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Ethnobotanical assessment of the plant species used in the treatment of diabetes in the Sudano-Guinean zone of Benin

Lawin IF[1], Lalèyè FOA[2], Agbani OP[1], Assogbadjo AE[1]
[1]*Laboratory of Applied Ecology, Faculty of Agronomic Sciences, University of Abomey-Calavi, 01 P. O. Box* 526 *Cotonou, Benin.*
[2]*Laboratory of Enzymology and Proteins Biochemistry, Faculty of Sciences and Technology, University of Abomey-Calavi, 05 P.O. Box 972 Cotonou, Benin*
***Corresponding author**: Fidèle Iboukoun LAWIN
Phone: +229 97181559 / +229 95114093 E-mail. ifilawin@yahoo.fr
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1 SUMMARY

This study aims at assessing knowledge of local population on anti-diabetic plant species in the Sudano-Guinean zone of Benin. One hundred and twenty six (126) persons including traditional practitioners, medicinal plant sellers, farmers, breeders and others stakeholders were investigated using ethnobotanical approach. Data collected was on anti-diabetic plant species; anti-diabetic plant parts used; the modes of remedy preparation and pre-emption. Results showed that 144 plant species were used as anti-diabetics in the study area. These species belong to 63 botanical families and 132 genera. Anti-diabetic species were mostly represented by Euphorbiaceaes and Leguminosae-Pipilionoideae families. *Citrus aurantifolia* was found to be the major anti-diabetic plant (RFC = 0.21) and leaves were the major anti-diabetic organs used (27% of the plants). Decoction was the most used (53 %) mode for remedy preparation. A total of 63 recipes related to anti-diabetic species were recorded. Inventoried plants were essentially used for their hypoglycaemic activity. This study has provided basic knowledge in pharmacological research.

2 INTRODUCTION

African populations at general and those from Benin are confronted with growing chronic diseases such as diabetes. The incidences of diabetes on the organism appear as serious complications and other troubles such as metabolic, degenerative, infectious, acid-ketosis, cardiovascular and renal affections. According to the International Federation of the Diabetes (FID), the number of diabetics was estimated at 382 million in 2013 in the world with a forecast of 592 million people likely to be recorded in 2035. This prevalence is still increasing in industrialized and developing countries (Wild *et al.,* 2004). In Africa, 19.8 million of patients were recorded in 2013 with a forecast of 41.5 million in 2035 (FID, 2013). In Benin, 66000 diabetics were recorded with a prevalence of 1.1% (Djrolo *et al.,* 2003). Considering that half of the number of diabetics is doubted (Tchobrousky, 1987; Djrolo *et al.,* 1999), one could estimate at approximately 130000 as the real number of diabetic in Benin (Djrolo *et al.,* 2003). Diabetics' death is caused by cardiovascular complications, arterial hypertension, renal insufficiency, blindness, etc. Approximately, 18 million of individuals die each year of cardiovascular complications mainly due to risk factors like the sugar diabetes or arterial hypertension (Hossain *et al.,* 2007). In contrast to an old and still very widespread opinion regarding the diabetes as a disease of industrial countries and rich men, this becomes

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more and more a major concerne in the developing countries and especially in the sub-Sahara of Africa (Gning *et al.,* 2007). This was known to affectthe production of countries because of the mortality and sick leave it causes. Today, patients would rather use medicinal plants for free no charge as costs are beyond their economic power (Tossoud *et al.,* 1995). A wide range of studies were conducted on anti-diabetic plants across the world (Aguiyi *et al.* 2000; Jouad *et al.* 2001; Gbolade, 2008; Soladoye *et al.* 2012 and Ocvirk *et al.* 2013). However, very few studies have concerned anti-diabetic plants in Benin apart of the one conducted by Fah *et al.* (2013) that exclusively concerned anti-diabetic plants used for pregnancy. In this study, we assessed knowledge of local communities on anti-diabetic plants in the Sudano-Guinean zone of Benin.

3 MATERIAL AND METHOD

3.1 Study area*:* The study area is located between 7°42' and 8°30' North latitude, 2°05' and 2°45' East longitude. This area included two localities (Glazoué and Savè) in the department of Collines in Benin. The two nearby localities count in bulk 18 districts including ten (10) in Glazoué and eight (08) in Savè (Figure 1). It is a Sudano-Guinean climatic zone referring to the transition zone between the Subequatorial and Sudanian zones. The annual average rainfall and temperature are respectively 1100 mm and 27°C. The vegetation is made up of galleries, tree and shrubby savannas and fallows. Man planted vegetations such as plantations of teaks and cashew trees are found in the area. Plant species are as well used for timber, firewood, charcoal as for the traditional treatment of diseases.

