

MEDICINAL TREE SPECIES IN BENIN (WEST AFRICA) : LITERATURE REVIEW AND PERSPECTIVE RESEARCHES

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ABSTRACT

Several ethnobotanical and ethnopharmacological studies have been carried out on medicinal plants in Benin and other countries sharing the same centers of endemism. A literature review could aid to assess the related data for perspective researches and decision-making for the conservation of those plants. The present work aims to determine the most important medicinal tree species of the study area and those which would be recommended for conservation due to the uses of their sensitive organs for medicinal purposes. Thirty eight (38) published articles were exploited from which about 263 medicinal tree species were recorded. Those medicinal tree species belong to 193 genera and 59 families used in Benin. They are used for 146 medicinal properties categorized into 17 groups, with the highest number of species used for treatment of digestive system diseases, cardiovascular system diseases, skin and cutaneous diseases, and malaria and similarly infectious diseases. Relative importance index has permitted to identify 27 important medicinal tree species among which some are recommended for conservation. This study suggests on the whole that the kind and prevalence of medicinal uses are taken into account in the course of conservation studies of medicinal plants.

Keywords : Medicinal plant, Literature review, Medicinal properties, Conservation, Benin

ESPÈCES LIGNEUSES MÉDICINALES DU BÉNIN (AFRIQUE DE L'OUEST) : REVUE DE LITTÉRATURE ET PERSPECTIVES DE RECHERCHES

RÉSUMÉ

Plusieurs études ethnobotaniques et ethnopharmacologiques ont été effectuées sur les plantes médicinales au Bénin et dans les pays voisins. A ce titre, une synthèse bibliographique pourrait aider à évaluer les données disponibles pour orienter les futures recherches et la prise de décision pour la conservation de ces plantes. Le présent travail vise à déterminer les espèces ligneuses médicinales les plus importantes du Bénin et ses pays voisins et celles qui pourraient être recommandées pour la conservation au regard de l'utilisation des parties sensibles de ces plantes pour des fins médicinales. Trente-huit (38) articles publiés ont été exploités et ont permis d'enregistrer environ 263 espèces ligneuses médicinales. Ces espèces médicinales appartiennent à 193 genres et 59 familles utilisées au Bénin. Elles sont utilisées pour 146 besoins médicaux qui sont catégorisés en 17 groupes, dont les maladies du système digestif, les maladies du système cardiovasculaire, les maladies de peau, le paludisme et les maladies infectieuses associées pour lesquelles un nombre très important d'espèces est sollicité. Indice d'importance relative a permis d'identifier 27 espèces ligneuses médicinales importantes parmi lesquelles certaines ont été recommandées

pour la conservation. En général, cette étude suggère que le type et la prévalence des usages médicinaux soient pris en compte dans le cadre des études de conservation des plantes médicinales.

Mots clés : Plante médicinale, Synthèse bibliographique, Usage médicinal, Conservation, Bénin

INTRODUCTION

All over the world, plants are given important consideration in pharmacological domain (Bako *et al.*, 2005). Thus, 80 % of the world population depends on plant to treat both human and animal ailments (Cunningham, 1993). Several recent studies reported that ailments such as diabetes, blood pressure, cancer and malaria are treated with plant drugs despite the progress in modern medicine. Likewise, in Africa, various plants and traditional products made from plants are sold on market place and roadsides for various diseases treatment. In Benin, since 1996 pharmacopeia and traditional medicine have been promoted and integrated to the national health system (PNPMT, 2009). Nowadays, traditional medicine has largely contributed to self various ailments treatment in Benin like in other developing countries (Adjakidjè, 2000).

Since the Convention for Biological Diversity (CBD) has firmly acknowledged the role of indigenous knowledge in biodiversity conservation; ethnobotanical researches have received an increasing interest these last decades. Additionally, with the introduction of quantitative approach in ethnobotany, several ethnobotanical and ethnopharmacological studies have been conducted and are providing various features of plant uses. Therefore, this could provide scientists with database on plants and their various uses for critical analysis. Hence there are needs to analyzing available literature in order to address consequent perspective researches.

Tree species constituted of sub-shrub, shrub and tree, are one type of plant that provides a variety of organs such as fruits, flower, leaves, bark, stem, serf and roots. Those organs have various medicinal properties. The high rate of harvesting plant's sensitive organs such as bark, stem, and roots for their medicinal uses can stress out the trees. However, since plant organs have neither the same sensitivity nor the same medicinal importance; medicinal tree species are not at the same risk. Thus, from literature, it may be important to know what medicinal tree species could be overexploited for traditional medicinal uses. The answer to this matter is a real starting point for the development of a rapid tool to assist in decision-making process for the conservation of medicinal plants.

