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## Medicinal plants used for treatment of diabetes by traditional practitioners in the markets of Abidjan district in Côte d'Ivoire

**Konkon NG, Ouatara D, Kpan WB and Kouakou TH**

### Abstract

Diabetes is a serious metabolic disorder. In Côte d'Ivoire, many plants are used as traditional medicines to treat diabetes and are sold on the popular markets of cities. The purpose of this work was to achieve an ethnobotanical investigation, with particular emphasis on herbal medicine. Three markets of Abidjan district were visited and we encountered 270 vendors of plants, aged of 30 to 60 years. Thus, 87 species of antidiabetic plants were identified. Various parts of the plant (root, stem, leaves, whole plant, flowers, fruits) are used to develop drug treatments. The drug preparation methods are varied (decoction, infusion, maceration, kneading). Among the 87 plants identified, 21 are used to treat diabetes and other ailments. The decoction is the most used mode of preparation of the plants sold in the district of Abidjan markets (75%) by traditional practitioners for the treatment of diabetes.

**Keywords:** Abidjan, antidiabetic, Côte d'Ivoire, diabetes, plant

### 1. Introduction

Diabetes is an important human ailment afflicting many from various walks of life in different countries. Around 200 million people of the world are currently suffering from diabetes and the figure is projected to rise to 300 million within 2025 by the World Health Organization (Rahmatullah *et al.*, 2012) <sup>[1]</sup>. The causes of this disease are not known; however, it is suspected that occurrences of the disease may result from increased number of elderly people, change in food habits, obesity, and adoption of a sedentary lifestyle (Kooti *et al.*, 2016) <sup>[2]</sup>. Because the human body cannot properly metabolize sugar when during diabetes, the first symptom of the disease is an increase in blood glucose or hyperglycemia. So, in several countries, various medicinal plants are used for the treatment of this disease, and claim to completely cure or at least alleviate major symptoms of diabetes (Gilani and Rahman, 2005; Mamun-or-Rashid *et al.*, 2014) <sup>[3-4]</sup>. In most countries of Africa, the traditional medicine accounts for over 85.00% of health coverage of the population with the same effectiveness as modern medicine. The lack of modern medicine treatments, the high cost of modern medicine treatments and socio-cultural habits of the population explain the use of traditional practices based on medicinal plants (Sanogo, 2006) <sup>[5]</sup>. In Côte d'Ivoire a number of populations still rely on their traditional medicinal practitioners for treatment of a diverse variety of ailments such as diabetes. This pathology is a major health problem, especially in the urban areas. Though there are various approaches to reduce the ill effects of diabetes and its secondary complications, herbal formulations are preferred due to lesser side effects and low cost.

The art of healing by plants is known and practiced in Africa for a long time, because it uses traditional knowledge passed down orally from generation to generation. So it is important to know who these people who have such knowledge, by what means, from which their secrets from the activity? Many questions raise approaches to knowledge and ensure in order to consume with peace these medicinal plants.

### 2. Material and Methods

The present study was conducted among the vendors of medicinal plants on three markets of Abidjan district in Côte d'Ivoire. During this ethnobotanical investigation, survey sheets and plastic bags were used. Consent was initially obtained from the responsible herbal markets. The practitioners were mentioned in detail about the purpose of our visit, and consent obtained to disseminate the information both nationally and internationally. Interviews were conducted

with the help of a semi-structured questionnaire and the guided field-walk method of Martin (2004) [6] and Maundu (1995) [7]. In this method, the interviewers on guided field-walks through markets go to the medicinal plants sellers, require plants used for treatment of diabetes, the description of the formulations and dosages. Plant specimens as pointed by the practitioners were collected, photographed, dried, and brought to laboratory for identification. Selected plants are used to make a herbarium.

The investigations were carried out in popular markets of Yopougon, Abobo and Adjamé, three municipalities of Abidjan district. In each municipality, the three most heavily supplied markets with medicinal plants was investigated regularly every week for 9 months. Then, a representative sample of the vendors to be interviewed in each market was set up. The sampling criteria such as volume of stocks, diversity of plants sold and presence of antidiabetic plants were used. Semi-direct or semi-structured interviews in French were carried out by all women selling medicinal plants, activities carried out entirely by women, to identify the vernacular or common names of the different plants sold and recommended for the treatment of diabetes. Plant identification was done by using the methods described by several authors (Lebrun *et al.*, 1997; Spichiger *et al.*, 2000; Aké-Assi, 2002; Poorter *et al.*, 2004; Bongers *et al.*, 2005) [8-12] and confirmed by the National Center for Floristics (Abidjan- Côte d'Ivoire).

### 3. Results

#### 3.1 Origins of knowledge and expertise

The sample size is 30 vendors per market, for a total of 270 vendors' interviewees across selected markets. 93 vendors, i.e. 34.45% are active in the markets as professional phytotherapists; Although they have offices in which they work, these women work in markets to get closer to customers. Similarly, 71 vendors, corresponding to 26.30% of the respondents, are mandated representatives of phytotherapists practicing in the provinces. They are supplied with plants by these traditional therapists and play the commercial agents' role. They act in the name and on behalf of the traditional therapists they represent. In addition, 106 womens, representing 39.25% of respondents are vendors of medicinal plants. They do not perform any other activity, with several years of experience in this sector.

