Piper nigrum* L.	Seeds, Leaves	Maceration, Powder, Chewing, Infusion	AHT+GU	Liana
	Peperomia pellucida (L.) Kunth	Leaves, Flower	Decoction	AHT	Herb
Poaceae	*Bambusa vulgaris* Schrad. ex J.C.Wendl.	Leaves, Roots, Stem	Decoction, Maceration	AHT+GU	Tree
	Cymbopogon citratus (DC.) Stapf	Leaves	Infusion, Decoction, Maceration	AHT+GU	Herb
	Imperata cylindrica (L.) Raeusch.	Leaves	Decoction	AHT	Herb
	Oxytenanthera abyssinica (A.Rich.) Munro	Leaves, Roots	Infusion, Decoction, Maceration	AHT	Tree
	Sorghum bicolor (L.) Moench	Leaves, Seeds, Stem	Infusion, Maceration	AHT+GU	Herb
	Saccharus officinarum L.	Leaves, Stem, Roots	Infusion, Decoction, Maceration, Chewing	GU	Herb
	Zea mays L.	Leaves, Ear, Roots, Stem	Infusion, Chewing, Decoction, Maceration	AHT+GU	Herb
Pontederiaceae	*Pontederia crassipes* Mart.	Leaves	Decoction	AHT	Herb
Rubiaceae	*Mitracarpus hirtus* (L.) DC.	Leaves, Whole plant	Infusion, Decoction	GU	Tree
	Crossopteryx febrifuga (Afzel. ex G.Don) Benth.	Leaves, Bark	Infusion, Decoction	AHT	Tree
	Morinda citrifolia L.	Leaves, Fruit	Infusion, Decoction, Crushing	AHT	Shrub
	Morinda lucida Benth.	Leaves, Fruit, Roots	Infusion, Decoction, Crushing	AHT+GU	Tree
	Sarcocephalus latifolius (Sm.) E.A.Bruce	Roots, Leaves, Fruit	Tea, Maceration, Decoction, Infusion	AHT+GU	Tree
Rutaceae	*Citrus x aurantiifolia* (Noël.) Swingle	Leaves, Fruit	Infusion, Maceration, Decoction	AHT+GU	Tree
	Citrus x aurantium f. aurantium	Leaves, Fruit, Roots	Infusion, Maceration, Decoction	AHT+GU	Tree
	Citrus x limon (L.) Osbeck	Leaves, Fruit, Roots	Infusion, Maceration, Decoction	AHT+GU	Tree
	Zanthoxylum zanthoxyloides (Lam.) Zepern. & Timler	Leaves, Fruit	Infusion, Decoction	AHT+GU	Tree
Sapindaceae	*Blighia sapida* K.D.Koeing	Leaves, Fruit	Decoction, Infusion	GU	Tree
Sapotaceae	*Vitellaria paradoxa* C.F.Gaertn.	Leaves, Fruit, Bark	Infusion, Maceration, Decoction	AHT+GU	Tree

Solanaceae	*Capsicum annuum* L.	Fruit	Soup, Maceration	GU	Herb
	Physalis angulata L.	Fruit	Decoction Maceration	GU	Herb
	Solanum macrocarpon L.	Leaves	Maceration	AHT	Herb
	Solanum tuberosum L.	Leaves	Soup, Maceration	GU	Herb
	Nicotiana tabacum L.	Leaves, Fruit	Decoction Maceration	AHT	Herb
Talinaceae	*Talinum fruticosum* (L.) Juss.	Whole plant, Leaves	Decoction, Maceration	AHT+GU	Herb
Typhaceae	*Typha domingensis* Pers.	Leaves, Bark	Infusion	AHT	Herb
Verbenaceae	*Verbena officinalis* L.	Leaves, Bark	Infusion	AHT	Herb
	Lantana camara L.	Leaves	Decoction	GU	Shrub
Zingiberaceae	*Aframomum melegueta* K.Schum.	Leaves, Fruit, Rhizome	Decoction, Maceration	AHT+GU	Herb
	Curcuma longa L.	Leaves, Flower, Rhizome	Decoction	AHT	Herb
	Zingiber officinale Roscoe.	Leaves, Rhizome	Decoction, Maceration	AHT	Herb