Approximately, 249 medicinal tree species of Benin's flora have been initially reported by Adjanohoun *et al.* (1989). Traditional knowledge on these species required scientifically fine studies for their suitable valorization. Thus, several ethnobotanical and ethnopharmacological studies have been carried out lately in Benin. A great amount of the finding on tree species, are published in peer-reviewed journal with or without impact factor. Thus, most local ethnobotanical published studies are available and have targeted some tree species such as *Adansonia digitata* (De Caluwé *et al.*, 2009), *Blighia sapida* (Ekué *et al.*, 2010), *Vitex doniana* (Dadjo *et al.*, 2012), *Tamarindus indica* (Fandohan *et al.*, 2010), *Chrysophyllum albidum* (Houessou *et al.*, 2012), *Caesalpinia bonduc* (Assogbadjo *et al.*, 2011), *Khaya senegalensis* (Gaoue & Ticktin, 2009), *Sclerocarya birrea* (Gouwakinnou *et al.*, 2011), *Milicia excelsa* (Ouinsavi *et al.*, 2005), *Parkia biglobosa* (Koura *et al.*, 2011), *Pentadesma butyracea* (Avocèvou-Ayisso *et al.*, 2011), *Irvingia gabonensis* (Codjia *et al.*, 2007). Additionally, some ethnopharmacological studies reported the list of several tree species for particular medicinal use such as general human diseases (Allabi *et al.*, 2011), malaria (Hermans *et al.*, 2004 ; Yetein *et al.*, 2013), hemorrhages (Klotoé *et al.*, 2012), Ulcer of Buruli (Yemoa *et al.*, 2008), Oral hygiene (Akpona *et al.*, 2009), Female sexual diseases (Deleke-Koko *et al.*, 2011) and animal diseases (Hounzangbé-Adoté, 2001). All these ethnobotanical and ethnopharmacological studies that are available in published literature nowadays could be used to assess various medicinal uses of many tree species. A literature review is expressed for documenting not only the diversity of medicinal tree species but also the various medicinal properties attributed to each of them. Indeed, this may be helpful to highlight the most important medicinal tree species for which the knowledge concerning their vulnerability is less available in Benin for assisting in decision-making for their conservation.

The Republic of Benin belongs to a large phytogeographical region (Regional endemic sudanian center and guino-congolian/sudanian transition zone) which encompasses other countries according to phytogeographical delimitation of White (1983). Both regions extend from western to central Africa countries. Consequently, tree species studied in Benin can spread from this country to others and vice versa. Thus, associating information available concerning medicinal plants used by communities in Benin and other countries sharing the same centers of endemism could help to develop a network of researchers with multidisciplinary science in the future. Additionally, such literature synthesis will help to contribute efficiently to local and regional development of ethnopharmacological studies. Thus, this

work aims to: (i) evaluate the diversity of species and the uses of medicinal trees reported in published articles; (ii) highlight the most important medicinal tree species and discuss their conservation implications.

METHODOLOGY

Literature survey

To better appreciate the diversity of medicinal tree species and the medicinal properties attributed to each of them, a literature review has been conducted on scientific articles related to medicinal tree species. Such literature review has concerned tree species used to treat human and domestic animals' ailments in Benin and other countries sharing the same centers of plant endemism (White, 1983) (Figure 1).