#### 3.2 Constraints on their activities

**3.2.1 The Medicinal plant organs are exposed to sun and rain:** during the survey with the 270 vendors, 100.00%

respondents complain about the fact that plant organs are poorly preserved. This can deteriorate the quality of plants that are sold to customers and even reduce their purchasing power:

**3.2.2 Transport of medicinal plants in Abidjan:** to convey the plants to often there is lack of vehicles, a few times where there are trucks their mechanical condition is lacking. They often spend days and nights on the road before arriving in Abidjan. 125 vendors representing 46.29% of respondents can take weeks before being refueled.

**3.2.3 Access to the plant sales site is difficult:** 269 vendors, 99.90% of respondents complained about access to their sales site which is not accessible to many people who wish to treat themselves with plants. It is necessary to create a site open to all that seeks the medicinal plants.

#### 3.3 Inventory of antidiabetic plants

During ethnobotanical investigation, we worked with 270 plant vendors, aged of 30 to 60 years. A total of 87 antidiabetic plant species, belonging to 80 genera and 46 families, were recorded in the three markets of the Abidjan district (Table 1). The most represented families are in descending order Rubiaceae (8 species), Euphorbiaceae (7 species), Asteraceae (6 species), Apocynaceae and Fabaceae (4 species). Other families have less than four species. Some of these plants number 21 (Table 2) are used to treat diabetes as well as other types of pathologies. Depending on the number of conditions associated with diabetes, four groups of plants were established. These are (1) very strongly requested plants. These plants are used for the treatment of at least seven conditions; Therefore, they constitute genuine natural pharmacy boxes. In this study, only *Mitragyna inermis* is concerned ; (2) the strongly requested plants allow o treat four or five affections. It consists of seven plants which are *Jatropha curcas*, *Ocimum gratissimum* and *Phyllanthus amarus* used to fight five affections and *Ageratum conyzoides*, *Azadirachta indica*, *Psidium guajava* and *Vernonia colorata* treating four affections; (3) the plants moderately requested. Among seven, *Boerhavia diffusa*, *Eclipta prostrata*, *Momordica charantia*, *Nauclea latifolia*, *Parkia biglobosa*, *Persea americana* and *Terminalia catappa* were used in treatment of three affections; (3) the weakly requested plant are used in the treatment of two affections. *Achyranthes aspera*, *Annona muricata*, *Catharanthus roseus*, *Cymbopogon citratus*, *Tamarindus indica* and *Tectona stans* constitute this group.

**Table 1:** List of plants used in traditional medicine for treatment of diabetes on nine markets in district of Abidjan (Côte d'Ivoire)

Name of plants	Families	Morphological types and biological types	Chorologic al affinities	Plant parts used	Preparation Methods	Modes of administration	Associated plants for the preparation
<i>Achyranthes aspera</i> Linné	Amaranthaceae	Herb, Theroph.	GC-SZ	Whole plant	Decoction	Drink the decoction in a beer glass three times a day.	
<i>Agelanthus dodonefoliusi</i> (DC.) Polhill	Loranthaceae	Ep Par	SZ	Leaves	Decoction	Drink the decoction because of a beer glass two times / day	<i>Solenostemon monostachyus</i> (P. Beauv.) Briq. Subsp. <i>monostachyus</i>
<i>Ageratum conyzoides</i> Linné	Asteraceae	Herb, np	GC-SZ	Whole plant	Decoction	Drink the decoction in a beer glass 3 times a day.	
<i>Anacardium occidentale</i> Linné	Anacardiaceae	mp	NI	Stem bark and dry leaves	Maceration or infusion of the stem bark and decoction of the	Drink at will the macerate, infusion brewed and decoction.	

