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Investigation through New Approach on Plants with Antihypertensive Properties Used by the Herbalists in the Maritime Region of Togo

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Authors' contributions

This work was carried out in collaboration among all authors. Author SC designed the study, performed the statistical analysis and wrote the protocol. Authors SC, KK and AB wrote the first draft of the manuscript. Authors RB, LB and NO managed the analyses of the study. Author SO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Like other countries in sub-Saharan Africa, hypertension is currently a public health problem in Togo. To decrease the insufficient of the methods previously used, a new survey technique, namely ATRM (Achat en Triplet des Recettes Médicinales), has been proposed. This study aims to contribute to a better knowledge of traditional remedies for their safe and sustainable use in the management of hypertension. ATRM method applied with 34 herbalists of 17 markets in maritime and Lomé-Commune health regions. Plant species and parts used, preparation and administration methods and market characteristics of plants were collected. In total, 62 plant species (56 genera and 30 families) were identified from 102 collected recipes. These recipes included 70% single plant recipes and 30% associated plant recipes, showing the influence of the ATRM method in reducing the number of plants in the recipes. *Lippia multiflora* Moldenke (23.50%) was the most

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used plant species followed by *Uvaria chamae* P. Beauv (8.20%), *Acanthospermum hispidum* DC. (4.92%), *Lannea kerstingii* A. Rich. (3.83%), *Vitex doniana* Sweet (3.83%), and *Senna sieberiana* DC. (3.28%). Leafy stems (33.33%), roots (20.83%) and trunk bark (16.67%) were the most used organs. The recipes were mainly prepared as a decoction and administered orally. In the transit market, *Sorghum bicolor* (L.) Moench (7.12 USD/kg), *Senna occidentalis* (L.) Link (4.98 USD/kg), *Senna angustifolia* Vahl (3.73 USD/kg) and *Gardenia aqualla* Stapf. & Hutch. (3.56 USD/kg) were the most expensive plants. 59.18% of the plant parts sold were roots, fruits, seeds, trunk bark and whole plants. These results suggest, on the one hand, an extensive biological investigation for effective management of hypertension. On the other hand, there is an urgent need to preserve the species whose vital organs were heavily sold.

Keywords: Ethnobotanical investigation; hypertension; monetary value; Togo.

1. INTRODUCTION

Hypertension, a major cardiovascular risk factor, has become an important public health challenge worldwide [1–4]. More than 25% of adults worldwide were suffering from this disease. This proportion is expected to rise in the coming years. In Sub-Sahelian Africa, it is estimated that 150 million persons will be hypertensive by 2025 [5]. Its prevalence rate in professional settings in Togo is 28.9% [6]. In neighboring Benin and Burkina Faso, the rates were respectively 27.9 % [7] and 17.3% in 2014 [8]. Several studies indicated that prevalence among urban populations is higher than their counterparts in rural areas and increases with age [9,10]. The consequences of the disease are target organ damage such as the heart, kidneys, brain, or retina [11,12]. Although conventional medicines exist in Togo for the treatment of hypertension, herbal medicines have often maintained a population for historical and cultural reasons [13]. However, the process of harvesting medicinal plants often constitutes a threat to their survival, and herbalists are one of the main actors [14]. In addition, the patterns of traditional drugs use are not always appropriate. This sometimes poses a problem of safety and therapeutic failure.

Important studies already conducted with traditional healers in Togo have shown how plants are used in the management of hypertension and diabetes [4,15]. The approaches used were mainly based on semi-structured interviews (SSI) that nowadays have some inadequacies due to the mistrust of traditional healers towards the world of research. The present study adopted the “ATRM” method (Achat en Triplet des Recettes Médicinales) developed by Koudouvo et al. [16] to limit these deficiencies. This study aimed to contribute to a better knowledge of traditional remedies for their safe and sustainable use in the management of hypertension. Specifically, it was:

- Evaluate the number of recipes sold in the Lomé markets for the management of hypertension
- Determine the floristic composition of the plants sold in the markets of Lomé city
- Determine the frequency of citation of plants sold in the markets of the Lomé city for the management of hypertension
- Evaluate the prices of plant organs sold in the markets of the city of Lomé for the management of hypertension

2. MATERIALS AND METHODS

2.1 Study Framework

The study was conducted in July 2017 in two health regions: Lomé-commune and maritime health regions (Fig. 1). This zone is located between 1°20’ to 1°50’ W and 6°10’ south latitude to 6°60’ N, with an area of 6,100 km^2 it is limited at the South part by the Atlantic Ocean, the North by the Health Region of Plateau, the East, and the West respectively by the Benin Republic and Republic of Ghana [17]. The climate of this area is sub-equatorial, characterized by a long rainy season from March to July (maximum in June: 1200 mm), and a short rainy season from September to November (maximum in October: 1000 mm). The minimal precipitations for these two seasons are 184.4 mm and 6.9 mm, respectively. The average annual temperature is around 27.5°C with a maximum of around 35.1°C in the warm season [18]. This zone is highly degraded, the vegetation is composed of disparate forests, relics of gallery forests, savannahs, grasslands, coastal thickets, or halophilic swamps. The region is inhabited by 1,828,000 people (density of 50–200 persons/km^2), the main ethnic groups being Ewe, Ouatchi, Mina, Fon, Adja [19,20].