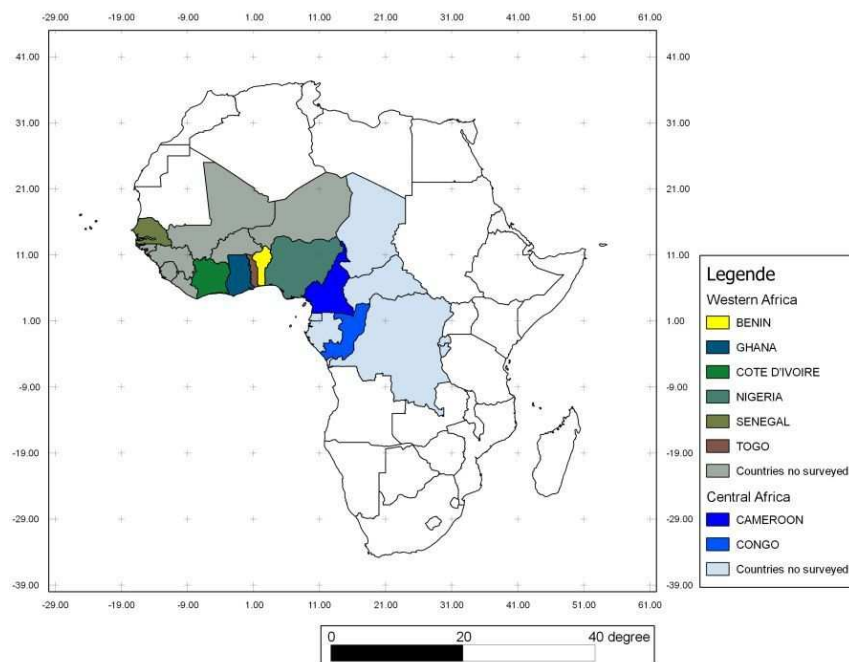


Figure. 1 Countries in western and central Africa concerned by literature review

A total of 38 articles published from 2001 to 2013 were selected. Among them, 19 are from Benin and 19 are from other countries sharing the same centers

of endemism such as: Cameroon, Congo, Nigerian, Togo, Ghana, Côte d'Ivoire, and Senegal. The most numerous works were taken from Nigeria (6), Ghana (5) and Cameroon (3). Two studies were found in Togo and only one in other countries. The research papers from Benin were obtained by direct contact with the authors and from the internet while those from other countries were obtained essentially from the publishers via internet. The main internet sources investigated were www.scolar.google.com and www.academicjournals.org for articles in open access and www.aginternet.net for those whose access is limited. The papers were retrieved from November 2012 to May 2013. The papers used were identified online by using the combination of the following keywords: Benin, western Africa, central Africa, medicinal plant, indigenous knowledge, ethnobotany and ethnopharmacology. These keywords were translated and used also in French.

All the 38 selected articles were those presenting information about human and domestic animals' ailments and plant parts used for their treatment. So, published articles that have not respected the required information were not taken into account. Concerning tree species recorded in these articles, their presence in Benin and their synonymous names were checked in analytical flora of Benin (Akoègninou *et al.*, 2006). Thus, the current taxonomic names were mainly used.

Data analysis

To assess the diversity of medicinal tree species, the number of species, genera and families of medicinal plants were considered. The species nomenclature was arranged by family name according to the international guidance (APG II) adopted in analytical flora of Benin (Akoègninou *et al.*, 2006). The medicinal properties attributed to the inventoried tree species were categorized according to the corporal system and type of affections adapted to the World Health Organization classification (WHO, 1999).

To determine the most important medicinal tree species, Relative Importance (RI) (Bennett & Prance, 2000 ; Albuquerque *et al.*, 2007) was used with the following formula:

$$RI = NAC + NP$$

Where: NAC = number of ailment categories of a given medicinal tree species (NACS) divided by the total number of ailment categories of the most

versatile species (NACVS) ; $N P =$ number of properties attributed to a given tree species (NPS) divided by the total number of properties attributed to the most versatile tree species (NPVS).

RESULTS

Diversity of medicinal trees species of Benin

A total of 263 tree species belonging to 193 genera and 59 families were inventoried from literature review as medicinal tree species in Benin (see Annexe 1). Some of the families were represented by more than 10 species. There are Leguminosae (50), Euphorbiaceae (17), Rubiaceae (17), Combretaceae (16), Apocynaceae (13), Moraceae (13), Anacardiaceae (11). Twenty seven families were represented with two and less than 10 species and twenty five (25) families with one species.

Medicinal properties of medicinal trees

A total of 146 medicinal properties categorized into 17 groups were attributed to all the 263 tree species inventoried (Table 1). Digestive system diseases, cardiovascular system diseases, skin and cutaneous diseases, and malaria and similarly infectious diseases were reported to be treated with the utmost number of tree species.

The most diversified category according to the number of ailments was digestive system diseases, with 23 ailments treated by 84 tree species. This could be explained by the fact that the digestive tract is the main gate of infestation of several diseases. As the humans get ill with what they eat, they have to cure themselves in the same way. Thus, the ailments such as stomachache, dysentery, diarrhea, worms, and diabetes were reported to be treated by a range of tree species (at least 10 plants). The category of malaria and similarly infectious diseases counting 5 ailments (colds, fever, malaria, shiver, and typhoid) was treated by 136 tree species.