					leaves		
<i>Anchomanes difformis</i> (Bl.) Engl.	Araceae	Herb, Geophyte	GC	Rhizome	Maceration	Drink a beer glass morning and evening to cure the macerate.	
<i>Albizia lebbeck</i> (L.) Benth.	Mimosaceae	mP	GC-SZ	Roots	Decoction	Drink a beer glass morning and evening.	
<i>Allium sativum</i> Linné.	Liliaceae	Herb, Geophyte	I	Bulb	Tincture and maceration	Drink before meals every other day.	
<i>Aloe buettneri</i> A. Berger	Liliaceae	Herb, H	SZ	Whole plant	Decoction, Maceration, Infusion	Drink the decoction, the maceration or infusion all day.	
<i>Annona muricata</i> Linné	Annonaceae	Np	I	Dried leaves	Infusion	Drink at will infusion into the day.	
<i>Annona squamosa</i> Linné	Annonaceae	Np	I	Leaves	Decoction	Drink at will all day.	
<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.	Combretaceae	mp	SZ	Leaves	Decoction	Drink at will all day.	
<i>Argemone mexicana</i> Linné	Papaveraceae	Th COAm	GC-SZ	Roots	Decoction	Drink the decoction three times a day.	
<i>Asystasia calycina</i> Benth.	Acanthaceae	np	GC	Leaves	Decoction	Drink the decoction all day in a beer glass.	
<i>Azadirachta indica</i> A-Juss	Meliaceae	mP	I	Leaves or Stem bark	Decoction	Drink the decoction ½ liter/day.	
<i>Bambusa vulgaris</i> Schra. ex.Wendel	Poaceae	Herb, Hemicyr.	Jav-I	Leaves	Decoction	Drink decoction at will all day.	
<i>Bidens engleri</i> O. E. Schutz	Asteraceae	Therophyte	GC-SZ	Whole plant	Decoction	Drink the decoction a glass morning, noon and night.	
<i>Bidens pilosa</i> Linné	Asteraceae	Therophyte	GC-SZ	Whole plant	Decoction	Drink the decoction a glass morning, noon and night.	
<i>Blighia sapida</i> K. D. Koenig	Sapindaceae	mP	GC- SZ	Seeds and immature fruits	Decoction	Toxic effect of immature fruit known by the population.	
<i>Boerhavia diffusa</i> Linné	Nyctaginaceae	Herb, Nanoph.	GC- SZ	Whole plant	Maceration	Drink the maceration a beer glass 3 times a day.	<i>Garcinia kola</i> Heckel (Seeds)
<i>Bridelia ferruginea</i> Benth.	Euphorbiaceae	mp	GC-SZ	Leaves and roots	Decoction	Drink the decoction two glasses of beer a day. Treatment duration 14 days.	
<i>Caesalpinia pulcherrima</i> (Linn.) Sw.	Caesalpiniaceae	Shrub, Nanoph.	I	Leafy stems	Decoction	Drink the decoction day in a teaspoon three times a day.	<i>Oxynanthera abyssinica</i> (leaves)
<i>Cassia occidentalis</i> Linné	Caesalpiniaceae	np	GC- SZ	Leaves	Decoction	Drink the decoction a glass morning and evening	
<i>Catharanthus roseus</i> (Linn.) G. Don, Aké Assi	Apocynaceae	np	GC	Leaves	Decoction	Drink the decoction at will all day.	
<i>Ceiba pentandra</i> (L.) Gaertn.	Bombacaceae	MP	GC-SZ	Fresh leaves	Decoction	Drink the decoction at will all day.	
<i>Chromolaena odorata</i> (L.) M. King and H. Robins	Asteraceae	Herb, np	GC	Leaves and Roots	Decoction	Drink the decoction at will all day.	
<i>Chrozophora senegalensis</i> (Lam.) A. Juss	Euphorbiaceae	np	SZ	Dry whole plant	Decoction	Drink the decoction three times a day.	
<i>Chrysophyllum cainito</i> Linné	Sapotaceae	Shrub, Micro.	I	Stem bark and leaves	Maceration	Drink the maceration in a beer glass three times a day	
<i>Citrus aurantiifolia</i> (Christm.) Swingle	Rutaceae	Amp- Mp	I	Leaves	Decoction	Drink the decoction at will all day.	
<i>Cleistopholis patens</i> (Benth.) Engl. and Diels	Annonaceae	mP	GC	Leaves	Trituration, Kneading	Triturate beverage and enema once a week	<i>Terminalia catappa</i> L. (leaves)
<i>Clerodendrum inerme</i> (L.) Gaertn	Verbenaceae	Liana, Micro.	I	Leaves	Decoction	Drink the decoction to lower of the blood sugar	
<i>Cnestis ferruginea</i> DC	Connaraceae	Liana, mp	GC	Leaves and roots	Decoction	Drink the decoction at will all day.	
<i>Coffea mauritiana</i> Lam.	Rubiaceae	Shrub, Microph.	GC	Leaves	Decoction or Infusion	Drink the decoction or the infusion at will.	
<i>Cymbopogon citratus</i> (DC.) Stapf.	Poaceae	Herb, np	GC-SZ	Rhizome	Decoction	Drink the decoction three times a day.	
<i>Daucus carota var. sativa</i> Linné	Apiaceae	Herb, G	I	Tubers	Expression, grating, juice	Drink the juice at will all day	
<i>Diospyros mespiliformis</i> Hochst.ex A. DC.	Ebenaceae	mp	GC-SZ	Leafy stems	Decoction	Drink the decoction at will all day.	
<i>Drimys glaucescens</i> (Engl. and K.	Liliaceae	G	SZ	Whole plant	Decoction	Drink the decoction at will all day.	