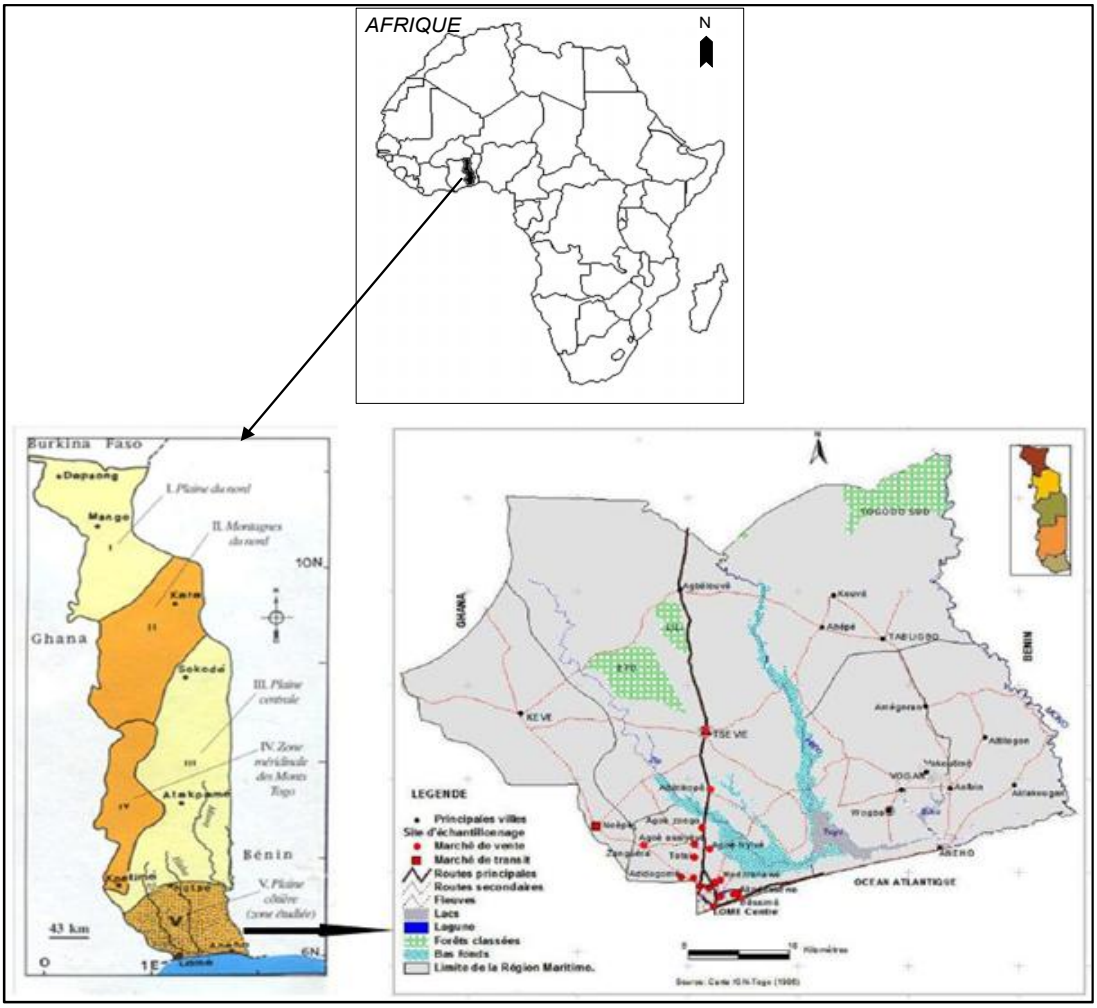

Fig. 1. Map of the study area

A map of the African continent, indicating the location of Tog is required.

2.2 Data Collection

The ATRM (Achat en Triplet des Recettes Médicinales) method was used to collect the data. Its already successfully tested in several works [14,17,18]. This method was carried out with 34 herbalists of 17 markets in July 2017 in maritime and Lomé-Commune health regions. These were the markets of Ablodessimè, Adamavo, Adidogomè, Agoè-Assiyéyé, Agoè-Atchanvé, Agoè-Zongo, Ahanoukopé, Ahligo, Akodesséwa, Attikpodji, Bessimè, Gbossimè, Hédzranawoé, Kélégougan, Nukafu, Totsi and Zanguera (Fig. 1). The method of ATRM consisted of visiting market herbalists three times separated by one week, to buy recipes of plants used in the treatment of hypertension. The three successive visits to the markets of sale (MS) were to buy medicinal plant recipes respectively in a large number (LN), reduced number (RN) and much reduced number (MR) or single plant (SP). The process was to attend the issue of the smallest number of plants in recipes for management of hypertension by the same practitioner. For each recipe, local names and plants organs used, therapeutic indications, mode of preparation and routes of administration were recorded. Recipes weight, price, and physical nature (fresh or dry) were also noted Koudouvo et al. [14]. After the surveys with an herbalist, three transaction markets (Noépé, Tsiévié and Akodessewa) were also visited. In these markets, plant materials have been purchased, their local name, weight and price were noted.