All the parts of the inventoried tree species were used for various medicinal purposes. Leaves of tree species come first (67.30 %), followed by the bark (42.21 %) and the roots (39.54 %). The number of medicinal properties attributed to a given plant part varied between 1 and 15.

Table 1 Medicinal properties attributed to tree species

Ailment categories	Diseases and medicinal properties attributed to species	Number of species
Digestive system disease	Hemorrhoids, diabetes, poor digestion, worm, constipation, gastro-intestinal infection, amoebiasis, dyspepsia, stomachache, diarrhea, cholera, dysentery, vomiting, gastritis, anorexia, stomach upset, ulcer, upset liver, purgative, antihelmintic, jaundice.	84
Female sexual diseases	Sterility, ovarian cyst, difficult conception, difficult delivery, improper positioning of a baby in the womb, pregnant woman blood flow, dysmenorrhoea, fibroids, induce menstruation, threatened abortion, strengthen pregnant women, clean uterus, stops vaginal discharge, puerperal fever, anticonception.	42
Male sexual diseases	Erection troubles, aphrodisiac, stimulant, impotence, sexual weakness, hernia, prevention of prostate gland diseases.	38
Cardiovascular system diseases	Anaemia, bilharziosis, hemorrhages, hypertension, blood circulation, heart palpitations.	78
Respiratory system diseases	Cough, tuberculosis, flu, pneumonia, pharyngitis, bronchitis, chest pains, catarrh, phlegms.	28
Eyes diseases	Eye illness, Conjunctivitis, Cataract, Crooked eye problem.	9
Musculo-skeletal diseases	Fractures, rheumatism, Stiff, Coolant, Stiffness, backache, Impaired growth.	28
Skin and cutaneous diseases	Wound, abscess, buttons, itching, burns, dermatitis, eczema, injuries, inflammation, measles, boils, candidiasis, Buruli ulcer, scabies, skin irritation, elephantiasis, oedema, varicella, mycosis, guinea worm.	81
Nervous and mental system diseases	Sleeping sickness, mental problems, madness, rashness, anti-insomnia.	8
Malaria and similarly infectious diseases	Colds, fever, malaria, shiver, typhoid.	136
Sexual Transmissible Diseases	Syphilis, gonorrhoea, gonococci, AIDS, reinforcement of the functions reflexes of the bladder.	21
Sedative/Tonic	Tiredness, toothache, earache, headache, pain, generalized pains, tonic, headache, waist pains, body pain.	41
Lactogenic	Lactation failure	8
Baby system	Subsidence of forehead treatment for babies, infantile treatment of disease, immune reinforcement and dentition, baby care.	4
Immune and dentition reinforcement		
Poison or venom	Poisoning, bites of scorpion or snake, insect bite, food intoxication.	10
Oral hygiene	Oral infection, Oral hygiene, dental decay.	35
Animal Diseases	Diarrhea, gastrointestinal infection, worm, external parasitosis, dystoccy, galactic and reproduction troubles	40

Most important medicinal tree species

According to the relative importance index (RI), the maximum value (1.85) was obtained with *Blighia sapida* whereas the minimum value (0.12) was observed in 97 species. Twenty five percent of the 263 tree species presented the value greater than or equal to 0.42. In fact, there are very few species that presented high value of relative importance index. Thus, 27 species represented ten percent of the 263 tree species that presented the value greater than or equal to 0.79 could be considered as the most important tree species according to their medicinal uses recorded in literature (Table 2). Among those important medicinal tree species, the uses of *Pentadesma butyracea* and *Irvingia gabonensis* were exclusively reported in Benin whereas the uses of *Securidaca longepedunculata* and *Alchornea cordifolia* were exclusively reported in other countries under investigation. The remaining 23 species were used both in Benin and other countries sharing the same centers of endemism in central and western Africa (*Blighia sapida*, *Vitex doniana*, *Morinda lucida*, *Newbouldia laevis*, *Sclerocarya birrea*, *Garcinia kola*, *Psidium guajava*, *Tamarindus indica*, *Vitellaria paradoxa*, *Senna alata*, *Hymenocardia acida*, *Zanthoxylum zanthoxyloides*, *Bridelia ferruginea*, *Elaeis guineensis*, *Ceiba pentandra*, *Vernonia amygdalina*, *Chrysophyllum albidum*, *Sarcocephalus latifolius*, *Ficus exasperata*, *Khaya senegalensis*, *Alstonia boonei*, *Rauvolfia vomitoria* and *Adansonia digitata*).