Krause) H. Scholz							
<i>Eclipta prostrata</i> (Linn.) Linn.	Asteraceae	Th	GC-SZ	Leaves	Decoction	Drink the decoction at will all day.	
<i>Entada gigas</i> (L.) Fawc. and Rendle	Mimosaceae	LmP	GC	Leafy stems	Decoction	Drink the decoction three times a day.	
<i>Ficus glumosa</i> Delile	Moraceae	mp	GC-SZ	Trunk bark and roots	Decoction	Drink the decoction two times / day, and wash with one time / day during seven days	<i>Hexabolus monopetalus</i> (roots)
<i>Ficus platyphilla</i> Delile.	Moraceae	mp	SZ	Stem bark	Decoction	Drink the decoction a glass morning, noon and night to decrease blood sugar levels.	
<i>Flueggea virosa</i> (Roxb. ex Willd.) Voigt	Euphorbiaceae	np	GC-SZ	Roots	Decoction	Drink the decoction at will all day.	
<i>Gardenia ternifolia</i> Schum. et Thonn. Subsp ternifolia	Rubiaceae	mp	GC-SZ	Leaves	Decoction	Drink the decoction three-four glasses / day before meals.	
<i>Graptophyllum pictum</i> (L.) Griff	Acanthaceae	Np	I	Leaves	Decoction	Drink the decoction a glass several times a day, drink nothing more.	
<i>Harrisonia abyssinica</i> Oliv.	Simaroubaceae	Lmp	GC-SZ	Leaves	Decoction	Drink the decoction ½ glass of beer morning and evening	
<i>Harungana madagascariensis</i> Lam. Ex Poir.	Hypericaceae	mp	GC	Leafy stems and stem bark	Decoction	Drink the decoction all day.	
<i>Holarrhena floribunda</i> (G. Don) var. <i>floribunda</i>	Apocynaceae	mp	GC- SZ	Palm leaves; stem bark	Decoction	Drink the decoction a glass/day during one week	
<i>Hotslundia opposita</i> M.Vahl	Labiatae	Herb, np	GC- SZ	Leaves	Decoction	Drink the decoction at will	
<i>Ipomoea batatas</i> (L.) Lam.	Convolvulaceae	Lmp	I	Leaves	Decoction	Drink the decoction at will	
<i>Jatropha curcas</i> Linné	Euphorbiaceae	Shrub, Nanoph.	I	Leafy stems	Maceration	Drink the maceration in a beer glass three times a day for an adult and a shot glass for a child.	
<i>Jatropha gossypifolia</i> Linné	Euphorbiaceae	Shrub, Nano.	I	Leaves and roots	Trituration	Drink 150 mL of triturate fasted for two days. Repeat once a week later. Use the pounded roots as bath soap. <i>Citrus aurantifolia</i> .	<i>Citrus aurantifolia</i> (Christm.) Swingle (juice)
<i>Lantana camara</i> Linné	Verbenaceae	Lmp	GC	Roots and leaves	Decoction	Drink the decoction, Adult: 10 teaspoon a day. Child 1 teaspoon two times a day.	<i>Mangifera indica</i> L.; (roots); <i>Anacardium occidentale</i> L.; <i>Olax subscorpoidea</i> , <i>Xylopia aethiopica</i> (Dunal) A. Rich. (fruit)
<i>Macrosphyra longistyla</i> (DC.) Hiern	Rubiaceae	Lmp	GC-SZ	Leaves	Decoction	Drink the decoction, Adult: two beer glasses/day for 1 week and child beer glass/day for 1 week.	<i>Garcinia kola</i> Heckel (seeds)
<i>Mitragyna inermis</i> (Willd.) Kuntze	Rubiaceae	mp / Hel.	SZ	Stem bark and leaves	Decoction	Drink the decoction a glass three times/day	
<i>Moghania faginea</i> (Guill. and Perr.) O. Ktze	Fabaceae	Th	GC-SZ	Leaves	Decoction	Drink the decoction all day.	
<i>Momordica charantia</i> Linné	Cucurbitaceae	Liana, np	GC	*Fresh fruits, *Stems with leaves *Fresh leaves or dried leaves *Whole Plant	Decoction	Drink the decoction at will.	
<i>Morinda lucida</i> Benth.	Rubiaceae	mp	GC-SZ	Fresh roots bark and dried leaves	Decoction	Drink the decoction 75 mL three times/ day.	
<i>Morinda morindoides</i> (Bak.) Milne-Redh	Rubiaceae	Lmp	GC	Roots	Decoction	Drink the decoction a glass three times a day.	
<i>Mucuna priuriens</i> var. <i>priuriens</i> (L.) DC.	Fabaceae	Th	GC-SZ	Whole plant	Decoction	Drink the decoction at will during the day.	
<i>Nauclea latifolia</i> Smith	Rubiaceae	Lmp	GC- SZ	Roots	Decoction	Drink the whole decoction in three doses in the day.	
<i>Ocimum gratissimum</i> Linné	Lamiaceae	Shrub, Nanoph.	GC-SZ	Leaves	Decoction	Drink the decoction at will over a week.	