2.3 Data Analysis

Botanical identification of species collected was performed according to APG (Angiosperms Phylogeny Group) III, [21] and the Analytical Flora of Benin [22]. Pr. K. Akpagana conducted confirmation of Latin names, and the local names were verified through previous ethnobotanical surveys. The Windows.10 Excel spreadsheet and SPSS 20.0 software were used for data processing and analysis. The citation frequency (Fc) of each plant species and their use value (UV) were determined by the following formulas [13,20]:

$$Fc = Fi/n$$

where Fi is the number of citations of the species, n the total number of recipes.

$$UV = \sum U/n$$

Where UV is the use value of a species, U the number of citations per species, N the number of informants

3. RESULTS AND DISCUSSION

3.1 Quantity of Recipes Sold in the Lomé Markets for the Management of Hypertension

In total, 102 recipes were collected from 34 herbalists in the 17 markets. These medicinal recipes were composed of 62 plant species. In general, the results (Table 1) indicate a decrease in the number of plants per recipe from the first to the third purchase from herbalists. The total number of plants per market was the number of plant species recorded during the three visits and not the sum of the plants per recipe. The market of Agoè-Assiyéyé presented the largest number of plants [19], representing 30.64% of the total number. The unique plant recipes erehigher (UR= 70%) than the associated plant recipes (AR) collected and the number of plants per recipe varied from one to twelve. Thus, the recipes with two associated plants (AR= 2), the recipes with three associated plants (AR= 3) and those with more than three associated plants (AR> 3) represented respectively 12%, 5%, and 13% of all recipes (Fig. 2). The high proportion of unique recipes would be related to the survey method used, which certainly reduced the number of recipes proposed by herbalists. It may also be due to low knowledge of hypertension among the herbalists surveyed. These results were different from those of Karou et al. [17], who, using the semi-structured interview method, identified twenty-one recipes of associated plants (60%) and fourteen unique plant recipes (40%) with a maximum of eight plants per recipe. Thirteen recipes (12.75%) sold by herbalists for the management of hypertension were each composed of more than three plants (Fig. 2). According to Karou et al. [17], these recipes should be used with care because of the limitless compounds that could occur in one plant.

Table 1. Number of plants collected by ATRM in each 17 markets

Markets	Herbalist 1			Herbalist 2			Total
	LN	RN	MR	LN	RN	MR	
Ablodessimè	3	2	2	11	6	2	15
Adamavo	2	1	1	1	1	1	4
Adidogomè	6	1	1	2	1	1	7
Agoè-Assiyéyé	12	2	1	6	2	1	19
Agoè-Atchanvé	1	1	1	1	1	1	4
Agoè-Zongo	1	1	1	1	1	1	5
Ahanoukopé	1	1	1	1	1	1	3
Ahligo	4	1	1	1	1	1	6
Akodesséwa	1	1	1	1	1	1	2
Attikpodji	3	1	2	4	1	1	8
Bessimè	1	2	1	1	1	1	5
Gbossimè	5	1	1	1	1	1	6
Hédzranawoé	3	1	1	4	1	1	6
Kélégougan	1	6	5	1	1	1	9
Nukafu	7	2	3	1	1	1	12
Totsi	8	1	2	1	1	1	9
Zanguera	3	1	1	2	1	1	5

LN: large number; RN: reduced number; MR: much reduced number

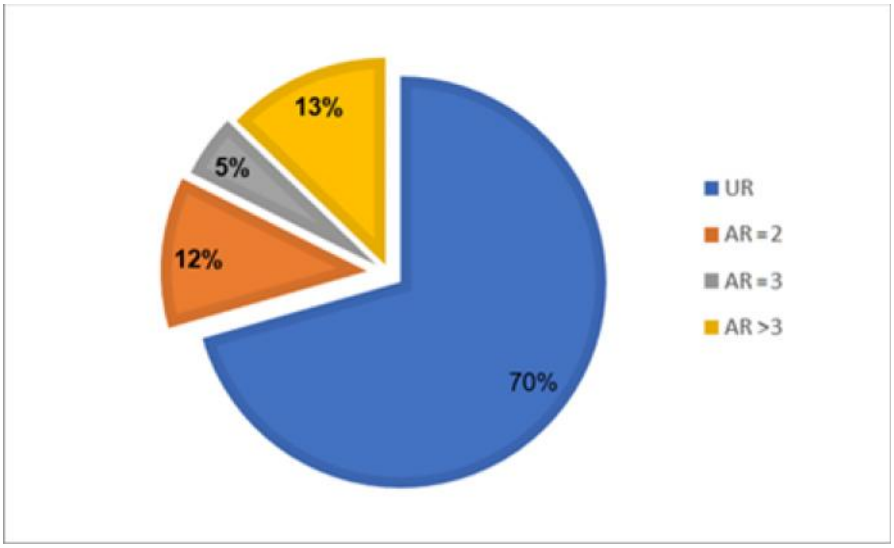

Fig. 2. Frequency of recipes (AR: associated plant recipes; UR: unique plant recipes)

3.5% - 2.12% 3.13% - UR 71%

The values have been corrected in the graph above

3.2 Floristic Composition and Frequency of Plants Citation

Sixty-two (62) plant species belonging to 56 genera and 30 families were recorded by the ATRM method. The family of Fabaceae (13.79%), Rubiaceae (10.33%) and Poaceae (6.90%) were the most represented, followed by Anacardiaceae, Apocynaceae, Bignoniaceae, Malvaceae and Phyllanthaceae were each represented by 5.17% of species total number (Fig. 3). The Fabaceae family contributed with 8 species namely *Mezoneuron benthamianum* Baill., *Parkia biglobosa* (Jacq.) Benth., *Piliostigma thonningii* (Sch.) Miln. Redh., *Senna alexandrina* Mill., *Senna occidentalis* (L.) Link, *Senna rotondifolia* L., *Senna sieberiana* DC., *Tetrapleura tetraptera* (Schumach. et Thonn.) Taub.