Table 2. List of 27 main medicinal tree species cited in 38 studies in Benin and other countries sharing the same centers of endemism in central and western Africa

Plant species	Local names	Plant parts	NPS	RI	References	
					Benin	Western & Central Africa
<i>Blighia sapida</i> Konig	lisetin (f)	Fr, Lf, Bk, Rt	24	1.85	1	2; 3
<i>Vitex doniana</i> Sweet	Fontin (f)	Fr, Lf, Bk, Rt	24	1.77	4; 5	6
<i>Pentadesma butyracea</i> Sabine	heinon (n)	Fr, Lf, Bk, St, Rt	14	1.58	7	
<i>Morinda lucida</i> Benth.	Houensin (f)	Lf, Bk, St, Rt	17	1.32	8; 9; 10	2; 11; 12; 13; 14; 15
<i>Irvingia gabonensis</i> (Aubry-Lecomte ex O'Rorke) Baill.	Aslotin (f)	Lf, Bk, Rt	15	1.32	4; 16	
<i>Newbouldia laevis</i> (P. Beauv.) Seemann ex Bureau	Désréman (f)	Lf, Bk, Rt	15	1.24	17; 9; 18; 4; 10	2; 15; 12; 19; 20; 21
<i>Sclerocarya birrea</i> (A.Rich.) Hochst.	mànyi (ba)	Lf, Bk, St, Rt	15	1.24	22	15

Plantes médicinales au Bénin

Plant species	Local names	Plant parts	NPS	RI	References	
					Benin	Western & Central Africa
<i>Garcinia kola</i> Heckel	ahowetin (f)	Bk, St, Rt	11	1.15	23; 17	24; 25; 26; 14; 15
<i>Psidium guajava</i> L.	Kekountin (f)	Lf, Bk, St	13	1.08	4; 8; 9;	11; 26; 3; 25; 19; 14; 15; 6
<i>Securidaca longepedunculata</i> Fresen.		Lf, Bk, Rt	13	1.08		15; 19; 13
<i>Tamarindus indica</i> L.	Djèviviman (f)	Fr, Lf, Bk	13	1.08	28; 10	29, 15; 12
<i>Vitellaria paradoxa</i> Gaertn	limutin (f)	Fr, Lf, Bk, St	13	1.08	23; 30; 17	3; 15; 6
<i>Senna alata</i> (L.) Roxb	amasu (f)	Lf, Bk, St, Rt	14	1.04	9	26; 14; 15
<i>Hymenocardia acida</i> Tul.	Sotinve (f)	Lf, Bk, St, Rt	11	1.00	23; 4; 8	15; 19
<i>Zanthoxylum zanthoxyloides</i> (Lam.) Zepernick & Timler	Xètin (f)	Lf, Bk, St, Rt	9	0.99	23, 4; 8; 9	11; 15; 25; 12; 13
<i>Bridelia ferruginea</i> Benth.	Honsu Kokwé (f)	Lf, Bk, St, Rt	10	0.96	23; 4; 8; 18; 17; 10	15; 19
<i>Elaeis guineensis</i> Jacq.	Détin (f)	Fr, Lf, Rt	10	0.96	4, 9; 10	31; 2; 27; 25; 14; 15; 12; 31
<i>Ceiba pentandra</i> (L.) Gaertn.	guédéhunsou (f)	Fr, Lf, Bk, Rt	11	0.92	4, 18	2; 32; 14; 15
<i>Vernonia amygdalina</i> Delile	Aloman (f)	Lf	11	0.92	18; 9; 10; 17	15
<i>Chrysophyllum albidum</i> G.Don	Azonbobwe (f)	Fr, Lf, Bk, Rt	11	0.92	33; 10	14; 15
<i>Sarcocephalus latifolius</i> (Sm.) E.A.Bruce	Codô (f)	Fr, Lf, Bk, St, Rt	10	0.88	23; 4; 30; 18; 8; 10	11; 29; 27; 25; 26; 15; 12; 19; 6
<i>Ficus exasperata</i> Vahl	Ahla (f)	Lf, Rt	8	0.87	8; 18; 17	2; 34; 14; 15; 12
<i>Khaya senegalensis</i> (Desr.) A. Juss.	Caïlcédra (fr)	Fr, Lf, Bk, Rt	8	0.87	4; 8; 10	11; 29; 27; 3; 6; 13
<i>Alstonia boonei</i> De Wild.		Lf, Bk, St, Rt	9	0.84	8	11; 12; 26; 14; 15
<i>Alchornea cordifolia</i> (Schumach. & Thonn.) Müll.Arg.	kamala (f)	Lf, St, Bk	9	0.84		25; 12; 14; 15; 19
<i>Rauvolfia vomitoria</i> Afzel.	Lè asu (f)	Lf, St, Rt	9	0.84	18	11; 25; 26; 14; 15; 19; 13
<i>Adansonia digitata</i> L.	Kpassatin (f)	Fr, Lf, Bk, Rt	8	0.79	4; 35; 30	15; 12; 6