Legend: AHT=Arterial hypertension, GU=Gastric ulcers

Preparation of remedies for AHT and gastric ulcers

The part of the plant considered, and the extraction of solvent are likely to impact active compound effectiveness and toxicity (Yirgu & Chippaux 2019). Leaves are widely preferred may be because of their central role in photochemical reactions and their function as reservoirs of resulting organic materials (Ould el Hadj *et al.* 2003). They mainly contain alkaloids, glycosides and essential oils. The excessive use of the bark in the preparation of remedies is thought to be due to ability to concentrate the plant's active principle (Kasali *et al.* 2021). Thus, it can be preserved and stored for marketing or future use, especially in unavailable of non-fresh plant material or in periods of severe drought. On the other hand, excessive collection of the bark of plant species could compromise the survival of plants unlike leaves which not only are easier to access but also the harvest has fewer negative impacts. To evaluate the effectiveness of remedies for AHT and gastric ulcers, either a one part or several parts of the plant are used with other additives, including animal parts and food supplements. For traditional therapists and herbalists, these additions (beef flesh, lemon juice, local alcohol, etc.) improve the organoleptic quality of the potions. The frequent use of *M. oleifera* in almost all remedies for AHT may have to do with the species' bioactive compound essential for the management of AHT carriers (Kouakou & Tahiri 2018). For gastric ulcers, beyond *M. oleifera, K. senegalensis* and *O. gratissimum* are also very present in remedies may be because of their metabolites known to prevent stomach infections (Dibong *et al.* 2011). These species are well known and listed by traditional therapists herbalists and consumers.

Characterization of knowledge of respondents on medicinal plants

The knowledge of medicinal plants used for AHT and gastric ulcers were distributed according to the cultural areas in Benin. The sociocultural groups Adja and Fon are the majority in the Adja-Tado cultural area, which extends from the Southern to Centre, across the Guinean ecological zone and the sudano-guinean transition ecological zone in Benin. The populations in this cultural area have nearly similar knowledge on medicinal plants, which could explain their knowledge on plants used for remedying AHT and gastric ulcers. Similarly, the sociocultural groups Baatombu and Dendi in the North-East and Yoa-Lokpa in the North-West share almost the same cultural areas and therefore have nearly similar knowledge on medicinal plants. The sociocultural groups Yoruba and Peulh have nearly similar knowledge may be because Yoruba has migrated from Nigeria, while Peulh is a transhumant and would share the same cultural areas with other sociocultural groups. This result confirms that the transmission of medicinal knowledge within the descendants, translates the fact that the migratory processes do not substantially influence the therapeutic knowledge. According to previous studies, the geographical and socio-cultural distribution of knowledge on medicinal plants is explained by the bioclimatic conditions, accessibility and availability of plant species (Alencar *et al.* 2010, Gaoue *et al.* 2017).

Threats to medicinal plants and conservation strategies

Excessive collection of plant organs, such as bark and roots, and other human disturbances on species and their habitats, such as forestry for various purposes and brush fires, are the main threats recognized by respondents, and which compromise medicinal plant survival. The most cited plants were bought at markets. Given that any plants sold at markets come from natural habitats, home gardens, or agricultural exploitation (fallows and farms), we recommend the promotion of home gardens, medicinal plants-based agroforestry systems, and the protection of natural habitats to ensure medicinal plant availability for human well-being. Thus, the creation of sacred groves already represents a good endogenous conservation strategy developed by communities which should be supported technically and scientifically. Techniques for preserving plant organ are also used to ensure the availability of medicinal plants when fresh plant material is not available. Among these, we have the drying and reduction of plant organs into powder and the preservation of plant organs in various solvents (water, alcohol, oil, etc.).

Conclusion

This study showed the preponderant place of herbal medicine in the management of arterial hypertension (AHT) and gastric ulcers in Benin. A total of 193 plants species belonging to 63 families are commonly used in remedies for AHT and gastric ulcers of which 83 are used treat both diseases. Knowledge of these plants varies according to sociocultural groups, users, accessibility and availability. It is becoming necessary to document ethnomedicinal knowledge for phytochemical screening of the plants most appetized by communities, for the development of new drugs safety and efficacy.

Declarations

Ethical approval and consent of participants: Ethical approval was obtained from the local ethics committee for biomedical research at the University of Parakou (CLERB-UP) on 8 January 2023. Participants gave their prior consent before the interviews after the objectives of the study had been clearly explained to them.

Availability of data and materials: Data used in this work are available from the corresponding author.

Consent to publication: All authors agreed on the content of the manuscript.
Conflict of interest: The authors declare that they have no conflict of interest.
Funding: This study was funded by the International Development Research Centre (IDRC) through project No. 109799-001 entitled "Strengthening gender inclusion in agricultural research for more conclusive results in West Africa".
Authors' contributions: Sèna Carine M.J. Aboua and Christine Ajokè I.N. Ouinsavi conceptualized and defined the subject of the research and the methodology for data collection and analysis. Sèna Carine M.J. Aboua collected, processed and analyzed the data. She also drafted the manuscript. Christine Ajokè I.N. Ouinsavi read, corrected and approved the final version of the manuscript. She supervised all the work. Towanou Houètchégnon, Adigla Appolinaire Wédjangnon, Bienvenue Nawan K. Sourou and Gwladys Azongnidé read and improved the final version of the manuscript.