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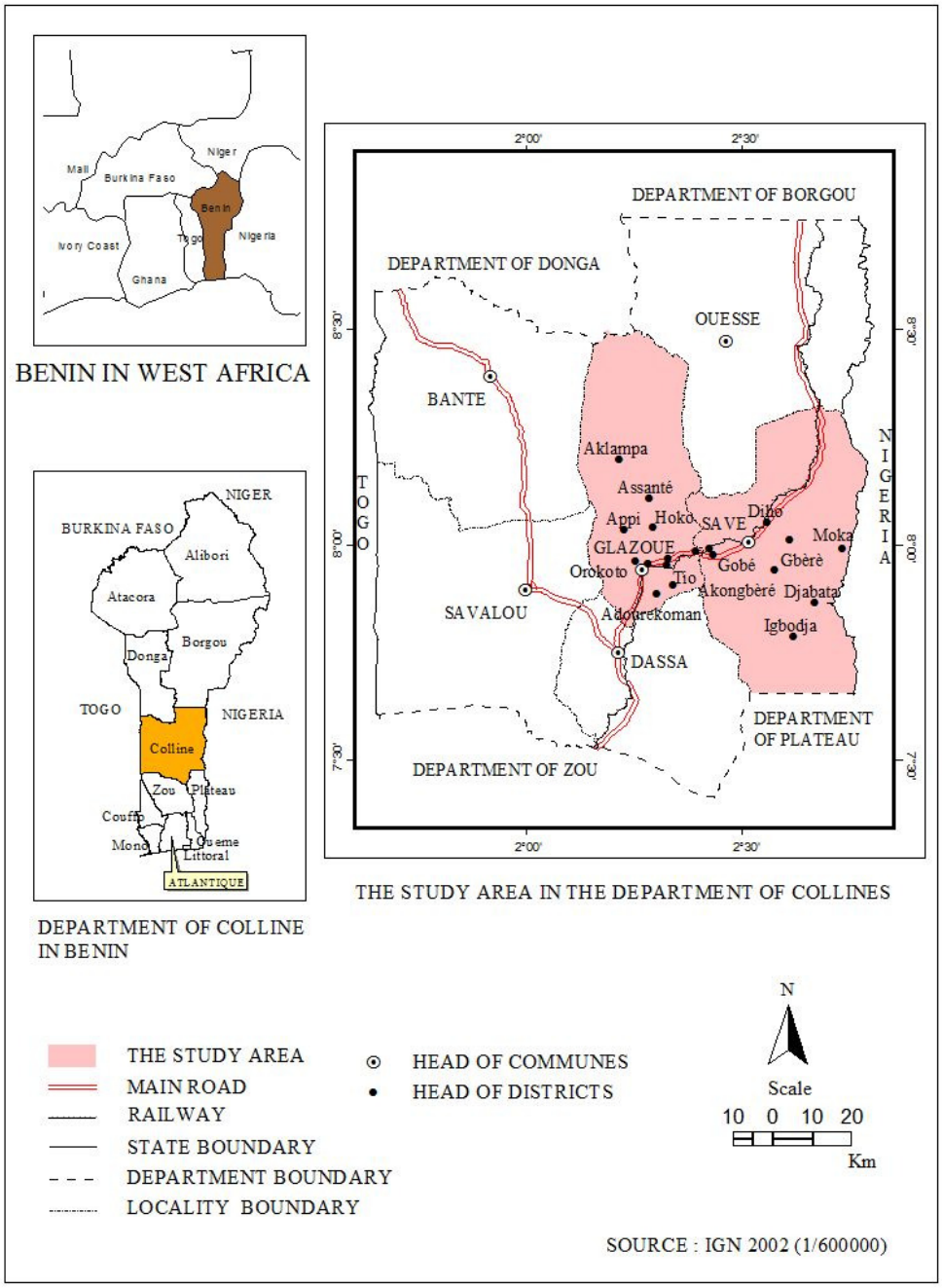

Figure 1: Geographical location of the study area

3.2 Data collection : Ethnobotanical investigations were carried out based on questionnaire addressed to eight ethnic groups (Adja, Ditamari, Fon, Idaasha, Mahi, Peulh and Shabè). Structural interview was used to investigate groups such as traditional doctors, sellers of medicinal herbs, farmers, stockbreeders and others stakeholders. This interview allowed us to make an inventory of plant species used in the treatment of diabetes, the various plant organs used in the treatment, the mode of remedy preparation and pre-

emption. To make sure of the effectiveness and the side effects of remedies, some diabetics using medicinal herbs were identified among the target groups and have shared their experiences. Overall, 126 people including 35 women and 91 men were investigated.

3.3 Specimens collection and plants identification : Different organs of the plant such as leaves, flowers, fruits, stems, tuber, bulbs and seeds were collected. Each organ specimen was numbered and the date of harvest, locality, habitat, local names of plants and other information were mentioned. Plants were identified in the national herbarium of Benin.

4 Data analysis: The list of anti-diabetic plant species was established and their botanical family, local names in the two major ethnic groups (Idaasha and Mahi), organs used and the modes of remedy preparation were identified. Relative Frequency of Citation (RFC) of each species (Tardio and Pardo-De-Santaynia, 2008) was calculated using the following equation: RFC= FC /N with FC: number of people having quoted the species; and N: total number of interviewed people.

5 RESULTS

5.1 Inventorying of anti-diabetic plant species: Overall, 144 plant species (Table 1) belonging to 132 genera and 63 botanical families were quoted. Families such as Euphorbiaceae and Leguminosae-Papilionoideae were found to be the most represented and were followed by the family of Leguminosae-Caesalpinioideae (Figure 2). *Citrus aurantifolia* was the most quoted anti-diabetic plant species (RFC= 0.21). Species such as *Garcinia cola*, *Khaya senegalensis, Momordica charantia* and *Phyllanthus amarus* (RFC = 0.15 each one) were also part of the principal plants species used against diabetes (Table 1).

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Table 1: List of anti-diabetic plants in the Sudano-Guinean zone of Benin