Language: ba: bariba; f: fon; fr: français; n: nago (yoruba).

Part plant: Bk: Bark; Fr: Fruits; Lf: Leaves; Rt: Roots; St=Stem.

NPS: number of medicinal properties; RI: Relative Importance.

References: 1= Ekué *et al.*, 2010; 2= Addo-Fordjour *et al.*, 2008; 3= Etuk and Mohammed 2009; 4= Allabi *et al.*, 2011; 5= Dadjo *et al.*, 2012; 6= Offiah *et al.*, 2011; 7= Avocèvou-Ayisso *et al.*, 2011; 8= Hermans *et al.*, 2004; 9= Hounzangbé-Adoté, 2001; 10= Yetein *et al.*, 2013; 11= Asase and Oppong-Mensah 2009; 12= Koudouvo *et al.*, 2011; 13= Van Andel *et al.*, 2012; 14= Jiofack *et al.*, 2008; 15= Jiofack *et al.*, 2010; 16= Codjia *et al.*, 2007; 17= Yemoa *et al.*, 2008; 18= Klotoé *et al.*, 2013; 19= Makumbelo *et al.*, 2008; 20= Sonibare *et al.*, 2009; 21= Joppa *et al.*, 2008; 22= Gouwakinnou *et al.*, 2011; 23= Akpona *et al.*, 2009; 24= Békro *et al.*, 2007; 25= Gbolade 2012; 26= Idu *et al.*, 2010; 27= Asase *et al.*, 2010; 28= Fandohan *et al.*, 2010; 29= Asase *et al.*, 2005; 30= Deleke Koko *et al.*, 2011; 31= Sonibare and Adegunde 2012; 32= Dibong *et al.*, 2011; 33= Houessou *et al.*, 2012; 34= Diop *et al.*, 2012; 35= De Caluwé *et al.*, 2009.

DISCUSSION

Medicinal tree species of Benin

This study had highlighted 263 medicinal tree species belonging to 193 genera and 59 families used to treat 146 human and animal ailments in Benin. The most recorded families were Leguminosae, Euphorbiaceae; Rubiaceae, Combretaceae, Apocynaceae, Moraceae and Anacardiaceae. It is not surprising these families be the most reported in various studies. The plant diversity of the study areas may explain this observation. The Dahomey Gap where these families are the most ecologically dominant (Adomou, 2005) will be the suitable areas of those families. This finding confirms an apparency hypothesis supposing that most ecological available species are mostly used by local people (Gueze *et al.*, 2014 ; Lucena *et al.*, 2007 ; Lucena *et al.*, 2012). For example, Leguminosae, Rubiaceae and Euphorbiaceae families have been seen to be the most used antimalarial species (Koudouvo *et al.*, 2011 ; Yetein *et al.*, 2013).

The inventoried tree species were mostly used for treatment of digestive system diseases, and malaria and similarly infectious diseases. Indeed, several ethnopharmacological studies were conducted on malaria in Benin, with reporting the uses of many tree species (Hermans *et al.*, 2004 ; Asase *et al.*, 2005 ; Asase & Oppong-Mensah, 2009 ; Asase *et al.*, 2010 ; Koudovo *et al.*, 2011 ; Yetein *et al.*, 2013). Other diseases such as colds or fever were often treated with the same species and over 15 tree species were reported by several studies to be used for treatment of typhoid disease (Addo-Fordjour *et al.*, 2008 ; Jiofack *et al.*, 2008 ; Jiofack *et al.*, 2010 ; Idu *et al.*, 2010). Among the digestive system diseases, diabetes disease has been specifically investigated in Nigeria (Etuk & Mohammed, 2009).