Acknowledgements

We would like to thank the International Development Research Centre (IDRC), which provided funding for the research through Project No. 109799-001 entitled "Strengthening gender inclusion in agricultural research for more conclusive results in West Africa". We also thank Messrs. Fiacre Awassi, Ibrahim Fatiou, Serge Tossou, Romuald Amoussou and Guillaume Koukoyi for their technical support in carrying out this study.

Literature cited

Adomou AC, Sinsin B, van der Maesen LJG. 2006. Notulae Florae Beninensis 12: Phytosociological and chorological approaches to phytogeography: a meso-scale study in Benin. Systematics and Geography of Plants 76(2): 155-178.

Adomou AC, Yedomonhan H, Djossa B, Lègba SI, Oumorou M, Akoègninou A. 2012. Ethnobotanical study of medicinal plants sold in the Abomey-Calavi market in Benin.International Journal of Biological and Chemical Sciences 6(2): 745-772.

Akoègninou A, Van der Burg W, Van der Maesen LJG, Adjakidjè V, Essou JP, Sinsin B. 2006. Flore analytique du Bénin. Leiden, Pays-Bas, Backhuys Publishers, 1034p.

Al Disi SS, Anwar MA, Eid AH. 2016. Anti-hypertensive herbs and their mechanisms of action : part I. Frontiers in Pharmacology 6(323): 24p.

Albuquerque UP, Lucena RFP, Monteiro JM, Florentino ATN, Almeida CFCBR. 2006. Evaluating Two Quantitative Ethnobotanical Techniques. Ethnobotany Research and Applications 4: 051-060.

Albuquerque UP, Soldati GT, Sieber SS, Ramos MA, De Sá JC, De Souza LC. 2011. The use of plants in the medical system of the Fulni-ô people (NE Brazil): a perspective on age and gender. Journal of Ethnopharmacology 133(2): 866-873.

Alencar NL, Araújo TADS, Amorim ELCD, Albuquerque UP. 2009. Can the Apparency Hypothesis explain the selection of medicinal plants in an area of caatinga vegetation? A chemical perspective. Acta Botanica Brasilica 23(3): 910-911.

Alencar NL, De Sousa Araújo TA, De Amorim ELC, De Albuquerque UP. 2010. The Inclusion and Selection of Medicinal Plants in Traditional Pharmacopoeias—Evidence in Support of the Diversification Hypothesis. Economic Botany 64(1): 68-79.

Aouamri S, Graib R, Hamdaoui T. 2020. Peptic ulcer: Phyto-appearance traditional therapy. University May 8, 1945 Guelma, Master Professionnel 78p.

Asfaw MM, Abebe FB. 2022. Traditional Medicinal Plant Species Belonging to Fabaceae Family in Ethiopia: A Systematic Review.International Journal of Plant Biology 12(1): 15-22.

Bello OI, Ayoola MD, Obembe O. & Akinwunmi KF. 2022. Antidiabetic and Toxicity Studies of the Extract of Four Nigerian Medicinal Plants. European Journal of Medicinal Plants 33(11): 32-45.

Bentahar A. 2017. Peptic ulcer caused by Helicobactere pylori: Aspects traditional epidemiological and phytotherapeutic in North-East Algeria [Doctorate in Science]. Ferhat Abbas Setif 1.

Bio A, Toyi MS, Yoka J, Djego GJ, Awede B, Laleye A, Sinsin BA. 2015. Contribution to knowledge of the main antihypertensive plants used in traditional medicine in Bassila (Benin, West Africa). CAMES Review – Series Pharmacopée et médecine traditionnelles africaines 17(2): 8-18.

Dassekpo SI, Achigan-Dako EG, Honfo HS, Tovissode F, Tente B, Houssou CS. 2017. Socio-cultural and cultural approaches to the uses of Newbouldia laevis and associated plants in the traditions of Benin.Ivorian Journal of Science and Technology 30: 291-304.

de Souza S. 2008. Flore du Bénin (Tome 3,2ème édition), Imprimerie TUNDE. 679p.

Dibong SD, Mpondo Mpondo E, Ngoye A, Kwin MF, Betti JL. 2011. Ethnobotany and phytomedicine of medicinal plants from Douala, Cameroon. Journal of Applied Biosciences 37: 2496-2507.

Diop M, Niang-Diop F, Dieng SD, Samb A, Manga GED, Sané AP, Sène MB, Sambou B, Goudiaby A, Diatta EA. 2022. Ethnobotanical study of medicinal plants for treatment of diabetes and hypertension used in communities near Fathala Forest, Senegal. Ethnobotany Research and Applications 23. Scopus.

Dossou AJ, Fandohan AB, Djossa AB, Assogbadjo AE. 2021. Diversity and knowledge of plants used in the treatment of snake bite envenomation in Benin. Ethnobotany Research and Applications 21(48): 1-20.