N°	Species	Families	Local names		Organs used	Preparation mode	FC	RFC
			IDAASHA	MAHI				
1	*Abrus precatorius* L.	Leguminosae-Papilionoideae	Ojou èga	Azétɔnounkoun	Leaf	TR	2	0.01
2	*Acanthospermum hispidum* DC.	Asteraceae	Ichakoro-oro	Godokɔ	Leaf	DE	1	0.007
3	*Acmella uliginosa* (Sw.) Cass.	Asteraceae	Awérékpé	Wélékpékpé	Whole plant	DE	2	0.01
4	*Aframomum melegueta* (Roscoe) K. Schum.	Zingiberaceae	Ata	Atakoun	Fruit/Seed	MA, DE, PO/DE, MA	10	0.07
5	*Allium ascalonicum* auct. non Strand	Alliaceae	Mansa éléwé	Ayoman winiwini	Bulb	MA, DE, PO	6	0.04
6	*Allium cepa* L.	Alliaceae	Mansa	Ayoman	Bulb	DE, PO	5	0.03
7	*Allium sativum* L.	Alliaceae	Ayo	Ayo	Bulb	CD, DE, MA, PO	11	0.08
8	*Aloe buettneri* A. Berger	Asphodelaceae	Chanmanchanman	Aloes	Leaf	TR, MA, PO	4	0.03
9	*Anacardium occidentale* L.	Anacardiaceae	Egui acajou	Kajoutin	Bark/Root/ Leaf	DE, PO/DE, MA/PO	3	0.02
10	*Ananas comosus* (L.) Merr.	Bromeliaceae	Abrèbrè	Agondé	Root/Fruit	-/DE	3	0.02
11	*Anchomanes dalzielii* N. E. Br.	Araceae	Chafarigbo	-	Tuber/Leaf	DE/-	7	0.05
12	*Annona senegalensis* Pers.	Annonaceae	Otrin-bobo	Gnigìwé	Root, leaf	DE	3	0.02
13	*Anogeissus leiocarpa*(DC.) Guill. & Perr.	Combretaceae	Agni	Hlihon	Bark	PO	1	0.007
14	*Anthocleista vogelii* Planch.	Loganiaceae	-	Gotun/guswé	Root	DE	1	0.007
15	*Aristolochia albida* Duch.	Aristolochiaceae	Warègou	Fondɔ	Root	MA, DE, IN	4	0.03
16	*Azadirachta indica* A. Juss.	Meliaceae	Jèdiya	Kininitin	Bark/Leaf	DE/TR	3	0.02
17	*Blighia sapida* König	Sapindaceae	Egui ishin	Lisɛtin	Bark or branches/Leaf	DE/-	2	0.01
18	*Borassus aethiopum* Mart.	Arecaceae	Egui agban	Agontin	Seedling	PO	1	0.007
19	*Brassica oleracea* L.	Brassicaceae	-	-	Leaf	CS	1	0.007
20	*Bridelia ferruginea* Benth.	Euphorbiaceae	Ira	Honsoukokoé	Leaf/Bark	DE/DE, PO	6	0.04
21	*Burkea africana* Hook.	Leguminosae-Caesalpinioideae	Atakpa	Ajasi kakè	Root/ Bark	DE, MA/DE	4	0.03
22	*Caesalpinia bonduc* (L.) Roxb.	Leguminosae-Caesalpinioideae	Egui adji	Djikouin	Leaf/ Root	IN/DE,MA, IN	12	0.09
23	*Caesalpinia pulcherrima*(L.) Sw.	Leguminosae-Caesalpinioideae	Chrochro	Fleur	Leaf	DE	2	0.01
24	*Calotropis procera* (Aiton) W. T. Aiton	Asclepiadaceae	Bambamba	Amonman	Leaf/ Root	TR, DE/DE	4	0.03
25	*Cannabis sativa* L.	Cannabaceae	Igbo	Guéman	Leaf	IN	1	0.007
26	*Capsicum frutescens* L.	Solanaceae	Tambo-olobré	Takin winiwini	Fruit	DE, PO	5	0.03
27	*Carica papaya* L.	Caricaceae	Aguidi akɔ	Kpintin	Leaf/ Root/Fruit	DE	5	0.03
28	*Carissa spinarum* L.	Apocynaceae	Ahanzo	Ahanzo	Root	DE, MA, PO	4	0.03
29	*Catharanthus roseus* (L.) G. Don	Apocynaceae	Bonjour bonsoir	Fleur	Leaf/ Root	DE	10	0.07
30	*Chromolaena odorata* (L.) R. M. King	Asteraceae	Agatou	Agatou	Root	DE	1	0.007
31	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	Kaka chaimkpè	Goussi	Endocarp	MA	1	0.007
32	*Citrus aurantifolia* (Christm. & Panzer) Swingle	Rutaceae	Jogorotan ogodo	Klétin	Leaf/Fruit/Jus/Root	DE/DE, PO/DE, MA , EJ/DE	27	0.21