Two species were cited in each family of Araceae, Connaraceae, Euphorbiaceae and Meliaceae, while the other families were each mentioned only once during the study. Fabaceae, Euphorbiaceae, Malvaceae, Apocynaceae, Asteraceae have also been cited as predominant families in ethnobotanical surveys for the management of hypertension in Togo [4], Nigeria [23], South Africa [24], and Cameroun [25]. *Lippia multiflora* Moldenke (23.50%) was the most used plant species. These species erefar followed by *Uvaria chamae* P. Beauv (8.20%), *Acanthospermum hispidum* DC. (4.92%), *Lannea kerstingii* A. Rich. (3.83%), *Vitex doniana* Sweet (3.83%), and *Senna sieberiana* DC. (3.28%). Twenty-seven species or 46.55% of the total number were cited once with a frequency of 0.55% (Table 2). Other authors have already proved the anti-diuretic activities and hypotensive properties of some of the most cited plants. Indeed, in Benin, Gbenou et al. [26] observed anti-diuretic activities of *Acanthospermum hispidum*, *Crateva adansonii* and *Uvaria chamea* on normal Wistar rats. Moreover, studies carried out in Nigeria and Congo respectively have shown hypotensive effects of *Vitex doniana* stem bark [27], and *Lippia multiflora* leaves extracts [28] on normal rats. Recent studies have shown that *Senna sieberiana* (*Cassia sieberiana*) was strongly used by three associations of traditional healers in Burkina Faso for the management of hypertension [29]. Despite their low frequency of citation, other studies have also highlighted the antihypertensive effects of seeds and trunk bark of *P. biglobosa* [30–32] and trunk bark of *Anogeissus leiocarpa* [33].

3.3 Patterns Use of Plants for the Management of Hypertension

Leafy stems (33.33%) are the most used in recipes sold by herbalists for the management of hypertension. These plant parts are followed by roots (20.83%), trunk bark (16.67%) then leaves

Table 2. Species cited by 34 herbalists of 17 markets in maritime and Lomé-Commune health regions for management of hypertension

Species of plants	Family	Frequency of citation
Lippia multiflora Moldenke	Verbenaceae	23.5
Uvaria chamae P. Beauv.	Annonaceae	8.20
Acanthospermum hispidum DC.	Asteraceae	4.92
Lannea kerstingii A. Rich.	Anacardiaceae	3.83
Vitex doniana Sweet	Lamiaceae	3.83
Senna sieberiana DC.	Fabaceae	3.28
Cymbopogon citratus (DC.) Stapf	Poaceae	2.19
Dichapetalum madagascariense (DC.) Keay.	Dichapetalaceae	2.19
Piliostigma thonningii (Sch.) Miln. Redh.	Fabaceae	2.19
Sanseviera liberica Ger. and Labr.	Agavaceae	2.19
Waltheria indica L.	Malvaceae	2.19
Anchomanes difformis (Blume) Engl.	Araceae	1.64
Cocos nucifera L.	Arecaceae	1.64
Crataeva religiosa Forst	Capparaceae	1.64
Gardenia ternifolia Schumach. & Thonn. Ssp. ternifolia	Rubiaceae	1.64
Hibiscus sabdariffa L.	Malvaceae	1.64
Moringa oleifera L.	Moringaceae	1.64
Sarcocephalus latifolius (Smith) Bruce	Rubiaceae	1.64
Senna occidentalis (L.) Link	Fabaceae	1.64
Senna rotondifolia L.	Fabaceae	1.64
Eucalyptus citriodora Hooker	Myrtaceae	1.09
Kigelia africana (Lam.) Benth.	Bignoniaceae	1.09
Mangifera indica L.	Anacardiaceae	1.09
Oldenlandia corymbosa L.	Rubiaceae	1.09
Paullinia pinnata L.	Sapindaceae	1.09
Pavetta corymbosa (DC.) F. N. Williams	Rubiaceae	1.09
Pavetta crassipes K.Schum.	Rubiaceae	1.09
Phyllanthus amarus Sch. et Th.	Phyllanthaceae	1.09
Securidaca longepedunculata Fres.	Polygalaceae	1.09
Securinega virosa (Reyb.) Baill.	Euphorbiaceae	1.09
Vitellaria paradoxa Gaertn C. F	Sapotaceae	1.09
Alstonia boonei De Wild.	Apocynaceae	0.55
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	0.55
Bambusa vulgaris Schrad ex. Wendel	Poaceae	0.55
Bridelia ferruginea Benth.	Phyllanthaceae	0.55
Byrsocarpus coccineus Sch. et Th.	Connaraceae	0.55
Calotropis procera (Aiton) R.Br.	Apocynaceae	0.55
Clausena anisata (Wild.) Hook. F.ex Benth.	Rutaceae	0.55
Cola millenii K. Schum.	Malvaceae	0.55
Cymbopogon giganteus (Hochst.) Chiov.	Poaceae	0.55
Gomphrena celosioides Mart.	Amaranthaceae	0.55
Hymenocardia acida Tul.	Phyllanthaceae	0.55
Jatropha gossypifolia L.	Euphorbiaceae	0.55
Khaya anthoteka C. DC.	Meliaceae	0.55
Khaya senegalensis (Desr.) A. Juss.	Meliaceae	0.55
Lactuca taraxacifolia (Willd.) Schum.	Asteraceae	0.55
Maytenus senegalensis (Lam.) Exell.	Celastraceae	0.55
Mezoneuron benthamianum Baill.	Fabaceae	0.55
Morinda lucida Benth.	Rubiaceae	0.55
Newbouldia laevis Seem.	Bignoniaceae	0.55
Parkia biglobosa (Jacq.) Benth.	Fabaceae	0.55
Rauvolfia vomitoria Afzel.	Apocynaceae	0.55
Rourea coccineus Schum et Thonn.	Connaraceae	0.55
Senna angustifolia Vahl	Fabaceae	0.55
Sorghum bicolor L.) Moench	Poaceae	0.55
Spathodea campanulata P. Beauv.	Bignoniaceae	0.55
Spondia mombin L.	Anacardiaceae	0.55
Tetrapleura tetraptera (Schumach. et Thonn.) Taub.	Fabaceae	0.55