<i>Ouatea affinis</i> (Hook. f.) Engl.	Ochnaceae	np	GC	Fresh leaves	Maceration or Decoction	Drink the mixture (maceration decoction) at a rate of three liters/day for three days. After a stop for two days with continued treatment: eat six raw fresh leaves every morning and evening for three days.	<i>Entada gigas</i> (Stem)
<i>Oxytenanthera</i> <i>abissynica</i> (A. Rich.) Munre	Poaceae	mp	SZ	Leaves	Decoction	Drink the decoction at will all day.	<i>Bredelia</i> <i>ferruginea</i> (leaves et roots)
<i>Parkia biglobosa</i> (Jacq.) Benth.	Mimosaceae	Mp	SZ	Leaves	Decoction	Drink the decoction at will all day	
<i>Persea americana</i> Mill.	Lauraceae	Mp	I	Leaves	Decoction	Drink the decoction at will during the day	
<i>Phaseolus vulgaris</i> Linné	Fabaceae	Th	I	Dried pods	Decoction	Drink the decoction a glass every morning fasting for a week.	
<i>Phyllanthus amarus</i> Schum. and Thonn.	Euphorbiaceae	Suffrutex, Nanoph.	GC	Leaves	Decoction, Tincture, Infusion Maceration	All extracts are administered orally.	
<i>Piper guineense</i> Schum. and Thonn.	Piperaceae	Lmp (Ep)	GC	Whole fruits	Decoction	Used a teaspoon of decoction every Tuesday for 30 days, then 15 days, then two times a week.	
<i>Portulaca oleracea</i> Linné	Portulacaceae	Th	GC-SZ	Stems with leaves	Decoction	Drink the decoction three times a day.	
<i>Psidium guajava</i> Linné	Myrtaceae	mp	I	Leaves	Decoction	Drink the decoction at will during the week.	
<i>Rauvolfia obscura</i> K. Schum	Apocynaceae	Np	GC- W	Fresh roots	Decoction	Decoction of the roots is used orally	
<i>Rauvolfia vomitoria</i> Afzel.	Apocynaceae	mp Shrub, Microph.	GC-SZ	Dried leaves	Infusion	Drink the infusion three times a day in a beer glass.	
<i>Ricinus communis</i> Linné	Euphorbiaceae	Np	I	Whole plant	Decoction	Drink the decoction at will all day.	
<i>Sarcocephalus</i> <i>latifolius</i> (Sm.) Bruce	Rubiaceae	Lmp	GC-SZ	Stem bark	Decoction	Drink the decoction all day in a beer glass.	
<i>Sclerocrya birrea</i> (A. Rich) Hochst. <i>subsp. birrea</i>	Anacardiaceae	Mp	SZ	Dried leaves	Powder	Powder of dried leaves to mix daily with food.	
<i>Securidaca</i> <i>longepedunculata</i> Fresen.	Polygalaceae	mp	SZ	Whole Plant	Decoction	Drink the decoction a glass/day for 10 to 30 days.	
<i>Scoparia dulcis</i> Linné	Scrophulariac eae	np	GC-SZ	Whole plant	Decoction	Drink the decoction all day.	
<i>Sida cordifolia</i> Linn., Aké Assi	Malvaceae	Np	GC-SZ	Stems with leaves and roots	Decoction	Drink the decoction at will.	
<i>Solanum</i> <i>lycopersicum</i> L. var. <i>cerasiforme</i> (Dunal) Voss	Solanaceae	Th	GC-SZ	Fruit	Decoction	Drink the decoction three times a day to lower blood glucose levels.	
<i>Stachytarpheta</i> <i>jamaicensis</i> (L.) Vahl.	Verbenaceae	np	GC	Leaves and axis flowering	Decoction or Infusion	Drink several glasses of this decoction or infusion into the day.	
<i>Stereospermum</i> <i>kunthianum</i> cham.	Bignoniaceae	mp	SZ	Leaves	Decoction	Drink the decoction in a cup one time a day.	
<i>Tamarindus indica</i> Linné	Caesalpiniace ae	Mp	GC-SZ	Leaves, roots and stem bark	Decoction	Drink the decoction at will for a week.	
<i>Tecoma stans</i> (L.) Kunth	Bignoniaceae	Mp	I	Leaves	Decoction	Drink the decoction for a week.	
<i>Terminalia catappa</i> Linné	Combretaceae	Microph.	I	Leaves	Decoction	Drink the decoction in a beer glass three times/day.	<i>Cleistopholis</i> <i>patens</i> (leaves)
<i>Terminalia mantaly</i> Linné	Combretaceae	Np	I	Stems with leaves	Decoction	Drink the decoction for a week.	
<i>Vernonia colorata</i> (Willd.) Drake	Asteraceae	Mp	GC-SZ	Leaves	Decoction	Drink the decoction all day.	
<i>Vigna unguiculata</i> (L.) Walp.	Fabaceae	Herb, Th	GC-SZ	Lugs (empty pods)	Decoction	Drink the decoction a beer glass of three times a day.	
<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae	mp	SZ	Leaves	Decoction	Drink the decoction in a beer glass all day.	

Table 2: Use of recovered plants in markets in district of Abidjan (Côte d'Ivoire)

Plants	Pathologies	Organs for the treatment	Methods of preparation
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<i>Achyranthes aspera</i>	Diabetes Diuretic	Whole plant Whole plant	Decoction Decoction
<i>Ageratum conyzoides</i>	Easy childbirth Diabetes Hypertension Headache	Leaves Whole plant Whole plant Leaves	Extract (Expression) Decoction Decoction Paste
<i>Annona muricata</i>	Malaria Diabetes	Fruit Dry leaves	Syrup Decoction
<i>Azadirachta indica</i>	Malaria Diabetes Edema Rheumatism	Leaves Leaves or Stem bark Leaves Leaves	Decoction Decoction Decoction Decoction
<i>Boerhavia diffusa</i>	Diabetes Poultices Angina	Whole plant Tubers Whole plant	Maceration Decoction Decoction
<i>Catharanthus roseus</i>	Diabetes Hypertension	Leaves Whole plant	Decoction Decoction
<i>Cymbopogon citratus</i>	Diabetes Cough	Roots Leaves	Decoction Decoction
<i>Eclipta prostrata</i>	Furuncles Diabetes Hemorrhoids	Leaves Leaves Leaves	Decoction Decoction Decoction
<i>Jatropha curcas</i>	Diabetes Wormer Malaria Diarrhoea Easy childbirth	Leafy stems Leaves Leaves Flower or Leaves Leaves	Decoction Trituration Decoction Purge Oral instillation
<i>Mitragyna inermis</i>	Diabetes Hypertension Antipyretic Dysentery Bilharzia Syphilis Jaundice Mental illness Infectious diseases Intercostal pain Epilepsy Wounds Arthritis	Leaves Leaves Stem bark Stem bark Stem bark Leaves Leaves Leaves Leaves Leaves and stem bark Palm rod Leaves Leaves and stem bark Leaves	Decoction Decoction Decoction/Maceration Decoction Decoction Decoction Decoction Decoction Decoction Decoction Decoction Decoction Decoction Decoction
<i>Momordica charantia</i>	Diabetes Malaria Zona	Fresh fruits, Leaves Leaves	Decoction Maceration or Trituration Paste
<i>Nauclea latifolia</i>	Diabetes Hemorrhoids Malaria	Roots Fresh leaves Trunk bark	Decoction Maceration Decoction
<i>Ocimum gratissimum</i>	Painful constipation Diabetes Hypertension General tiredness Malaria	Leaves Leaves Leaves Leaves Leaves	Decoction Decoction Decoction Trituration Decoction or Paste (Purge)
<i>Parkia biglobosa</i>	Diabetes Hypertension Maux de reins	Leaves Leaves Root bark	Decoction Decoction Paste (friction)
<i>Persea americana</i>	Diabetes Hypertension Rheumatism	Leaves Leaves Seed	Decoction Decoction Pilat (friction)
<i>Phyllanthus amarus</i>	Diabetes Typhoid fever Hypertension Malaria Sore tummy	Leaves Leaves Leaves Leaves Rameau leaved	Decoction Paste Decoction Decoction Maceration
<i>Psidium guajava</i>	Diarrhoea Diabetes Hypertension Zona	Leaves Leaves Leaves Stem epidermis	Decoction Decoction Decoction Absorption
<i>Tamarindus indica</i>	Diabetes Measles	Leaves, Roots Fruit pulp	Decoction Maceration
<i>Tectona stans</i>	Diabetes Typhoid fever	Leaves Leaves	Decoction Decoction
<i>Terminalia catappa</i>	Diabetes Asthma	Leaves Bark rod	Decoction Paste