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33	*Cocos nucifera* L.	Arecaceae	Egui agonkin	Agonkintin	Leaf/Root/Bark/coco water	DE/DE, MA/DE/DE	8	0.06
34	*Cola acuminata* (P. Beauv.) Schott & Endl.	Sterculiaceae	obi abata	Vi	Fruit	DE, MA	12	0.09
35	*Cola nitida* (Vent.) Schott & Endl.	Sterculiaceae	Goro	Golo	Fruit	DE, MA	2	0.01
36	*Combretum collinum* Fresen.	Combretaceae	Irinkoya	Yahoui	Leaf	DE	1	0.007
37	*Commelina erecta* L. ssp. *Erecta*	Commelinaceae	Olirékou	Hanwin hanwin	Root	DE	1	0.007
38	*Corchorus olitorius* L.	Tiliaceae	Yɔyɔ	Ninnounwi	Seed	PO	1	0.007
39	*Crateva adansonii* DC. ssp. *Adansonii*	Capparaceae	Agni-wèwè	Onton zunzin	Leaf	DE	4	0.03
40	*Crinum zeylanicum* (L.) L.	Amaryllidaceae	Adɔdjɛ	Soulou	Whole plant/Bulb	-/DE	3	0.02
41	*Crotalaria retusa* L.	Leguminosae-Papilionoideae	Okounkrounmanro	Aza	Root	MA	1	0.007
42	*Croton gratissimus* Bureh.	Euphorbiaceae	Adjèkofolé ilé	Jélélé	Leaf/Root	DE	5	0.03
43	*Curculigo pilosa* (Schumach. & Thonn.) Engl.	Hypoxidaceae	Ikoulé-gouchou	Ayoté	Tuber	DE	1	0.007
44	*Cussonia arborea* Hochst. ex A. Rich.	Araliaceae	Edigo	Toflo-gotoun	Root	MA	1	0.007
45	*Cymbopogon citratus* (DC.) Stapf	Poaceae	Ofrin	Cha/Timan	Leaf	DE	1	0.007
46	*Cymbopogon giganteus* (Hochst.) Chiov.	Poaceae	Igbakpo	Gbézin	Leaf	DE	1	0.007
47	*Daniellia oliveri*(Rolfe) Hutch. & Dalziel	Leguminosae-Caesalpinioideae	Iya	Zantin	Bark /Root	DE/DE, MA	4	0.03
48	*Daucus carota* L. ssp. *sativus* (Hoffm.) Arcang.	Apiaceae	-	-	Root	CS	1	0.007
49	*Detarium microcarpum* Guill. & Perr.	Leguminosae-Caesalpinioideae	Ajèkofolé-oko	Dakpa	Bark /Root	-/DE	3	0.02
50	*Dioscorea cayenensis* Lam.	Dioscoreaceae	Kokoro	Kokolo	Tuber	CB	1	0.007
51	*Elaeis guineensis* Jacq.	Arecaceae	Egui êkpê	Détin	Branch/ Root	DE/MA	1	0.007
52	*Eriosema glomeratum*(Guill. & Perr.) Hook.f. var. *glomeratum*	Leguminosae-Papilionoideae	Kolo-koriko	-	Leaf	MA	1	0.007
53	*Erythrina senegalensis* DC.	Leguminosae-Papilionoideae	Ochiichè	Kpaklessi	Root / Bark of root	DE, MA/PO	3	0.02
54	*Eugenia aromatica* (L.) Baill.	Myrtaceae	-	Atikin gbadota	Fruit	DE	2	0.01
55	*Euphorbia hirta* L.	Euphorbiaceae	Ignankoun ayira	Nonsinwé	Whole plant	PO	1	0.007
56	*Euphorbia hyssopifolia* L.	Euphorbiaceae	-	Nonsinwé	Leaf	-	1	0.007
57	*Ficus platyphylla* Delile	Moraceae	Agbèdè	Kapité	Bark	PO	1	0.007
58	*Ficus sycomorus* L.	Moraceae	Ofo	Votin	Sap	DE	1	0.007
59	*Ficus umbellata* Vahl	Moraceae	Ɔrɛ	Vounvountin	Leaf/Root	DE	1	0.007
60	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	Jogboro	Gbohounkajé	Branch	DE	1	0.007
61	*Flueggea virosa* (Roxb.ex Willd) Voigt.	Euphorbiaceae	Wadjédjé	Chakè-chakè	Root/Leaf	DE, MA/DE	8	0.06
62	*Garcinia kola* Heckel	Clusiaceae	Iwo	Ahowé	Fruit	CD, DE, MA, PO	20	0.15
63	*Gardenia erubescens* Stapf & Hutch.	Rubiaceae	Kankanrambo	Dakpla	Root	IN	1	0.007
64	*Gladiolus dalenii* van Geel	Iridaceae	ɔshɛko	Baka	Bulb	DE, PO	3	0.02
65	*Glycine max* (L.) Merr.	Leguminosae-Papilionoideae	Soja	Soja	Seed	PO	1	0.007
66	*Gossypium arboreum* L.	Malvaceae	Owou-akèchè	Avɔkanfoun chèké	Leaf	DE	1	0.007
67	*Gymnosporia senegalensis* (Lam.) Loes.	Celastraceae	Fréfré-ira	Jadoman	Root	DE	1	0.007
68	*Heliotropium indicum* L.	Boraginaceae	Ogbolé aroukɔ	Koklossou dinpaja	Leaf	DE	2	0.01

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69	*Hymenocardia acida* Tul.	Euphorbiaceae	Oroukpa	Sotivè	Root	MA	1	0.007
70	*Hyptis pectinata* (L.) Poit.	Lamiaceae	Kobojoujou	Houéflou	Root	MA	1	0.007
71	*Imperata cylindrica* (L.) P. Beauv.	Poaceae	Iguan	Sê	Root/ dry Leaf	DE, MA	4	0.03
72	*Isoberlinia doka* Craib & Stapf	Leguminosae-Caesalpinioideae	Kpakpa	Kpakpa	Leaf	DE	1	0.007
73	*Jatropha curcas* L.	Euphorbiaceae	Ɔkpɔkpɔrou founfoun	Kpotin wéwé	Leaf/ Root	DE, TR/DE	3	0.02
74	*Jatropha gossypiifolia* L.	Euphorbiaceae	ɔkpɔkpɔru kpikpa	Kpotin vɔvɔ	Leaf	DE, TR	2	0.01
75	*Khaya senegalensis* (Desr.) A. Juss.	Meliaceae	Esisa	Akao	Bark/ Root	DE, MA, PO/DE	20	0.15
76	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	Gnankpo	Gnanblikpotin	Root/Fruit	DE	2	0.01
77	*Lannea acida* A. Rich. s. l.	Anacardiaceae	Assoguidɔka	Zonzon	Bark	DE	2	0.01
78	*Lannea barteri* (Oliv.) Engl.	Anacardiaceae	Akou	Zonzon	Bark	DE	2	0.01
79	*Lantana camara* L.	Verbenaceae	-	Hlaciayo	Root	DE	1	0.007
80	*Mangifera indica* L.	Anacardiaceae	Mango	Mangatin	Leaf/ Bark/ Root	DE	1	0.007
81	*Manihot esculenta* Crantz	Euphorbiaceae	Adjagoun	Fingnignin	Tuber	MA	3	0.02
82	*Merremia quinquefolia* (L.) Hallier f.	Convolvulaceae	-	Alɔvi-aton	Leaf	PO	1	0.007
83	*Milicia excelsa* (Welw.) C.C.Berg	Moraceae	Iroko	Lokotin	Bark	PO/MA	2	0.01
84	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	Alèkou	-	Leaf	PO	1	0.007
85	*Momordica charantia* L.	Cucurbitaceae	Kpalari	Yinsikin	Leaf	DE, TR	19	0.15
86	*Monodora myristica* (Gaertn.) Dunal	Annonaceae	Ariwo	Sassalikoun	Seed/Bulb	DE, MA, PO/MA	7	0.05
87	*Morelia senegalensis* A.Rich. ex DC.	Rubiaceae	Agnidja	Aviwin	Root	MA	1	0.007
88	*Morinda lucida* Benth.	Rubiaceae	Owouwo	Houinsi/Wètin	Root/Leaf/Bark	DE	6	0.04
89	*Moringa oleifera* Lam.	Moringaceae	Lagalaga	Kpatinman	Leaf/ Seed	PO, TR, CS/CD	17	0.13
90	*Musa paradisiaca* L.	Musaceae	Dɔbɔrɔ-agbamgba	Kokwé sozou	Fruit	PO	2	0.01
91	*Newbouldia laevis* (P.Beauv.) Seemann ex Bureau	Bignoniaceae	Akoko	Kpatin	Leaf/Bark	DE	2	0.01
92	*Nicotiana tabacum* L.	Solanaceae	Taba	Kla	Leaf	PO, TR	2	0.01
93	*Ocimum americanum* L.	Lamiaceae	Hizihizi	Kessou kessou	Root/Leaf	DE/DE, MA	5	0.03
94	*Ocimum gratissimum* L.	Lamiaceae	Aribra	Chiayo	Leaf	DE, TR, PO	4	0.03
95	*Olax subscorpioidea* Oliv.	Olacaceae	Egui miitin	Miitin	Root	MA	1	0.007
96	*Omphalogonus calophyllus* Baill.	Asclepiadaceae	ƆgbƆ doundoun	-	Root	MA	1	0.007
97	*Opilia amentacea* Roxb.	Opiliaceae	Gnandoro	Touahantouman	Leaf	DE	1	0.007
98	*Oxytenanthera abyssinica*(A.Rich.) Munro	Poaceae	Dawé	Dawé	Leaf/ Root	DE, MA/MA	4	0.03
99	*Parinari curatellifolia*Planch. ex Benth.	Chrysobalanaceae	Idifoun	Awètoun	Root/Bark	DE, PO	2	0.01
100	*Paullinia pinnata* L.	Sapindaceae	Akpa	Adaklɔman	Leaf	-	1	0.007
101	*Pavetta crassipes*K.Schum.	Rubiaceae	Etira	Dakplassou	Leaf	DE	2	0.01
102	*Pennisetum americanum* (L.) Leeke	Poaceae	Iwassè	Likoun	Root/Seed	DE/DE, PO	1	0.007
103	*Pericopsis laxiflora*(Benth. ex Baker) Meeuwen	Leguminosae-Papilionoideae	Ichèdoun	Sèdon	Leaf	DE	1	0.007
104	*Persea americana* Mill.	Lauraceae	Egui avoka	Avokatin	Leaf	DE	1	0.007