Engwa GA, Matjuda EN, Nkeh-Chungag BN. 2022. Hypertension in Africa and Medicinal Plants with Anti-Hypertensive Properties.Research Journal of Pharmacognosy (RJP) 10(2): 57-73.

Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H. 2017. Theorie ; and Major Hypotheses in ethnobotany. Economic Botany 71(3): 269-287.

Gueye M, Cisse A, Diatta C, Diop S, Koma S. 2012. Ethnobotanical study of plants used against constipation among the Malinké of the rural community of Tomboronkoto, Kédougou (Senegal). International Journal of Biological and Chemical Sciences 6(2): 773-781.

Institut National de la Statistique et de la Démographie. 2016. Main Sociodemographic and Economic Indicators (RGPH-4, 2013). Ministry of Development, Economic Analysis and Foresight, Cotonou, Benin, 27p.

Kasali MF, Irenge AC, Hamuli MP, Mulashe BP, Katabana MD, Mokoso MJDD, Mpiana PT, Kadima NJ. 2021. Ethnopharmacological Survey on Treatment of Hypertension by Traditional Healers in Bukavu City, DR Congo.Evidence-Based Complementary and Alternative Medicine 2021: 10p.

Kéïta A. 2005. Study of three plants used in the traditional treatment of ulcers gastroduodenal in the district of Bamako [Pharmacy Thesis]. University of Bamako, Mali 198p.

Kouakou KR, Tahiri A. 2018. Phytochemical screening, acute and subacute toxicity of aqueous extract of *Moringa oleifera* (Moringaceae) Lam 1885 on rats wistar. Journal of Medicinal Plants Studies 6(3): 96-102.

N'Danikou S, Achigan-Dako EG, Tchokponhoue DA, Agossou COA, Houdegbe CA, Vodouhe RS and Ahanchede A. 2015.Modelling socioeconomic determinants for cultivation and in-situ conservation of Vitex doniana Sweet (Black plum), a wild harvested economic plant in Benin. Journal of ethnobiology and ethnomedicine 11(28): 1-16.

WHO. 2013. WHO Strategy for Traditional Medicine 2014-2023. World Health Organization.

WHO. 2022. Monitoring progress in the fight against non-communicable diseases 2022.

Orch H, Douira A, Zidane L. 2015. Ethnobotanical study of medicinal plants used in the treatment of diabetes and heart disease in the Izarene region (northern Morocco). Journal of Applied Biosciences 86: 7940-7956.

Ould el Hadj M, Didi, Hadj-Mahammed M, Zabeirou H. 2003. Place of plants spontaneous in traditional medicine in the Ouargla region (eastern northern Sahara). Courier of Knowledge 47-51.

Pan S-Y, Zhou S-F, Gao S-H, Yu Z-L, Zhang S-F, Tang M-K, Sun J-N, Ma D-L, Han Y-F, Fong W-F, Ko K-M. 2013. New Perspectives on How to Discover Drugs from Herbal Medicines: CAM's Outstanding Contribution to Modern Therapeutics. Evidence-Based Complementary and Alternative Medicine 2013: 1-25.

Pila Cando D, Hernández Maqueda R. 2023. Traditional knowledge and use of plants as agricultural insecticides from a gender perspective in three rural communities of the Ecuadorian Andes. Ethnobotany Research and Applications 26(22): 12p.

Sewani-Rusike C, Mammen M. 2014. Medicinal Plants Used as Home Remedies: A Family Survey by First Year Medical Students.African Journal of Traditional, Complementary and Alternative Medicines 11(5): 67.

Sinsin B, Eyog Matig O, Assogbadjo AE, Gaoué OG, Sinadouwirou T. 2004. Dendrometric characteristics as indicators of pressure of Afzelia africana Sm. Dynamic changes in trees found in different climatic zones of Benin.Biodiversity and Conservation 13(8): 1555-1570.

Susalit E, Agus N, Effendi I, Tjandrawinata RR, Nofiarny D, Perrinjaquet-Moccetti T, Verbruggen M. 2011. Olive (Olea europaea) leaf extract effective in patients with stage-1 hypertension: Comparison with Captopril. Phytomedicine 18(4): 251-258.

Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G. 2013. Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy) —An alpine ethnobotanical study. Journal of Ethnopharmacology 145(2): 517-529.

Voeks RA. 2004. Disturbance Pharmacopoeias: Medicine and Myth from the Humid Tropics. Annals of the Association of American Geographers 94(4): 868-888.

Yirgu A, Chippaux J-P. 2019. Ethnomedicinal plants used for snakebite treatments in Ethiopia: A comprehensive overview. Journal of Venomous Animals and Toxins Including Tropical Diseases 25,e20190017: 1-15.