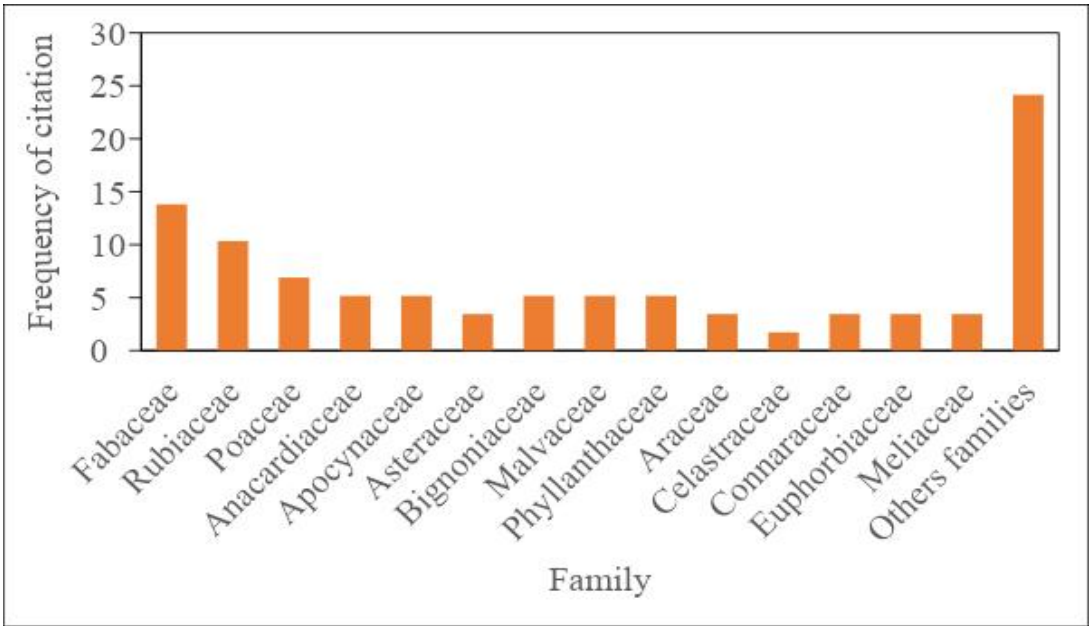

Fig. 3. Spectrum of plant families sold by herbalists in Togo, African

(15.28%). Organs such as the whole plant and others (fruit, seeds, and tuber) are lightly used (less than 10%) (Fig. 4). Indeed, the harvesting of leafy stems is much easier; they are accessible and often at hand. Moreover, their harvest does not strongly compromise the life span of the plant. On the other hand, roots and trunk bark are difficult to access, and their heavy use can be prejudicial to the life plant [34]. Indeed, the recurrent and anarchic removal of bark weakens the plant and makes it vulnerable to bad weather and parasite attacks [35]. The decoction and the oral route are respectively, the main modes of formulation and administration of the recipes (Fig. 5ab). These results corroborate those of other authors' studies [29,36,37]. According to Salhi et al. [38], the decoction is a method of preparation which allows obtaining the maximum of active ingredients, reduces or cancels the toxic effects of certain recipes.

3.4 Monetary Value and the Disadvantages of the Sale of the Antihypertensive Plant on Biodiversity

The leaves, trunk bark, roots, or leafy stems of 49 species were found and paid in transit markets. The prices range from 13 FCFA per kg (0.02 USD/kg) to 4,000 FCFA per kg (7.12 USD/kg). Indeed, *Sorghum bicolor* (especially the leaves) is the most expensive plant (7.12 USD/kg) in the markets visited. This plant is followed by *Senna occidentalis* (4.98 USD/kg); *Senna angustifolia* (3.73 USD/kg) and *Gardenia aqualla* (3.56 USD/kg) (Table 3). In the same markets of the city of Lomé, Koudouvo et al. [14] had collected 16 antimalarial plants at prices ranging from 0.8 (leaves of *Parkia biglobosa*) to 7.2 USD/kg (Stem bark of *Alstonia boonei*). More than half (51.02%) of the species inventoried are sold at more than 200 FCFA per kg (0.36 USD/kg). Moreover, 59.18% of the plant parts sold are roots, fruits, seeds, trunk bark, and whole plants, which are the sensitive organs of plants. Although the sale of the plants brings money to the people in rural areas, it is nevertheless deplorable that this can lead to the disappearance of species that are exploited anarchically or wrongly. This is the case of species such as *Alstonia boonei*, *Lannea kerstingii*, *Cola millenii*, *Pavetta corymbosa*, *Uvaria chamae*, *Senna occidentalis,* and *Securidaca longepedunculata* which are most used in the treatment of hypertension and whose vital organs are expensive in the markets. Previous studies have already shown that most of these species are threatened with extinction in Togo [39,40]. The immediate consequence of the disappearance of these species will be a reduction of availability of the ecosystem service they provide [41]. This situation suggests the adoption of urgent strategies to preserve these species of interest for hypertension.