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105	*Phaseolus lunatus* L.	Leguminosae-Papilionoideae	Ibè	Akpakoun	Seed	PO, MA	1	0.007
106	*Philenoptera cyanescens* (Schumach. & Thonn.) Roberty	Leguminosae-Papilionoideae	Ɛlou	Aho	Root	DE	1	0.007
107	*Phyllanthus amarus* Schumach. & Thonn.	Euphorbiaceae	Aribissohou	Hlinwé	Whole plant/ Leaf	DE	19	0.15
108	*Picralima nitida* (Stapf.) T. & H.Durand	Apocynaceae	Abéré	Ayokpè	Seed	DE, MA, PO	12	0.09
109	*Piper guineense* Schumach. & Thonn.	Piperaceae	Idjayé	Ninninkoun	Seed	DE, MA, PO	7	0.05
110	*Plumbago zeylanica* L.	Plumbaginaceae	Anan	Dangblan	Leaf	PO	2	0.01
111	*Pseudocedrela kotschyi* (Schweinf.) Harms	Meliaceae	Chahizi	Atindokpwé	Root	DE	1	0.007
112	*Psidium guajava* L.	Myrtaceae	Kèkoun	Kinkountin	Leaf/ Root	DE	2	0.01
113	*Pteleopsis suberosa* Engl. & Diels	Combretaceae	Okroukrou	Klui-klui	Leaf/Bark	DE/PO	3	0.02
114	*Raphionacme brownii* Scott-Elliot	Asclepiadaceae	-	-	Tuber	MA	1	0.007
115	*Rauvolfia vomitoria* Afzel.	Apocynaceae	-	Lèwé	Root	DE	2	0.01
116	*Rhynchosia pycnostachya* (DC.) Meikle	Leguminosae-Papilionoideae	-	-	Root	DE	1	0.007
117	*Rourea coccinea* (Thonn. ex Schumach.) Benth.	Connaraceae	Amɛjɛ	Ganganlisɛ	Root	MA	1	0.007
118	*Saba comorensis* (Boj.) Pichon	Apocynaceae	-	-	Root	DE	1	0.007
119	*Saccharum officinarum* L.	Poaceae	Ɔkpa-soucré	Léké	Root/Leaf	DE	2	0.01
120	*Sansevieria liberica* hort. ex Gerome & Labroy	Dracaenaceae	-	Akpognan	Leaf/Fruit/Root	DE	3	0.02
121	*Sarcocephalus latifolius* (Sm.) E.A.Bruce	Rubiaceae	Igbessin	Ko	Root	DE, MA, PO	7	0.05
122	*Schrankia leptocarpa* DC.	Leguminosae-Mimosoideae	Arobokou	Vehoun	Leaf	DE	1	0.007
123	*Secamone afzelii* (Schult.) K.Schum.	Asclepiadaceae	Abèrè-rèwan	Anonsiman	Leaf	DE	1	0.007
124	*Securidaca longepedunculata* Fresen.	Polygalaceae	Kpatalè	Kpata	Root	DE, PO	3	0.02
125	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Leguminosae-Caesalpinioideae	Cassia	Kénoun	Root/Bark	DE	6	0.04
126	*Sesamum radiatum* Schumach. & Thonn.	Pedaliaceae	Agbɔ	-	Leaf	TR	1	0.007
127	*Spondias mombin* L.	Anacardiaceae	Egui iwéwé	Akikontin	Leaf/Bark/Root/ Fruit	PO, MA/PO/DE/IN	2	0.01
128	*Sterculia setigera* Delile	Sterculiaceae	Akporo	Azilokoué	Bark	DE, MA	2	0.01
129	*Stereospermum kunthianum* Cham.	Bignoniaceae	-	Hounsadii	Bark	-	1	0.007
130	*Strophanthus hispidus* DC.	Apocynaceae	Chaaro	Adikoun	Root	DE	2	0.01
131	*Swartzia madagascariensis* Desv.	Leguminosae-Papilionoideae	-	-	Root	DE	1	0.007
132	*Tacca leontopetaloides* (L.) Kuntze	Taccaceae	Ossangni	Zinwohouéhè	Bulb/Tuber	PO/DE	3	0.02
133	*Tamarindus indica* L.	Leguminosae-Caesalpinioideae	Egui ariran	Jɛvivi	Bark	DE	2	0.01
134	*Tetrapleura tetraptera* (Schumach. & Thonn.) Taub.	Leguminosae-Mimosoideae	Aidan	Lindja	Fruit/clove	DE/PO	2	0.01
135	*Trichilia emetica* Vahl	Meliaceae	Ichin igbê	Chivi	Root	DE	1	0.007
136	*Uvaria chamae* P. Beauv.	Annonaceae	Yaha	Ayadaha	Root	DE, MA, PO	8	0.06
137	*Vangueriella spinosa*(Schumach. & Thonn.) Verdc.	Rubiaceae	-	-	Root	DE	1	0.007
138	*Vernonia amygdalina* Delile	Asteraceae	Aroman	Aman-vivè	Bulb/Bark de la Root/Leaf	DE/PO/MA, TR	9	0.07
139	*Vernonia cinerea* (L.) Less.	Asteraceae	Ewé jèdi jèdi	Houssikoussè	Leaf	PO	1	0.007