In addition to malaria and diabetes, other particular diseases have been subject to ethnopharmacological studies in Benin. They are animal diarrhea (Hounzangbé-Adoté, 2001), man sexual troubles (Békro *et al.*, 2007), Buruli ulcer (Yemoa *et al.*, 2008), Oral hygiene (Akpona *et al.*, 2009), female sexual diseases (Deleke-Koko *et al.*, 2011), hypertension (Gbolade, 2012), hemorrhages (Klotoé *et al.*, 2012). In the light of these important medicinal proprieties, we suggest as the previous authors the screening and the test of particular medicinal proprieties of the most important tree species. Likewise, the anthelmintic properties of some tree species such as *Morinda lucida*, *Zanthoxylum zanthoxyloides*, and *Newbouldia laevis* have been tested in vivo or in vitro (Azando *et al.*, 2011 ; Hounzangbé-Adoté *et al.*, 2005a, 2005b,

Olounladé *et al.*, 2012) and screened (Adomi, 2008 ; Joppa *et al.*, 2008 ; Raji *et al.*, 2005). Therefore, these species could be the potential source for production of improved traditional drugs for treatment of animal diseases.

Conservation implications of medicinal trees

At whole, 27 important medicinal tree species were identified, including 9 which had yet been focused for ethnobotanical studies: *Blighia sapida* (Ekué *et al.*, 2010), *Vitex doniana* (Dadjo *et al.*, 2012), *Pentadesma butyracea* (Avocèvou-Ayisso *et al.*, 2011), *Irvingia gabonensis*, (Codjia *et al.*, 2007), *Sclerocarya birrea* (Gouwakinnou *et al.*, 2011), *Tamarindus indica* (Fandohan *et al.*, 2010), *Chrysophyllum albidum* (Houessou *et al.*, 2012), *Khaya senegalensis* (Gaoue & Ticktin, 2009) and *Adansonia digitata* (De Caluwé *et al.*, 2009). In fact, these studies have contributed to improve understanding of medicinal importance of these tree species in Beninese pharmacopeia. But, concerning some tree species such as *Milicia excelsa* (Ouinsavi *et al.*, 2005), *Parkia biglobosa* (Koura *et al.*, 2011) and *Caesalpinia bonduc* (Assogbadjo *et al.*, 2011), although the detailed ethnobotanical studies targeted them, their medicinal importance remained weak.

Indeed, some of these species are useful for other purposes in addition to medicinal uses. The leaves and fruits of *Parkia biglobosa* are highly used as food while *Milicia excelsa* was appreciated for its wood. As for *Caesalpinia bonduc* basically used for medicinal uses, its medicinal importance is weak even though, their roots are frequently used against sexual weakness, prostate gland diseases and malaria (Hessou *et al.*, 2009 ; Assogbadjo *et al.*, 2011) that are more frequent and prevalent in Africa. Thus, Relative Importance Index (RI) was not effective in highlighting such virtuous species. That is also the case of numerous tree species such as *Pavetta crassipes* and *Opilia amentacea* used for the treatment of Malaria (Hermans *et al.*, 2004) and *Caesalpinia benthamiana* and *Carpolobia lutea* used for the treatment of man sexual troubles (Békro *et al.*, 2007). In sum, quantitative index such as relative importance index (RI) based only on species versatility seems not to be very effective in highlighting some important medicinal plants. This raises the question of the relative importance of the species specialized in the treatment of limited number of diseases. In addition, as well as all diseases do not have the same importance, it would be difficult to identify a given specialized species as an important medicinal plant without prioritizing certain diseases. Then, it may be important to take into account the kind and prevalence of some diseases while reflecting on the conservation need of medicinal plants.

For most of 27 important medicinal tree species, several medicinal properties were attributed to sensitive plant parts such as the roots and the bark. Indeed, harvesting bark and roots or chopping all plant branch can result in the whole plant destruction (Dzerefos & Witkowski, 2001 ; de Oliveira *et al.*, 2007). Djego *et al.* (2011) had also criticized the methods of harvesting plant parts used in traditional medicine in Benin. Among these medicinal tree species, those which roots are sought for numerous diseases (at least 5) were *Pentadesma butyracea*, *Morinda lucida*, *Securidaca longepedunculata*, *Garcinia kola*, *Bridelia ferruginea*, *Ceiba pentandra*, *Rauvolfia vomitoria*, *Senna alata*, *Zanthoxylum zanthoxyloides*, and *Sarcocephalus latifolius*. In addition, the bark of most of these species was also used for various diseases treatment. Elsewhere, the bark of species such as *Khaya senegalensis*, and *Alstonia boonei* were specially used for various diseases treatment. Given the number of diseases treated by the sensitive part of these species, they are more likely to be overexploited as per the hypothesis by which the more the number of medicinal properties attributed to sensitive organs of a given plant increases, the more its harvesting risk will increase. Indeed, it will be of utmost scientific interest to investigate the relationships between an increase uses of a given plant parts for medicinal purposes and the plant vulnerability to extinction.