	Infectious diseases	Fruits	Without preparation
<i>Vernonia colorata</i>	Dermatoses	Leaves	Decoction
	Diabetes	Leaves	Decoction
	Hypertension	Leaves	Decoction
	Malaria	Leaves	Decoction

### 3.4 Botanical characteristics of antidiabetic plants encountered

The taxa identified during the inquiries were divided into four groups according to the size and the plant type. Figure 1 shows that the shrubs are mostly the most used plants (33.33%). Trees with 8.33% are the least used. All biological types have been listed. The phanerophytes are the majority with 77.53% followed by therophytes with 12.36%. The parasites are weakly used and represent only 1.12% of the plants surveyed (Figure 2). Besides, The distribution of species by chorological affinity is shown in Figure 3. Five groups of plants were observed. The common taxa to the Guineo-Congolese (GC) and Sudan-Zambia (SZ) regions are the majority with 40.23%. Introduced taxa (I), cultivated for various purposes, come in second position after those common to GC and SZ (GC-SZ), including *Catharanthus roseus* (Apocynaceae) and *Azadirachta indica* (Meliaceae). Otherwise, plants of GC represent 18.39% rate with 16 result from wet forest. In addition, the taxa of SZ are naturally localized in the savannas and in clear forests or steppes. We encountered 13 species including *Chrozophora senegalensis* (Euphorbiaceae), *Gardenia ternifolia* (Rubiaceae) and *Parkia biglobosa* (Mimosaceae). Finally, West African endemic taxa (W) are represented by a single species: *Rauvolfia obscura* (Apocynaceae).

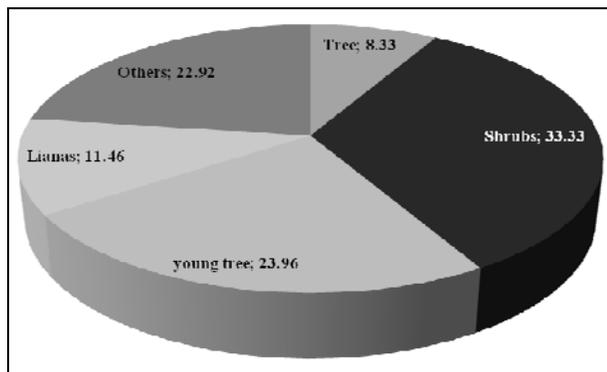


Fig 1: Spectre of species distribution by morphological type Values are expressed in percentage

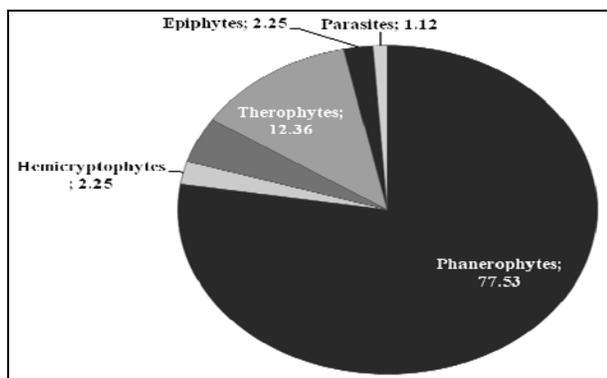


Fig 2: Spectre of species distribution by biological type Values are expressed in percentage