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140	*Vitellaria paradoxa* C.F.Gaertn. ssp. *paradoxa*	Sapotaceae	Ɛmi	Limoutin	Bark	DE	3	0.02
141	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	Oroun	Kpéjélékoun	Fruit	DE, MA, PO	13	0.1
142	*Zanthoxylum zanthoxyloides*(Lam.) Zepernick & Timler	Rutaceae	Atá	Hɛtin	Root/Bark	MA	3	0.02
143	*Zea mays* L.	Poaceae	Gbado	Gbadé	Fleur	DE	1	0.007
144	*Zingiber officinale* Roscoe	Zingiberaceae	Atalè	Dotè	Root	DE, MA, PO	4	0.03

FC=Citation Frequency; FRC= Citation Relative Frequency; DE=Decoction; IN=Infusion; MA=Maceration; TR='Triturating; PO=Powdering; CD=Direct Consumption; CS=Consumption in form of Sauce; CB=Consumption in braised form; EJ=Extraction of Juice

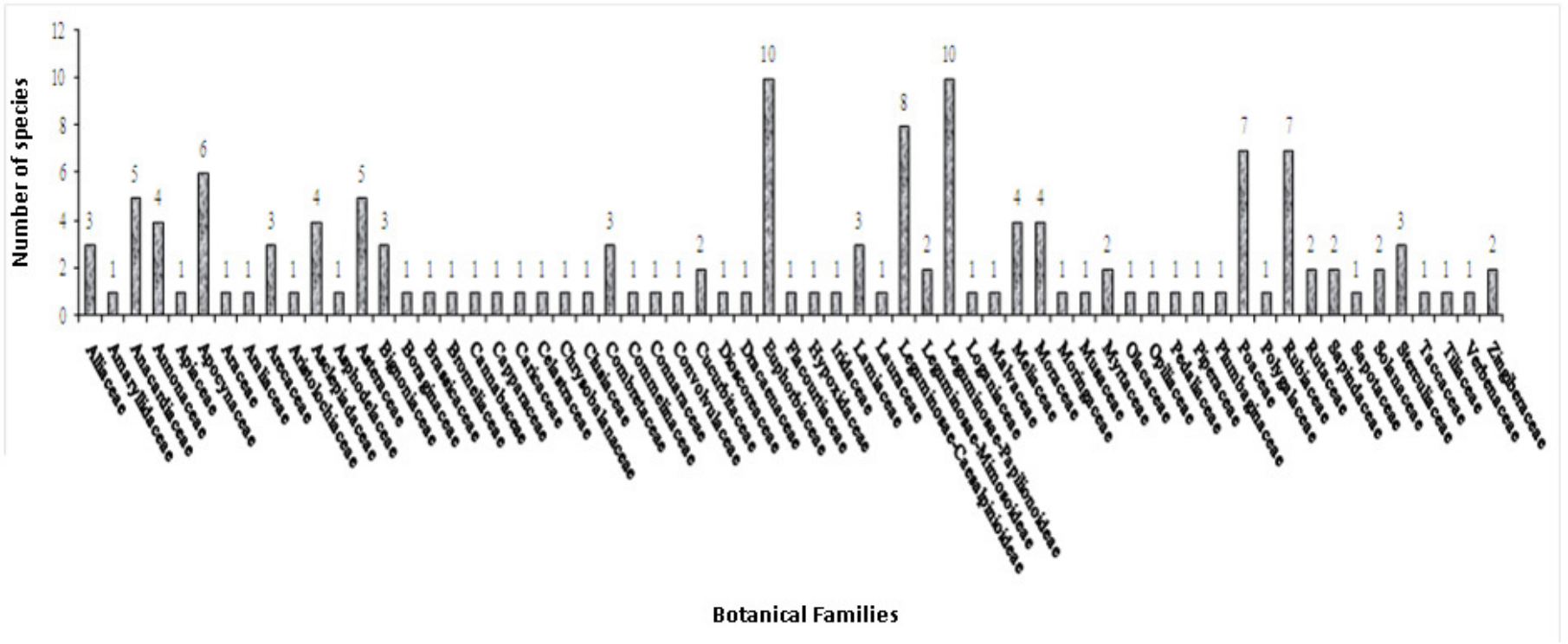

Figure 2: Histogram of anti-diabetic plants' families

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5.2 Different organs used and modes of remedy preparation: The anti-diabetics organs used and the modes of remedy preparation vary according to the species. Organs can be distributed in 9 various classes: leaves, fruits, seeds, barks, roots, bulbs, tubers, the whole plant and different parts such as flower, branches, endocarp, coco water, etc. Leaves (27%) were the most used anti-diabetic organs followed by roots (24%) and fruits (14%) (Figure 3). Six modes of remedy preparation were identified (Figure 4): decoction, infusion, maceration, powder, triturating and others (direct consumption, consumption in form of vegetable sauce or in sauce, consumption in braised, mixed form). The decoction (53%) was the most frequent mode of remedy preparation (Figure 4).