Table 3. Market characteristics of plants

Species	Organs	Weight (g)	Price (FCFA/kg)	Price (USD/kg)
Sorghum bicolor L.) Moench	Lv	50	4,000	7.12
Senna occidentalis (L.) Link	Se	250	2,800	4.98
Senna angustifolia Vahl	TB	23.86	2,096	3.73
Gardenia aqualla Stapf. & Hutch.	TB	100	2,000	3.56
Securidaca longepedunculata Fres.	Rt	400	1,250	2.22
Abrus precatorius L.	Rt	160	1,250	2.22
Pavetta corymbosa (DC.) F. N. Williams	St	50	1,000	1.78
Cocos nucifera L.	Rt	530	943	1.68
Senna occidentalis (L.) Link	Rt	250	800	1.42
Tetrapleura tetaptera (Schumach. et Thonn.) Taub.	Fr	750	667	1.19
Acacia nilotica (L.) Willd. ex Delile	Fr	950	526	0.94
Rauvolfia vomitoria Afzel.	Rt	600	500	0.89
Jatropha gossypifolia L.	St	100	500	0.89
Alstonia boonei De Wild.	Rt	1,250	400	0.71
Chassalia kolly (Schumach.) Hepper	Rt	500	400	0.71
Lannea kerstingii A. Rich.	TB	600	333	0.59
Bridelia ferruginea Benth.	TB	350	286	0.51
Uvaria chamae P. Beauv.	Rt	350	286	0.51
Phyllanthus amarus Sch. et Th.	Wp	190	263	0.47
Gomphrena celosioides Mart.	Wp	1,230	244	0.43
Cassytha filiformis L.	Wp	440	227	0.40
Fluggea virosa (Roxb. ex Willd.) Voigt	St	470	213	0.38
Paullinia pinnata L.	Rt	3,450	203	0.36
Hibiscus sabdariffa L. var. Sabdariffa	St	500	200	0.36
Cymbopogon citratus (DC.) Stapf	Lv	250	200	0.36
Hibiscus sabdariffa L.	St	1,240	161	0.29
Senna rotondifolia L.	Wp	475	158	0.28
Pterocarpus erinaceus Poir.	TB	1,350	148	0.26
Sanseviera liberica Ger. and Labr.	Rh	700	143	0.25
Paullinia pinnata L.	St	390	128	0.23
Spathodea campanulata P. Beauv.	St	800	125	0.22
Spondia mombin L.	St	200	125	0.22
Lactuca taraxacifolia (Willd.) Schumach. ex Hornem.	Wp	850	118	0.21
Acanthospermum hispidum DC.	St	240	104	0.19
Vitellaria paradoxa C.F.Gaertn.	TB	1,950	103	0.18
Waltheria indica L.	St	250	100	0.18
Mangifera indica L.	TB	2,030	99	0.18
Dialium guineense Willd.	St	775	97	0.17
Dichapetalum madagascariense (DC.) Keay.	St	1,050	95	0.17
Morinda lucida Benth.	St	1,050	95	0.17
Vitex doniana Sweet	TB	2,250	89	0.16
Sarcocephalus latifolius (Smith) Bruce	TB	1,800	83	0.15
Kigelia africana (Lam.) Benth.	Fr	2,500	80	0.14
Cola millenii K. Schum.	St	875	57	0.10
Anthocleista nobilis Afzel. ex. R. Br.	TB	2,100	48	0.08
Anchomanes difformis (Blume) Engl.	Tu	4,600	43	0.08
Piliostigma thonningii (Sch.) Miln. Redh.	St	600	42	0.07
Lippia multiflora Moldenke	St	2,950	34	0.06
Parkia biglobosa (Jacq.) Benth.	TB	1,900	13	0.02

Lv: leave; LS: leafy stem; Rt: root; St: stem; TB: trunk bark; WP: whole plant; Fr: fruit; Se: seed; Tu: tuber; Rh: rhizome

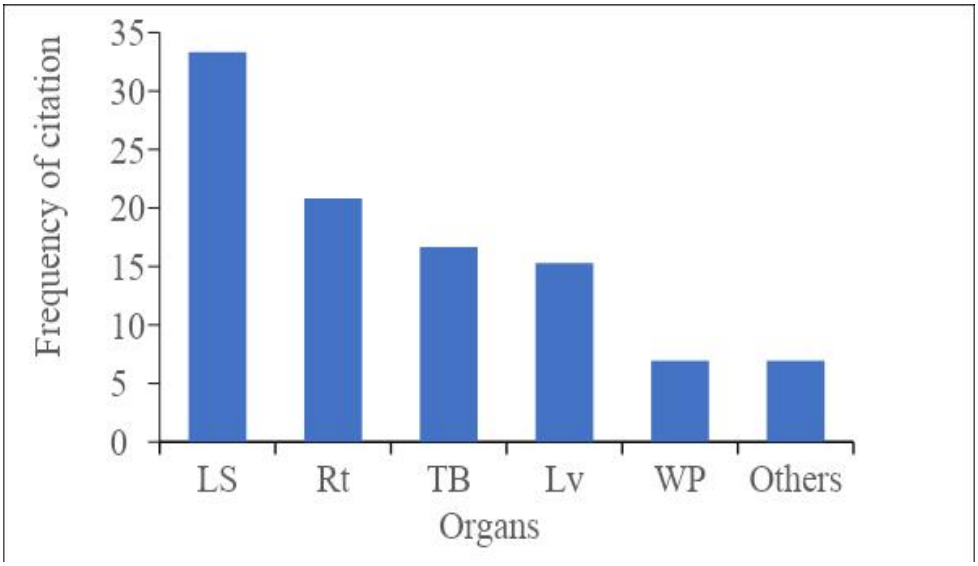

Fig. 4. Frequency of plant organs use
Lv: leave; LS: leafy stem; Rt: root; TB: trunk bark; WP: whole plant; Others: fruit, seed, and tuber