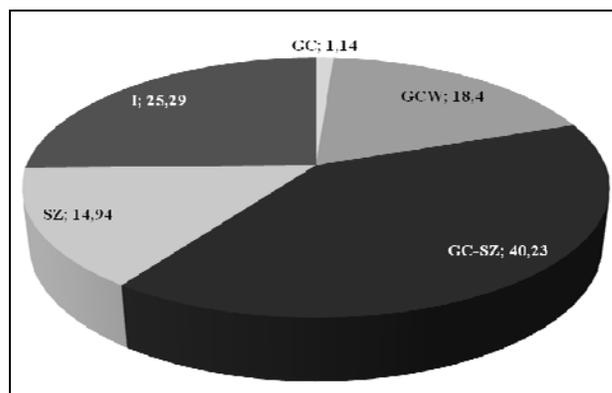


Fig 3: Spectre of species distribution by chorological affinity Guinea-Congolese Region (GC); Introduced taxa (I); Region of Sudan-Zambia (SZ); Endemic taxa of West Africa (W). Values are expressed in percentage

### 3.5 Treatment of Diabetes

To propose a treatment to any patient presenting diabetes traditional practitioner requires the diagnosis of a doctor. It is a perfect collaboration between two medicines which are called to be complementary. Recipes are prepared from vegetable drugs essentially. Sometimes the traditional practitioner adds extracts of animal and mineral origin. The investigation allowed to note that 87 plants are used to prepare 97 drug recipes, among which 91 are monospecific. The duration of the treatment varies according to the used plants and the traditional practitioner who treats the sick patient. This duration is between three months and one year. About the efficiency of treatments, 40.00% of patients responded satisfied with the glycemia. Organs used for the treatment of the diabetes in this study are mainly dominated by leaves with 45.28%, followed by roots with 13.20% and whole plants with a 12.26% rate. Flowers, bulbs and seeds, with 0.94%, were the parts most weakly used (Figure 4). The figure 5 shows that among the various modes of drugs preparation, the decoction is used predominantly (75%). By far follow maceration and infusion with 9.00 and 7.00% respectively. Pressure, kneading and flowing had the lowest rates (1.00%). Otherwise, the oral modes of drug administration, in the form of drink, are the most requested (Figure 6). At the level this, the decocted is the most used mode of beverage (75.00%), followed by the macerated and the infused with 9.00 and 7.00%, respectively. Furthermore, powders is most weakly used form of drug administration (1.00%).

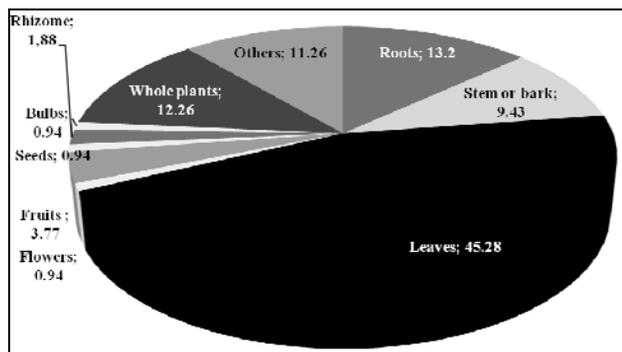


Fig 4: Distribution of species by organ used for drug preparation Values are expressed in percentage

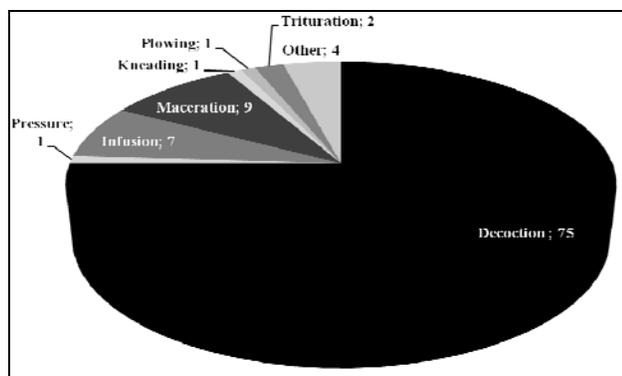


Fig 5: Spectre of the modes of preparation of medicine Values are expressed in percentage

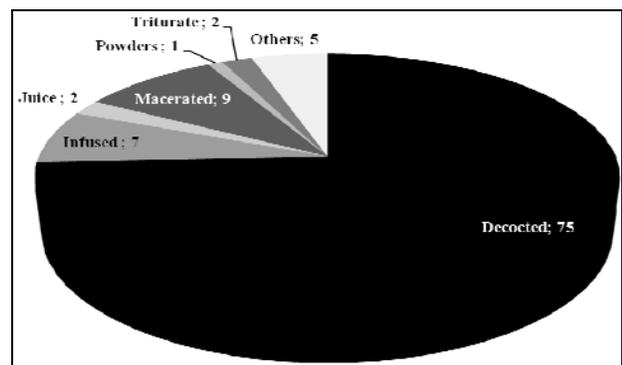


Fig 6: Spectre of drugs forms Values are expressed in percentage

#### 4. Discussion

In total 87 species belonging to 80 genera and 46 families. The most represented families are in order: Rubiaceae (eight species), Euphorbiaceae (seven species), Asteraceae (six species), Apocynaceae and Fabaceae with four species. The other families with fewer than four representatives. This representation was also observed, with some variations, during the ethnomedicinal investigations conducted in the other regions of the country by Kamanzi *et al.* (2002) [13] and by Diehl (2004) [14]. This is explained by the fact that these families are in the number of genera and species, the most important of the Ivorian flora (Aké-Assi, 1984; Kouamé, 1998) [15-16]. Elsewhere in Africa, the prevalence was observed for the families of the Euphorbiaceae and Asteraceae in Uganda (Hamill, 2003; Kamatanesi-Mugisha *et al.*, 2007) [17-18] and then to the Asteraceae by Fennel *et al.* (2004) [19] in South Africa. These two plant families listed among those that provide well as plants in the African pharmacopeia. The most used plants are *Mitragyna inermis*, *Phyllanthus amarus*,

*Azadirachta indica*, *Ageratum conyzoides*, *Catharanthus roseus*, *Vernonia colorata*, *Momordica charantia*, *Jatropha curcas*, *Cymbopogon citratus*, *Annona muricata* and *Ocimum gratissimum*.