Some ethnobotanical studies have revealed the vulnerability of the species such as: *Pentadesma butyracea* (Avocèvou-Ayisso *et al.*, 2011), and *Khaya senegalensis* (Gaoue & Ticktin, 2009). Such traditional knowledge may be used to recommend these species for conservation. As for other native species such as : *Morinda lucida*, *Securidaca longepedunculata*, *Garcinia kola*, *Bridelia ferruginea*, *Ceiba pentandra*, *Rauvolfia vomitoria*, *Zanthoxylum zanthoxyloides*, *Alstonia boonei*, and *Sarcocephalus latifolius*, further field researches should be investigated for better conservation plan. Anyhow, the concerned medicinal tree species need more attention for sustainable and suitable uses and conservation.

Therefore, among these medicinal tree species which could be overexploited according to this study, only *Pentadesma butyracea*, *Rauvolfia vomitoria*, *Garcinia kola*, and *Zanthoxylum zanthoxyloides* have been recognized as threatened species in Benin in line with IUCN Red List (Adomou *et al.*, 2011). The other native species such as *Morinda lucida*, *Ceiba pentandra*, *Alstonia boonei*, *Securidaca longepedunculata*, and *Bridelia ferruginea*, are proposed for further assessment of their extinction risk.

Elsewhere, various plant products of some of these medicinal tree species were sold in many markets in Benin (Djego *et al.*, 2011 ; Van Andel *et al.*, 2012 ; Quiroz *et al.*, 2014). Indeed, Quiroz *et al.* (2014) reported the exportation of important quantities of roots of threatened species such as *Zanthoxylum zanthoxyloides*, and *Rauvolfia vomitoria* and the bark of *Khaya senegalensis* from Benin to Italy and Guadeloupe. The consequence of this trade can be fatal to the survival of tree species which roots or bark are at stake.

In sum, the vulnerability of medicinal tree species in general is not only related to the harvesting methods. Other factors such as agriculture, wildfire, animal feeding, deforestation and urbanization have been counted as having an impact on the availability of plants in the wildlife (Adomou *et al.*, 2007 ; Delvaux *et al.*, 2009 ; Deleke-Koko *et al.*, 2011 ; Djego *et al.*, 2011). With regard to many factors supposed to cause the scarcity of medicinal tree species, it is important to further investigate on the real causes to better establish the suitable strategies for their conservation.

In addition, some species could be also vulnerable to climate change as the case of *Adansonia digitata*, *Parkia biglobosa*, and *Vitellaria paradoxa* (Heubes *et al.*, 2012). Indeed, it would be useful to delineate the ecological niche of the most important tree species and to assess the impact of climate change on their suitable production areas.

CONCLUSION

The present literature review had permitted to record a total of 263 medicinal tree species belonging to 193 genera and 59 families. These tree species were used for about 146 medicinal properties categorized into 17 groups. Digestive system diseases, cardiovascular system diseases, skin and cutaneous diseases, and malaria and similarly infectious diseases were treated with a great number of those tree species. Overall, 27 important medicinal tree species were identified. Some of these tree species such as *Pentadesma butyracea*, *Morinda lucida*, *Securidaca longepedunculata*, *Garcinia kola*, *Bridelia ferruginea*, *Ceiba pentandra*, *Rauvolfia vomitoria*, *Senna alata*, *Zanthoxylum zanthoxyloides*, and *Sarcocephalus latifolius* were revealed as being worth for conservation due to the use of their sensitive parts such as roots, stem and bark. Given the importance of their medicinal uses, researches for their domestication and screening must be envisioned. Some tree species highly sought for their special effects in treating of some recurrent diseases such as sexual diseases and malaria in Africa, were not

found among the list of main medicinal plants. These results show the need to conduct the field investigations which could permit to identify the most important species based on the most recurrent diseases and propose some of them for conservation.

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