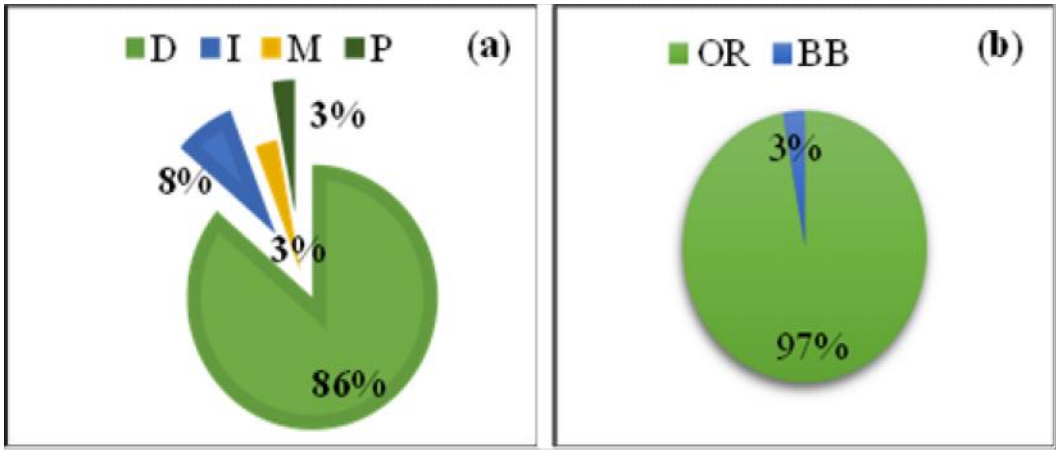

Fig. 5. Distribution of recipe formulation (a) and administration (b) modes
D: decoction; I: infusion; M: maceration; P: powder; OR: oral route; BB: body bath

4. CONCLUSION

Through the ATRM method, this study was the very first to be applied in Africa and in Togo, particularly for the inventory of plants with antihypertensive properties. It is of great interest for the effective management of hypertension as it allowed identifying directly in the herbalist 62 plant species related to it. Among these species, *Alstonia boonei*, *Lannea kerstingii*, *Cola millenii*, *Pavetta corymbosa*, *Uvaria chamae*, *Senna occidentalis* and *Securidaca longepedunculata*, which already most used in the management of hypertension, are strongly threatened through the sale of their vital organs. These species deserve better management, hence the urgency to act if we want to preserve the biodiversity they shelter and the services they provide to human beings. It is recommended to:

- Establishing awareness sessions for local populations on the importance of endangered plants.
- To carry out continuous training on good practices for the harvesting and cultivation of endangered plants for the benefit of home traditional healers and herbalists.
- Consolidate regulation and control of plant resource exploitation

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Species identified by the ATRM method for the management of hypertension