The ethnomedicinal surveys conducted in other developing countries reported the use of certain plants against diabetes. The latest show *Allium sativum* (Eddouks *et al.*, 2002) [20], *Catharanthus roseus* and *Momordica charantia* (Lans, 2006) [21]. The antidiabetic activity of some of these plants has also been proven experimentally. This is the case of *Phyllanthus amarus* (Srividya *et al.*, 1995) [22] *Ceiba pentandra* (Ladeji *et al.*, 2003) [23], *Parkia biglobosa* (Odetola *et al.*, 2006) [24] and *Vernonia colorata* (Sy *et al.*, 2007) [25]. All the morphological types were encountered during our ethnobotanical survey of the three municipalities of the city of Abidjan. Our study shows that 33.33% of plants surveyed in the markets for the treatment of diabetes are shrubs. In fact, most of the plants used come from the north of the Ivory Coast and it has a vegetation rich in shrubs. The most sought-after species belong to the phanerophytes with 77.53%. The results also show that hemicryptophytes and geophytes, which are abundant and easily accessible to collectors, represent only 2.25 and 4.49% of the taxa surveyed. On the other hand, no plants belonging to the chamephytes were present in the plants used to treat diabetes in the markets. Thus, the distribution of species by biological type seems to be linked to the medicinal values known to plants by traditional medicinal practitioners and not to their accessibility.

The species listed belong to the Guineo-Congolese and Sudan-Zambesian regions with 40.22%. The introduced taxa ranked second with 25.28% followed by taxa in the Guineo-Congolese region and those in the Sudan-Zambesian region with 18.39 and 14.94%, respectively. The roots, stems and leaves are the main parts of the plants used for the formulation of anti-diabetic extractions. Thus, our survey made it possible to classify the plants in four groups of plants for antidiabetic use in order of importance. Group I consists of plant leaves. They are the most stressed and represent 45.28% of the organs used; Group II is represented by roots and whole plants with 13.20 and 12.26% utilization rates; Group III concerns plants whose stem bark is used (9.43%); Finally, group IV consists of the reproductive organs (flowers, fruits and seeds) which are used very little, with about 4.65% of the cases. In regards to preparation methods, the decoction with a rate of 75.00% was the most used. This preponderance may therefore be justified by the fact that the boiling of the plant organs allows rapid extraction of the active ingredients, as reported by Adjanohoun and Ake-Assi (1979) [26]. In addition, preparation techniques such as kneading (Zirihi, 1991; N'guessan, 2008) [27-28], pulping (Piba *et al.*, 2006) [29] and spraying (Vangah, 1986) [30] have already been successfully used with several other plants. The preponderance of monospecific receipts in the treatment of diabetes in the study area suggests that plant sellers in markets are aware of the interactions between active ingredients caused by the mixture of plant organs. These interactions cause mixed toxicity. Indeed, Piba *et al.* (2006) [29], reported that 32% of deaths of traditional medicine patients in Africa are caused by mixtures. Moreover, the mixture of two extracts can have toxic, synergistic or potentiating effects (Viau, 2002; Touré, 2015) [31-33]. Therefore, it would be advantageous for toxicological screenings of the various plant formulations to be carried out in order to provide traditional medicinal practitioners with mixtures of high therapeutic power. These results seem to show the presence of a relationship between

diabetes and other diseases (hypertension, asthma, infectious diseases, zoster etc.). Thus, study of these medicinal plants opens interesting perspectives in the formulation of the traditional medicines improved (MTA) able to act simultaneously on several pathologies (Ahmed and Azam, 2014)<sup>[33]</sup>.

## 5. Conclusion

Ethnobotanical investigations identified 87 plants used in the treatment of diabetes. These plants belong to 80 genus grouped within 40 families. The most represented families are in order: the Rubiaceae (eight species), the Euphorbiaceae (seven species), the Asteraceae (six species), the Apocynaceae and the Fabaceae with four species. *Mitragyna inermis*, *Phyllanthus amarus*, *Azadirachta indica*, *Ageratum conyzoides*, *Catharanthus roseus*, *Western anacardium*, *Morinda lucida*, *Jatropha curcas*, *Cymbopogon citratus*, *Annona muricata*, *Bridelia ferruginea*. The shrubs, with 33.33% are the most solicited plants. At the level of the phanerophytes, mostly used trees (77.53%), the nanophanerophytes which are best represented with 58.00%. From the point of view of the chorological affinities, the plants encountered are divided into five groups which are: West African endemic plants, plants of the Guineo-Congolese region, plants of the Sudano-Zambesian region, introduced plants and plants common to the Guinea- Congolese and the Sudan-Zambesian region. The common taxa of Guineo-Congolese and Sudano-Zambesian regions are predominant with 40.22%. The parts of the most used plants are the leaves (45.28%) with decoction as the most used method of preparation (75.00%).

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