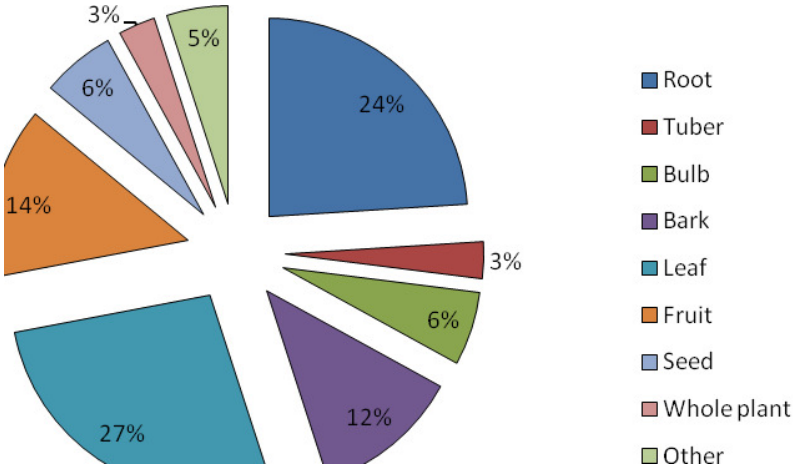

Figure3. Different organs used of identified anti-diabetic plants

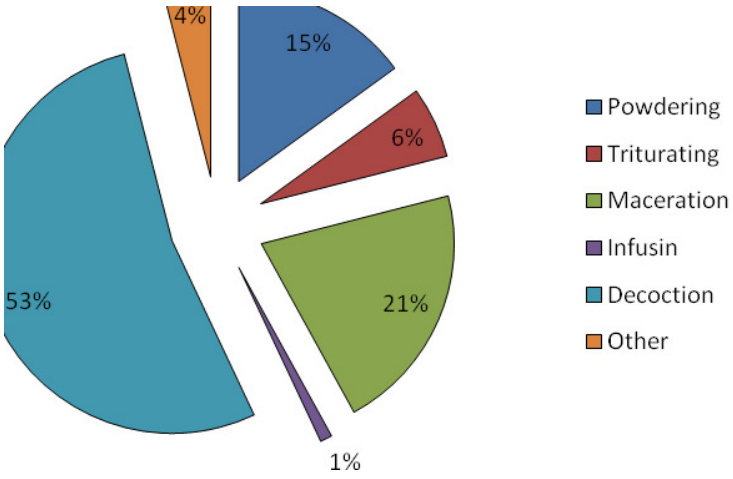

Figure 4: Pie chart of modes of remedy preparation

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5.3 Recipe related to identified anti-diabetic plants : A total of 63 recipe were recorded. Some of them are presented in the (Table 2) in term of example. Plants are generally combined for the treatment of the diabetes. Remedy Side-effects were quoted by 15.87 % of interviewees. Vomiting (4%) were the most quoted side-effect followed by abdominal pains (2.4%) and tiredness (1.5 %).

Table 2: Examples of recipe related to identified anti-diabetic plants species

No	Scientific names	Organs used	Mode of preparation	Mode of preemption (including the dose and duration of the treatment)	Side-effects	Effectiveness
1	*Anchomanes dalzielii* *Momordica charantia* *Catharanthus roseus*	Bulb Leaf Leaf	Boiling	Drinking a cup of bamboo 3 times per day. One must control the glycemia regularly in order to stop the consumption of the remedy when the rate of sugar returns to the normal	Tiredness hypoglycemia in case of prolonged consumption	Very good
2	*Euphorbia hirta* *Capsicum frutescens*	Whole plant Fruit	Crushing on a grinding stone or pilling in a mortar the whole plant of *Euphorbia hirta* and a few pieces of fruits of the green *Capsicum frutescens*, drying the crushed of pilled product; sieve the dry product in order to extract the powder.	Put one spoon of powder in the boil and take it each morning and night for 2 months	Body hot for 30 minutes	Acceptable
3	*Ocimum gratissimum*	Leaf	Taking a sufficient number of fresh leaves of *Ocimum gratissimum* and pilling them in a mortar, afterward pressing the pilled product in a bottle to get one liter of juice.	Drink a small cup of the product every three days till drinking 3 (initial stage) to 7 litters (developed stage)	Regular toilet	Good
4	*Anacardium occidentale*	Bark and leaf	Drying barks and leaves of *Anacardium occidentale*; powdering the two organs and making the mixture of the powders with equal quantity.	Taking a super spoon of the powder twice daily. Control the glycemia after 3 days of treatment and continue if necessary	None	Very good