Species	Family	Local name	FC	Organs	Preparation mode	Administration route
Acanthospermum hispidum DC.	Asteraceae	Afegban; Dougban	4.92	WP	D	OR
Alstonia boonei De Wild.	Apocynaceae	Nyami Dua; Siaketekre	0.55	TB	D	OR
Anchomanes difformis (Blume) Engl.	Araceae	-	1.64	Tu	D	OR
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	Hehetsi; Hehe	0.55	TB	D	OR
Bambusa vulgaris Schrad ex. Wendel	Poaceae	Pamplo; pamploti	0.55	St	D	OR
Bridelia ferruginea Benth.	Phyllanthaceae	Kamati; Hlihoin	0.55	TB	D	OR
Byrsocarpus coccineus Sch. et Th.	Connaraceae	-	0.55	St	D; I	OR
Calotropis procera (Aiton) R.Br.	Apocynaceae	Adzema; Gbolobavi	0.55	Rt	D	OR
Clausena anisata (Wild.) Hook. F.ex Benth.	Rutaceae	Eyra; Iratsi	0.55	Lv	Po	OR
Cocos nucifera L.	Arecaceae	Yovoninti; Yevunetsi	1.64	Rt	D	OR
Cola millenii K. Schum.	Malvaceae	Assiviatoe; Kessedui	0.55	St	D	OR
Crataeva religiosa Forst	Capparaceae	Wataïzan; Ontoezin	1.64	St	D	OR
Cymbopogon citratus (DC.) Stapf	Poaceae	Tsigbe; Gbehoin	2.19	St	D;I	OR; BB
Cymbopogon giganteus (Hochst.) Chiov.	Poaceae	-	0.55	Lv	D	BB
Dichapetalum madagascariense (DC.) Keay.	Dichapetalaceae	Atihali; Tchokpleti	2.19	St	D	OR
Eucalyptus citriodora Hooker	Myrtaceae	Tilo; Ekalypti	1.09	St	D	OR
Gardenia ternifolia Schumach. & Thonn. Ssp. ternifolia	Rubiaceae	Flifeti; Lanmaleti	1.64	St	D	OR
Gomphrena celosioides Mart.	Amaranthaceae	Papataxe; Gnagantahé	0.55	WP	D	BB
Hibiscus sabdariffa L.	Malvaceae	Gnatoxe; Gnatu	1.64	St	D	BB
Hymenocardia acida Tul.	Phyllanthaceae	-	0.55	Rt	D	BB
Jatropha gossypifolia L.	Euphorbiaceae	Babatidjin; Kpoti	0.55	St	D	OR
Khaya anthoteka C. DC.	Meliaceae		0.55	TB	M	BB
Khaya senegalensis (Desr.) A. Juss.	Meliaceae	Mahogen; Mahogani	0.55	TB	M	OR
Kigelia africana (Lam.) Benth.	Bignoniaceae	Vinokpa; Gnakpekpe	1.09	Fr	D	OR; BB
Lactuca taraxacifolia (Willd.) Schum.	Asteraceae	-	0.55	St	D	OR
Lannea kerstingii A. Rich.	Anacardiaceae	Melonkou; Monlonkou	3.83	TB	D	OR
Lippia multiflora Moldenke	Verbenaceae	Avudati; Avoloti	23.50	Lv	D; I; M	OR; BB
Mangifera indica L.	Anacardiaceae	Mongoti; Atontsi	1.09	TB	D	BB
Maytenus senegalensis (Lam.) Exell.	Celastraceae	-	0.55	Rt	D	BB
Mezoneuron benthamianum Baill.	Fabaceae	-	0.55	Rt	D	BB
Morinda lucida .Benth.	Rubiaceae	Zanklan; Dadaklan	0.55	Rt	D	BB
Moringa oleifera L.	Moringaceae	Yovovigbe; Kpotsi	1.64	Lv	D; Po	OR
Newbouldia laevis Seem.	Bignoniaceae	Kpatima; Kpoti	0.55	St	D	OR
Oldenlandia corymbosa L.	Rubiaceae	Tsoèvissihin	1.09	WP	D	OR
Parkia biglobosa (Jacq.) Benth.	Fabaceae	Ewati; Ewoti	0.55	TB	D	OR
Paullinia pinnata L.	Sapindaceae	Assiviatoè; Hokouika	1.09	Rt;St	D	OR
Pavetta corymbosa (DC.) F. N. Williams	Rubiaceae	Sifafa; Siafati	1.09	St	D	OR
Pavetta crassipes K.Schum.	Rubiaceae	Pagalagbe	1.09	St	D	OR
Phyllanthus amarus Sch. et Th.	Phyllanthaceae	Tchekoulemègbè	1.09	WP	D	OR

Species	Family	Local name	FC	Organs	Preparation mode	Administration route
Piliostigma thonningii (Sch.) Miln. Redh.	Fabaceae	Klonti; Eklo	2.19	Lv	D	BB
Rauvolfia vomitoria Afzel.	Apocynaceae	-	0.55	Rt	D	BB
Rourea coccineus Schum et Thonn.	Connaraceae	Tomègavi; Letuiletui	0.55	St	D	BB
Sanseviera liberica Ger. and Labr.	Agavaceae	Yodobou; Yoboo	2.19	Rt	D	BB
Sarcocephalus latifolius (Smith) Bruce	Rubiaceae	Nyimon; Vevitsi	1.64	Rt	D	OR
Securidaca longepedunculata Fres.	Polygalaceae	Etritou; Kpeta	1.09	Rt	D	BB
Securinega virosa (Reyb.) Baill.	Euphorbiaceae	Hesre; Tsaka-tsaka	1.09	St	D	OR
Senna angustifolia Vahl	Fabaceae	Agoègbe; Asragbe	0.55	Lv	M	OR
Senna occidentalis (L.) Link	Fabaceae	Bessissan; Avakofè	1.64	Se	D	OR
Senna rotondifolia L.	Fabaceae	Azingbe; Zigbe	1.64	WP	D	OR
Senna sieberiana DC.	Fabaceae	Gati-Gati	3.28	Rt	D; I	OR
Sorghum bicolor L.) Moench	Poaceae	-	0.55	Lv	D	OR
Spathodea campanulata P. Beauv.	Bignoniaceae	Adassigolo; Adatsigo	0.55	TB	D	OR
Spondia mombin L.	Anacardiaceae	Akoukondi; Klikonti	0.55	Lv	D	OR
Tetrapleura tetraptera (Schumach. et Thonn.) Taub.	Fabaceae	-	0.55	Fr	D	BB
Uvaria chamae P. Beauv.	Annonaceae	Agbanlan; Gbana-gbana	8.20	Rt	D	OR
Vitellaria paradoxa Gaertn C. F	Sapotaceae	-	1.09	TB	D	BB
Vitex doniana Sweet	Lamiaceae	Fonyimakpa; Fonti	3.83	TB	D	OR
Waltheria indica L.	Malvaceae	Adouwèti; Adoufanti	2.19	St	D	OR

Lv: leave; LS: leafy stem; Rt: root; St: stem; TB: trunk bark; WP: whole plant; Fr: fruit; Se: seed; Tu: tuber; Rh: rhizome; D: decoction; I: infusion; M: maceration; P: powder; OR: oral route; BB: body bath

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