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5	*Vernonia amygdalina*	Leaf	Triturating in water the leaves of *Vernonia amygdalina*, filtering it and put it in a bottle.	Drinking thrice a day one cup of Bamboo until getting satisfaction	None	Very good
6	*Moringa oleifera*	Leaf	Drying and crushing or pilling the leaves till getting powder	Put one super spoon of the powder in the sauce and do this for a month	None	Very good
7	*Bridelia ferruginea* *Allium cepa* *Khaya senegalensis*	Dry Leaf and Bark Bulb Bark	Boiling in two liters of water a handle of the dry leaves and barks of Bridelia ferruginea and a handle of barks of Khaya senegalensis with two large fragments of bulbs of *Allium cepa*	Drinking one cup of Bamboo twice a day during one week and repeat it if necessary	None	Very good
8	*Momordica charantia* *Citrus aurantifolia*	Leaf Juice	Extracting the juice from the leaves of *Momordica charantia* and adding it to the one of *Citrus aurantifolia* ripe fruits	Drinking every morning one cup of product until getting satisfaction	None	Very good

NB: one cup of bamboo contains about 285 ml; a small cup contains about 42 ml

6 DISCUSSION

6.1 Inventorying of anti-diabetic species : This study reported 144 medicinal anti-diabetic herbs. This number was higher than that (34) reported by Etuk *et al.* (2010) in an ethnobotanical study on the anti-diabetic medicinal herbs in the North-West of Nigeria. The same pattern of comparison was found with the studies by Gbolade (2008), Soladoye *et al.* (2012) in the South-West of Nigeria and Jouad *et al.* (2001) in Morocco reporting respectively 49, 132 and 54 anti-diabetic plants. In comparison to the current study, 19 anti-diabetic plants were identified in Ivory Coast by Tra Bi *et al.* (2008). The high number of anti-diabetic plants recorded in the current study reflects the diversity of plant species in the study area. Vandebroek *et al.* (2004) indicated that populations knowledge reflects the wealth of vegetations in which they live and asserted that more a vegetation is rich, more it offers diverse species used by local populations. Other various ethnobotanical studies have mentioned the use of some of anti-diabetic plants quoted in this study. These includes *Allium sativum* (Eddouks *et al.,* 2002), *Catharanthus roseus and Momordica charantia* (Lans, 2006), *Heliotropium indicum, Mangifera indica, Azadirachta indica* and *Tamarindus indica* (Ocvirk *et al.,* 2013). The anti-diabetic activity of some of these plants was also proved in experiments. This is the case of *Mangifera indica* (Aderibigebe *et al.,* 1999), *Vernonia amygdalina* (Akah and Okafor, 1992; Erato *et al.,* 2005), *Ocimum gratissimum* (Aguiyi *et al.,* 2000), *Momordica charantia* (Ali *et al.,* 1993; Raza *et al.,* 1996), *Spondia monbin* (Gbolade *et al.,* 2008),

Anacardium occidentale (Ojewole, 2003), *Zingiber* officinale (Ojewole, 2006) and *Phyllanthus amarus* (Srividya and Periwals, 1995). This study reported elsewhere nine principal anti-diabetic species (*Cola acuminata, Citrus aurantifolia, Caesalpinia bonduc, Garcinia cola, Khaya senegalensis, Momordica charantia, Moringa oleifera, Phyllanthus amarus, Picralima nitida*). These species were the most quoted and are hence the common anti-diabetic species in the study area. Most quoted anti-diabetic plants were represented by three botanical families (Euphorbiaceae, Leguminosae-Papilionoideae and Leguminosae-Caesalpinioideae). Gbolade (2008) and Soladoye *et al.* (2012) reported that Euphorbiaceae was the most represented anti-diabetic plants family in Nigeria. This indicates that species of the three families are important in the traditional medicine and suggests their consideration in forest ecosystems conservation. Such species would be richer in anti-diabetic active substances compared to the others; what could justify their large-scale use by the populations. For Joy *et al.,* (2001) these families are of great richness in medicinal herb.

6.2 Organs used and modes of remedy preparation: Populations use various parts of medicinal herbs in the preparation of anti-diabetic remedies. Leaves were the most used organs (27%). Similar observations were reported in several studies (Asase *et al.,* 2010; Nguta *et al.,* 2010; Koudouvo *et al.,* 2011; Yetein *et al.,* 2013). The highest usage frequency of leaves resides in their ease and speed in harvest (Bitsindou, 1986) but by the fact that they are the seat of the photosynthesis and sometimes the storage of the secondary metabolites responsible of the plant biological properties (Bigendako-Polygenis and Lejoly, 1990). Moreover, the use of leaves is less dangerous to the plant life than the use of its underground parts, its stem, bark or whole plant (Abebe and Ayehu, 1993; Giday *et al.,* 2003; Zheng and Zing, 2009). With regard to the mode of preparation, decoction (53%) is the most frequent mode and is followed by maceration (21%) and the powdering one (15%). The decoction was the most interested mode of remedies preparation as it helps to extract the most active ingredients and mitigates or cancels the toxic effect of certain recipe (Salhi *et al.,* 2010).

6.3 Recipe related to identified anti-diabetic plants: Sixty three (63) recipes were recorded from the use of anti-diabetic plants. This number is higher than those reported by Tra Bi *et al.* (2008) and Gbolade (2008) reporting respectively 19 and 50 recipes for the treatment of diabetes. The oral way is the only practiced mode of medicine pre-emption. Principal side-effects raised from traditional medicines use were vomiting (4%), abdominal pains (2.4%) and tiredness (1.5%). Hanae (2012) indicated in a study conducted in the area of Fez boulemane in Morocco that the principal side effects related to the use of anti-diabetic plants are digestive troubles, tiredness as general, palpitations and pains. The same author revealed that side effects are caused by preparations associating several plants and this is in relation with the toxicity of plants or overdose or interaction of active ingredients in 75 % of the cases. However, in the present study, most quoted plants are used in association and this is probably the cause of the side-effects appearance.

7 CONCLUSION

Ethnobotanical evaluation of anti-diabetic plant species in the Sudano-Guinean zone of Benin enable to discover the diversity of the anti-diabetic plants. This study has provided basic information to pharmacological researches. It is advisable in the future to deepen the studied local knowledge through ethno-pharmacological studies and to integrate it into a scientific framework. The laboratories of plant therapy are then called for chemical study up on the listed plants in order to identify active ingredients with hypoglycaemia action.

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